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Fossil Localities in Torlesse Rocks of the North Island, New Zealand

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Abstract

Data on 110 fossil localities in Torlesse rocks of the North Island of New Zealand are tabulated, and the distribution of localities shown on maps. Zones are fewer and less well defined than in the South Island. The Permian is particularly fossiliferous, but no Kaihikuan (Ladinian) fossils are known. Much of the Torlesse might be Late Jurassic except for anticlinal cores, possibly in part faulted, of Permian, Late Triassic, and Early Jurassic. Although tectonic mobility is demonstrated by the occurrence of derived fossils, the distribution of fossil localities, is, by itself, of limited value in paleoenvironmental, paleogeographic, and provenance interpretations.

INTRODUCTION

Campbell and Warren's (1965) compilation of fossil localities in Torlesse rocks of the South Island has over the past 10 years promoted significant research on the Torlesse (Bradshaw 1973; Landis and Bishop 1972). The success of their compilation, together with a resurgence of interest in Torlesse rocks, has demonstrated a need for a comparable tabulation of localities in the Torlesse of the North Island which is presented herein.

Although the diversity of lithofacies is greater than normally accepted (Andrews, Speden, and Bradshaw, in press), the Torlesse rocks of both islands characteristically consist of a structurally complex suite of sparsely fossiliferous, both volcanoclastic and quartzo-feldspathic greywacke sandstone and siltstone, with minor conglomerate, limestone, chert, basic volcanic rocks and manganiferous sediment, and are thought to have been deposited in mainly deep water. These rocks, generally referred to as Torlesse Supergroup, facies, or zone (in a textural sense; Carter *et al.* 1974), contrast with the well-bedded, structurally simple, relatively fossiliferous and predominantly volcanoclastic sediments of the Hokonui facies, the other major facies of the New Zealand Geosyncline (Carter *et al.* 1974).

Stevens (1963) extended the application of the name Torlesse (Suggate 1961; Campbell and Coombs 1966) from the South to the North Island, where Grindley (1960) had previously recognized several "greywacke" units within the Torlesse in western Raukumara Peninsula (Speden 1972). Kear (1971) classified the Torlesse of the northern part of the North Island into two distinct facies (Morrinsville and Hunua) and compared these with his Oparau (= Hokonui) facies.

An important feature of the geographic distribution of the Torlesse rocks in the North Island is that the simplest structural and/or depositional relationship between the Torlesse and Hokonui Zones may occur in the Waikato region. Even though the contact is largely masked by Tertiary rocks and marked by Tertairy faults, there is an abrupt change in physical properties over a short distance (Fleming 1970). The contact is interpreted by Kear (1971, p. 279) to correspond to "the position of the steep, possibly faulted, continental slope". North of the Waikato River the position of the contact is marked approximately by the eastern peak, the Junction Magnetic Anomaly of Hatherton and Sibson (1970), of the double-peaked Stokes Magnetic Anomaly (Wellman 1973).

Because many of the areas of Torlesse are bounded by Tertiary rocks or the sea, the problem of the upper boundary is not as acute as it is in the South Island (Campbell and Warren 1965, p. 100; Suggate in Stevens 1972, p. 9; Andrews, Speden, and Bradshaw in press). In western Raukumara Peninsula the Torlesse is unconformably overlain by Korangan Stage (Taitai Series, Aptian) or Clarence Series (Albian) (Speden 1973, 1975). Rocks forming the main ranges of Raukumara Peninsula were classified as Taitai Series by Kingma (1965) and as Torlesse by Speden (1972, fig. 1). Mapping in progress in the catchment of the Waioeka River indicates that Torlesse rocks occur as inliers surrounded by and unconformably overlain by Cretaceous rocks of Clarence and possibly Korangan age locally. This mosaic of Torlesse and Cretaceous rocks may continue throughout Raukumara Peninsula within the limit of Torlesse rocks plotted on Figure 1, much in the manner shown for southern Wairarapa, and explain isolated Cretaceous fossil localities as at Hawai River (N70/f501, GS5773; Wellman 1959). In the Wairarapa, the only other area in the North Island where a gradation between Torlesse and Cretaceous might be found, unconformities between units are reported by Johnston (1974) in the Tinui district. Elsewhere deformed sediments at present included in the Mokoiwian Stage (Aptian-Neocomian) are sedimentologically and faunally part of the Clarence Series (I. G. Speden, Status of the Mokoiwian Stage, in prep.).

As there is no positive evidence of continuous deposition between the Torlesse and Clarence Series in the North Island, the alternative adopted here is that the Torlesse does not include any of the recognized faunal zones of the Cretaceous (Wellman 1959; Speden 1975). This does not deny the possibility of Torlesse deposition extending locally into the earliest Cretaceous (Neocomian).

FAUNAL ZONES IN THE TORLESSE OF THE NORTH ISLAND

Fossiliferous localities are considerably fewer in the North Island than in the South Island. Only 110 localities are known, and these are concentrated in the Wellington region (35 localities) and adjacent to the Hauraki Gulf, Auckland (24 localities). Three collections (N43/f2; N56/f9, N65/f528) contain fossils of two different ages. No invertebrate fossil localities are known over a large area from near Lake Waikaremoana (N96) to the south end of the Ruahine Range (N140). Localities are sparse in many other areas. Location of collections close to or alongside roads, or in regions frequented by hunters and trampers, and in areas mapped in detail, suggests that close examination of sequences could provide many further collections.

Two collections previously classified as Torlesse are now classed as post-Torlesse. N96/f504, from a boulder in gravels near Ruatahuna which was classed as Late Jurassic by Stevens (1963), is on lithology probably Mata Series (Late Cretaceous; see Speden 1973, p. 267), and N78/f510 is now known to occur in a Motuan sequence at the mouth of Tauranga Stream, Waioeka Gorge.

Only 11 of the 21 Permian to Late Jurassic faunal zones (stages) of the Hokonui facies are recognized in the Torlesse of the North Island (Fig. 1; Tables 1, 2; Appendix 1).

Table 1.—List of fossil localities and collections

F No.: New Zealand Fossil Record File number to a fossil locality recorded on maps of the NZMS1 (1:63360) topographic Series. All localities are in the North Island, and have the prefix N.

Grid Reference: Normally as determined by the collector from an NZMS1 map, although some are altered to a revised grid when a map has been published since collection. The date in round brackets is the date of publication of the map; all were published between 1943 and 1969. Letter c as a prefix indicates a position established by compiler, usually because no grid reference was recorded.

Collector: Identified by initials from the list below. Date of collection or observation is followed where appropriate, by a collection number allocated by the institution holding the collection, as follows:

AM Auckland Museum
AU Geology Department, University of Auckland
B N.Z. Geological Survey Catalogue of Plant Collections
F N.Z. Geological Survey Catalogue of Foraminifera
GS N.Z. Geological Survey Catalogue of Macrofossil Collections
L N.Z. Geological Survey Catalogue of Palynological Slides
PC Private Collection
T N.Z. Geological Survey Catalogue of Microfossil thin-sections
V Geology Department, Victoria University of Wellington

J. H. Adams	C. Fraser	D. Kear	J. C. Schofield
W. A. Applebe	M. Gage	J. T. Kingma	A. A. Somerville
J. K. Ash	H. S. Gair	P. C. Lecouteur	I. G. Speden
P. F. Ballance	R. Garrick	H. Leed	K. B. Spörli
B. Batley	G. W. Gibson	J. Lowery	G. R. Stevens
A. C. Beck	J. Gilkinson	A. McKay	B. N. Thompson
W. N. Benson	J. A. Grant-Mackie	H. W. R. Maehl	C. T. Trechmann
F. E. Bowen	T. L. Grant-Taylor	P. L. Manion	C. M. Ward
J. D. Campbell	D. R. Gregg	J. Marwick	B. C. Waterhouse
A. J. Cawood	H. M. Halcrow	D. C. Mildenhall	J. B. Waterhouse
J. D. Colebrook	R. F. Hay	E. N. Milligan	B. D. Webby
C. A. Cotton	J. Healy (JHy)	D. Milne	H. W. Wellman
J. C. Crawford	J. Hector	M. Ongley	D. N. Williams
R. J. Dent	B. H. Horner	T. Ozawa	M. Willoughby
H. B. Fell	N. de B. Hornibrook	D. R. Petty	G. J. Wilson
L. Fitness	F. W. Hutton	I. M. Paltridge	B. Zutelija
C. A. Fleming	J. G. Hyndman	C. C. Rich	

Lithology: Sedimentary features are expressed by standard symbols used on the Fossil Record Form of the Geological Society of New Zealand (GSNZ-F1, 1971; Fig. 4), with the exception that the category for weathering is omitted. This gives four numbers or a letter followed by three numbers before the entry of a letter and number for colour.

IP (In place): Y=Yes; N = No; A = Almost (loose material believed very locally derived); ? = unknown.

Latest Determination: Most of the collections have been re-examined by the compiler (IGS). For every collection, the determiner's name is abbreviated as for collector, and where the determination is quoted as a personal communication, the entry is followed by an asterisk. Otherwise the determination is that appearing on the fossil record form, or in a published paper (reference given).

Age: The letters refer to the standards symbols for New Zealand Series and Stages, with the capital letter being the first letter of the Series name and the lower case letter being, where practicable, the first letter of the stage name, as follows (see also Fig. 2):

Period	INTERNATIONAL CORRELATIVE Stage	Symbol	NEW ZEALAND UNIT Stage	Series
JURASSIC	L. Tithonian	OP	Puaroan	Oteke
	Kimmeridgian	KO	Ohauan	
		Kh	Heterian	Kawhia
	Bajocian-Oxfordian	Kt	Temaikan	
	Pliensbachian-Toarcian	Hu	Ururoan	Herangi
	Hettangian-Sinemurian	Ha	Aratauran	
TRAISSIC	Rhaetian	Bo	Otapirian	
	Norian	Bw	Warepan	
	Karnian	Bm	Otamitan	Balfour
		Br	Oretian	
	Ladinian	Gk	Kaihikuan	
	Anisian	Ge	Etalian	Gore
	Scythian	Gm	Malakovian	
PERMIAN	Tatarian	YDm	Makarewan	
		YDw	Waiitian	D'Urville
		YDp	Puruhauan	
	Kazanian, Ufimian	YAb	Braxtonian	
	Baigendzinian	YAm	Mangapirian	
	Aktastinian, Sakmarian U	YAt	Telfordian	
	Sakmarian L, Asselian		(present in N.Z. but not named)	

nd age not determinable from fossils
? age uncertain

TABLE 1

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
8/505	301838(54)	Kairauwaru Bay, Whangaroa Harbour	RFH,AAS 50 (GS5074, F842)	8743L2	Y	Brachiopoda: Martiniopsis woodi Waterhouse	JBW 68	YDp	Hornibrook 1951; Leed 1956; May 1960; Waterhouse 1964, 1968; T.Ozawa (letter 3.7.70)
8/507	301838(54)	Kairauwaru Bay, Whangaroa Harbour	JM, RFH 50 (GS5074, T1000)	8743L2	Y	Coelenterata: Waagenophyllum novaezelandiae Leed, Wentzelella maoria Leed Foraminifera: Lepidolina multiseptata (Deprat), Dunbarula sp., Codonofusiella sp., Khalerina sp. (= Yerbeekina sp.), Cribrogenerina cf. obesa Lange, Colania douvillei (Ozawa), Neoschwagerina margaritae Deprat, Chusenella sp., Codonofusiella sp., Bigenerina sp., Pachyphloia sp., Crinoid stems, ostracod, Bryozoa	HL56 TO*	YDp	
8/506	401803(54)	Maturi Bay	RFH 49 (T1028)	8743L2	Y	Shell fragments indet.	NdeBH *	nd	
8/510	302837(54)	Marble Bay, Whangaroa Harbour	NdeBH 51; JCS 65 (GS 10625, T1092)	8743M2	Y	Indeterminable micro-organisms	NdeBH *	nd	Kear & May 1961
8/518	300838(42)	Wherowhero Pt., Orua Bay	HWRM, JAGM 66 (AU 2482)	7543M24T	Y	fusuline Foraminifera	HWRM *	YAt-YDm	
8/519	300838(42)	Wherowhero Pt., Orua Bay	HWRM, PGB 67 (AU 2483)	4332M47T	Y	Waagenophyllum novaezelandiae Leed Lepidolina multiseptata (Deprat), Khalerina sp., Neoschwagerina sp.	HWRM GWG *	YDp-m	
8/520	301837(42)	West side of Orua Bay, Whangaroa	HWRM 67 (AU 2484)	8743L2	Y	Coelenterata, Foraminifera, Bryozoa, crinoid ossicles	HWRM *	YAt-YDm	
8/526	452853(54)	Motokawanui, Cavalli Is.	FEB 69 (GS10511)	8732L62W	Y	No determinable fossils	IGS 72	nd	
11/562	578626(63)	Wairoa Bay, Bay of Islands	RFH 50 (T1005)	8732L2	Y	Cribrogenerina sp., Neoschwagerina sp., Schwagerinidae gen. et sp. indet., Bryozoa	NdeBH *	YAt-YDm	Hay 1960; C.Ross Letter 2.9.70)
16/502	694462(42)	Cooks Point, Waikare Inlet Bay of Islands	RFH 50 (T1006)	8743L1	Y	Cribrogenerina sp., Bryozoa	NdeBH *	YAt-YDm	Hay 1960
30/507	c.983440(53)	Harataonga Bay, Great Barrier Island	FWH 1866 (GS292*)	-	?	? Coral	FWH 1866	nd	Hutton 1877: 33
30/508	906555(53)	North end of Great Barrier Island	JKA 67 (AU 890)	P342D82	N	Hibolithes cf. arkelli Stevens	GRS 67	?Op	Stevens 1970: 722
34/503	388100(67)	Burgess Bay, Kawau Island	ENM 55 (AU *)	4542D82Q	Y	?Inoceramus sp. indet.	ENM 65	nd	Milligan 1959: 196; Hopgood 1961

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
34/f546	355194(65)	Tawharanui Peninsula	KBS,CMW 72 (AU1801)	9941D2	Y	Malayomaorica malayomaorica (Krumbeck), Inoceramus sp.cf. haasti, cf. Rhizocorallum sp.	IGS 74; JAGM 72 *	?Ko(-Kh)	Spörli & Grant-Mackie in prep.
34/547	355194(65)	Tawharanui Peninsula	KBS,JAGM et al.72 (AU1802)	9941D2	Y	Malayomaorica sp., cf. Rhizocorallum sp.	JAGM 72 *	?Kh-Op	Spörli & Grant-Mackie in prep.
34/548	356195(65)	Tawharanui Peninsula	KBS,JAGM et al.72 (AU1158)	9941D2	Y	cf. Rhizocorallum sp.	JAGM 72 *	nd	Spörli & Grant-Mackie in prep.
39/1	c.942823(66)	Amodeo Bay, Coromandel Peninsula	CF,JHA 07	P741D *	?	Prismatic shell fragments		nd	Fraser & Adams 1907: 49; Kear 1955
39/516	c.653712(66)	Owhiti Bay, Waiheke Island	HMH 53 (AU *)	mylonite	Y	Radiolaria	NdeBH 54	nd	Halcrow 1956: 59
40/529	c.224767(49)	Kuaotunu, Coromandel Peninsula	RJD 64 (AM *)	P741D	N	Belemnopsis sp. ex gr. aucklandica (Hochstetter)	GRS 64	Ko-Op	Stevens 1970
43/1	c.979638(63)	?Manaia Hill, Coromandel Peninsula	AM 05	?P741D *	?	?Monotis richmondiana Hochstetter[1]	AM 05	Bw	Sollas & McKay 1905: 42; Kear 1955; Stevens 1970
43/2	c.979638(63)	Manaia Hill Quarry	CF,JHA 07	P741D *	Y	Inoceramus cf. galoi Boehm[1], ? aff. Hibolithes marwicki marwicki Stevens	IGS 72* GRS 65	?Kh & Op	Fraser & Adams 1907: 49; Kear 1955; Marwick 1955; Stevens 1965: 104
43/3	933542(63)	Otakeao Stream Coromandel Peninsula	CF 10	P741D *	?	Belemnite	CF 10	nd	Fraser 1910: 21; Kear 1955.
43/4	967514(63)	Near Waitorotoro Stream, Coromandel Peninsula	CF 10	P741D *	?	Belemnite	CF 10	nd	Fraser 1910: 21, Kear 1955.
43/501	707614(63)	Bryants Bay, Ponui Island	ENM 56 (AU *)	3331M52	Y	Inoceramus sp. cf. galoi Boehm	ENM 56	?Kh	Milligan 1959: 196 Schofield in press
43/502	708616(63)	Bryants Bay, Ponui Island	ENM 56 (AU1800)	3331M52	Y	Inoceramus sp. cf. galoi Boehm	IGS 74	?Kh	Milligan 1959: 196 Schofield in press
43/512	736485(63)	Puatiti Point	PCL 67 (AU *)	7851L62	N	Inoceramus sp. (cf. Anopaea n. sp. of Fleming 1958)	IGS 74*	?Op	Schofield in press
43/519	995492(63)	Waikawau River, Coromandel Peninsula	BNT 64 (GS10022)	9961D3	Y	borings?	IGS 72*	nd	
43/520	736409(63)	Tapapakanga Stream, Hunua Hills	JCS,DRP 70 (GS10611)	9861D3	Y	Inoceramus sp. (? cf. Anopaea of Fleming 1958)	IGS 74*	Kh-Op	Schofield in press
43/521	932544(63)	Otakeao Stream, Coromandel Peninsula	JCS 71 (GS10830)	8851D2	Y	cf. Hibolithes arkelli Stevens	GRS 71*	?Op	Schofield in press
43/522	978486(63)	Waikawau River Coromandel Peninsula	JCS 71 (GS10831)	P571M2	Y	Hibolithes arkelli Stevens	GRS 71*	Op	Schofield in press

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
164/593	331243(67)	Tinakori Hill	HBF pre-59 (PC)	argillite*	Y	Torlessia mackayi Bather	BDW 59*	?Br-m	Webby 1967
164/594	287223(67)	Karori Quarry	HBF pre-59 (PC)	argillite*	Y	Torlessia mackayi Bather	BDW 59*	?Br-m	Webby 1967
164/605	225276(67)	Ohau Bay	TLGT 69 (GS10527)	6741D23*	Y	Torlessia mackayi Bather	IGS 72*	?Br-m	
164/612	286130(67)	Sinclair Head	LF 72 (PC)	7731L2*	?	Reptilian bone	GRS 72*	nd	
164/617	c.311143(67)	Bay west of Owhiro Bay	CAC, WND pre 1921	-	?	amphicoelous vertebra[6]	WNB 21*	nd	Benson 1921: 62; Grant-Taylor & Waterhouse 1963: 6
164/619	325145(67)	Wellington Quarries Ltd., Island Bay	DNW 73	7831M2*	Y	Torlessia mackayi Bather	DNW 73*	?Br-m	

6 Specimen lost in mail.

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
160/642	417435(65)	Paremata	BDW 58	chert*	Y	Radiolaria and plant fragments	BDW 59	nd	Webby 1959: 475
160/643	413394(65)	Porirua East	BDW 58	Jasper*	N	Radiolaria (Spumellaria group)	BDW 59	nd	Webby 1959: 475
160/644	c.425345(65)	Belmont Hill, Hutt Valley	JCC pre-1866	-	?	Possibly Titahia	BDW 67	?Br-m	Webby 1967: 185
160/649	509414(65)	Trail, old tip, Haywards Road	DNW TLGT 73 (GS11262)	7731M2	Y	Titahia corrugata Webby	IGS 73	?Br-m	
160/650	382431(65)	Titahi Bay	DNW 73	7831L2	Y	Torlessia mackayi? Bather	DNW 73	?Br-m	
161/498	573304(67)	Mangaroa, Devine Trig.	TLGT 47 (B103)	4521L12W	Y	wood Fragments	DCM 72*	nd	
161/523	866490(67)	Tauherenikau Valley	TLGT 62 (GS9092)	P741D2 breccia	Y	Indet., ?organic	IGS 72*		
164/492	291131(67)	Red Rocks Point	HWW MG 46 (GS3720)	7641M82	Y	Torlessia mackayi Bather	IGS 72*	?Br-m	Wellman 1949
164/493	292132(67)	Red Rocks Point	HWW MG 46 (GS3721)	6741M82	Y	?Torlessia sp.	IGS 72*	?Br-m	Wellman 1949
164/494	349147(67)	Houghton Bay	CTT 14-16 (GS4880)	7641L2	?	Torlessia mackayi Bather	IGS 72*	?Br-m	
164/498	-	Karori	JH 1866 (GS430)	-	?	?Plants[4]		nd	
164/499	-	Karori	AM 1879 (GS809)	7841D23	?	Torlessia mackayi Bather	IGS 72*		
164/500	c.187220(67)	Cape Terawhiti	AM 1880 (GS811)	-	?	Torlessia mackayi Bather[4]	AM 1879*	?Br-m	McKay 1879: 133
164/503	366162(50)	Moa Point, Lyall Bay[5]	HWW 50 (GS5235)	7841M2	N	?Torlessia sp., fragments	IGS 72*	?Br-m	
164/589	291131(67)	Red Rocks Point	TLGT 65 (GS9573)*	7841M2	Y	Torlessia mackayi Bather	TLGT 65*	?Br-m	
164/590	229271(67)	Te Ikaamaru Bay	BDW 58 & 65 (GS9739)	7841D3	Y	Torlessia mackayi Bather	IGS 72*	?Br-m	Webby 1967
164/591	468035(67)	Cape Turakirae	BDW 58	6741D82	Y	Urohelminthoida sp.	BDW 67	nd	Webby 1967
164/592	195205(67)	Oteranga Bay, Cape Terawhiti	BDW 65 (GS9738)	7641D82	Y	Titahia corrugata Webby	IGS 72*	?Br-m	Webby 1967

4 Not located by McKay during 1904-06 when compiling his catalogue of fossil collections. 5 Site now buried under reclamation

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.		References
153/520	-	4-5 miles SW of Eketahuna	?AM 87 (GS5718)	Limestone*	Y	obscure fossils, collection not found		nd	McKay 1888: 18-19
153/522	172936(65)	Makakahi River, Eketahuna	MO 32 (GS5917)	7943L12	Y	Prismatic and radial cross-lamellar shell fragments	IGS 72*	nd	Ongley 1933: 5
153/526	-	Mangaone Stream	?MO c.32 (GS7067)	1341D52	N	?Buchia sp.	IGS 72*	?Kh-Op	
157/539	738768(64)	Otaki River	TLGT JBW 62 (GS9142); JAGM 65 (AU2473)	8741D82S	Y	Monotis aff. richmondiana Zittel, M. aff. pachypleura (Teller)	JAGM 71	Bw	Grant-Taylor & Waterhouse 1963
157/540	719751(64)	Pukehinau Stream, Otaki River	TLGT JBW 62 (GS9143); JAGM 65 (AU2474)	8742M82S	Y	Monotis sp. ex gr. scutiformis (Teller)	JAGM 71	Bw	Grant-Taylor & Waterhouse 1963
157/541	738765(64)	Otaki River	TLGT JBW, 62 (GS9152)	8741D82	Y	?boring	IGS 72*	nd	
157/555	736767(64)	Otaki River	TLGT JBW 65 (GS9519)	8741M82	Y	Monotis richmondiana Zittel	IGS 72*	Bw	
157/559	738766(64)	Otaki River	JL 71 (GS10901)	8731M82S	Y	Monotis sp.ex gr. hemispherica Trechmann	JAGM 71	Bw	
157/561	-	Neill Creek, Tararua Range	JBW 51	-	N	Vertebrate fragment	JBW 51*	nd	Grant-Taylor & Waterhouse 1963: 6
159/435	c.462811(65)	Makirikiri Stream, Tinui	MO JM 33 (GS1867)	8943L21	N	Buchia hochstetteri Fleming	IGS 72*	Op	Fleming 1959
160/499	-	Porirua Harbour (and Sinclair Head, N164)	AM 1879 (GS810)	-	?	?plants, collection not found	AM 1879*	nd	McKay 1879: 133
160/500	528305(65)	Moores Valley, Wainuiomata	TLGT 47 (B102)	7621L12W	Y	Cycad leaf fragment, wood fragment	DCM 72	nd	
160/538	347408(65)	Rock Point	BDW 57 (GS6973)	8941D82Q	Y	Titahia corrugata Webby	BDW 58	?Br-m	Webby 1958
160/539	389447(65)	Titahi Bay	BDW 57 (GS6974)	5741M82Q	N	Torlessia mackayi Bather	BDW 58	?Br-m	Webby 1959: 475
160/617	289329(65)	Ohariu Bay	BDW 58 (GS9735)	6741M82	Y	Torlessia mackayi Bather	BDW 67	?Br-m	Webby 1967
160/618	302355(65)	Pipinui Point	BDW 58	-	N	Torlessia mackayi Bather	BDW 67	?Br-m	Webby 1967
160/619	423531(65)	Pukerua Bay	BDW 58 (GS9736)	6741M82	Y	Torlessia mackayi Bather	BDW 67	?Br-m	Webby 1967
160/620	430531(65)	Pukerua Bay	BDW 58 (GS9740)	6741M82	Y	Torlessia mackayi Bather	BDW 67	?Br-m	Webby 1967
160/621	275300(65)	Ohariu Bay	BDW 58 65 (GS9741)	7641M82	Y	Torlessia mackayi Bather	BDW 67	?Br-m	Webby 1967
160/639	347410(65)	Rock Point	JAGM 71 (AU1316)	7741D2	Y	Titahia corrugata Webby	JAGM 71	?Br-m	
160/641	402458(65)	Onehunga Bay	BDW 58	-	Y	Torlessia mackayi Bather	BDW 59	?Br-m	Webby 1959: 475

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
78/501	c.469110(62)	Waimana Gorge, Taneatua	ACB 52 (GS5500, T1033)	9842L82	N	Pseudaucella marshalli (Trechmann), Dentalina sp., (Foraminifera)	CAF 53; NdeBH 53	Hu	Fleming 1953; Hornibrook 1953; Speden 1972
78/579	463112(62)	Waimana Gorge, Taneatua	IMP 57	9942D92*	Y	Pseudaucella marshalli (Trechmann)	IMP 58*	Hu	Speden 1972
78/580	478152(62)	Tarepe Stream, Taneatua	IMP 57	9941M25*	Y	Pseudaucella marshalli (Trechmann)	IMP 58*	Hu	Speden 1972
87/553	784647(69)	Koranga River, Koranga	HSG 66 (L5196)	8741D82	Y	Spores	GJW 66*	Kt-Um	
87/561	764682(69)	Moanui Road	RG et al.66 (GS9763)	3541M2	Y	indet. shell fragment	IGS 72	nd	Speden 72
87/573	784647(69)	Koranga River, Koranga	IGS et al.66 (GS9809)	6831L82	Y	indet. shell fragment	IGS 72	nd	Speden 72
87/1172	547828(69)	Waimana River	PLM 73 (AU1803)	7640D2	Y	Neocrassina cf. spitiensis (Stoliczka)	IGS 73	Kt-O	
88/560	892732(63)	Motowai-Opotiki Highway	HSG et al.66 (GS9743)	5641M27	Y	Buchia aff. plicata (Zittel), ?Coelastarte sp.	IGS 72	Op	Speden 72
95/502	295471(57)	Te Whaiti-Ruatahuna Road	DRG 55 (GS6406)	7861M52	Y	Belemnopsis indet. ex gr. aucklandica (Hochstetter), ?Belemnopsis sp.juv. indet.	GRS 63	?Kh-Op	Stevens 1963
95/504	c.265485(57)	Te Whaiti - Ruatahuna Road	HWW 59 (GS7475)	7841L5	Y	?Belemnopsis sp. juv. indet.	GRS 63	nd	Stevens 1963
124/545	036621(44)	Opau Stream, Kaweka Range	JTK 57 (L940,944)	8941D82	Y	pollen and spores	DCM 71*	Ko-Op	Kingma 1958: 493
140/517	462853(66)	Oroua River, Ruahine Range	DM 67 (V1427)	8742D82	N	Monotis (Entomonotis) routhieri Avias n. subsp., M. (E.) ochotica richmondiana Zittel	JAGM 66	Bw	Milne & Campbell 1969
140/518	506850(66)	Tunipo Stream, Ruahine Range	DM AJC 66 (V2150)	8741D82	Y	Monotis ochotica cf. gigantea Avias, M.? ochotica pachypleura Teller, M.? calvata Marwick	JAGM 66	Bw	Milne & Campbell 1969
140/519	513827(66)	Umutoi Stm., Ruahine Range	DM AJC 66 (V1605)	3743M82	Y	Halorella ruahinensis Campbell	JDC 67	Bm-w	Milne & Campbell 1969
140/522	476838(66)	Oroua River, Ruahine Range	AJC 66 (V2632)	7841D82	N	Monotis aff. ochotica gigantea Avias	JAGM 66	Bw	Milne & Campbell 1969
145/522	498794(62)	Coal Creek, Oroua Valley	JAGM AJC 71 (AU906)	2142M45	N	Halobia cf. hochstetteri Mojsisovics, Terebratuloidea indet.	JAGM 71	Br-w	
149/591	310245(69)	Mangatainoka River	MW 68 (GS10156)	4361M2	N	Belemnopsis sp.	GRS 68*	?Kh-Op	
149/638	214273(69)	Ramiha Trig., Pahiatua	CCR 59 (V *)	Chert	Y	Radiolaria	CCR 59*	nd	Rich 1959
149/644	292393(69)	Manawatu Gorge	BZ 73 (AU2481)	Ch t	A	Radiolaria	BZ 74	nd	
150/483	c.559271(55)	Mangatoro Stream, Waewaepa Range	MO 32 (GS5915)	7841D28S	Y	Malayomaorica malayomaorica (Krumbeck)	IGS 72	Kh-o	

f No.	Grid Ref.	Locality	Collector	Lithology	IP	Fossils	Latest Determin.	Age	References
43/523	978486(63)	Waikawau River, Coromandel Peninsula	JCS 71	P741D	Y	? Radiolaria	NdeBH 71*	nd	Schofield in press
43/517	c.575635(63)	Omiha (Rocky) Bay, Waiheke Island	HMH 53 (AU *)	9861M4	Y	Radiolaria	HMH 56	nd	Halcrow 1956: 60
48/598	708339(64)	Mangatangi Stream, Hunua Hills	JD Col 58 (AU734)	7641D82	N	Inoceramus cf. galoi Boehm, Malayomaorica malayomaorica (Krumbeck)	IGS 58*	?Kh	Milligan 1959; Schofield in press
48/647	775309(64)	Whakatiwai Stream	JCS 73	2541L2	Y	Foraminifera	NdeBH 74	nd	
52/575	826081(67)	Pokeno-Waihi Highway	DK 53 (GS5890)	5441L65C	Y	?Malayomaorica sp. indet.	IGS 72*	?Kh-Op	Kear & Schofield 1968
52/617	900945(67)	Matahura-Kaihere Road	DK 54 (GS6375)	5341D52	Y	Malayomaorica sp. indet., Belemnopsis sp. juv. indet.	IGS 72* GRS 72*	Kh-Op	Kear & Schofield 1968
56/9	988551(65)	Motumaoho Quarry, Morrinsville	BHH pre-37 (AU740); DK 54 (GS4803); BCW 57 (GS4803)	7741D23	Y	Inoceramus galoi Krumbeck, Monotis richmondiana Hochstetter[1], indet. bivalve	IGS 72*	Bw,Kh	Bartrum 1937; Kear 1955
57/507	112528(65)	Hyndman's Quarry, Morrinsville	JGH 54 (GS6426)	8841D82	Y	Inoceramus cf. subhaasti Wandel[2], ?Malayomaorica sp. indet., ?Anaptychus, Ammonoid indet., Gastropod	IGS 72*	?Ko	Kear & Tolley 1957: 504.
65/528	972482(65)	Tauwhare Quarry (new)	Smith 54 (GS6424)	8641L2 7141M72	N	Inoceramus galoi Boehm[3], Halobia cf. hochstetteri Mojsisovics[1]	IGS 72*	Br-w & Kh	Kear & Schofield 1965
65/529	963487(65)	Tauwhare Quarry (old)	DK,JCS 55 (GS6425); BB 68 (AU738)	8841L82	Y	Inoceramus galoi Boehm, Malayomaorica malayomaorica (Krumbeck)	IGS 72*	Kh	Kear & Schofield 1965
66/1	039305(63)	Karapiro damsite	JG 40 (GS2905)	9841D3	Y	Malayomaorica malayomaorica (Krumbeck)	IGS 72*	Kh-O	Kear 1955; Stevens 1972
69/524	c.460260(69)	Otarawairere Bay, Ohope	DK 72 (GS11019)	9931D27	Y	?Cylindroteuthis sp. indet.	GRS 72*	?Hu-Kt	
74/501	c.965153(55)	Puahue Quarry, Te Awamutu	WAA 51 (AM6442)	8841D82		Neocrassina cf. spitiensis (Stoliczka)	IGS 74*	Kt-o	
75/507	014172(47)	Putaruru Quarry, Pukeatua	DK 61 (GS9150)	8841D82	Y	Inoceramus sp.	IGS 72*	Kh-Op	
77/540	314158(65)	Henderson's Quarry, Awakeri	DK, JHy 61; DK 73 (GS7982)	P741D52	Y	Belemnopsis sp. ex gr. aucklandica (Hochstetter), Neocrassina cf. spiti- (Stoliczka)	GRS 63	Ko-Op	Stevens 1963

1. In pebbles in conglomerate (derived). 2. In matrix. 3. Questionably in matrix.

TABLE 2. Faunal zones and number of localities in the Torlesse rocks in the North Island.

Based on Table 1 and Appendix 1.

c. *Inoceramus* cf. *galoi* associated with *Hibolithes marwicki marwicki* at N43/f2.

b. *Monotis* associated with *I. galoi* at N56/f9, and with *I.* cf. *galoi* and *Hibolithes* in the Moehau Formation at Manaia Hill (N43/f1, 2).

a. *Halobia* associated with *I. galoi* at N65/f528.

? Identification of species uncertain.

Zone Species	Local stage in which zone species occurs	Approximate overseas equivalent		Number of localities in zone
Buchia sp., *Malayomaorica* sp. *Belemnopsis* sp.	Heterian - Puaroan	Kimmeridgian - Tithonian		3 + 5 ?
Buchia hochstetteri, *B.* cf. *subpallasi*, *B.* cf. *plicata*, *Hibolithes arkelli*, *H. marwicki marwicki*	Puaroan (lower, upper)	Lower Tithonian		4 + 3 ? [c]
Belemnopsis sp. ex gr. *aucklandica*	Ohauan - Puaroan	Kimmeridgian - Tithonian		2
Malayomaorica malayomaorica	Heterian - Ohauan	Lower - Middle Kimmeridgian		2
Inoceramus haasti	Ohauan	Middle Kimmeridgian		2 ?
Inoceramus galoi	Heterian	Lower Kimmeridgian		3 + 4 ? [a, b, c]
Pseudaucella marshalli	Ururoan	Pliensbachian - Toarcian		3
Monotis spp.	Warepan	Norian		9 [b]
Torlessia mackayi, *Titahia corrugata*	? Oretian	Karnian		21 + 4 ?
Halobia sp.	Oretian - Warepan	Karnian - Norian		2 [a]
Martiniopsis woodi, *Waagenophyllum novaezelandiae*, *Wentzelella maoria*, fusulines	Telfordian - Makarewan	Permian		7
Localities with fossils of unknown or uncertain age				39
			TOTAL	110

1. Zone of Permian fossils

Localities with definite or supposed Permian fossils are restricted to the area between Whangaroa Bay (N8), and the southern part of the Bay of Islands (N16), North Auckland, although a belt of Permian rocks has been mapped southwards as a lithological continuation to Whangarei Harbour (N20; Thompson 1961). The fossils occur in bands of limestone (or marble) or chert closely associated with volcanic rocks within deformed sandstone-siltstone sequences of 1974). These sequences are classed as Waipapa Group (Kear and Hay 1961) or Hunua Facies (Kear 1971).

Determinable fossils are known from four of the nine localities and a diverse fauna has been collected at Kairauwaru Bay (N8/f505), Whangaroa Harbour (Table 1). Here, 13 species of reef-forming corals (Leed 1956) and fusulines, and miscellaneous other organisms, occur in lenses below a main limestone band which contains the brachiopod *Martiniopsis woodi* Waterhouse, the pumpellyite-actinolite or prehnite-pumpellyite facies (Reed 1967; Brothers an indicator of the Puruhauan Stage (Tatarian-Capitanian; Waterhouse 1969). Waterhouse (1967, p. 173) considers that the fauna belongs to a different zone from the type Puruhauan. Faunas from other Permian localities lack index species and are classified as Permian (YAt-YDm) or Late Permian (YDp-m).

The faunas are characteristic of shallow marine reef habitats in a warm-water province. Dr C. A. Ross (pers. comm.), Western Washington State College, Bellingham, considers that the assemblage at N8/f505 belongs to a fore-reef facies and that at Wairoa Bay N11/f562 possibly to a back-reef facies.

2. Halobia *Zone (Oretian-Warepan Stages; Karnian-Norian, Late Triassic)*

Halobia cf. *hochstetteri* Mojsisovics is known at two widely-separated localities; in neither case is the source of the specimens known. At the "new" Tauwhare Quarry (N65/f528) *Halobia* is apparently derived, as it is presumed to occur in pebbles of laminated siltstone and very fine-grained sandstone, in a gritty, very-fine-grained sandstone matrix which contains the Late Jurassic (Heterian Stage) *Inoceramus galoi* Boehm (Kear and Schofield 1965). The specimens from Coal Creek, Orua Valley (N145/f522), were collected from a coarse sandstone boulder. In each case rocks of the zone may occur nearby, although if Kear's (1971) interpretation is correct the specimens at Tauwhare may have been derived during Heterian time from Late Triassic sediments exposed on the continental slope. In Oroua Valley, as at some localities in the South Island (Andrews, Speden, and Bradshaw in press), there is a close geographic proximity to *Monotis* occurrences.

3. Torlessia *Zone (?Oretian-Otamitan Stages; Karnian, Late Triassic)*

Agglutinating tubes of the annelids *Torlessia* and *Titahia* have been collected only in N160 and N164, south of Pukerua Bay, Wellington, where one or other of the species is present at 21 localities and reported from four others (Fig. 1). Fifteen of the 21 samples for which there is lithological information occur in siltstone (argillite) or sandy siltstone; the remaining six in very-fine- to fine-grained sandstone (see also Webby 1967, p. 187). Specimens mainly occur as fragments lying randomly in the plane of bedding or in the upper argillaceous part of a bed. Fragments vary greatly in size, with the diameter ranging from about 1 to 10 mm and the length from a few millimetres to at least 20 cm. Specimens of *Titahia* tend to be larger than those of *Torlessia*.

Mr D. N. Williams' discovery of numerous fragments in a bioturbated siltstone phase at the top of a graded-bed unit at Haywards (N160/f649) demonstrates the occurrence of specimens inland as suspected by Webby (1967, p. 185). Careful examination will be necessary to ascertain if tubes are definitely absent from Torlesse rocks east of Wellington Harbour. Webby's (1967, p. 186) suggestion of a western belt characterized by *Torlessia* and *Titahia* and an eastern belt with *Torlessia* only requires further study. The belts may be separated by the Wellington Fault, in which case stratigraphic displacement is possible. Other alternatives are that the belts are lateral facies variants or are distinct because of the lack of discovery of fossils.

Sedimentological evidence convinced Webby that the annelids lived in deep water in specialized environments. Because of the size of the fragments and their position in beds, he discounted the possibility of transportation and concentration by turbidity currents. The occurrence of fragments in bioturbated siltstone at Haywards suggests an alternative mechanism of breakage of tubes by burrowing organisms after the death of the animal and before consolidation of the sediment.

There is no direct evidence for a Late Triassic age for rocks containing *Torlessia* and *Titahia,* and the possibility of the annelids being facies fossils cannot be discounted (Andrews, Speden, and Bradshaw in prep.). Although they are generally considered to be Oretian-Otamitan in New Zealand (Campbell and Warren 1965), extension of the range of *Torlessia* downwards into the Kaihikuan (Ladinian) and upwards into the Warepan (Norian) is suggested by the records of *Torlessia*-like tubes with *Daonella* at Misol, Timor (Jaworski 1915), and in calcareous concretions in siltstone conformably overlying *Monotis* beds at Otaki (Grant-Taylor and Waterhouse 1963).

4. Monotis *Zone (Warepan Stage; Norian, Late Triassic)*

Species of *Monotis,* including subgenera and subspecies recognized by Grant-Mackie (in Milne and Campbell 1969), are known at widely scattered localities in the North Island; four adjacent to the Otaki River (N157), three in the Ruahine Range at Oroua (N140), and at Motumaoho Quarry (N56/f9) near Morrinsville and Manaia Hill Quarry (N43/f1; Skinner 1972), Coromandel Peninsula. Although the stratigraphic relationship of the locality with *Halorella ruahinensis* Campbell (Milne and Campbell 1969) at Oroua is uncertain, the species may fall with the *Monotis* Zone.

All the specimens occur in siltstone or calcareous siltstone, although shellbeds are present at Oroua and Otaki, where the matrix is almost a limestone (Grant-Taylor and Waterhouse 1963). At Motumaoho and Manaia Hill Quarries, where the specimens are found as or in pebbles in conglomerate, the specimens are clearly derived, as either the matrix or other pebbles contain fossils of Late Jurassic age.

Grant-Taylor and Waterhouse (1963) concluded that the *Monotis* specimens at Otaki lived and died in place, and that the number and density of individuals favour shallow marine conditions in the photic zone. Similar conditions possibly existed at Oroua. *Monotis* occurs in pebbles at both Manaia Hill (Skinner 1972, pers comm.) and Motumaoho (Kear 1955) quarries. Both Kear and Skinner consider that the specimens were derived by erosion from unconformably underlying sequences.

The fossils demonstrate the existence of the zone over limited areas in the Tararua and Ruahine Ranges, and adjacent to Coromandel and Morrinsville, during the Late Jurassic or younger time; it is not possible to reliably delimit a zone on a regional scale.

5. Pseudaucella *Zone (Ururoan Stage; Pliensbachian-Toarcian, Early Jurassic)*

Pseudaucella marshalli (Trechmann) is present at three localities in well-indurated, complexly deformed rocks near Taneatua, Bay of Plenty (Fleming 1953; Paltridge 1958; Speden 1972). These probably occur in the core of a faulted anticlinal structure flanked to the west and east by Late Jurassic (Speden 1972). The belemnoid ?*Cylindroteuthis* sp. collected by D. Kear from Otarawairere Bay, Ohope (N69/f524), comes from the same belt of rocks and may be Ururoan. In New Zealand the genus ranges (Stevens 1965) from just above the zone of *Pseudaucella* in the Awakino Gorge (Grant-Mackie 1959) into the Lower Temaikan in the Catlins, South-east Otago (Speden 1971). All specimens are enclosed in siltstone or calcareous siltstone. It is not possible to determine whether this epifaunal bivalve is preserved in its place of life or was transported.

6. Late Jurassic Zones

Late Jurassic fossil localities are widely distributed in the North Island, from Great Barrier Island (N30) in the north to near Eketahuna (N153) in the south. All the major zones of the Late Jurassic as characterized by species of *Buchia, Malayomaorica* and *Inoceramus* (Speden 1970) and belemnoids (Stevens 1965), are represented (Table 1). Numbers and diversity of fossils at localities are low (Appendix 1), and as in the Torlesse of the South Island (Andrews, Speden, and Bradshaw in press), epifaunal species predominate. Mapping of individual zones over any significant area and the recognition of lithofacies patterns are prevented by the low density of localities and the complex structure of the sequences. Individual zones are discussed as follows:

a. Zone of Inoceramus galoi *(Heterian Stage; Lower-Middle Kimmeridgian)*

The characteristic species of this zone is definitely known from three and possibly from four other localities scattered over the area from Hauraki Gulf (N30) to near Morrinsville (N65) (Appendix 1). It occurs in siltstone pebbles in conglomerate at two localities (N43/f2, N56/f9), and possibly at a third (N65/f528), and is associated with late Triassic fossils at each locality. The time of deposition of the rocks is Heterian or younger, although the definite occurrence of *I. galoi* in the matrix at the old Tauwhare Quarry (N65/f529) strongly suggests that the Torlesse in this vicinity is actually Heterian. The fossils occur in siltstone except at N43/f2, 501, and 502 where the matrix is a coarse sandstone. Another epifaunal bivalve, *Malayomaorica malayomaorica,* is the only other species known from the zone.

b. Zone of Inoceramus haasti *(Ohauan Stage; Middle Kimmeridgian)*

Specimens from two widely-spaced localities are best classed in the *haasti* species group: *I.* cf. *haasti* at Tawharanui Peninsula (N34/f546) and *I.* cf. *subhaasti* at Hyndman's Quarry (N57/f506), Morrinsville. Two other localities in the near vicinity of N34/f546 might also fall within the range-zone of *haasti.* If *subhaasti* is an intermediate part of a *galoi-haasti* lineage, as seems possible (Speden 1970, p. 827), its range-zone might span parts of both the Heterian and Ohauan.

c. Zone of Malayomaorica malayomaorica *(Krumbeck) (Heterian-Ohauan Stages; Lower - Middle Kimmeridgian)*

This species occurs by itself in siltstone at two widely-separated localities at Karapiro (N66/f1) and in the Waewaepa Range (N150/f483), Wairarapa. Other possible specimens of the species may also fall within the zone, although closely similar species are associated with Puaroan fossils (Fleming 1958). Specimens of Heterian (N48/f598, N65/f529) and Ohauan (N34/f546) age are also known.

d. Zone of Belemnopsis *sp. ex gr.* aucklandica *(Hochstetter) (Ohauan-Puaroan Stages; Middle Kimmeridgian - Lower Tithonian)*

Belemnoids of the *aucklandica* group are present at two localities: at Kuaotonu (N40/f529) in a conglomerate boulder derived from Manaia Hill Group (Skinner 1972; Stevens 1970) and in conglomerate at Awakeri (N77/f540;

Stevens 1963). Poorly-preserved specimens possibly belonging in the species group were collected near Ruatahuna (N95/f502; Stevens 1963).

e. Zones of Buchia plicata *(Zittel),* B. hochstetteri *Fleming,* Hibolithes arkelli *Stevens, and* H. marwicki *Stevens (Puaroan Stage; Lower Tithonian)*

Seven localities have fossils characteristic of these zones. The species are mainly of *Buchia* and belemnoids, although the zone has the largest number of species (8) and the most diverse faunas of any of the Mesozoic zones in the Torlesse of the North Island. Localities are known from Great Barrier Island (N30/f508) to the Tinui District (N159/f435) in the Wairarapa.

D. N. B. Skinner (pers. comm.), New Zealand Geological Survey, Otara, has noted that all the Late Triassic and Jurassic fossils in the Manaia Hill Group, Coromandel Peninsula, except one, are found in the unconformable upper conglomerate of the Moehau Formation of Skinner (1972, p. 206) in which the fossils occur in pebbles or are believed by Skinner to be clasts rather than *in situ* in the matrix. The exception (N43/f521, cf. *Hibolithes arkelli* Stevens) is present in siltstone below the base of the conglomerate, but as this siltstone contains scattered pebbles at other localities Dr Skinner suspects that the belemnoid specimen might also be a clast. Clearly, the conglomerate, at last, is Puaroan or younger. Skinner's (1972, p. 215) interpretation of the conglomerate as allochthonous, and more recently (pers. comm.) as an olistostrome, which may have eroded some or all of the fossils from submarine outcrops (Skinner 1972, p. 213), is reasonable.

Fossils occur in a range of lithologies: limestone at three localities (N11/f650, N62/f520, N159/f435), conglomerate at two localities (N43/f2, 522, but see above), and sandstone and siltstone. The limestones and possibly the conglomerates suggest shallow-water deposition, an interpretation reinforced by the nearly absolute dominance of the assemblages by epifaunal and nektonic species.

Index fossils of both the Lower and Upper Puaroan zones (Purser 1961) have been collected. Records of *Buchia hochstetteri* (Lower Puaroan) at Makirikiri Stream (N159/f435), Tinui, and *Malayomaorica malayomaorica* in the Waewaepa Range (N150/f483), are a major reason for considering the Torlesse rocks east of the main Tararua and Ruahine Ranges to be Late Jurassic (Kingma 1967).

f. Non-specific Late Jurassic fossils

Six widely scattered localities have species of *Buchia* and belemnoids which indicate, positively or possibly, one of the Late Jurassic zones discussed above (Appendix 1). These epifaunal or nektonic species occur in fine- to coarse-grained sandstone, except for one which has a siltstone matrix.

g. Fossils at localities of uncertain or unknown age

These fossils are mostly indeterminable, of uncertain taxonomic status, or representatives of groups which have no stratigraphic significance in New Zealand. Many are the remains of species of *Inoceramus, Buchia,* and belemnoids. Potentially useful are the occurrences of Radiolaria. Noteworthy are the records, apparently in the *Torlessia* Zone (N164/f612, 617), of vertebrate remains near Wellington.

UPPER JURASSIC FOSSILS
ASSOCIATED WITH VOLCANIC ROCKS

Puaroan fossils are associated with volcanic rocks in two areas: Houto Hills (N19/f650) and Cape Runaway (N62/f520). Pink limestone and siltstone in pillow lavas of Tangihua Volcanics on the flank of Houto Hill (Brothers 1974) contain *Buchia* aff. *subpallasi* (Krumbeck), *Inoceramus* sp. indet., *Lacunosella*? sp., and an echinoid spine. Other localities (N19/f597, 624-5, 628; Hay 1960) in the neighbourhood have *Inoceramus* sp. indet., globigerinid Foraminifera, Radiolaria, and indeterminable shell fragments and tubes. Interbedded or interstitial limestone and siltstone in the Matakaoa Volcanics near Cape Runaway have a very similar fauna of *Buchia* aff. *subpallasi* (Krumbeck), *Inoceramus* sp. indet., and a large terebratuloid brachiopod.

Brothers (1974) interprets the Tangihua Volcanics and adjacent Cretaceous-Oligocene rocks as allochthonous and derived from an easterly source. Hatherton and Sibson (1970), in contrast, favour a westerly source for Onerahi Chaos rocks which Brothers associates with Tangihua Volcanics. Brothers also discussed the possibility of the Matakaoa Volcanics being allochthonous, although Chapman-Smith and Grant-Mackie (1971) suggest that the limestone lenses with Late Jurassic fossils at Cape Runaway may have been torn from basement by rising magma.

Classification of the two Jurassic localities in the Torlesse is suggested by their geographic proximity to Torlesse rocks and, conversely, their remoteness from Hokonui rocks, and the known association of fossils with volcanic rocks and limestones in the Torlesse of the South Island (Campbell and Warren 1965; Andrews, Speden, and Bradshaw, in press). However, because of their possible allochthonous derivation the localities are for the present excluded from the list of Torlesse localities.

Fossils identified as Jurassic (Hay 1960) or Cretaceous to Early Tertiary (Bowen 1965) are present in limestone and siltstone associated with the Whangakea Volcanics, Northland. The macrofossil identified as *Meleagrinella* sp. is represented by indeterminable fragments of a pterioid or pectinoid bivalve. Fragments of *Inoceramus* indicate an age no younger than Maastrichtian, while Dr P. N. Webb (pers. comm.), University of Southern Illinois, De Kalb, has recently identified planktonic Teratan-Haumurian (Campanian-Maastrichtian) Foraminifera. This information and the lack of positive evidence of an earliest Cretaceous or older age suggest that the Whangakea Volcanics are not part of the New Zealand Geosyncline and belong to a suite different from the Matakaoa Volcanics at Cape Runaway and the Tangihua Volcanics at Houto Hills.

DISCUSSION

Stratigraphic and Geographic Distribution of Zones

Representation of the 21 Permian to Late Jurassic faunal zones of the Hokonui facies in the Torlesse of the North Island is very incomplete (Fig. 2). Only one of the seven Permian zones is justified by fossils, although other zones may be represented. Gaps present in the Torlesse of the South Island (Andrews, Speden, and Bradshaw, in prep.) are also present in the North Island, notably those of the Early Triassic and latest Triassic to Late Jurassic, except for the *Pseudaucella* Zone (late Early Jurassic). Major differences from the South Island are the absence of Carboniferous fossils and particularly of the relatively very fossiliferous shallow marine and non-marine Kaihikuan (Ladinian) sequences and plant beds, and the presence of more diverse Permian assemblages.

The possible geographic distribution of major fossil zones in the Torlesse of the North Island is shown in Figure 3. Boundaries of zones are based in part on field evidence as compiled on sheets of the 1:250 000 Geological Map of New Zealand, and locally coincide with faults on these maps. Establishment of the limits and continuity of zones is uncertain because of the low number and density of localities and the lack of adequate stratigraphic and structural control; the position of many boundaries is probably largely meaningless.

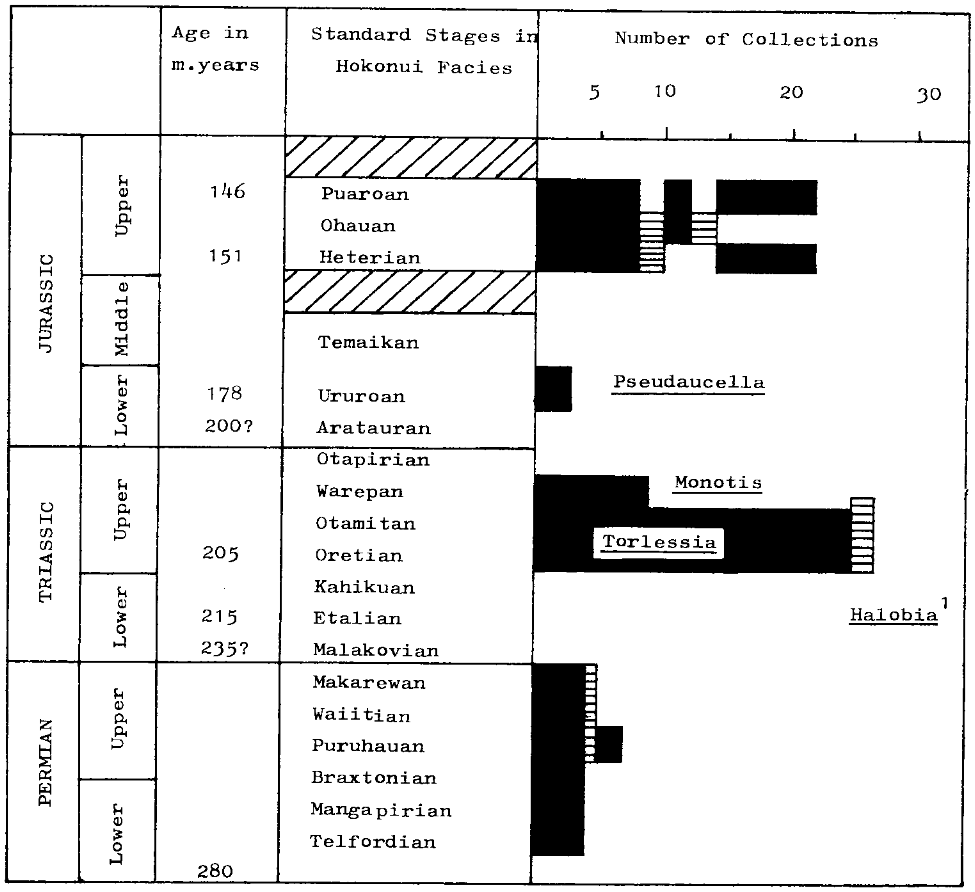

FIG. 2.—Age and number of datable fossil localities in Torlesse rocks in the North Island. Boxes indicate number of localities for a given stage range.
[1] not in place, in rocks of Late Jurassic or younger age.

No locality has a sequence of zones in place. Triassic and Jurassic fossils, other than those at Houto Hills, are not represented in Northland north of Tawharanui Peninsula, Triassic fossils are not known in place in southwest Auckland or Coromandel Peninsula, the distribution of Torlesse rocks in Raukumara Peninsula is poorly understood, and only two Late Jurassic zones are known in the south of the North Island. Paucity of localities prevents the mapping of individual zones within the Permian and Late Jurassic, although the latter is the most extensive zone and apparently extends down the east side of the island from Northland to Cook Strait.

Present disturbance of fossil zones north and south of Cook Strait suggests marked eastward displacement of the Torlessia Zone and the west boundary of the late Jurassic Zone north of Cook Strait (Fig. 3). Displacement may be in response to (a) faulting or folding during the Late Jurassic-Early Cretaceous Rangitata Orogeny, (b) doming and uplift on major north-striking transcurrent faults, branches of the Alpine Fault, associated with the late Cenozoic Kaikoura Orogeny, and possibly in part by movement on southeast-striking faults through Cook Strait as proposed by Cope and Reed (1967) and Hatherton (1967).

Geophysical evidence does not favour major dextral transcurrent displacement of the schist belt or uplift on the north side of faults through Cook Strait. However, lateral and vertical movement and associated doming on north-striking faults are well documented (Stevens 1974). As faulting and folding occurred during the Rangitata Orogeny, a combination of the alternatives suggested is possible.

Other major uncertainties on the distribution and relationships of the zones are:

1. The age of Waipapa Group rocks south of the Bay of Islands and west of the Permian zone is uncertain. Documentation of a Late Jurassic age for much of the unit would extend the zone northward, confirm the regional anticline adopted by many authors, and simplify the regional geology, except that a major unconformity would then be indicated.

2. Evidence is required for the age of Torlesse rocks west and northwest of Lake Taupo, in the centre of the island between Lake Waikaremoana (N105) and Oroua (N140), in Raukumara Peninsula, and in the Aorangi Range, southern Wairarapa.

   The subdivision into Permian-Triassic and Triassic-Jurassic units (Fig. 3) in the Kaimanawa and Kaweka Ranges southeast of Lake Taupo is based on the assumption that degree of metamorphism is not only related to depth of burial, but also to major structures (Grindley 1960). Spörli and Barter (1973) demonstrated a possibility of two bands of schist separated by non-schistose rocks in the Kaimanawa Range rather than a homogeneous belt. Research in the South Island (Bishop 1970; Landis and Bishop 1972) has established that an increase in rank may be, at least locally, towards younger parts of the stratigraphic column. Consequently, the age of the rocks in the ranges requires verification by other means and could be considerably younger than mapped at present.

3. *Monotis* is known in place from two widely separated areas at Oroua (N140) and Otaki Forks (N157). For simplicity they are included in one continuous zone (Fig. 3). The relationship of the zone to unfossiliferous rocks and the Late Jurassic zone to the north and east, and to the *Torlessia* zone to the south, are obscure.

4. The presence of derived fossils at widely spaced localities in the Late Jurassic of the Waikato and Coromandel Peninsula indicates tectonic mobility. The source of the derived fossils and the mechanisms of derivation are unknown. If derived from outside the present area of outcrop of the Late Jurassic, then the possibility of part of the sequence being allochthonous cannot be dismissed. If derived from within the zone, then rocks of Late Jurassic or younger age may cover, conformably or unconformably, older zones.

Lithological Relationships

Most fossils occur in siltstone or in very fine- to coarse-grained sandstone, respectively at 48 and 27 of the 102 localities for which lithological information is available (Table 1). Other common matrices include conglomerate (11), limestone (11) and chert (4). Occurrences in conglomerate are notable, for most indicate erosion of older deposits and tectonic mobility within the New Zealand Geosyncline, probably within the area of Torlesse facies. The matrix of samples within zones show no patterns which indicate provenance or paleogeography.

Paleoecology

Numbers of fossils at most localities are low, frequently only one or a few specimens. Exceptions are the annelid fragments in the *Torlessia* zone and aggregations of the epifaunal species *Monotis* and *Pseudaucella.* Preservation is generally good although many specimens, especially belemnoids, are incomplete or fragmentary. Epifaunal and nektonic species are dominant and normally the only species present. An exception is in the *Torlessia* zone, in which the occurrence of tubes of infaunal annelids only is suggestive of unusual environmental conditions. These paleoecological aspects and others described in earlier sections of this paper are also characteristic of the Torlesse of the South Island (Andrews, Speden, and Bradshaw, in press). Evidence for the transportation of specimens is widespread, although the amount of transportation is difficult to evaluate and requires careful attention in the field. Because of the transportation and the occurrence of specimens in conglomerates, possibly deposited on or at the foot of the continental slope, and in mélanges, paleoecological interpretations may have little meaning. Interbedded limestones and reef-building organisms undoubtedly indicate shallow-water deposition, as may shellbeds of the epifaunal bivalves such as *Monotis* and *Pseudaucella.* Limestone and chert, if not associated with submarine volcanism, suggest local low rates of deposition.

Provenance and relationship to the Hokonui facies

For the New Zealand Geosyncline, the favoured or generally accepted model is that the Torlesse facies represents a lateral deeper-water equivalent of the Hokonui facies, with the sediments of both facies being derived from a cratonic landmass to the west (Fleming 1970; Landis and Bishop 1972; Mayer 1969). Kear (1971) developed this concept to relate the facies to a "steep, possibly faulted, continental slope" (p. 279). This allowed for the distinct and geographically relatively sudden change in many characteristics between the two facies and for the intermediate composition of the Torlesse rocks of parts of the South Auckland region (marginal facies of Reed 1966, 1967). Kear also emphasized the gradational relationship between his Morrinsville (foot of continental slope) and Hunua (beyond the continental slope) facies.

Recently, however, Bradshaw and Andrews (1972) and Andrews, Speden, and Bradshaw (in press) have documented evidence for derivation, locally at least, of Torlesse sediments in the South Island from a landmass to the east. In the North Island there is also evidence for sources to the east. On the basis of maximum pebble size in conglomerates assumed to be the same age, from Great Barrier and Kawau Islands, and of geophysical evidence (Officer 1955), Hopgood (1961) favoured an eastern source for Torlesse rocks north of Auckland. More significantly, Schofield (1971, 1974), from detailed mapping in the southern Hauraki Gulf and South Auckland, recognized facies patterns he related to growing north-striking geanticlines and intervening basins of deposition with sediments being derived locally from east and west and, perhaps, also from the south along the axis of a basin. Schofield, in contrast to Kear's (1971) option of a faulted continental slope, prefers a model of an active geanticlinal ridge, possibly faulted along its east limb, separating the Hokonui and Torlesse facies.

Complex patterns of highs and troughs of deposition changing loci in space and time, with sediments being derived from west, east or along the axis of a basin, may explain the existence of cores of older rocks, the presence of derived fossils, and the variable direction of transport observed in separate areas, such as from the east in the Whakarara Range (Kingma 1962) and the north-northeast direction of transport in the Wellington District (Webby 1959). It may also help to explain the geographic patterns of Torlesse rocks of different composition,

SEDIMENTARY FEATURES

LITHOLOGIC DATA Information given should apply to the specific lithologic unit (e.g. bed) in which the fossils occur.

PREDOMINANT GRAIN-SIZES: Specify primary and secondary modes		pri. sec.*	GRAIN-SIZE COMPARATOR USED? Yes/No *	STRATIFICATION (a) Bed Thickness:		(b) Internal Features
B boulder	1 granule	4 medium sand	7 silt } 9 mud	1 non-bedded	4 5-60 cm	G graded
C cobble	2 very coarse sand	5 fine sand	8 clay } 9 mud	2 > 120 cm	5 1-5 cm	S slump-folded
P pebble	3 coarse sand	6 very fine sand		3 60-120 cm	6 < 1 cm (laminated)	X cross-bedded

WEATHERING	HARDNESS	CARBONATE	COLOUR	Wet/Dry		
1 none or slight	1 unconsolidated	1 non-calcareous	L light	1 white	4 red	7 green
2 moderate	2 moderately soft	2 calcareous	M medium	2 grey	5 brown	8 blue
3 intense	3 moderately hard	3 limestone	D dark	3 black	6 yellow	9 purple
	4 hard					

ADDITIONAL FEATURES (Feature present, one letter; abundant, two letters):

C	carbonaceous	M	micaceous	P	pyritic	Z	sulphurous	S	shelly	O	concretionary	Q	highly quartzose
G	glauconitic	F	phosphatic	T	tuffaceous	B	bentonitic	U	burrowed	R	rock fragments	X	feldspathic

FIG. 4.—Classification of sedimentary features according to the Fossil Record Form, Geological Society of New Zealand (GSNZ—F1, 1971).

quartzo-feldspathic or volcanic or intermediate, now being found in many areas (Halcrow 1956; Hopgood 1961; Mayer 1969; Paltridge 1958; Reed 1957; Schofield 1974; Skinner 1972).

The geographically and stratigraphically scattered localities in the Torlesse of the North Island provide limited evidence for local paleoenvironmental patterns, such as reef environments indicated by the Permian faunas (p. 76), but except for warm-water conditions during the Puruhauan there is no convincing evidence for regional patterns. Campbell (1974) has noted the restriction of Permian fusulinids and reef-building corals to Torlesse rocks in both islands of New Zealand and has pointed out the presence of two genera (*Halorella* (Late Triassic) and *Burmirhynchia* (Late Jurassic)) with Tethyan affinities (Ager 1968) in the Torlesse. The brachiopods are rare, each being known from only one locality widely separated geographically and stratigraphically, and both belong to the ancestral or main stocks of rhynchonellid brachiopods. Even though I consider the similarities between Torlesse and Hokonui faunas to be more important than these minor differences at three times, Campbell's suggestion that the difference might be significant should not be overlooked especially in view of Force's (1970) recognition of distinct petrological and sedimentological differences between Torlesse and Hokonui sediments of Kaihikuan age.

The presence of fossils diagnostic of zones or stages characteristic of the Hokonui facies gives an age to Torlesse localities or, sometimes, geographically and stratigraphically limited units. Extrapolation of boundaries between fossil localities is not justified in sparsely fossiliferous, litho-stratigraphically poorly subdivided and structurally complex sequences. Boundaries can be plotted, as in Figure 3, but may be meaningless. Nor is absence of fossils, as used by Landis and Bishop (1972), a reliable basis for interpretation of Torlesse geology, as absence may reflect non-discovery or lack of recognition. Discoveries such as the collection of *Titahia* and *Torlessia* at Akatore, South Otago (Campbell and Campbell 1970), Carboniferous fossils at Kakahu, South Canterbury (Jenkins and Jenkins 1971), and *Pseudaucella* (Ururoan Stage, Early Jurassic) at Kaiwara, North Canterbury (Speden and Maxwell, in prep.), may profoundly alter the geographic distribution of a zone and the stratigraphic representation, and significantly influence existing structural and paleogeographic interpretations.

Detailed mapping incorporating litho-stratigraphic, sedimentological, structural and paleontological studies, as so successfully integrated by Schofield (1974) is the basic pre-requisite for understanding and interpreting Torlesse sequences.

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REFERENCES

AGER, D. V. 1968. The supposedly ubiquitous Tethyan brachiopod *Halorella* and its relations. *Journal of the Paleontological Society of India, v. 5–9*: 54–70.

ANDREWS, P. B.; SPEDEN, I. G.; BRADSHAW, J. D. in press: Lithological and paleontological content of the Torlesse Supergroup, southern and central New Zealand; a re-appraisal. *N.Z. Journal of Geology and Geophysics.*

BARTRUM, J. A. 1937. A Jurassic fossil from Motumaoho Quarry, Morrinsville. *N.Z. Journal of Science and Technology* B19: 458–9.

BENSON, W. N. 1921. Recent advances in New Zealand geology. *Report of the Australian and N.Z. Association for the Advancement of Science* 15: 45–132.

BISHOP, D. G. 1970. Structure, stratigraphy and metamorphism in the Dansey Pass area, Otago, New Zealand. Unpublished Ph.D. thesis lodged in Library, University of Otago.

BOWEN, F. E. 1965. On the age of the Whangakea Volcanics of Northland. *N.Z. Journal of Geology and Geophysics* 8: 1223–5.

BRADSHAW, J. D. 1973. Allochthonous Mesozoic fossil localities in mélange within the Torlesse rocks of North Canterbury. *Journal of the Royal Society of New Zealand* 3: 161–167.

BRADSHAW, J. D; ANDREWS, P B. 1972. Geotectonics and the New Zealand Geosyncline. *Nature* 241: 14–16.

BROTHERS, R. N. 1974. Kaikoura Orogeny in Northland, New Zealand. *N.Z Journal of Geology and Geophysics* 17: 1–18.

CAMPBELL, J. D. 1974. Torlesse Supergroup — a Review. *Geological Society of New Zealand Newsletter* 37: 30–35.

CAMPBELL, J. D.; COOMBS, D. S. 1966. Murihiku Supergroup (Triassic-Jurassic) of Southland and South Otago. *N.Z. Journal of Geology and Geophysics* 9: 393–398.

CAMPBELL, J. D.; WARREN, G. 1965. Fossil localities of the Torlesse Group in the South Island. *Transactions of the Royal Society of New Zealand, Geology* 3: 99–137.

CAMPBELL, J. K.; CAMPBELL, J. D. 1970. Triassic tube fossils from Tuapeka Rocks, Akatore, South Otago. *N.Z. Journal of Geology and Geophysics* 13: 392–9.

CARTER, R. M.; LANDIS, C. A.; NORRIS, R. J.; BISHOP, D. G. 1974. Suggestions towards high-level nomenclature for New Zealand rocks. *Journal of the Royal Society of New Zealand* 4: 5–18.

CHAPMAN-SMITH, M.; GRANT-MACKIE, J. A. 1971. Geology of the Whangaparaoa Area, Eastern Bay of Plenty. *N.Z. Journal of Geology and Geophysics* 14: 3–38.

COPE, R. N.; REED, J. J. 1967. The Cretaceous paleogeology of the Taranaki-Cook Strait area. *The Australasian Institute of Mining and Metallurgy, Proceedings* 222:63–72.

FLEMING, C. A. 1953. Lower Jurassic fossils from Taneatua, Bay of Plenty, New Zealand. *N.Z. Journal of Science and Technology* B35: 129–133.

——— 1958. Upper Jurassic fossils and hydrocarbon traces from the Cheviot Hills, North Canterbury. *N.Z. Journal of Geology and Geophysics* 1: 375–394.

——— 1959. *Buchia plicata* (Zittel) and its allies, with a description of a new species, *Buchia hochstetteri*. *N.Z. Journal of Geology and Geophysics* 2: 889–504.

——— 1970. The Mesozoic of New Zealand: Chapters in the history of the Circum-Pacific Mobile Belt. *Quarterly Journal of the Geological Society of London* 125: 125–170.

FORCE, E. R. 1970. Sedimentation, petrology and stratigraphy of the Kaihikuan (Upper Middle Triassic) of South Island, New Zealand. Unpublished Ph.D. dissertation, Lehigh University, U.S.A., 283 p, map.

FRASER, C. 1910. The Geology of the Thames Subdivision, Hauraki, Auckland. *N.Z. Geological Survey Bulletin 10.*

FRASER, C.; ADAMS, J. H. 1907. The Geology of the Coromandel Subdivision, Hauraki, Auckland. *N.Z. Geological Survey Bulletin (n.s.) 4.*

GRANT-MACKIE, J. A. 1959. Hokonui Stratigraphy of the Awakino-Mahoenui area, South-west Auckland. *N.Z. Journal of Geology and Geophysics* 2: 755–87.

GRANT-TAYLOR, T. L.; WATERHOUSE, J. B. 1963. *Monotis* from the Tararua Range, Wellington. *N.Z. Journal of Geology and Geophysics* 6: 623–7

GRINDLEY, G. W. 1960. Sheet 8 Taupo. "Geological Map of New Zealand 1:250 000" Department of Scientific and Industrial Research, Wellington.

HALCROW, H. M. 1956. The Geology of Waiheke Island, Auckland. *Transactions of the Royal Society of New Zealand,* 84: 51–69.

HATHERTON, T. 1967. A Geophysical study of Nelson-Cook Strait region, New Zealand. *N.Z. Journal of Geology and Geophysics* 10: 1330–47.

HATHERTON, T.; SIBSON, R. H. 1970. Junction Magnetic Anomaly north of Waikato River. *N.Z. Journal of Geology and Geophysics* 13: 655–62.

HAY, R. F. 1960: The geology of Mangakahia subdivision. *N.Z. Geological Survey Bulletin (n.s.) 61.*

HOPGOOD, A. M. 1961. The Geology of the Cape Rodney-Kawau District, Auckland. *N.Z. Journal of Geology and Geophysics* 4: 205–30.

HORNIBROOK, N. de B. 1951. Permian fusulinid Foraminifera from the North Auckland Peninsula, New Zealand. *Transactions and Proceedings of the Royal Society of New Zealand* 79: 319–21.

——— 1953. Jurassic Foraminifera from New Zealand. *Transactions of the Royal Society of New Zealand* 81: 375–8.

HUTTON, F. W. 1877. Report on the geology of the north-east portion of the South Island, from Cook Straits to the Rakaia. *New Zealand Geological Survey, Reports of Geological Explorations, 1873–4,* 8: 27–58.

JAWORSKI, E. 1915. Die Fauna der Obertriadischen *Nucula*-Mergel von Misol. *Paläontologie von Timor* 2: 73–174.

JENKINS, D. G.; JENKINS, T. B. H. 1971. First diagnostic Carboniferous fossils from New Zealand. *Nature* 233: 117–8.

JOHNSTON, M R. 1974. A Lower Cretaceous unconformity in Eastern Wairarapa. *N.Z. Journal of Geology and Geophysics* 17: 143–8.

KEAR, D. 1955. Mesozoic and Lower Tertiary Stratigraphy and limestone deposits, Torehina, Coromandel. *N.Z. Journal of Science and Technology* B37: 107–14.

——— 1971. Basement rock facies — northern North Island. *N.Z. Journal of Geology and Geophysics* 14: 275–83.

KEAR, D.; HAY, R. F. 1961. Sheet 1, North Cape (1st Ed.) "Geological Map of New Zealand 1:250 000." Department of Scientific and Industrial Research, Wellington.

KEAR, D.; SCHOFIELD, J. C. 1965. Sheet N65 — Hamilton. "Geological Map of New Zealand 1:63 360". Department of Scientific and Industrial Research, Wellington.

——— 1968. N52, Te Kauwhata. "Geological Map of New Zealand 1:63 360". Department of Scientific and Industrial Research, Wellington.

KEAR, D.; TOLLEY, W. P. 1957. Notes on Pleistocene and Jurassic beds near Morrinsville. *N.Z. Journal of Science and Technology* B38: 500–506.

KINGMA, J. T. 1958. The structural position of the Opau Greywackes, Hawke's Bay. *N.Z. Journal of Geology and Geophysics* 1: 490–500.

——— 1962. Sheet 11 Dannevirke. "Geological Map of New Zealand 1:250 000". Department of Scientific and Industrial Research, Wellington.

——— 1965. Sheet 6 East Cape. "Geological Map of New Zealand 1:250 000". Department of Scientific and Industrial Research, Wellington.

——— 1967. Sheet 12 Wellington. "Geological Map of New Zealand 1:250 000". Department of Scientific and Industrial Research, Wellington.

LANDIS, C. A.; BISHOP, D. G. 1972. Plate Tectonics and regional stratigraphic-metamorphic relations in the southern part of the New Zealand Geosyncline. *Geological Society of America Bulletin* 83: 2267–84.

LEED, H. 1956: Permian reef-building corals from North Auckland Peninsula, New Zealand. *N.Z. Geological Survey Paleontological Bulletin* 25 (2).

MCKAY, A. 1879. The geology of the neighbourhood of Wellington. *N.Z. Geological Survey Reports of Geological Exploration during 1878–99* [12]: 131–5.

——— 1888. On certain calcareous rocks occurring near Eketahuna, County of Wairarapa North. *N.Z. Geological Survey Reports of Geological Explorations, 1887–88* [19]:. 18–20.

MARWICK, J. 1955. Supplement to N.Z. Geological Survey, Paleontological Bulletin 21: Corrigenda.

MAYER, W. 1969. Petrology of the Waipapa Group, near Auckland, New Zealand. *N.Z. Journal of Geology and Geophysics* 12: 412–435.

MILLIGAN, E. N. 1959. Some fossils from hitherto undifferentiated Permian-Triassic-Jurassic rocks near Auckland. *N.Z. Journal of Geology and Geophysics* 2: 195–7.

MILNE, J. D. G.; CAMPBELL, J. D. 1969. Upper Triassic Fossils from Oroua Valley, Ruahine Range, New Zealand. *Transactions of the Royal Society of New Zealand, Geology* 6: 247–250.

OFFICER, C. B. 1955. Southwest Pacific crustal structure. *Transactions American Geophysical Union* 36: 449–59.

ONGLEY, M. 1933. Eketahuna Subdivision. *N.Z. Geological Survey 27th Annual Report* (*n.s.*): 4–5.

PALTRIDGE, 1958. The geology of the north-east part of Whakatane County. Unpublished M.Sc. thesis, Auckland University Library, Auckland.

PURSER, B. H. 1961. Geology of the part Waikato Region (Onewhero Sheet N51). *N.Z. Geological Survey Bulletin 69.*

REED, J. J. 1957. Petrology of the Lower Mesozoic rocks of the Wellington District. *N.Z. Geological Survey Bulletin 57.*

——— 1966. Mineralogy and Petrology in the New Zealand Geological Survey 1865–1965. *N.Z. Journal of Geology and Geophysics* 8: 999–1087.

——— 1967. Application of recent petrological advances to selection of road aggregates. Roading Symposium Session L "Road aggregate Quality". (Published by the Road Research Unit, N.Z. National Roads Board): 31–66.

RICH, C. C. 1959. Late Cenozoic geology of the lower Manawatu Valley, New Zealand. Unpublished Ph.D. dissertation, Harvard University, Cambridge, Massachusetts, U.S.A.

SCHOFIELD, J. C. 1971. Stratigraphy, facies and structure of the Waiheke Group. Abstr., Symposium on Torlesse Supergroup, Victoria University of Wellington.

——— 1974. Stratigraphy, facies and setting of the Waiheke and Manaia Hill Groups, East Auckland. *N.Z. Journal of Geology and Geophysics* 17: 807-838.

SKINNER, D. N. B. 1972. Subdivision and petrology of the Mesozoic rocks of Coromandel (Manaia Hill Group). *N.Z. Journal of Geology and Geophysics* 15: 203–27.

SOLLAS, W. J.; MCKAY, A. 1905. The Rocks of Cape Colville Peninsula, Auckland, New Zealand. Vol. 1. Government Printer, Wellington viii + 289 pp., 104 pls.

SPEDEN, I. G. 1970. Three new inoceramid species from the Jurassic of New Zealand. *N.Z. Journal of Geology and Geophysics* 13: 825–51.

——— 1971. Geology of Papatowai Subdivision South-east Otago. *N.Z. Geological Survey Bulletin 81.*

——— 1972. New fossil localities in the Torlesse Supergroup, western Raukumara Peninsula, New Zealand. *N.Z. Journal of Geology and Geophysics* 15: 433–45.

——— 1973. Distribution, stratigraphy and stratigraphic relationships of Cretaceous sediments, western Raukumara Peninsula, New Zealand. *N.Z. Journal of Geology and Geophysics* 16: 243–68.

——— 1975. Cretaceous stratigraphy of Raukumara Peninsula Part 1. Koranga (pts N87 & N88). Part 2. Lower Waimana and Waiotahi Valleys (pt N78). *N.Z. Geological Survey Bulletin 91.*

SPEDEN, I. G.; MAXWELL, P. A. in prep. Early Jurassic (Ururoan Stage) *Pseudaucella* from Torlesse rocks at Kaiwara, North Canterbury.

SPÖRLI, K. B.; BARTER, T. P. 1973. Geological reconnaissance in the Torlesse Supergroup of the Kaimanawa Ranges along the lower reaches of the Waipakihi River, North Island, New Zealand. *Journal of the Royal Society of New Zealand* 3: 363–380.

SPÖRLI, K. B.; GRANT-MACKIE, J. A. in prep: Late Jurassic fossils from Tawharanui Peninsula, North Auckland.

STEVENS, G. R. 1963. Jurassic belemnites in the Torlesse Group of the North Island. *N.Z. Journal of Geology and Geophysics* 6: 707–10.

——— 1965. The Jurassic and Cretaceous belemnites of New Zealand and a review of the Jurassic and Cretaceous belemnites of the Indo-Pacific Region. *N.Z. Geological Survey Paleontological Bulletin 36.*

——— 1970. Upper Jurassic belemnites from Kuaotunu (Coromandel Peninsula) and North-eastern Great Barrier Island. *N.Z. Journal of Geology and Geophysics* 13: 721–5.

——— 1972. Paleontology of the Torlesse Supergroup. *N.Z. Geological Survey Report 54.*

——— 1974. *Rugged Landscape: The Geology of Central New Zealand, including Wellington, Wairarapa, Manawatu and the Marlborough Sounds.* A. H. and A. W. Reed, Wellington.

SUGGATE, R. P. 1961. Rock-stratigraphic names for the South Island schists and undifferentiated sediments of the New Zealand Geosyncline. *N.Z. Journal of Geology and Geophysics* 4: 392–399.

THOMPSON, B. N. 1961. Sheet 2A Whangarei. "Geological Map of New Zealand 1:250 000". Department of Scientific and Industrial Research, Wellington.

WATERHOUSE, J. B. 1964. Permian stratigraphy and faunas of New Zealand. *N.Z. Geological Survey Bulletin 72.*

——— 1967. Proposal of Series and Stages for the Permian in New Zealand. *Transactions of the Royal Society of New Zealand, Geology* 5: 161–80.

——— 1968. The classification and descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica* 129A. pp. 4–94. 18 pls.

——— 1969. World correlation of New Zealand Permian Stages. *N.Z Journal of Geology and Geophysics* 12: 713–37.

WEBBY, B. D. 1958. A Lower Mesozoic annelid from Rock Point, South-western Wellington, New Zealand. *N.Z. Journal of Geology and Geophysics* 1: 509–13.

——— 1959. Sedimentation of the alternating greywacke and argillite strata in the Porirua District. *N.Z. Journal of Geology and Geophysics* 2: 461–78.

——— 1967. Tube fossils from the Triassic of south-west Wellington, New Zealand. *Transactions of the Royal Society of New Zealand, Geology* 5: 181–191.

WELLMAN, H. W. 1949. Pillow lava at Red Rock Point, Wellington. *Transactions of the Royal Society of New Zealand* 77: 306–12.

——— 1959. Divisions of the New Zealand Cretaceous. *Transactions of the Royal Society of New Zealand* 87: 99–163.
——— 1973. The Stokes Magnetic Anomaly. *Geological Magazine* 110: 419–29.

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APPENDIX 1: FOSSILS IN STRATIGRAPHIC UNITS IN TORLESSE ROCKS IN THE NORTH ISLAND

Based on Table 1.

1. PERMIAN
   N8/f505–7, 510, 518–520, 526; N11/f562; N16/f502).
   Brachiopoda: *Martiniopsis woodi* Waterhouse
   Coelenterata: *Waagenophyllum novaezelandiae* Leed, *Wentzelella maoria* Leed.
   Foraminifera: *Lepidolina multiseptata* (Deprat), *Dunbarula* sp., *Codonofusiella* sp., *Khalerina* (= *Verbeekina*) sp., *Cribrogenerina* cf. *obesa* Lange, *Cribrogenerina* sp., *Colaria douvillei* (Ozawa), *Neoschwagerina margaritae* Deprat Schwagerinidae gen. et sp. indet., *Chusenella* sp., *Bigenerina* sp., *Pachyphloia* sp.
   Other: crinoid stems, ostracod, bryozoa, indeterminable macro- and micro-organisms.

2. *Halobia* ZONE (ORETIAN — WAREPAN STAGES, LATE TRIASSIC) (N65/f528; N145/f522).
   Bivalvia: *Halobia* sp. cf. *hochstetteri* Mojsisovics*
   Brachiopoda: Terebratuloidea indet.

* Occurs in a siltstone pebble in conglomerate in N65/f528; the matrix apparently has *Inoceramus galoi* Boehm (Heterian Stage).

3. *Torlessia* ZONE (?ORETIAN—OTAMITAN STAGES, LATE TRIASSIC) (N160/f538–9, 617–21, 639, 641, 644, 649, 650; N164/f492–4, 499, 500, 503, 589, 590, 592–4, 605, 619).
   Annelida: *Torlessia mackayi* Bather
   Titahia corrugata Webby
   (Rocks with Radiolaria (N160/f642–3), reptile bones (N164/f612, 617) and plants (N160/f499, 500, 642; N161/f498; N164/f498) almost certainly fall within the zone).

4. *Monotis* ZONE (WAREPAN STAGE, LATE TRIASSIC) (N43/f1; N56/f9; N140/f517–8, 522; N157/f539, 540, 555, 559).
   Bivalvia: *Monotis richmondiana* (s.l.) Zittel, *M.* (*Entomonotis*) *ochotica richmondiana*, *M.* (*E.*) *ochotica* cf. *gigantea* Avias, *M.?*(*E.*) *ochotica pachypleura* Teller, *M.* (*E.*) *routheri* Avias, *M.? calvata* Marwick
   Monotis as a derived fossil is associated with *Inoceramus galoi* or *I.* cf.

galoi at Manaia Hill (N43/f1, 2) and Motumaoho Quarry (N56/f9). The locality (N140/f519) at Oroua Creek, with the brachiopod *Halorella ruahinensis* Campbell may be in the zone of *Monotis*.

5. *Pseudaucella* ZONE (URUROAN STAGE, EARLY JURASSIC)
   (N78/f501, 579, 580).
   Bivalvia: *Pseudaucella marshalli* (Trechmann)
   Foraminifera: *Dentalina* sp.
   The locality (N69/f524) at Otarawairere Bay with ?*Cylindroteuthis* sp. may fall within the zone.

6. *Inoceramus galoi* ZONE (HETERIAN, LATE JURASSIC)
   (?N43/f2, ?f501–2; N48/f598; f56/f9; N65/f528–9)
   Bivalvia: *Inoceramus galoi* Boehm,
   I. cf. *galoi* Boehm,
   Malayomaorica malayomaorica (Krumbeck)
   Inoceramus galoi is associated with derived fossils in N56/f9 and N65/f528, and with *Monotis* is a derived fossil at Manaia Hill (N43/f1, 2).

7. *Inoceramus haasti* ZONE (OHAUAN, LATE JURASSIC)
   (N34/f546; N65/f528)
   Bivalvia: *Inoceramus* cf. *haasti,* Hochstetter
   I. cf. *subhaasti* Wandel,
   Malayomaorica malayomaorica,
   ?*Malayomaorica* sp. indet.
   Cephalopoda: Ammonoid indet.,
   ?*Anaptychus*
   Other: Gastropod indet.,
   cf. *Rhizocorallum* sp.
   Localities N34/f547 and 548 may, on stratigraphic proximity, also belong to this zone.

8. *Malayomaorica malayomaorica* ZONE (HETERIAN-OHAUAN, LATE JURASSIC)
   (N66/f1; N150/f483)
   Bivalvia: *Malayomaorica malayomaorica*

9. ZONE OF *Belemnopsis* sp. ex. gr. *aucklandica* (OHAUAN-PUAROAN, LATE JURASSIC)
   (N40/f529; N77/f540)
   Bivalvia: *Neocrassina* cf. *spitiensis* (Stoliczka)
   Belemnoidea: *Belemnopsis* sp. ex. gr. *aucklandica* (Hochstetter)

10. ZONES OF THE PUAROAN STAGE (LATE JURASSIC)
   (?N30/f508; N43/f2, ?512, ?521, 522; N88/f560; N159/f435)
   Bivalvia: *Buchia hochstetteri* Fleming,
   B. aff. *plicata* (Zittel),
   Inoceramus sp. (cf. *Anopaea* n.sp.),
   ?*Coelastarte* sp.
   Belemnoidea: *Hibolithes arkelli* Stevens.
   H. cf. *arkelli,*
   H. marwicki marwicki Stevens*

11. HETERIAN-PUAROAN STAGES (LATE JURASSIC)
   (?N43/f547, 520; ?N52/f575, 617; N75/f507; ?N95/f502; ?N149/f591; ?N153/f526).
   Bivalvia: ?*Buchia* sp.,
   Malayomaorica sp.,

	Inoceramus sp. (? cf. *Anopaea* n.sp.),
	Inoceramus sp.
Belemnoidea:	*Belemnopsis* sp.,
	B. sp. indet. ex gr. *aucklandica* (Hochstetter)
Other:	cf. *Rhizocorallum* sp.

* This species is associated with derived *I. galoi* and *Monotis* at Manaia Hill (N43/f1, 2).

12. FOSSILS AT LOCALITIES OF UNCERTAIN OR UNKNOWN AGE (N8/f506, 510, 526; N30/507; N34/f503, 548; N39/f1, 516; N43/f3–4, 517, 519, 523; N69/f524; N74/f501; N87/f533, 561, 573, 1172; N95/f504; N124/f545 N140;/f519; N149/f638, 644; N153/f520, 522; N157/f541, 561; N160/f499, 500, 642–3; N161/f498, 523; N164/f498, 591, 612, 617).

Bivalvia:	*Neocrassina* cf. *spitiensis* (Stoliczka; ? Kt–o)
Belemnoida:	*Belemnopsis* sp. indet.
	?*Cylindroteuthis* sp. indet. (?Hu–Kt)
	belemnites indet.
Brachiopoda:	*Halorella ruahinensis* Campbell (Bm–w)
Microfossils:	Radiolaria, indeterminable micro-organisms
Plant remains:	Spores, pollen, cycad leaf fragments, wood, leaves
Other:	?coral, vertebrate remains,
	Urohelminthoida sp., indeterminable shell fragments, tubes, borings, and *Rhizocorallum*