

Fig. 7. Map showing location of stratigraphic columns within NZMS 260 Sheet V20.

Stratigraphic Column No: **64** Grid Reference: Top Bottom
 GPS Waypoint No(s): Wp 122 E: 2813055
 Region: Pakaututu N: 6212369
 Location: Limestone sections in hills above Pakaututu Road. Altitude: 748m -
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Age Int.	N.Z.	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description							
		Early Pliocene														
		Upper Opoitian														
		Mangaheia Group/Pakaututu Formation														
		Hukanui Limestone Member														
					BC ₃				<p>Moderately to well cemented coarse-grained whole shell-rich sandy limestone. Dominated by <i>Tucetona laticostata</i>. Lower contact with underlying sandstone is sharp. <i>Panopea</i> sp. valves were found protruding from the lower contact.</p>							
					S ₁₁				<p>Clean, well sorted non to well cemented, non to highly fossiliferous siliciclastic sandstone with common concretionary lenses and horizons. Concretions are up to 0.6 m thick, average 0.3 m in thickness and are typically non fossiliferous. Shell lenses are common and are generally 0.2-0.3 m thick, though they show thickness changes through them. They were found to contain <i>Glycymeris (Mania) mahiana</i>, the Opoitian-restricted gastropod <i>Strutholaria dolorosa</i>, <i>Struthilaria (Callusaria)</i> sp., <i>Lamprodominea</i> sp., <i>Amalda</i> sp., <i>Oraria</i> sp., <i>Zeocolpus/Stiracolpus</i> sp., barnacles (<i>Tasmanomegabalanus</i>) and <i>Crepidula radiata</i>. Shellhash and fragments are common, although articulated and disarticulated valves are present.</p> <p>Well sorted, non to poorly cemented siliciclastic sandstone.</p>							
			<table border="1"> <tr> <td>mud</td> <td>fine silt</td> <td>coarse med.</td> <td>fine med.</td> <td>coarse granu.</td> <td>pebb.</td> <td>cobb.</td> <td>bould.</td> </tr> </table>	mud	fine silt	coarse med.	fine med.	coarse granu.	pebb.	cobb.	bould.					
mud	fine silt	coarse med.	fine med.	coarse granu.	pebb.	cobb.	bould.									

Stratigraphic Column No: 65	Grid Reference: Top	Bottom	NZMS 260 V20 65 1 of 2
GPS Waypoint No(s): Wp 120	E: 2812713	-	
Region: Pakaututu	N: 6212372	-	
Location: Bluffs above Pakaututu Road overlooking switchback	Altitude: 741m	-	
NZMS 260 Sheet: V20 Esk	Page 1 of 1	Author: K. Bland	

Age	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description					
									Int.	N.Z.			
Early Pliocene	Upper Opoitian	Hukanui Limestone Member	50 45	BC ₃	WP 119			Coarse-grained, moderately to well cemented shell-rich limestone. Fauna in the unit is dominated by <i>Tucetona laticostata</i> , with common <i>Phialopecten</i> (?marwicki) valves also present. Few greywacke grains are contained in this limestone.					
	(?Lower) Opoitian	Mangaheia Group/Pakaututu Formation	40 35 30 25 20 15 10 5	S ₁₁ Cg ₁ Cg ₃ Cg ₁ Cg ₃ Cg ₁				Clean, well sorted, non cemented, fine to medium sandstone with common concretionary lenses and horizons up to 0.6 m thick and averaging 0.3 m in thickness. These concretions frequently contain well-rounded greywacke pebbles up to 30 mm diameter. Some concretions are highly fossiliferous with <i>Zeacolpus</i> sp., and <i>Struthiolaria</i> ? <i>dolorosea</i> dominating. The upper and lower contacts of this unit are not exposed. Coarse-grained non to slightly cemented, laminated to trough cross-bedded sandstone composed of greywacke grains with occasional greywacke conglomerate stringers. Very poorly sorted greywacke conglomerate bed that coarsens up through the section. Clasts are up to 0.2 m in diameter, and are well rounded and oblate in shape. Coarse-grained, non to slightly cemented trough cross-bedded sandstone composed of greywacke grains with occasional greywacke pebbles up to 30 mm in diameter. Well sorted clast-supported greywacke conglomerate with clasts averaging 40 mm in diameter that coarsens upward into a poorly to moderately sorted greywacke conglomerate. Clasts are between 5 and 150 mm in diameter, and average 25 mm in diameter.					
		<table border="1"> <tr> <td>mud</td> <td>fine coarse med.</td> <td>fine med.</td> <td>coarse granu. pebb. cobb. bould.</td> <td>gravel</td> </tr> </table>	mud	fine coarse med.	fine med.	coarse granu. pebb. cobb. bould.	gravel						
mud	fine coarse med.	fine med.	coarse granu. pebb. cobb. bould.	gravel									

65

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Stratigraphic Column No: 66	Grid Reference: Top	Bottom	NZMS 260 V20 66 1 of 2
GPS Waypoint No(s): Wp 484-485	E: 2809922	2809961	
Region: Puketitiri	N: 6205216	6205368	
Location: Summit of hill 930 m in southern corner of Anawhenua Station	Altitude: 922 m	852 m	
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Age	Strat. Unit		Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description	
	Int.	N.Z.								
Late Pliocene		Mangapanian	Te Waka Formation	66	BC ₂				Cream, moderately cemented, moderately weathered, flaggy, sandy, slightly pebbly shellhash limestone. Comprises coarse sand-sized, well sorted stacked bioclastic-dominated sheets up to 0.2 m thick. Partial recrystallisation of some bioclastic components is evident. Scattered greywacke clasts of granule to fine pebble size are scattered through the unit (<5%). Laminations, trough and tabular cross-stratifications are present through the limestone, with occasional <i>Ostrea chilensis</i> valves, and scattered disarticulated bivalves.	
				65						
				64						
				63						
				62						
				61						
				60						
				59						
				58						
				57						
		?Waipiian	Puketitiri Formation	55	S ₂				Patchy exposure up hillside through non cemented, non fossiliferous fine sandstone.	
				54						
				53						
				43						
				33						
				23						
				13						
				3						
				2						
				1						
			<div style="display: flex; justify-content: space-between; font-size: small;"> mud fine med. coarse fine med. coarse granu. pebb. cobb. bould. </div>							



FAUNAL LIST

A- Highly fossiliferous shellbed containing *Crassostrea ingens* (some articulated and *in situ*), *Maoricardium spatiosum* (some articulated), *Trachycardium rossi*, *Alcithoe* sp., *Crepidula*, *Maoricolpus roseus*, *Stiracolpus*, *Panopea*, *Eumarca benhami*, *Dosinia* sp. (fine ribbed, **not** *D. greyi*), *Notocallista multistriata*, *Atrina pectinata zelandica*, *Phialopecten* undet. sp., Pectinidae undet. gen. (resembles *Sectipecten*), and barnacles undet. gen.

B- Non cemented fine sandstone. Contains *Atrina pectinata zelandica*, *Talochlamys gemmulata*, *Chlamys ?zelandiae*, *Pellicaria acuminata/caniculata*, *Porireria zelanica*, *Struthiolaria (Struthiolaria) papulosa/orata*, *Zeacolpus vittatus*, *Maoricolpus roseus*, *Austrofusus pliocenicus* (fat, strongly built species), *Crepidula radiata*, *Sigapatella novaezelandiae*, *Divaricella huttoniana*, *Pratulum pulchellum*, *Lamprodomea neozelandica*, *Amalda mucronata*, *Glycymeris* c.f. *shrimptoni*, *Dosinia greyi*, *Patro undatus*, *Serratina*, *Fissidentalium*, and articulated, *in situ* *Panopea*.

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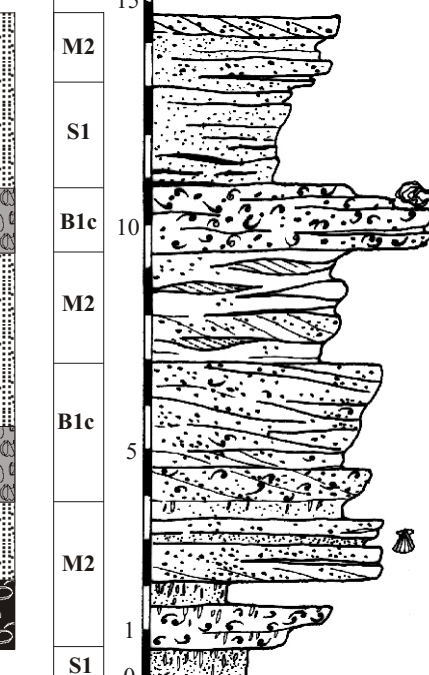
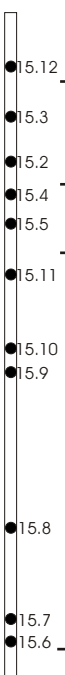


Stratigraphic Column No: 70	Grid Reference: Top	Bottom	NZMS 260 V20 70 1 of 1
GPS Waypoint No(s): Wp 155	E: 2817463		
Region: Puketitiri	N: 6206812		
Location: Outcrop in farm paddock 20m north of Puketitiri Road	Altitude: 564m	-	
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Age	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description
Late Pliocene	Mangapanian	Te Waka Formation	4	F	BC ₆			Moderately cemented pebbly limestone with up to 50% greywacke pebbles that are generally between 3-8 mm in diameter, are well rounded and very well sorted. Pebbles are spheroidal to lensoidal in shape. The matrix of the limestone comprises siliciclastic-dominated sandstone with shellhash. The unit is moderately fossiliferous with <i>Zethalia coronata</i> present. The lower contact of this bed is very sharp and intensely burrowed.
	?Waipipian-Mangapanian	Puketitiri Formation	1	1	F	S ₉	WP 155	
2								
	Mangaheia Group							

mud	fine coarse med.	fine med.	coarse granu. pebb. cobb. bould.
silt			gravel

Stratigraphic Column No: 72	Grid Reference: Top	Bottom	NZMS 260 V20 72 1 of 2
Section: W3	E: 2816900	-	
GPS Waypoint No(s):	N: 6204300	-	
Region: Central Hawkes Bay	Altitude:	-	
Location: Hawkeston	Author: V. Caron		
NZMS 260 Sheet: V20			

INTERNATIONAL DIVISION & NEW ZEALAND STAGE	Fm Mb	FACIES ASSEMBLAGE	FACIES	LITHOLOGY	SAMPLE CONTACTS	COMMENTS
PLIOCENE MANGAPANIAN TE WAKA FORMATION LIMESTONE 3 Siltstone 2			15 M2 S1 10 B1c M2 B1c 5 M2 1 S1 0 Metres			<p>Coarsening-upwards facies from planar laminated terrigenous packstone to coarse pebbly barnacle-rich grainstone. Moderately sorted, moderately to well cemented.</p> <p>Well cemented, sharp-based shell bed consisting of scattered Torlesse pebbles, oysters and sparse <i>Phialopecten thomsoni</i> valves.</p> <p>Pebbly and barnacle-rich grainstone, containing common, well-rounded Torlesse pebbles and granules up to 1 cm across. The interval is organized in thickening-upwards tabular bed sets that exhibit internal low-angle planar and tangential cross-stratifications. Poorly-sorted, moderately to well cemented.</p>

Stratigraphic Column No: 72
 Section: W3
 GPS Waypoint No(s):
 Region: Central Hawkes Bay
 Location: Hawkeston
 NZMS 260 Sheet: V20

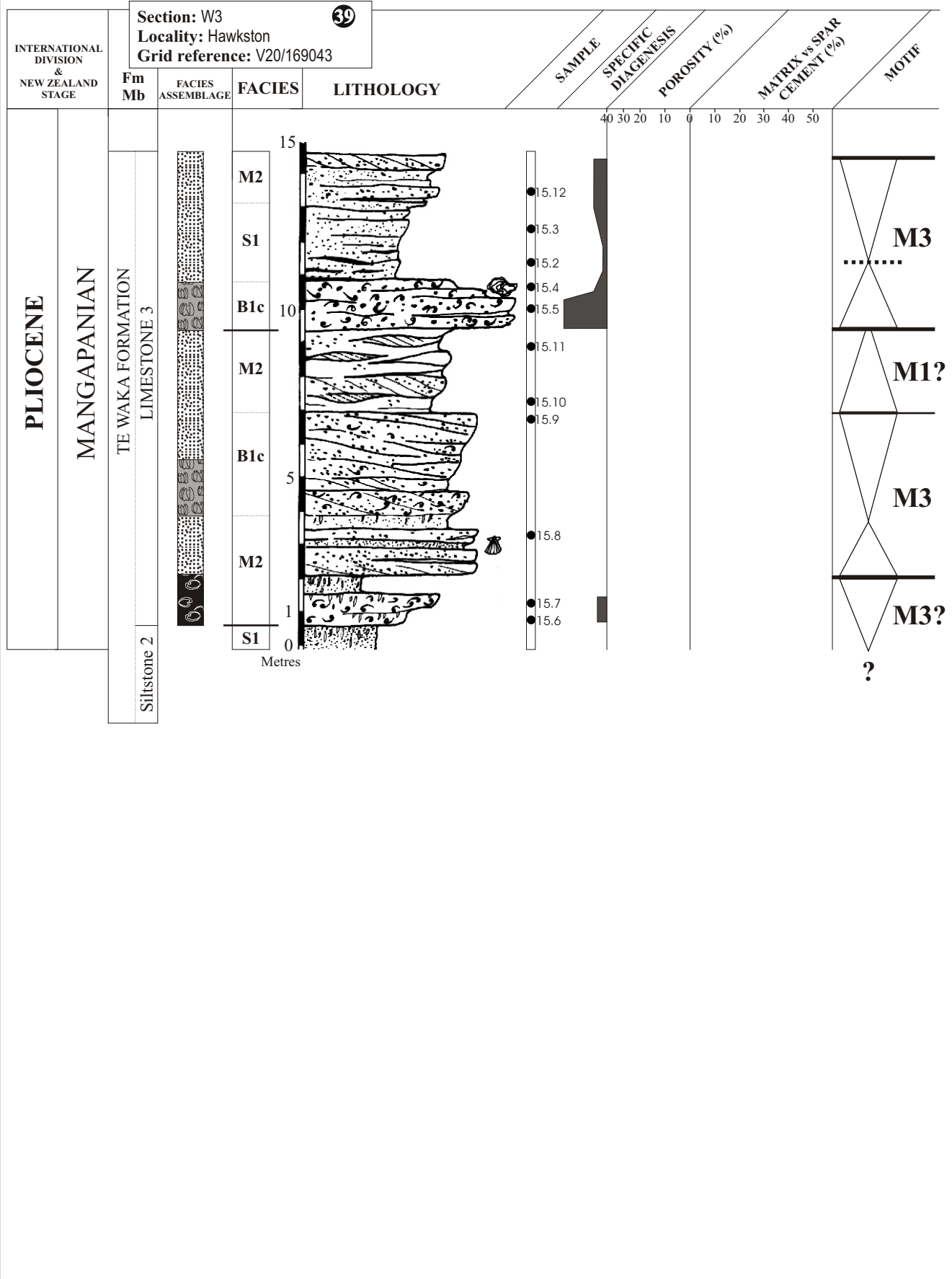
Grid Reference: Top Bottom
 E: 2816900 -
 N: 6204300 -
 Altitude: -

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Author: V. Caron

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Stratigraphic Column No: 73a	Grid Reference: Top	Bottom	NZMS 260 V20 73a 1 of 3
GPS Waypoint No(s): Wp 133, 137, 138 and 369	E: 2820891	2820709	
Region: Patoka	N: 6204875	6204975	
Location: Opau Stream section near metal pit off Puketitiri Road.	Altitude: 540m	-	
NZMS 260 Sheet: V20 Esk	Page 1 of 2		Author: K. Bland

Age	Strat. Unit	Scale (metres)	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description
Late Miocene	Upper Tongaporutuan				F				<p>The thickness of this unit varies dramatically through this section due to the presence of an angular unconformity between Torlesse basement, Te Ipouhape Sandstone Member and the overlying Te Waka Formation. In southwestern parts of the section Te Waka Formation directly overlies Torlesse basement, with no underlying Te Ipouhape Sandstone Member.</p>
	Tolaga Group				F				<p>Dirty-cream, strongly bioturbated, laminated, siltstone with sandstone interbeds up to 0.25 m thick containing <i>Fissidentalium</i>. Interbeds comprise non-cemented fine sandstone. Small clusters of greywacke granules, shellhash, barnacles and <i>Zeacolpus</i> are present in this unit. Although not exposed, upper and lower contacts of this unit are inferred to be gradational.</p>
	Waitere Formation/Te Ipouhape Sst. Mbr				F				<p>Blue-grey, well sorted fine sandstone with greywacke pebble and shellhash bands. Greywacke clasts are of granule to fine pebble size and well rounded and well sorted.</p>
					F				<p>Blue-grey, highly fossiliferous, well sorted, strongly concretionary sandstone. Non to strongly cemented, with abundant <i>Struthiolaria</i> in concretions. <i>Zenatia acinaces</i> is also present. This bed is inferred to onlap the greywacke basement that dips steeply beneath this locality (Photo F).</p>

Stratigraphic Column No: 73a	Grid Reference: Top	Bottom	NZMS 260 V20 73a 2 of 3
GPS Waypoint No(s): Wp 133, 137, 138 and 369	E: 2820891	2820709	
Region: Patoka	N: 6204875	6204975	
Location: Opau Stream section near metal pit off Puketitiri Road.	Altitude: 540m	-	
NZMS 260 Sheet: V20 Esk	Page 2 of 2		Author: K. Bland

Age	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description			
									Int.	N.Z.	
Late Pliocene	Mangapanian	Mangaheia Group Te Waka Formation	65						<p>Strongly trough to tabular bidirectional cross-bedded (large-scale) shellhash-rich limestone.</p> <p>Very barnacle rich zone of moderately well cemented flaggy, case hardened sandy limestone comprising alternating bioclastic-siliciclastic sheets. The unit displays very fine laminations visible in zones with less case hardening. The majority of barnacles in this bed are intact. <i>Scolicia</i> burrows are present, as are echinoid spines. Valves of <i>Crassostrea ingens</i> are scattered through the unit.</p> <p>Very poorly sorted, coarse-grained greywacke breccia with clasts up to boulder size (rare), typically to 70 mm across. Greywacke clasts are very angular to sub-rounded (less common). The bed contains abundant <i>Crassostrea ingens</i> valves and <i>Flabellum</i> corals with common <i>Phialopecten ?thomsoni</i> and encrusting bryozoans. Many of the more rounded clasts in the breccia are pholad bored. This unit fines-upwards, and passes into the overlying limestone.</p> <p>Intensely bioturbated, jointed, moderately to strongly concretionary sandstone containing highly fossiliferous shell lenses unconformably underlying greywacke breccia. An angular discordance of approximately 30 degrees is present between this unit and the overlying breccia.</p>		
			64								
			63								
			62								
			61								
			60				BC ₅				
			59								
			58								
			57								
			56				MX ₄				
55											
54											
53											
52				Cg ₇							
51				S ₁₁	WP 138						
50											
49											
48											
47											
46				S ₁₀							
Late Miocene	Upper Tongaporutuan	Tolaga Group Waitere Formation/Te Ipouhape Sst. Mbr									

mud	fine coarse med.	silt	fine med.	sand	coarse granu. pebb.	gravel	cobb. bould.
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73a

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Stratigraphic Column No: 73

Grid Reference: Top

Bottom

NZMS 260 V20

GPS Waypoint No(s): Wp 129-132

E: 2820819

2820651

Region: Patoka

N: 6204046

6204204

Location: Opau Station, on track at "The Bend".

Altitude: -

537m

NZMS 260 Sheet: V20 Esk

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73b

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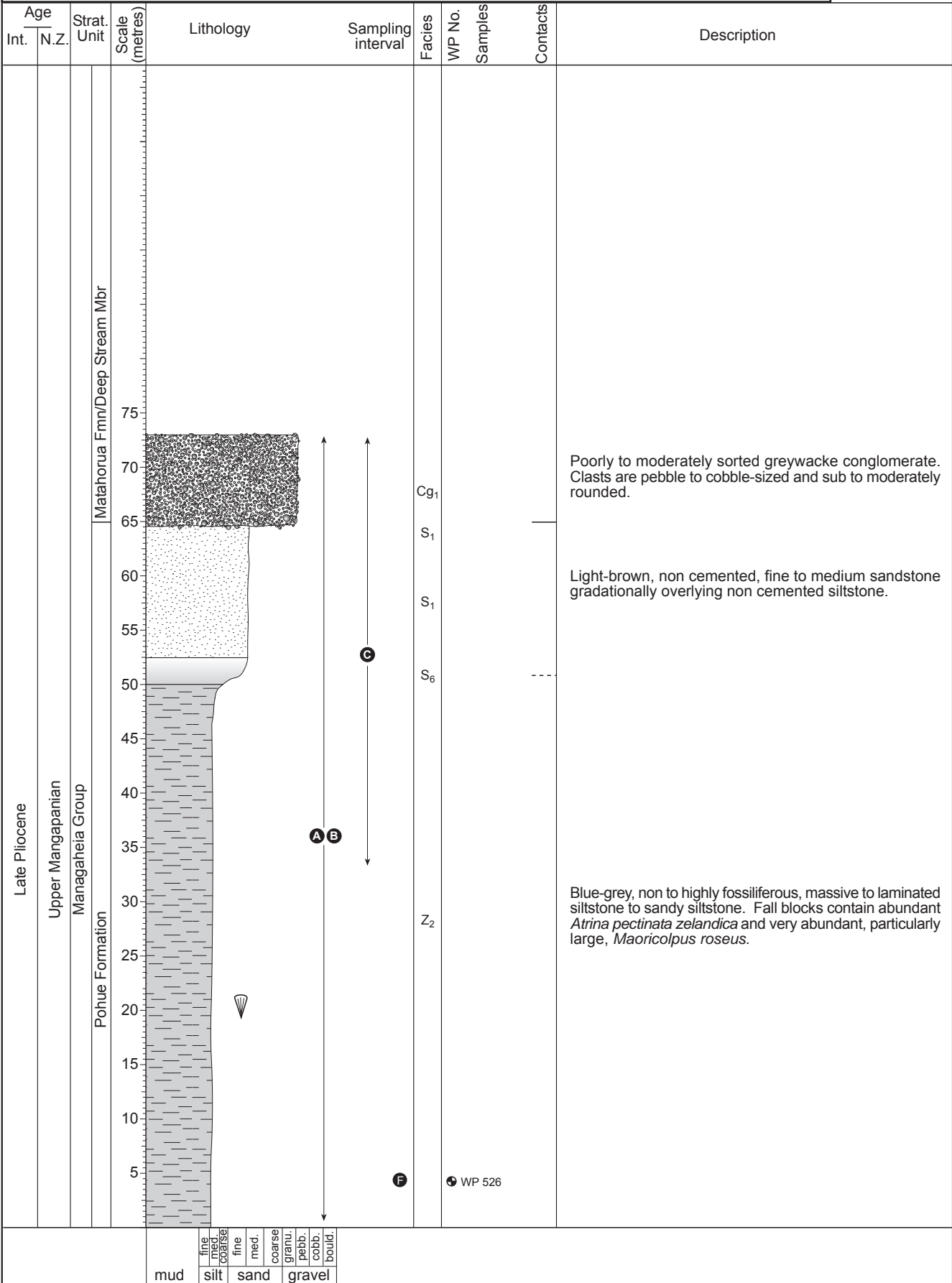
Age Int.	N.Z.	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description
		Late Pliocene							
		Managapanian							
		Mangaheia Group							
		Te Waka Formation							
			40		S ₁₀				Well-sorted, clean, moderately weathered and leached concretionary sandstone. The unit is strongly bioturbated with common bioturbated "blebs" arranged in bands 7 cm thick. Concretions are generally unfossiliferous, with <i>Zeacolpus vitattus</i> and <i>Dosinia</i> sp. present in the sandstone.
			38		S				
			36					WP 131	
			34						
			32						
			30		R			WP 130	Moderately fossiliferous, concretionary medium sandstone with occasional sparsely-packed oyster beds. Barnacle fragments and plates become more common in this interval.
			28		Q				
			26		P				
			24		O				
			22		N				
			20		M				
			18		L				
			16		K				
			14		J				
			12		I				
			10		H				
			8		G				
			6		F				
			4		E				
			2		D				
					C				
					B				
					A				
								WP 129	
					S ₁				Non fossiliferous, moderately to strongly weathered, slightly micaceous, massive, well sorted fine to medium sandstone.

mud
 fine sand
 coarse sand
 med. sand
 fine gravel
 med. gravel
 coarse gravel
 granu. pebb.
 cobb. pebb.
 bound.

Stratigraphic Column No: 73	Grid Reference: Top	Bottom	NZMS 260 V20 73b 2 of 2
GPS Waypoint No(s): Wp 129-132	E: 2820819	2820651	
Region: Patoka	N: 6204046	6204204	
Location: Opau Station, on track at "The Bend".	Altitude: -	537m	
NZMS 260 Sheet: V20 Esk	Page 2 of 2	Author: K. Bland	

Age	Strat. Unit	Lithology	Sampling interval	Facies	WP No.	Samples	Contacts	Description																					
Int.	N.Z.																												
		<p>A- Slightly fossiliferous sandstone containing <i>Dosinia lambata</i>, <i>Atrina (pectinata) zelandica</i>, <i>Pratulium pulchellum</i>, <i>Sigapatella novaezelandiae</i>, shell hash.</p> <p>B- Moderately fossiliferous sandstone dominated by <i>Atrina pectinata zelandica</i> which appear to be <i>in situ</i> and are articulated. Also present are <i>Nucula nitidula</i>, <i>Talochlamys gemmulata</i>, and <i>Polinices scalptus</i>.</p> <p>C- Non cemented sandstone containing <i>Talochlamys gemmulata</i>, articulated <i>Panopea</i> sp., <i>Dosinia</i> sp., <i>Gari lineolata</i> and <i>Pratulium pulchellum</i>.</p> <p>D- Slightly concretionary, moderately to strongly bioturbated sandstone dominated by <i>Talochlamys gemmulata</i>, with common <i>Atrina pectinata zelandica</i> and <i>Crepidula radiata</i>. <i>Zeacolpus</i>, <i>Gari</i> sp. and polychate tube worm casts are also present.</p> <p>E- Moderately fossiliferous sandstone containing <i>Talochlamys gemmulata</i>, <i>Serratina</i> sp., <i>Dosinia greyi</i>, <i>Pratulium pulchellum</i>, <i>Pteromyrtea dispar</i>, <i>?Maoricolpus</i>/<i>?Zeacolpus</i> and <i>Gari lineolata</i>.</p> <p>F- Moderately concretionary, non cemented sandstone that coarsens upward through the sampling interval. Dominated by <i>Pratulium pulchellum</i>, with common <i>Talochlamys gemmulata</i>. Also present are <i>Zeacolpus vitattus</i> and <i>Maoricolpus roseus</i>.</p> <p>G- Non cemented sandstone with an increasing bioclastic and mica content compared with underlying beds. <i>Atrina pectinata zelandica</i>, <i>Pratulium pulchellum</i>, <i>Xymene</i> sp., <i>Pteromyrtea dispar</i> and <i>Notocallista ?notostriata</i> are present.</p> <p>H- <i>Polinices</i> sp., <i>Crassostrea ingens</i>, <i>Pratulium pulchellum</i>, <i>Struthiolaria</i> sp. An articulated <i>Atrina pectinata zelandica</i> is present, although is not in life position.</p> <p>I- <i>Zenatia acinaces</i>, <i>Notocallista</i> sp., <i>Dosinia lambata</i>, <i>Maoricardium spatiosum</i>.</p> <p>J- A sparse <i>Crassostrea ingens</i> bed with some <i>Atrina pectinata zelandica</i>.</p> <p>K- Numerous <i>Talochlamys gemmulata</i> with <i>Dosinia greyi</i> and <i>Sigapatella novaezelandiae</i>.</p> <p>L- <i>Atrina pectinata zelandica</i> present in a hydrodynamically stable position.</p> <p>M- A 0.15-0.2 m-thick, moderately fossiliferous <i>Crassostrea ingens</i> shellbed.</p> <p>N- <i>Crepidula radiata</i>, <i>Crassostrea ingens</i> and the barnacle <i>Austromegabalanus</i> sp.</p> <p>O- Dominated by <i>Sigapatella novaezelandiae</i>, with <i>Atrina pectinata zelandica</i>, <i>Lamprodominea</i> sp., <i>Patro undatus</i> and <i>Talochlamys gemmulata</i>.</p> <p>P- <i>Zeacolpus vitattus</i> and <i>Atrina pectinata zelandica</i>.</p> <p>Q- A 0.5 m-thick concretionary bed with abundant <i>Crassostrea ingens</i> and <i>Maoricolpus roseus</i>.</p> <p>R- <i>Talochlamys gemmulata</i>, <i>Atrina pectinata zelandica</i>, <i>Crepidula radiata</i>, <i>Sigapatella novaezelandiae</i> and barnacles.</p> <p>S- A moderately concentrated bed of <i>Zeacolpus vitattus</i>.</p>																											
								<p>Moderately- to well-cemented, calcareous sandstone. The bed is unfossiliferous, although there is some evidence of bioturbation and burrowing visible.</p> <p>Well-sorted, clean, moderately weathered and leached concretionary sandstone. The unit is strongly bioturbated with common bioturbated "blebs" arranged in bands 7 cm thick. Concretions are generally unfossiliferous, with <i>Zeacolpus vitatus</i> and <i>Dosinia</i> sp. present in the sandstone.</p>																					
		<table border="1"> <tr> <td></td> <td>fine</td> <td>coarse</td> <td>med.</td> <td>fine</td> <td>med.</td> <td>coarse</td> <td>granu.</td> <td>pebb.</td> <td>cobb.</td> <td>bould.</td> </tr> <tr> <td>mud</td> <td>silt</td> <td>sand</td> <td>gravel</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>		fine	coarse	med.	fine	med.	coarse	granu.	pebb.	cobb.	bould.	mud	silt	sand	gravel												
	fine	coarse	med.	fine	med.	coarse	granu.	pebb.	cobb.	bould.																			
mud	silt	sand	gravel																										

Stratigraphic Column No: 75	Grid Reference: Top	Bottom	NZMS 260 V20 75 1 of 2
GPS Waypoint No(s): Wp 526	E: 2826799	-	
Region: Patoka	N: 6202918	-	
Location: River cutting in Mangaone River upstream of Patoka Stream	Altitude: 66 m?	-	
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