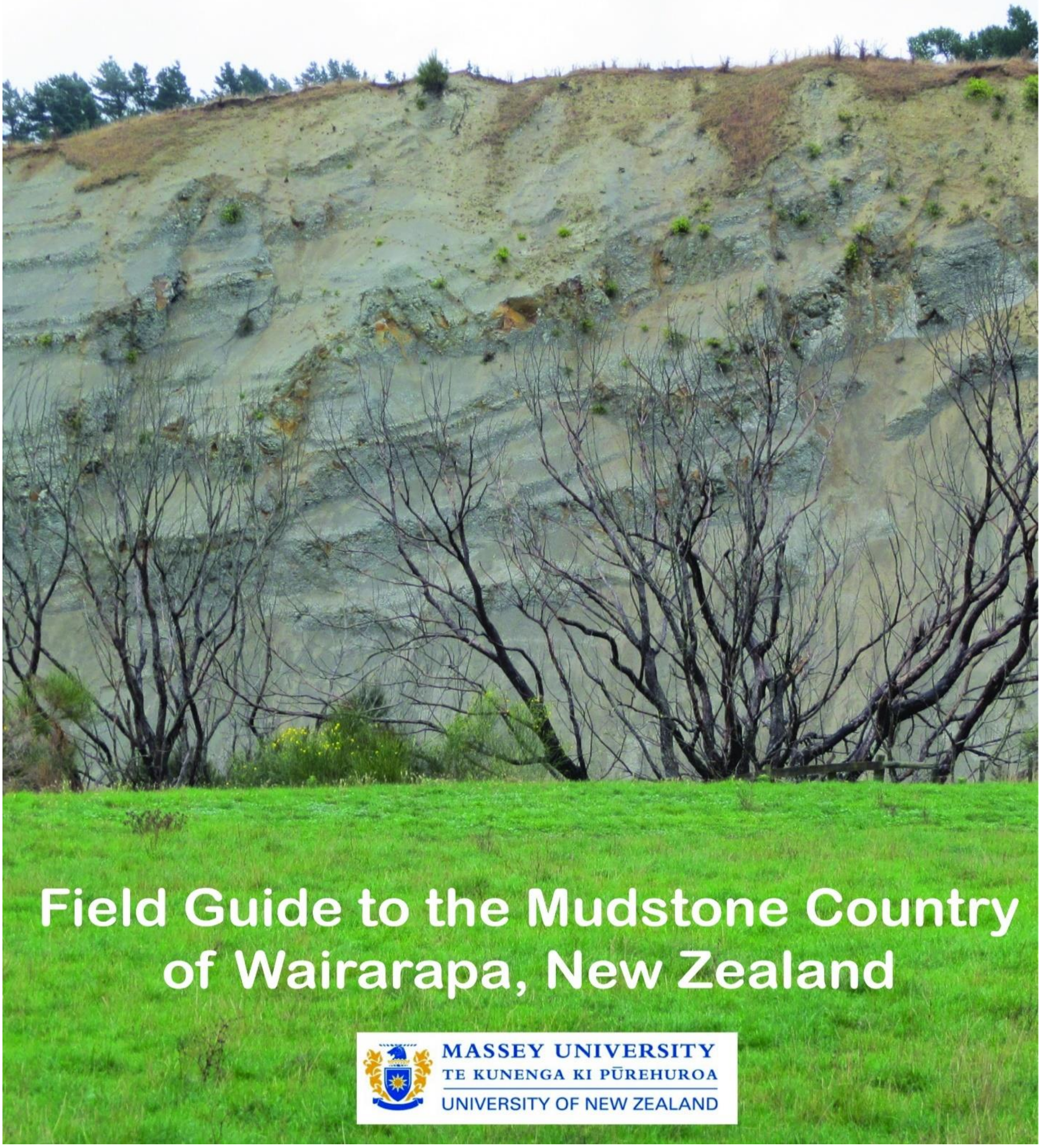
Earth Sciences Teaching Manual

Compiled by Karoly Nemeth, Julie Palmer and John Irons



Field Guide to the Mudstone Country of Wairarapa, New Zealand

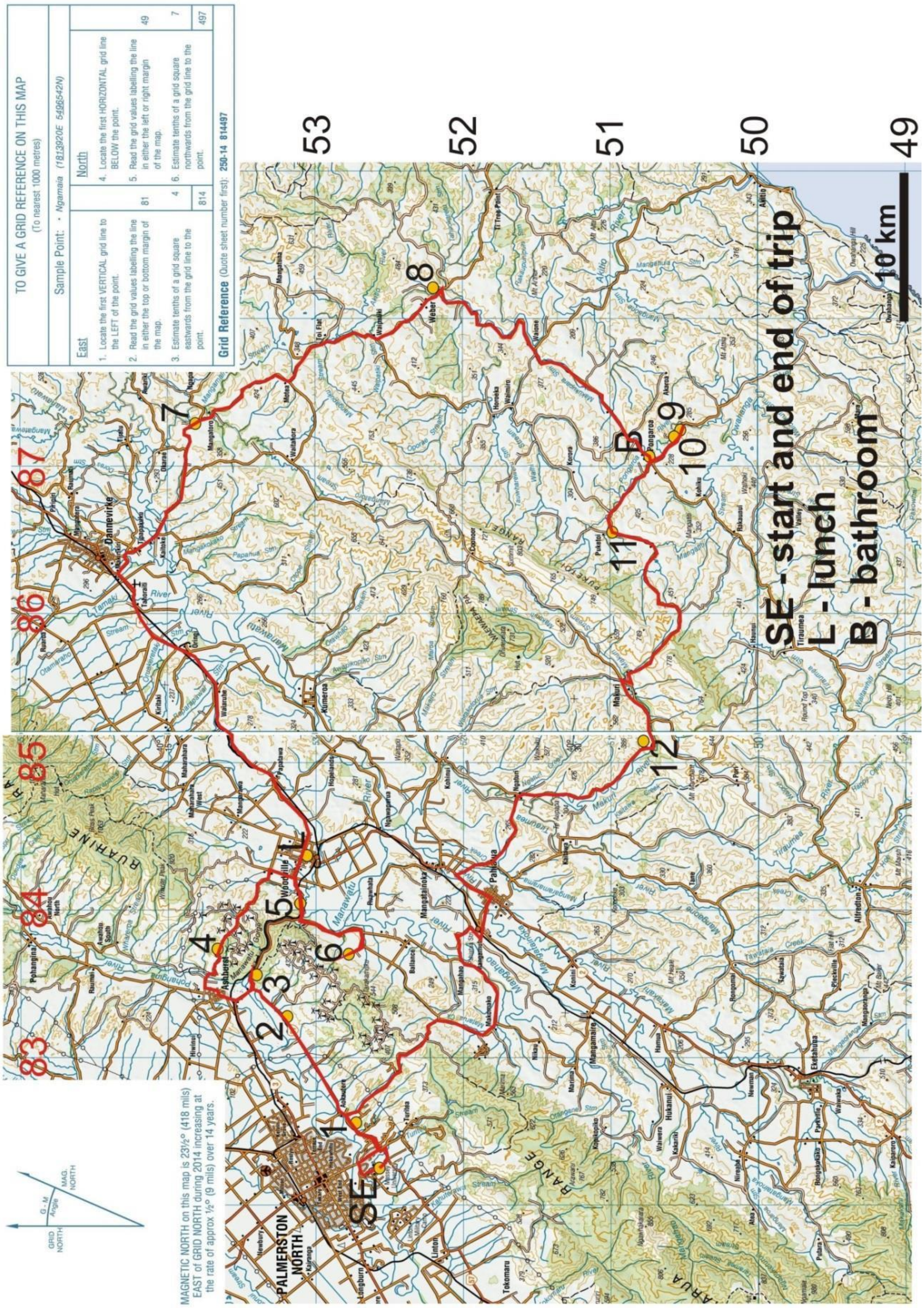
MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Meeting at Massey University at 8.15 AM

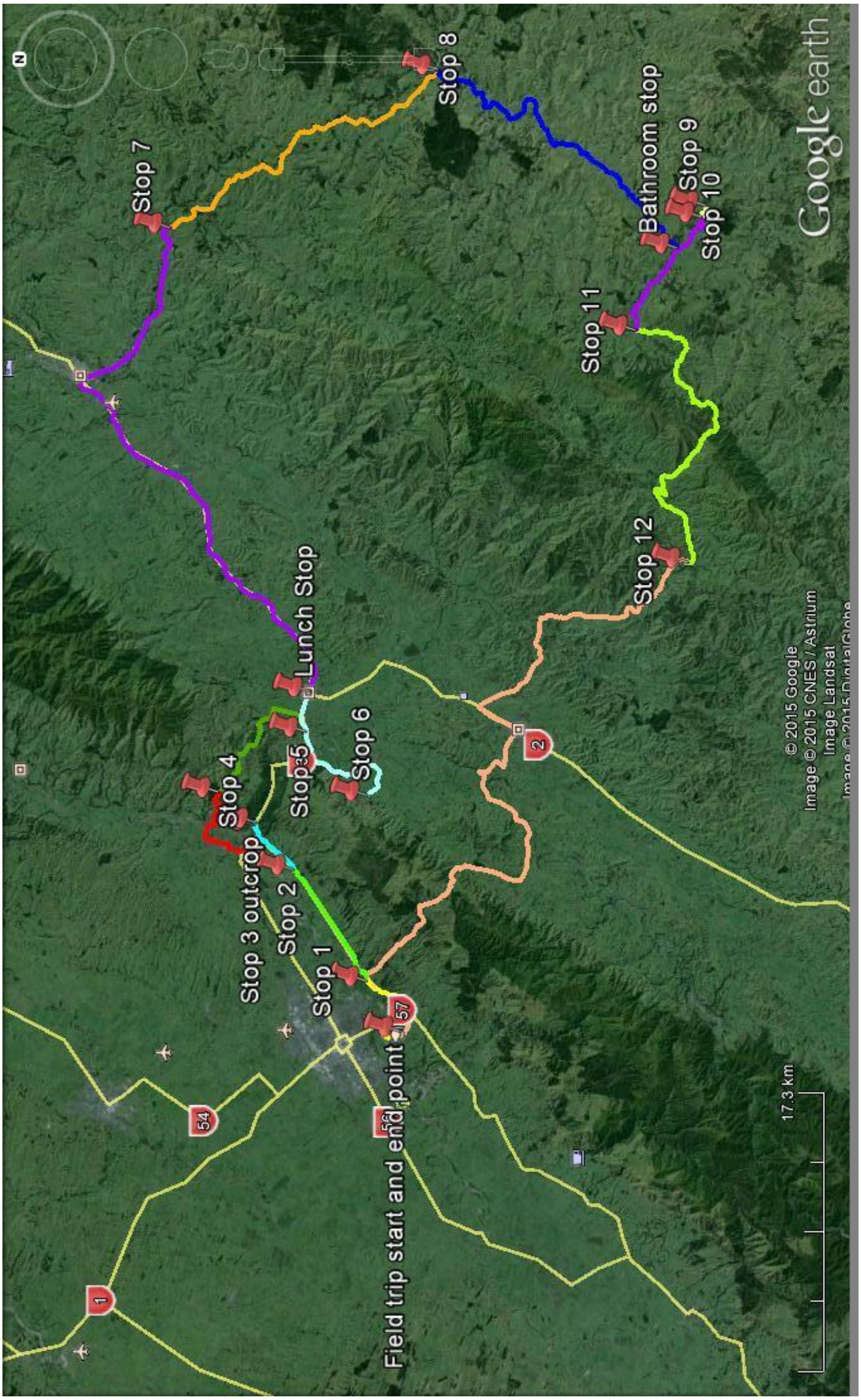
Departure from Massey University at 8.30 M

Internal Students normally take the trip by **big bus**; **External Students** might take the trip by **minivans**. The field trip will take the students to the Manawatu River catchment area, the Manawatu Gorge, the Tararua Ranges and the region of the Wairarapa between the Dannevirke – Pongaroa – Pahuatua triangle (See map in figures below). Field trip program is below: *Departure and Arrival time are generously rounded on the basis of the travel time (70 km/h average speed) and at least the amount of field time listed in the table.*

Departure	**Arrival**	**Distance**	**Travel time**	**Field time**	**Stop**
8.30 AM		6.9 km	10 min		Departure from Massey
	8.40 AM			10 min	Stop 1 (alternative)
8.50 AM		8.49 km	10 min		
	9.00 AM			20 min	Stop 2
9.20 AM		4.15 km	5 min		
	9.25 AM			45 min	Stop 3
10.10 AM		8.84 km	10 min		
	10.20 AM			25 min	Stop 4 (alternative)
10.45 AM		10.2 km	10 min		
	10.55 AM			25 min	Stop 5
11.20 AM		8.96 km	10 min		
	11.30 AM			30 min	Stop 6
12.00 AM		11.7 km	15 min		
	12.15 noon			45 min	LUNCH
1.00 PM		39.3 km	30 min		
	1.30 PM			20 min	Stop 7
1.50 PM		23.1 km	20 min		
	2.10 PM			20 min	Stop 8
2.30 PM		24.3 km	20 min		
	2.50 PM			10 min	Bathroom
3.00 PM		4.1 km	5 min		
	3.05 PM			10 min	Stop 9
3.15 PM		1 km	5 min		
	3.20 PM			25 min	Stop 10 (alternative)
3.45 PM		9.42 km	10 min		
	3.55 PM			25 min	Stop 11
4.20 PM		24.3 km	20 min		
	4.40 PM			30 min	Stop 12
5.10 PM		56.5 km	50 min		
	6.00 PM				Arrival to Massey



Overview map of the Wairarapa field trip (Stop 1 and 4 are only examined during the "**Extramural**" version of the trip if the trip commences by vans. **Internal students** will get explanation in the bus pointing out these stops **only**)



233.101 field trip on GoogleEarth satellite image.

The main goals of the field trip:

1) Providing an introduction to understand the relationship between landscape and geological features,
2) To see diverse variety of rock types in their real position,
3) Expand your horizons on the variety of similar rock types such as mudstones and sandstones,
4) To provide fundamental basics for geological field work,
5) To give hints how to record field data including geological sketch preparation, cross sections, strike and dip measurements (using geological compass),
6) To provide practical hints what the main questions you need to formulate in every location to get the most information out of your study area,
7) Understand the geological evolution of the region of New Zealand after its landmass separated from Gondwanaland about 85 million of years ago when the Tasman Sea has started to open,
8) Provide some conceptual model to link the post-85 million years geological history of New Zealand with the Cambrian to 85 million of years evolution of the active continental margin of Gondwanaland,
9) Provide some hint on understanding the geological and geomorphological meaning of the Waipounamu Erosional Surface versus the Otago Peneplain concept,
10) Show graphic examples for strike-slip faulting in a compressional (transpressional) setting where tectonic horses forming complex fault zones along major axial ranges,
11) Understand the sedimentary processes take place in an active continental margin such as the eastern margin of New Zealand was/is through the Tertiary (post 60
12) Understand the geological, sedimentological and tectonic significances of the formation and preservation of an accretionary wedge,
13) Provide some ideas how clastic sedimentary rocks can turn to be weak metamorphic rocks,
14) Show evidences of cold-water continental margin carbonate rocks and their fossil assemblages,
15) Provide some basic graphical and literature representation on the variety of geological beauties the Wairarapa Region can offer.

In the following section you will find some key figures that can help to understand the discussions on the field as well as some link to further readings. In your Dropbox folder few of those key files are uploaded and you can submerge to understand the geology of the eastern active continental margin of New Zealand.

Map Coordinates

TO GIVE A GRID REFERENCE ON THIS MAP (To the nearest 1000 metres) *Full coordinates are given on the sheet corners.* *Use only the second and third numbers when taking a 6-figure grid reference.*			
SAMPLE POINT: *Taumatawhakatangihangakoauauotamateapokaiwhenuakitanatahu*			
East Locate first VERTICAL grid line to LEFT of point and read figures labelling line. Estimate tenths eastward from grid line to point.	81 0	North Locate first HORIZONTAL grid line BELOW of point and read figures labelling line. Estimate tenths northward from grid line to point.	08 9
	810		089
SAMPLE REFERENCE: (Give sheet name first) WAIRARAPA 810089			

The western boundary of this map differs from that used for the LINZ topographical map of this area at the same scale.

This map is drawn on the New Zealand Map Grid Projection, a minimum-error conformal projection. The grid is the New Zealand Map Grid, showing coordinates in metres in terms of the Geodetic Datum 1949, based on the International (Hayford) Spheroid.

Record the visited sites coordinates:

Stop 1 =

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Stop 2 =

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Stop 12 =
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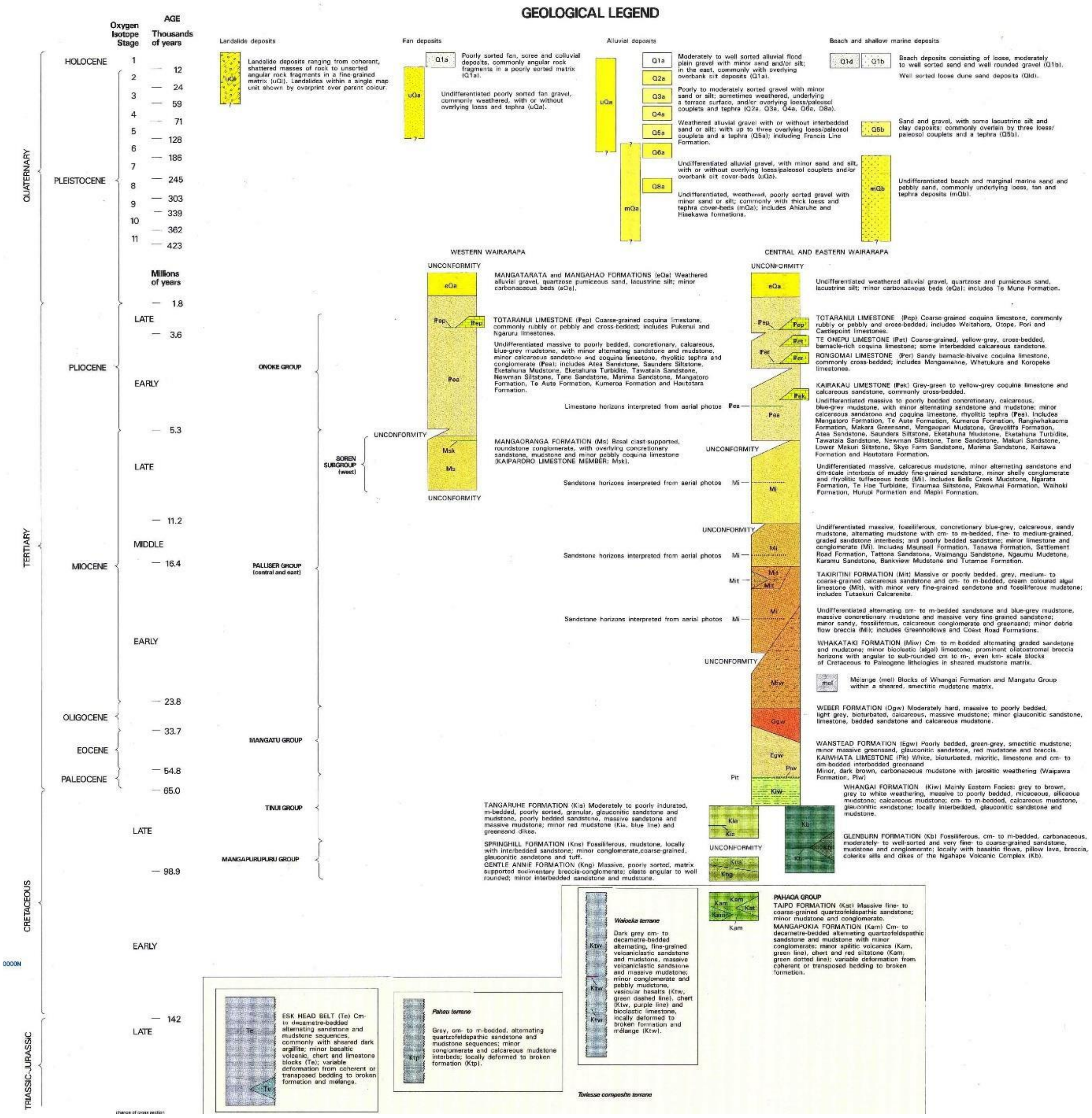
Legend



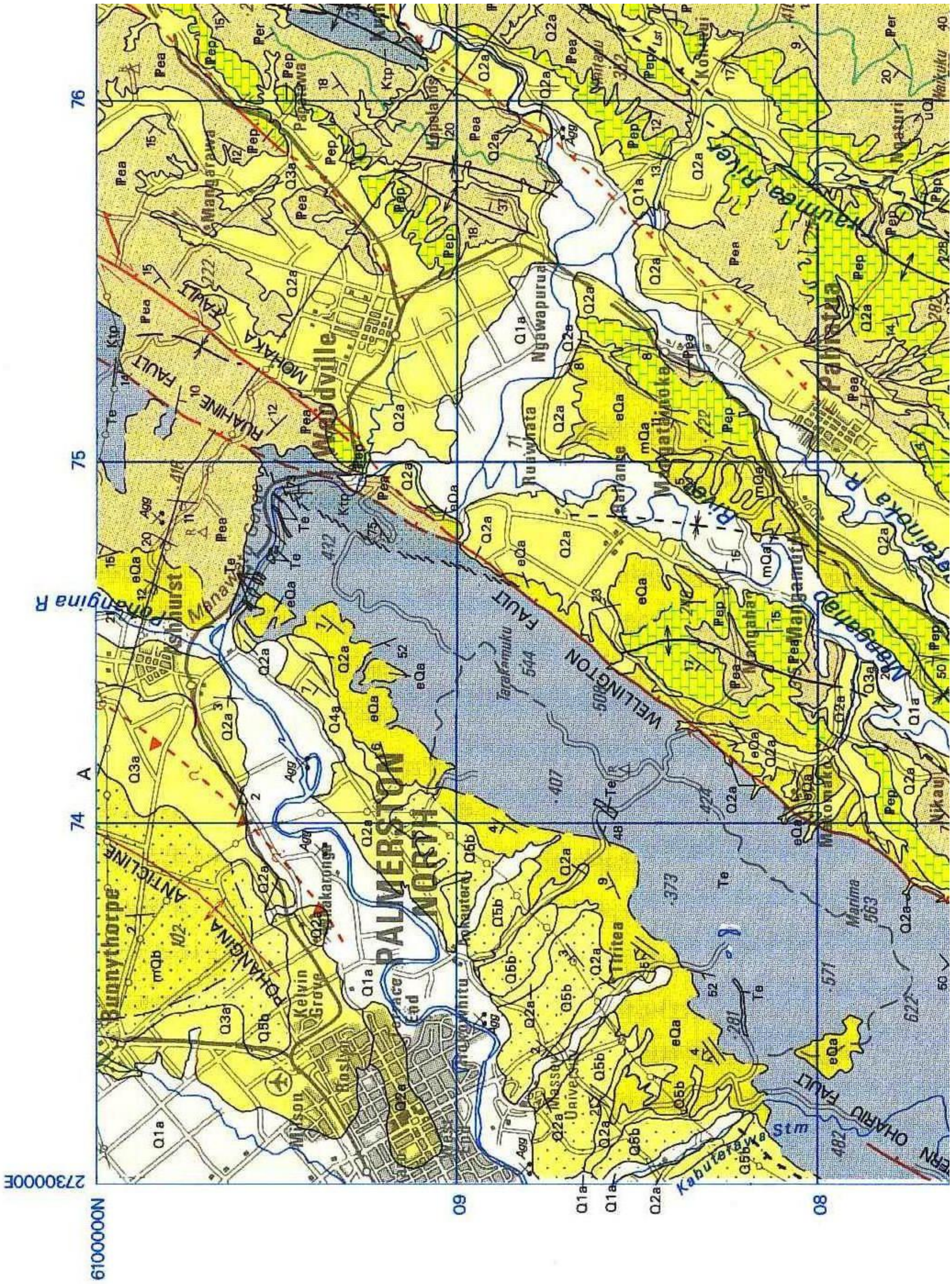
Notes on geology Map Reading (legend of the Wairarapa QMap sheet):

Lee, J.M.; Begg, J.G. (compilers) 2002: Geology of the Wairarapa area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited. Institute of Geological & Nuclear Sciences 1:250,000 geological map 11. 66 p. + 1 folded map

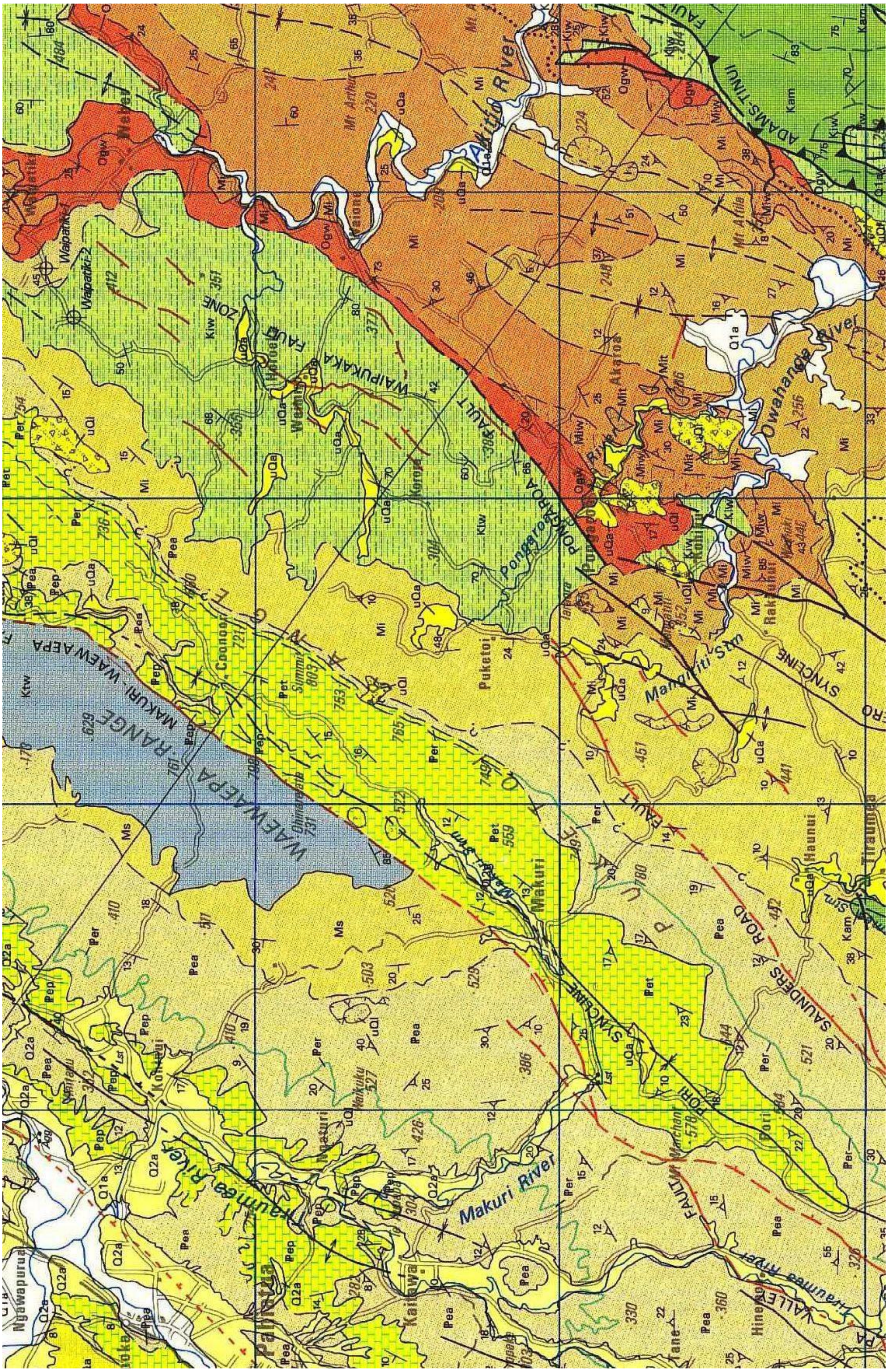
In the field guide map frames are provided from the Wairarapa QMap series.

Palmerston North – Woodville Geology Map

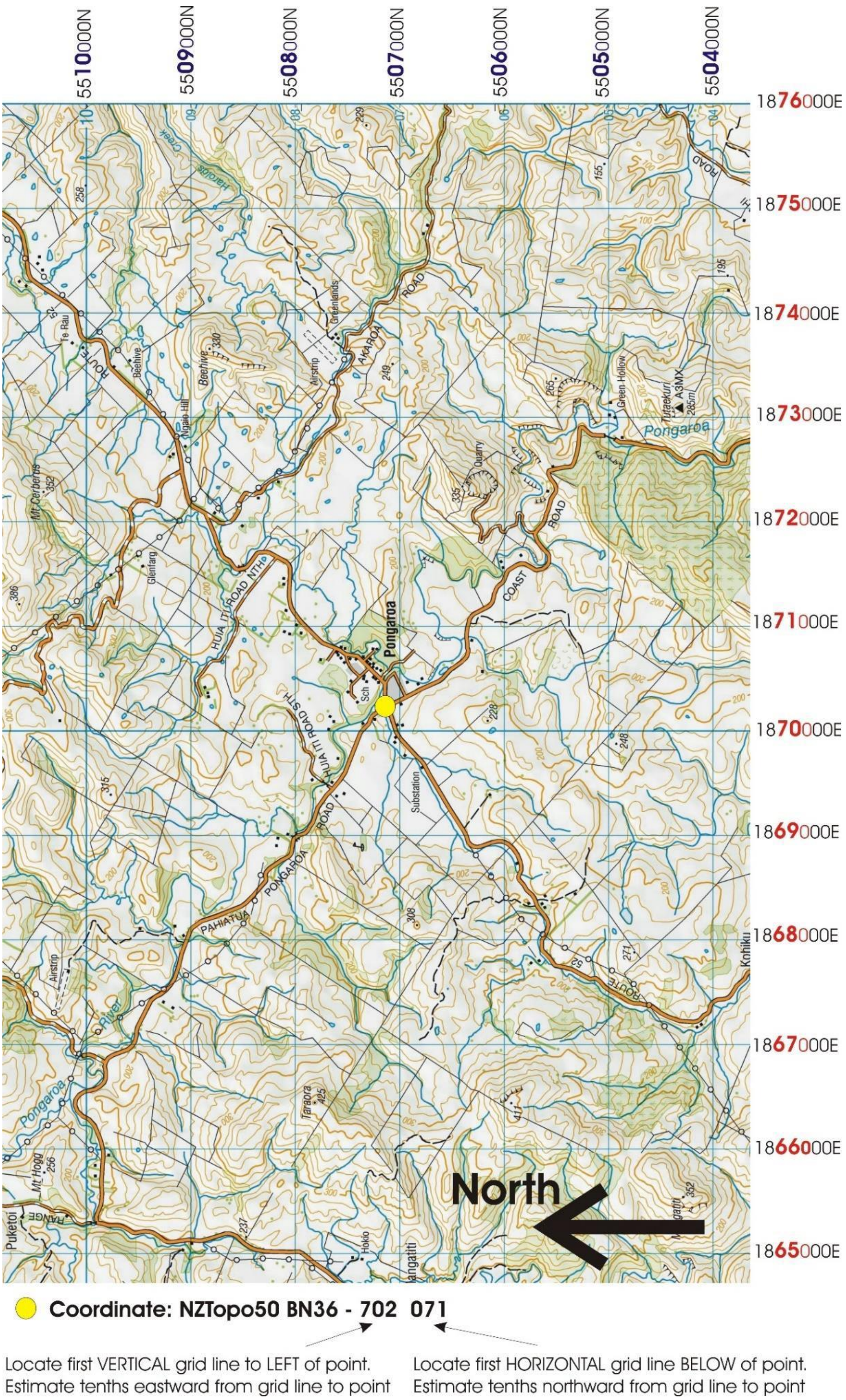
(details from Wairarapa 1:250,000 QMap Series)



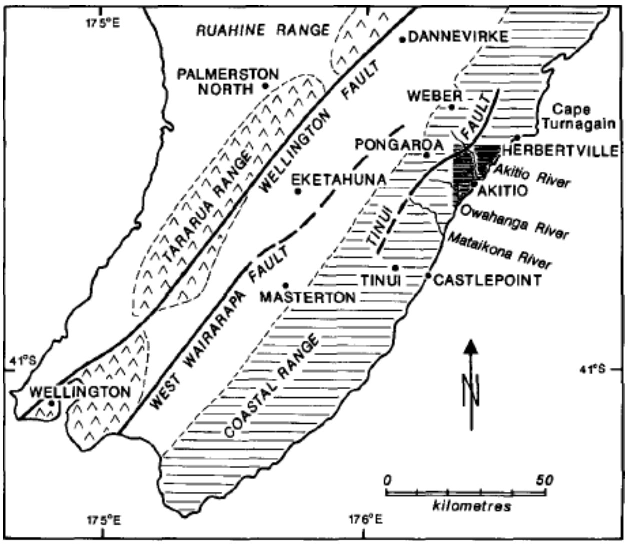
Weber – Pongaroa – Makuri (details from Wairarapa 1:250,000 QMap Series)

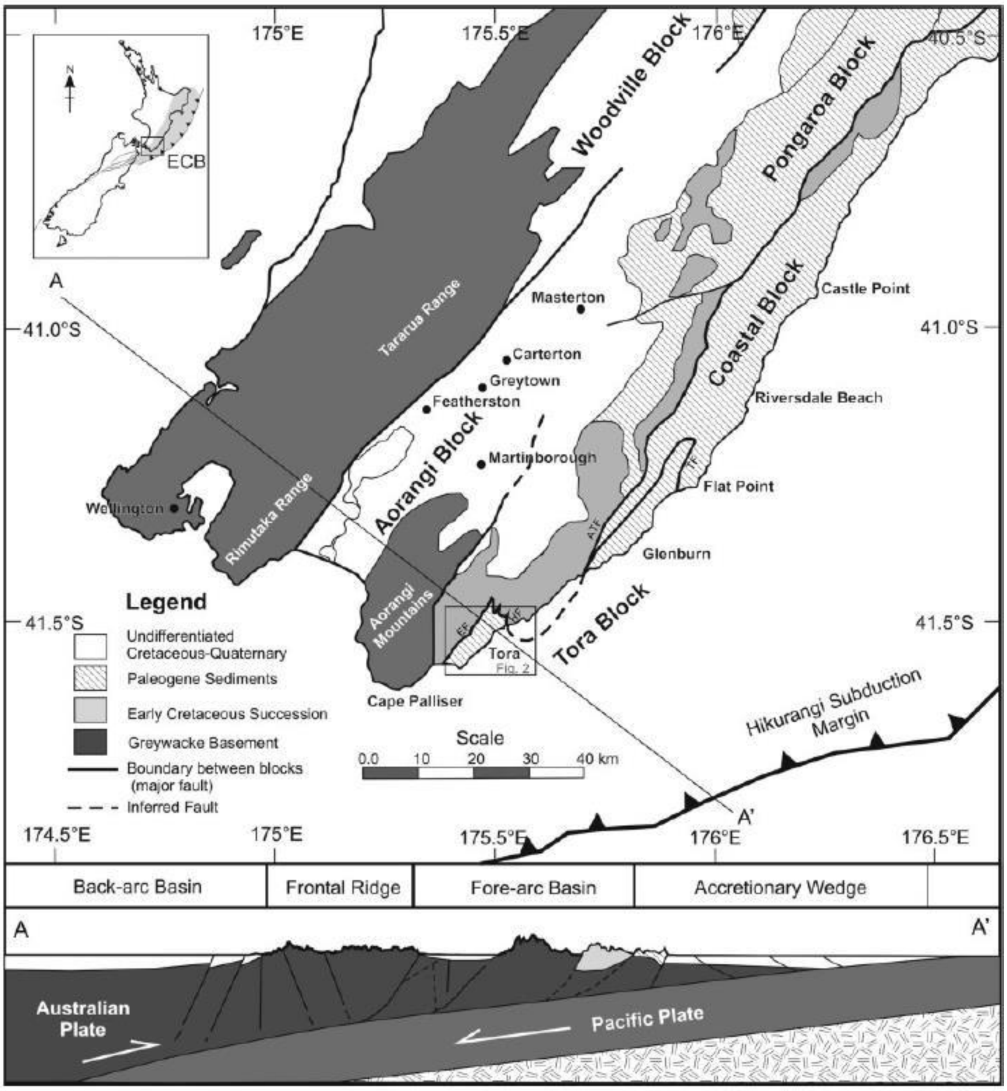


Details from NZTopo 50 BN36 1:50,000 scale Topography Map

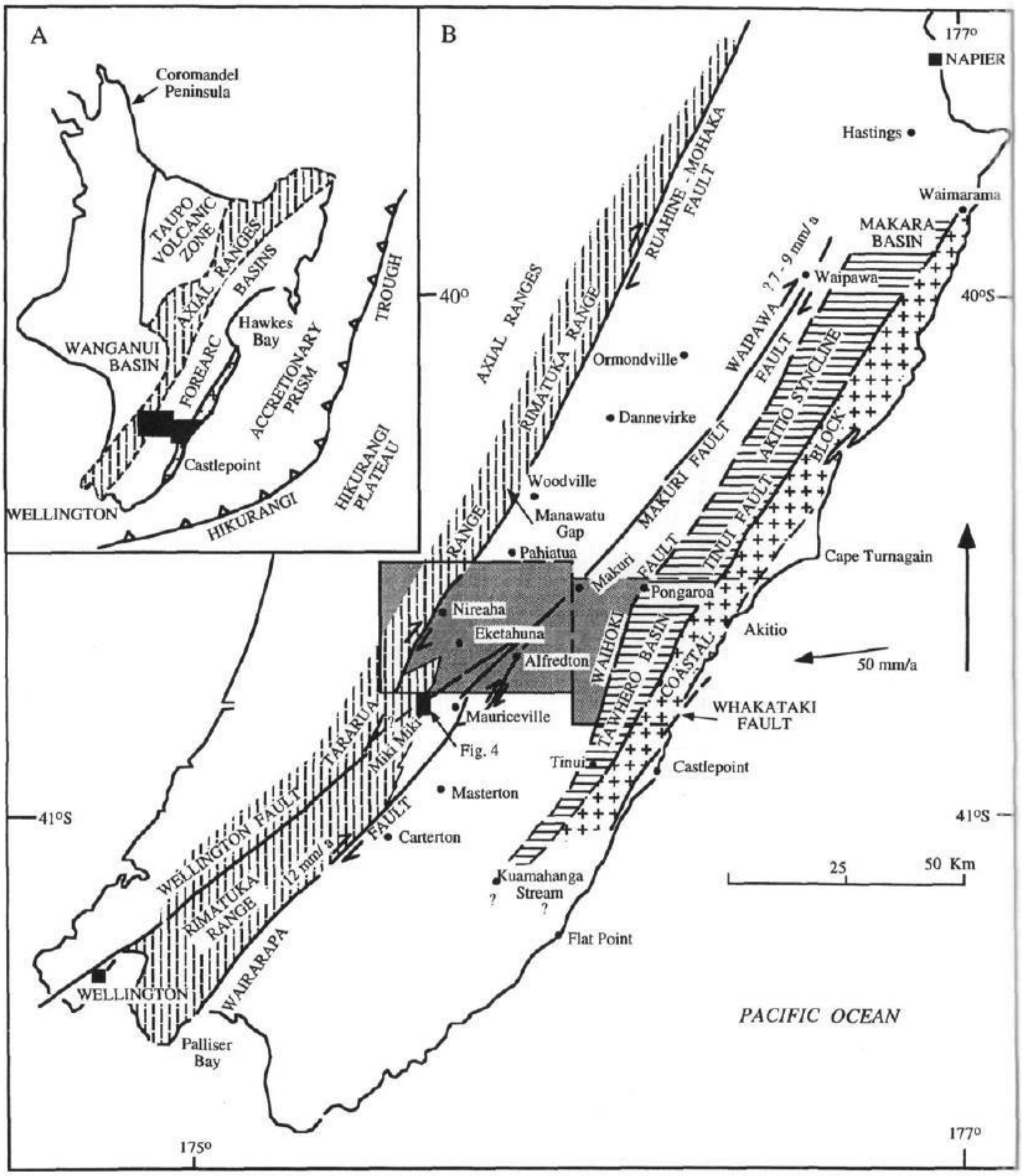


Regional Geology Setting

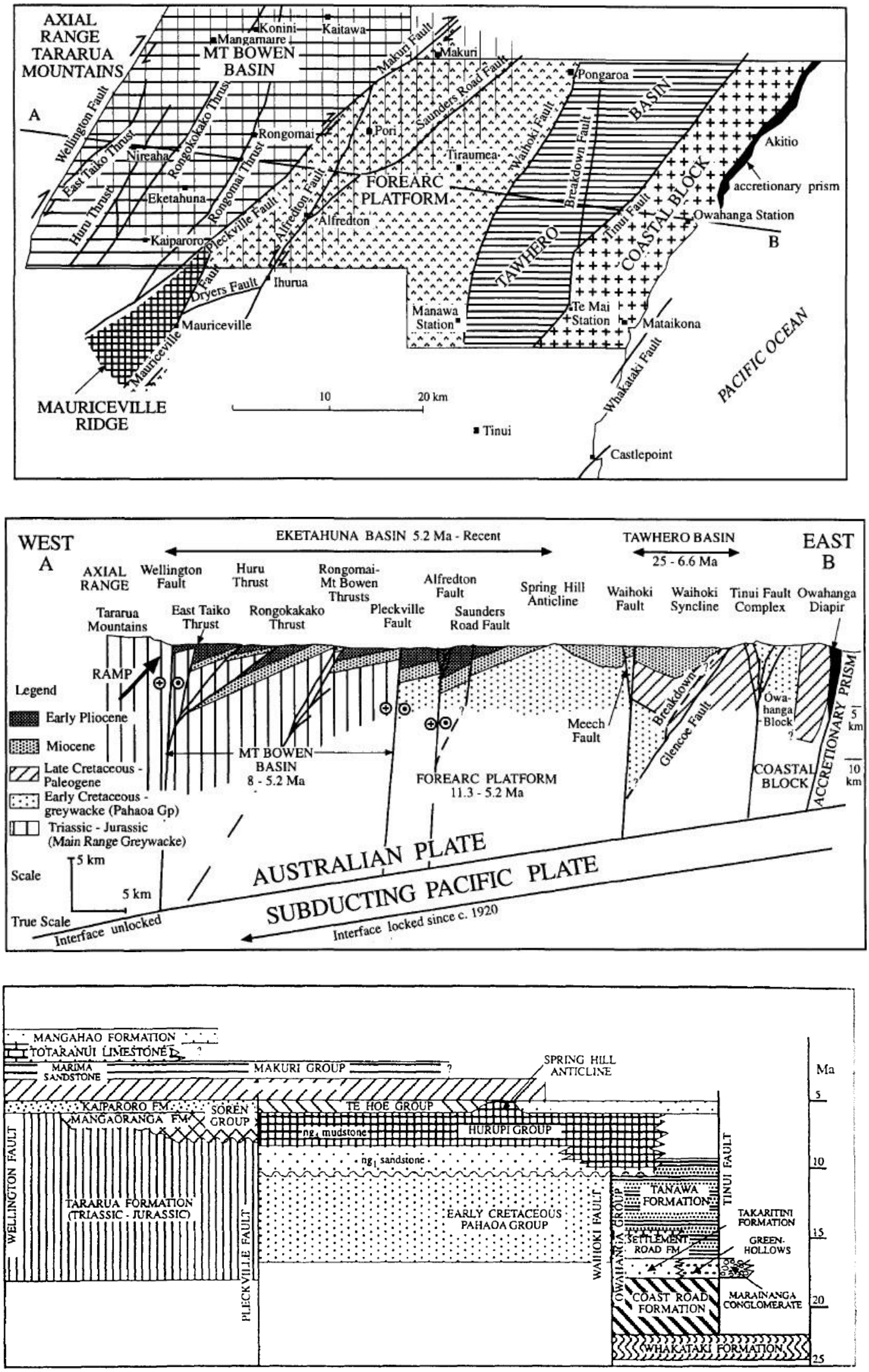




From: Hines et al (2013) NZJGG 56(4): 243-262.

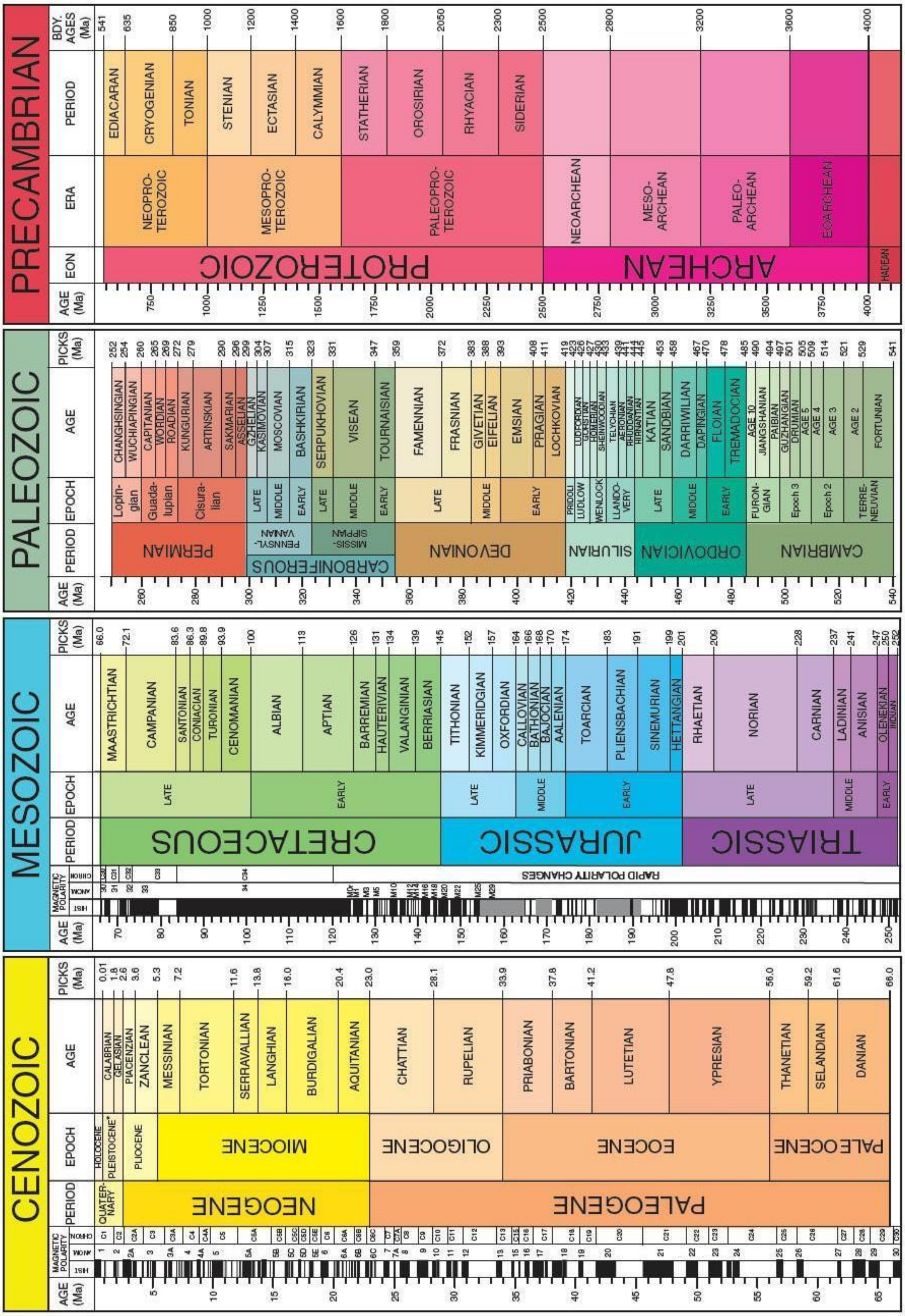


From: Neef (1999) NZJGG 42; 113-135.



From: Neef (1999) NZJGG 42; 113-135.

Geological time scale



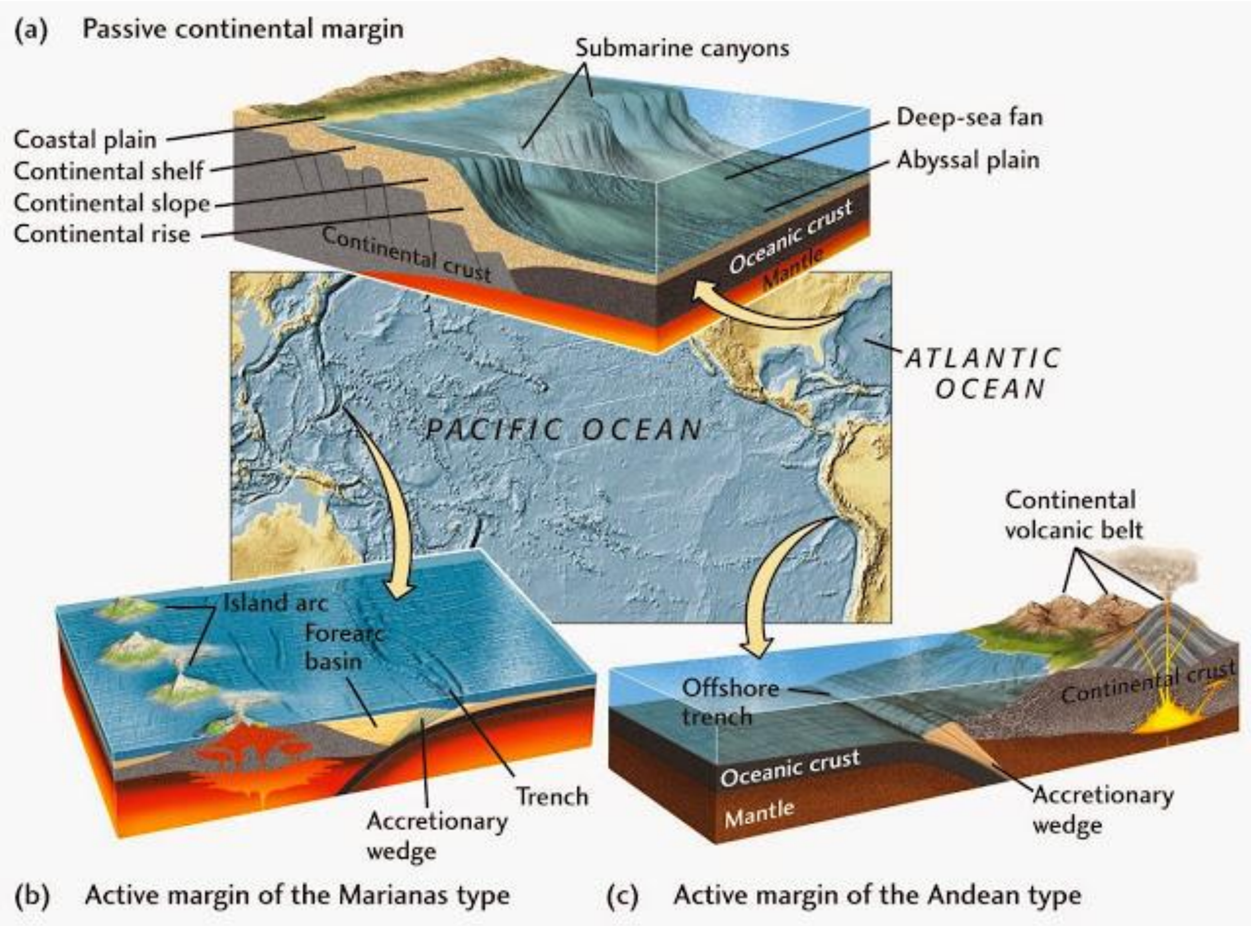
http://www.geomore.com/wp-content/uploads/GEOLOGIC-TIME-SCALE-COURTESY-GSA.jpg

ERA	PERIOD	EPOCH	AGE*	MAJOR EVENTS
CENOZOIC	Quaternary	Holocene	0.01	
		Pleistocene	1.8	Earliest *Homo sapiens*
	Tertiary	Pliocene	5.3	Earliest hominids
		Miocene	23.8	
		Oligocene	33.7	Dominance of mammals
		Eocene	55	
		Paleocene	65	*Widespread extinctions*
MESOZOIC	Cretaceous		145	First flowering plants
	Jurassic		200	Dinosaurs dominant
	Triassic		251	*Widespread extinctions*
PALEOZOIC	Permian		299	
	Carboniferous		359	First reptiles
	Devonian		417	
	Silurian		443	Fishes dominant
	Ordovician		490	First fishes
	Cambrian		542	*Appearance of fossils*
PRECAMBRIAN				Soft-bodied animals
			3000	First one-celled organisms
			4600	Origin of the earth

*Age in millions of years (Ma)

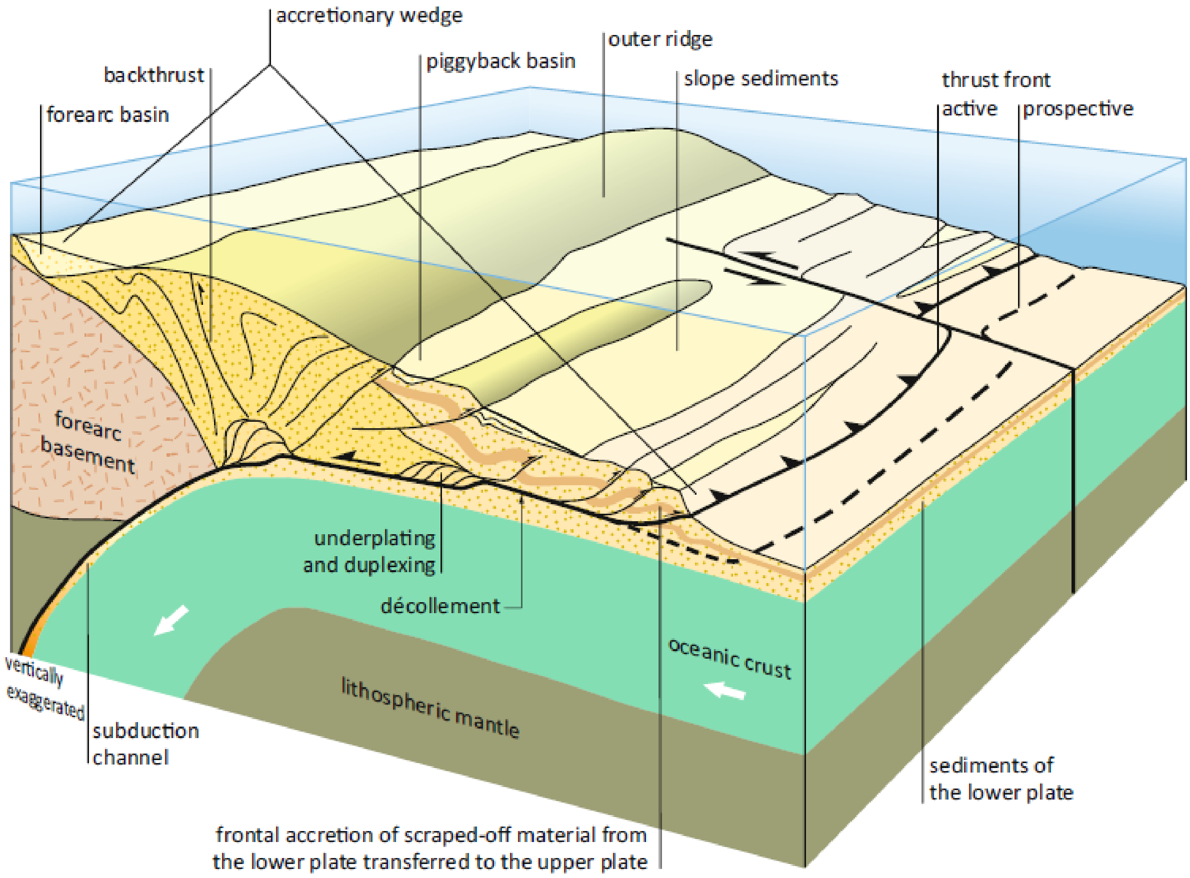
http://www.teara.govt.nz/files/di-9019-enz.gif

Active and Passive Continental Margins



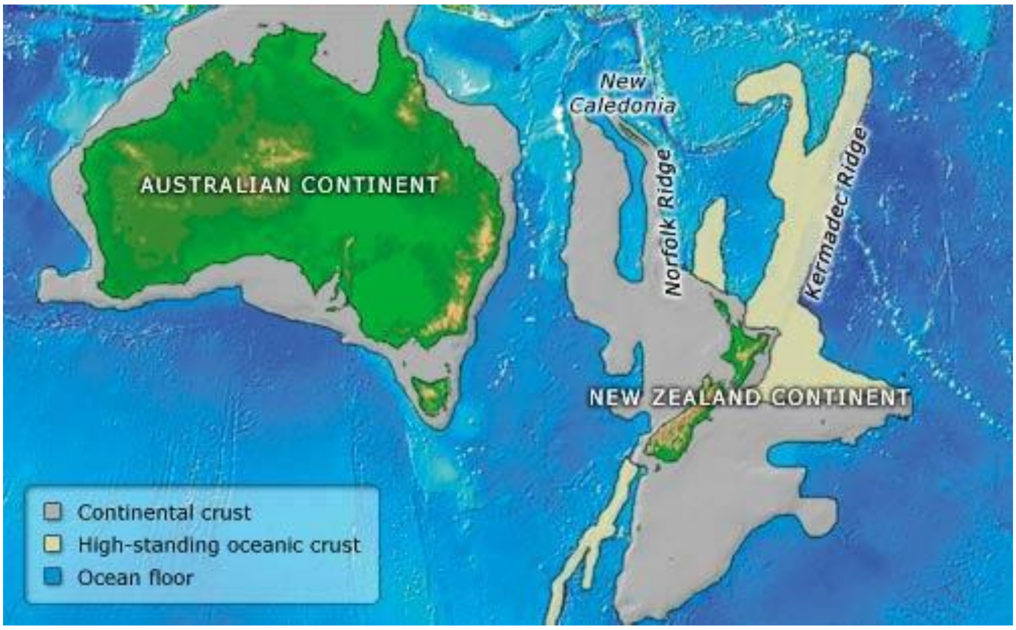
From: http://www.geologyin.com/2014/10/whats-difference-between-active-and.html

Accretionary prism and subduction

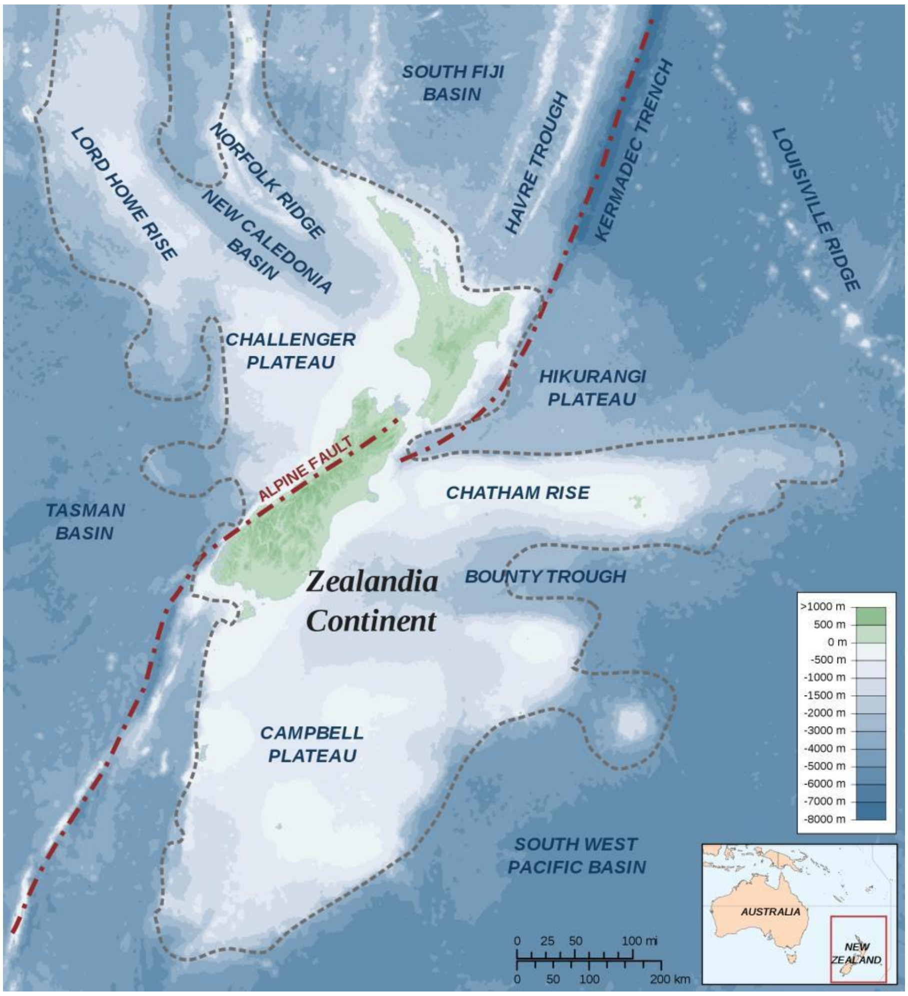


From: https://link.springer.com/content/pdf/10.1007%2F978-94-007-6644-0_101-1.pdf

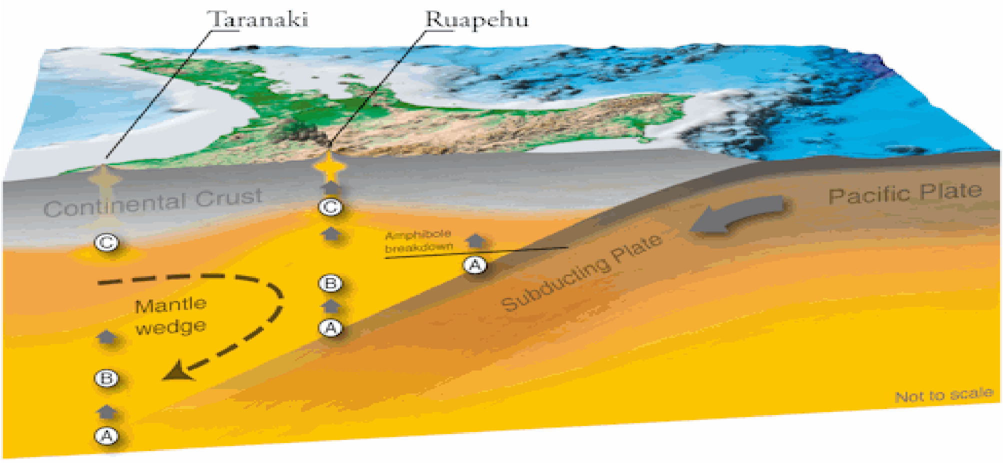
Eastern active plate margin of New Zealand (Zealandia Continent)

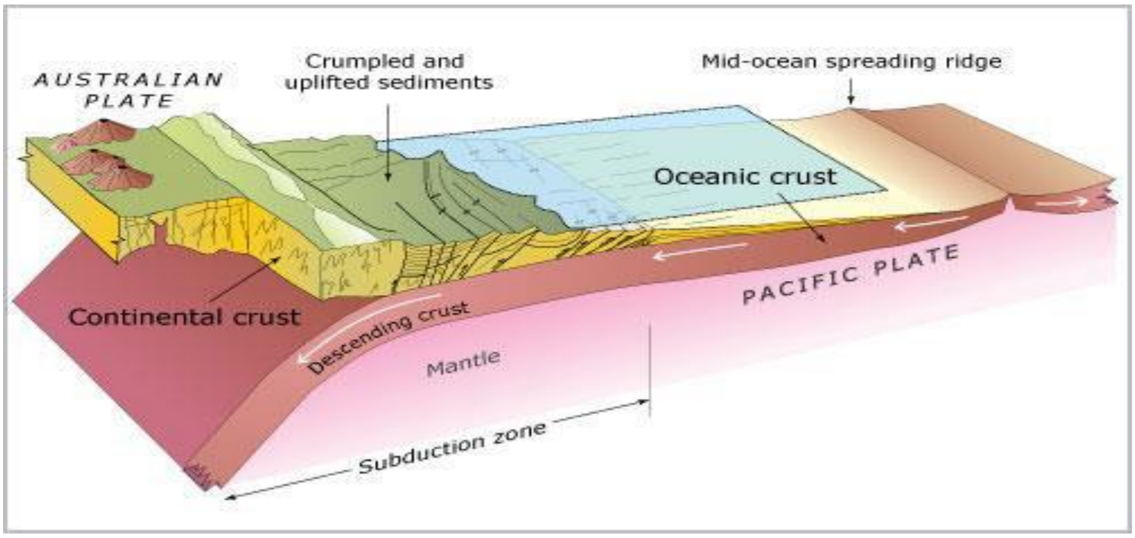


http://www.teara.govt.nz/files/m-5579-enz.jpg



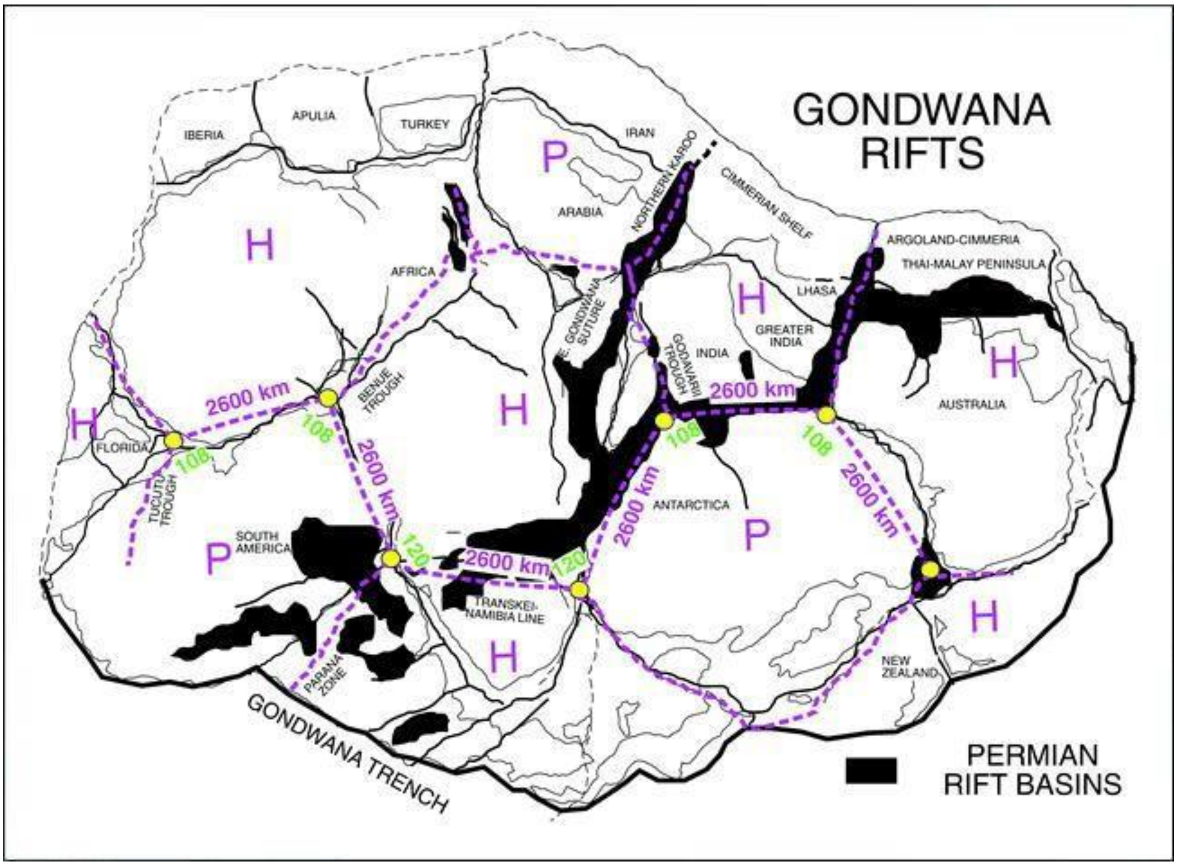
http://www.gns.cri.nz/Home/Learning/Science-Topics/Ocean-Floor/History-of-Zealandia





http://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/Volcanoes-at-a-Plate-Boundary

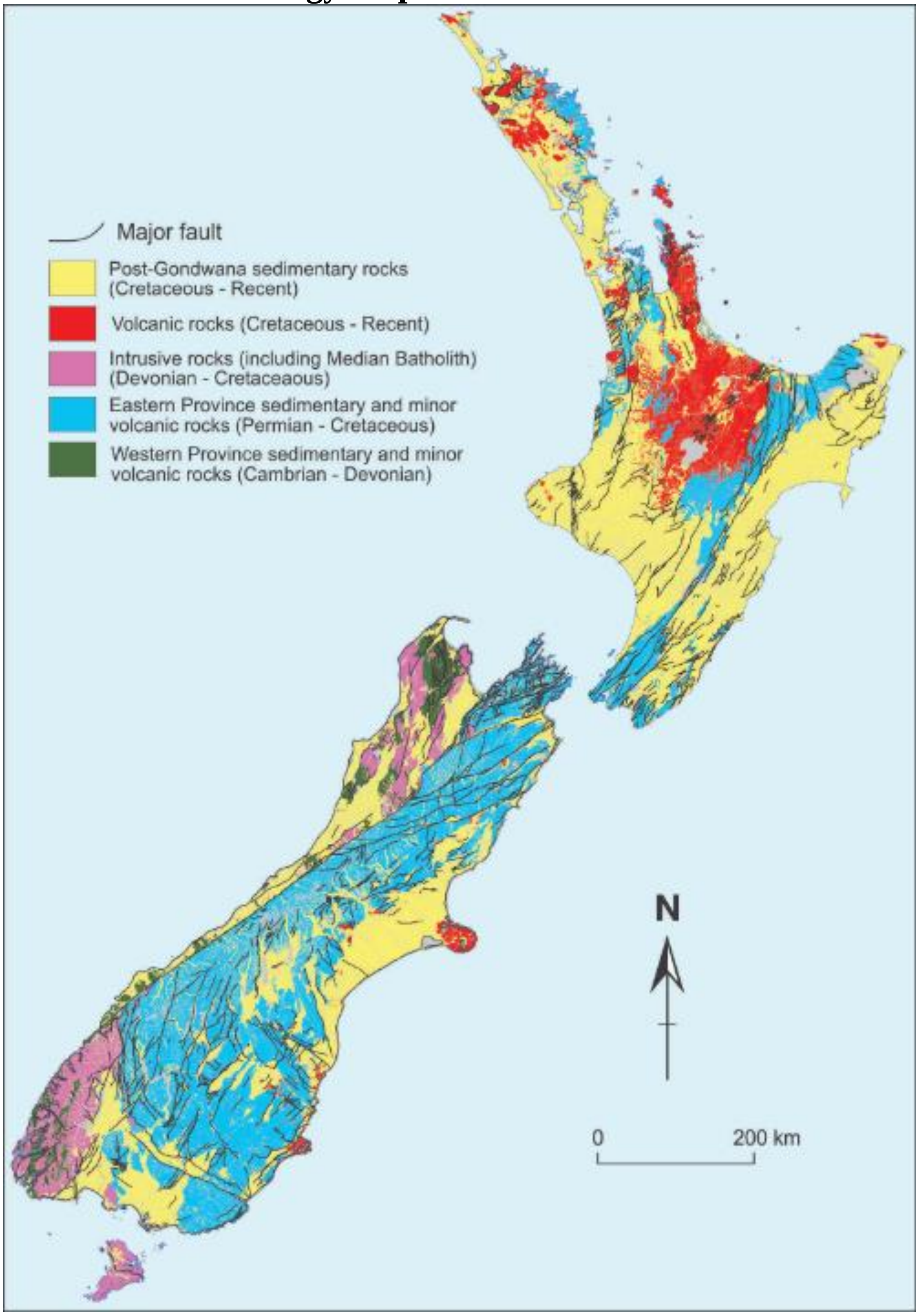
Gondwana



http://specialpapers.gsapubs.org/content/430/593/F1.large.jpg

http://www.visitzealandia.com/wp-content/uploads/2012/02/map-170-mya-500.gif

New Zealand Geology Map

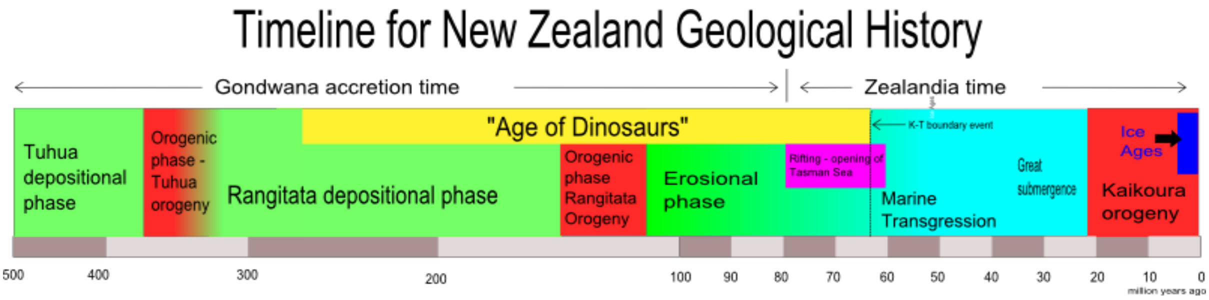


http://www.teara.govt.nz/files/di-9019-enz.gif

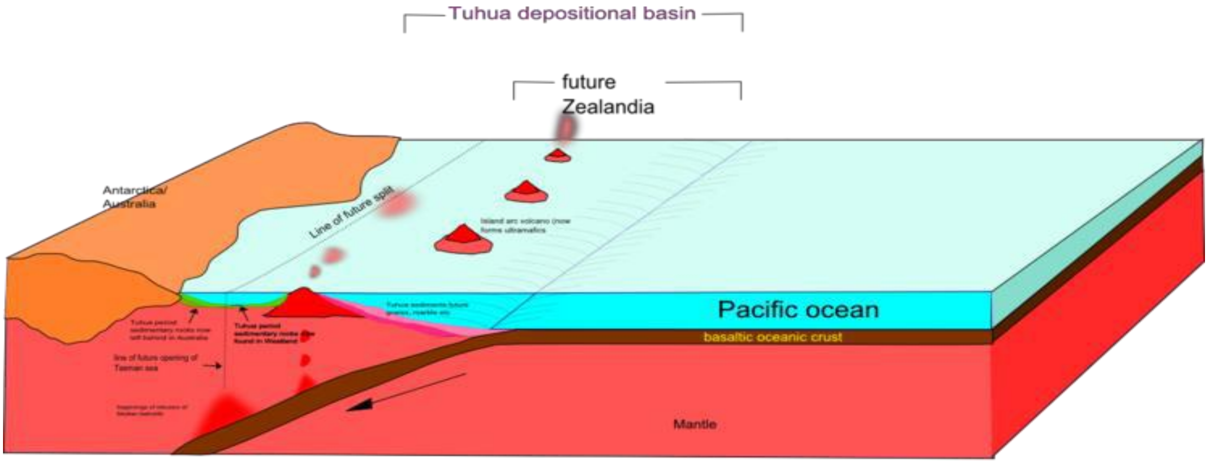
New Zealand Geological Evolution

Visit the following website for details:

http://ncealevel2sci.wikispaces.com/Geology

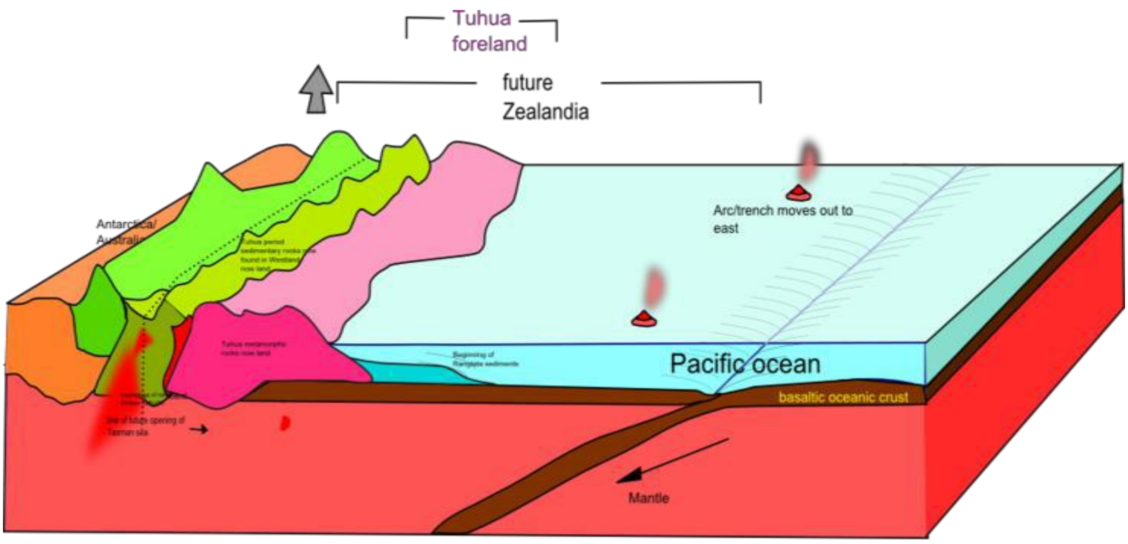


TUHUA DEPOSITIONAL PHASE – Early Palaeozoic (~550 – 380 My)



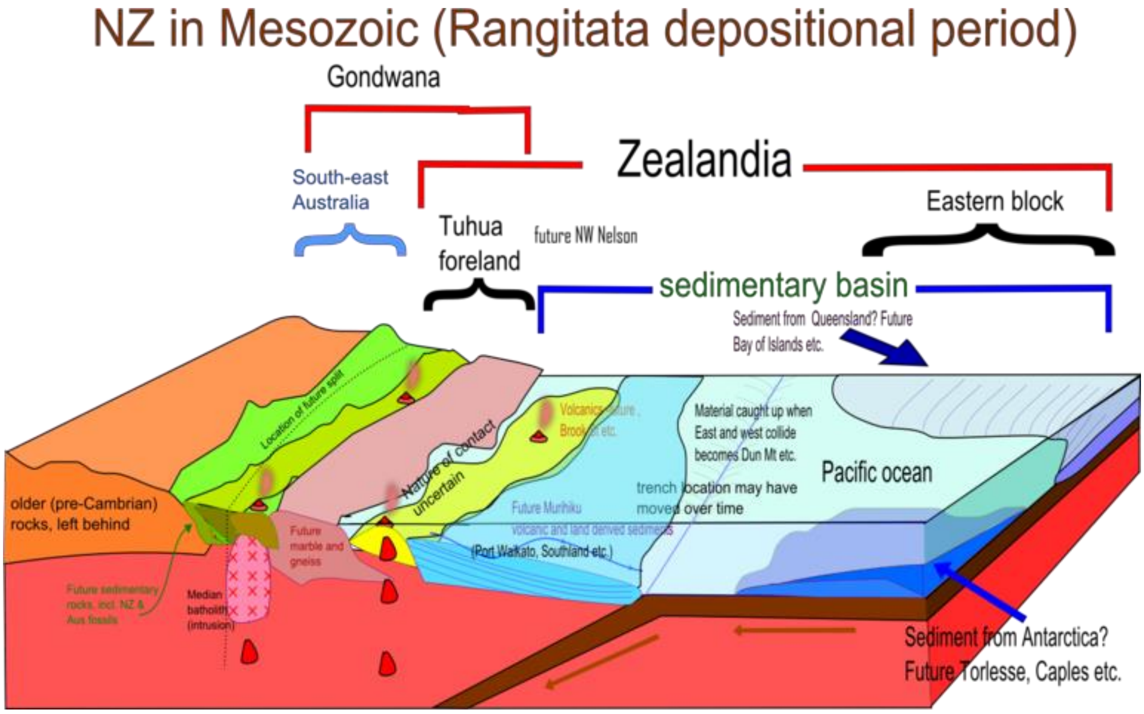
New Zealand and eastern Gondwana in Tuhua times

TUHUA OROGENY PHASE – Early - Middle Palaeozoic (~380 – 330 My)

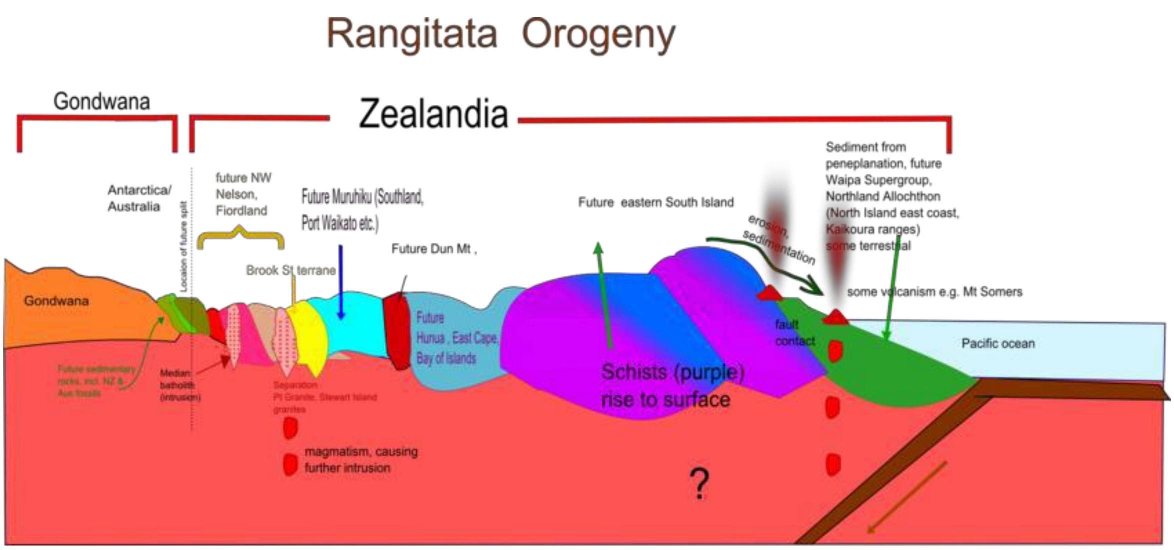


Tuhua Orogeny

RANGITATA DEPOSITIONAL PHASE – Early Mesozoic (~315 – 250 My)

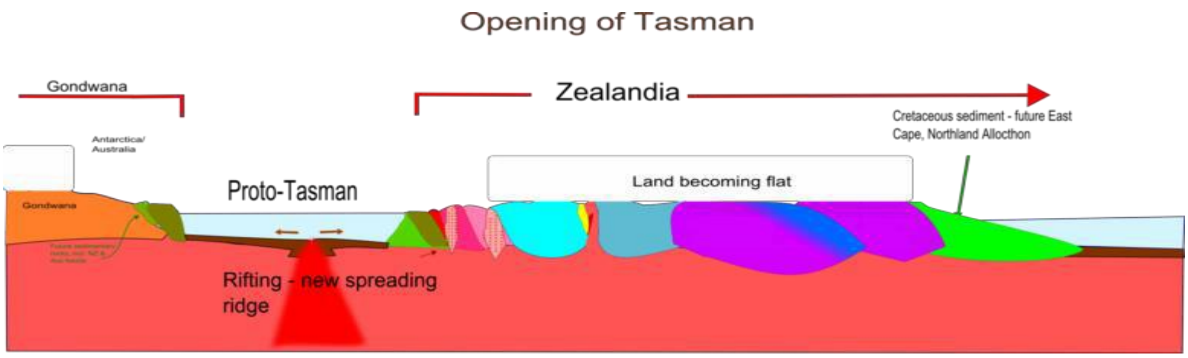


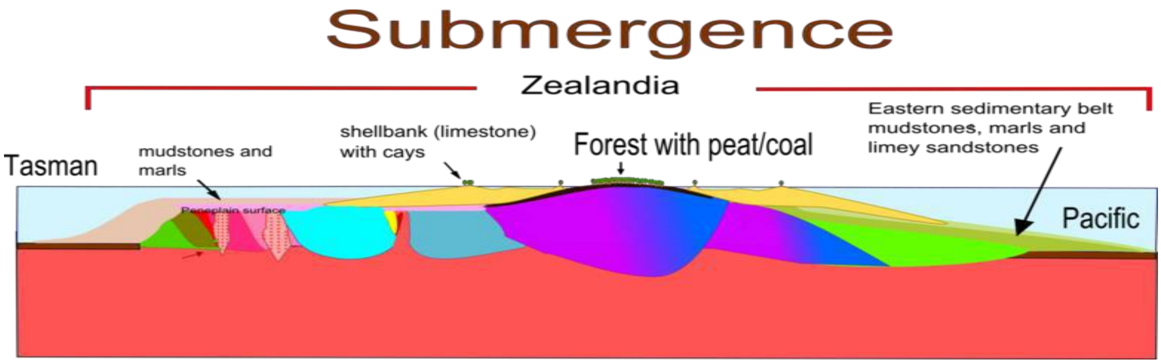
RANGITATA OROGENY PHASE – Early - Middle Palaeozoic (~250 – 130 My)



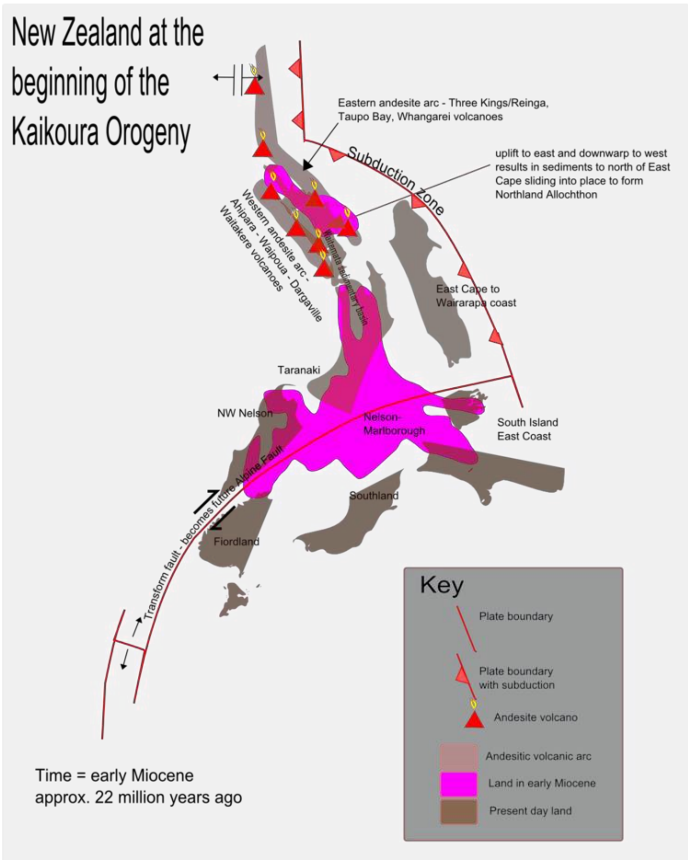
ZEALANDIA DEPOSITIONAL (AND EORSIONAL/SUBMERGENCE) PHASE

Late Mesozoic – Early Cenozoic (~85 – 25 My)

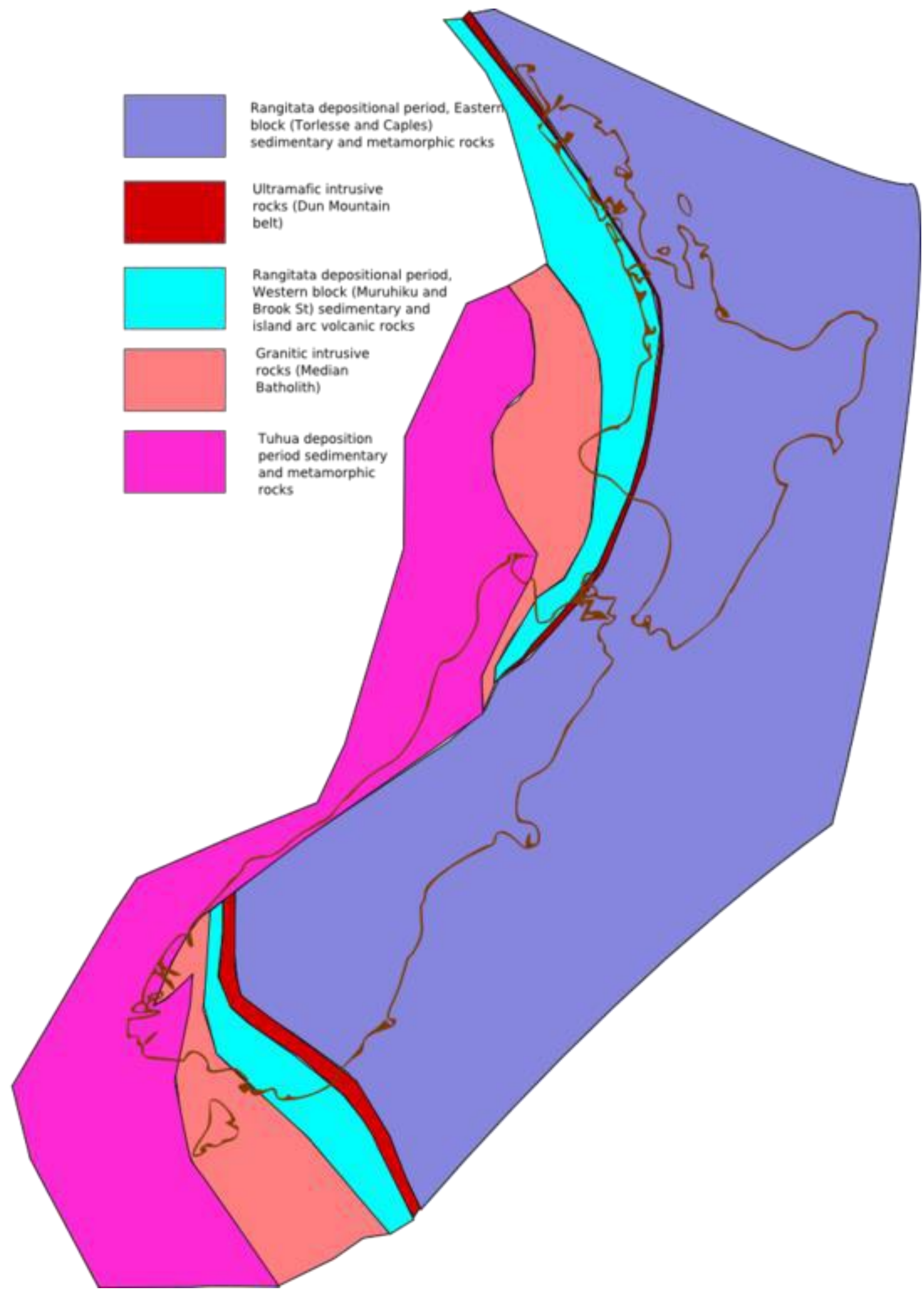




KAIKOURA OROGENY PHASE – Late Cenozoic (from ~ 25 My onward)



New Zealand's Geological Terrains (Basement Rocks)



http://ncealevel2sci.wikispaces.com/file/view/submergence.png/109314949/778x343/submergence.png

Stop 1 River Terraces versus Marine Terraces

Stop is ONLY for Extramural Students if the trip commences by vans.

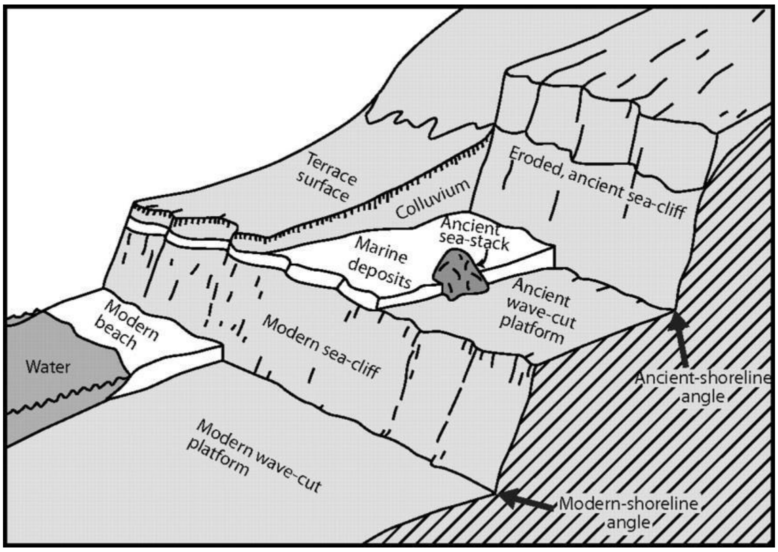
Internal student (and Extramural students if we take big bus) will get explanation on the site during the bus ride.

Write down the NZ Grid Reference of the location:

Measure/Estimate from the map the orientation of the outcrop face:

Marine Terrace:

http://geosphere.gsapubs.org/content/8/2/386/F2.large.jpg



"Falling sea levels leading into the Last Glacial Maximum (LGM) and tectonic uplift resulted in the exposure of Last Interglacial marine deposits and the subsequent dissection of a seaward sloping raised marine terrace. Remnants of the Last Interglacial (Oturi; c. 128-115 ka) are well preserved in the Manawatu district forming broad planar surfaces flanking the adjacent Tararua-Ruahine Range known as the **Tokomaru Marine Terrace** (Fig. 1; Heerdegen and Shepherd, 1992). The terrace comprises soft sandstones, siltstones and gravels. Between 1 and 4 m of loess blown in from river beds by the prevailing northwesterly winds during the LGM cover the terraces. The Kawakawa Tephra, a volcanic ash associated with the Oruanui eruption dated at 22,590±230 yr BP (Wilson et al., 1988; locally known as the Aokautere Ash) is present within the loess, providing a chronological control in the Manawatu area. To the south of the Manawatu Gorge the narrow Tokomaru Marine Terrace rises to an elevation of 30 m near Levin to ***c. 90 m near Palmerston North***, reflecting a northerly increase in uplift rates along the western flanks of the range (Heerdegen and Shepherd, 1992)." From: http://www.gsnz.org.nz/file_downloads/fieldtrip/MP122B_FT1.pdf

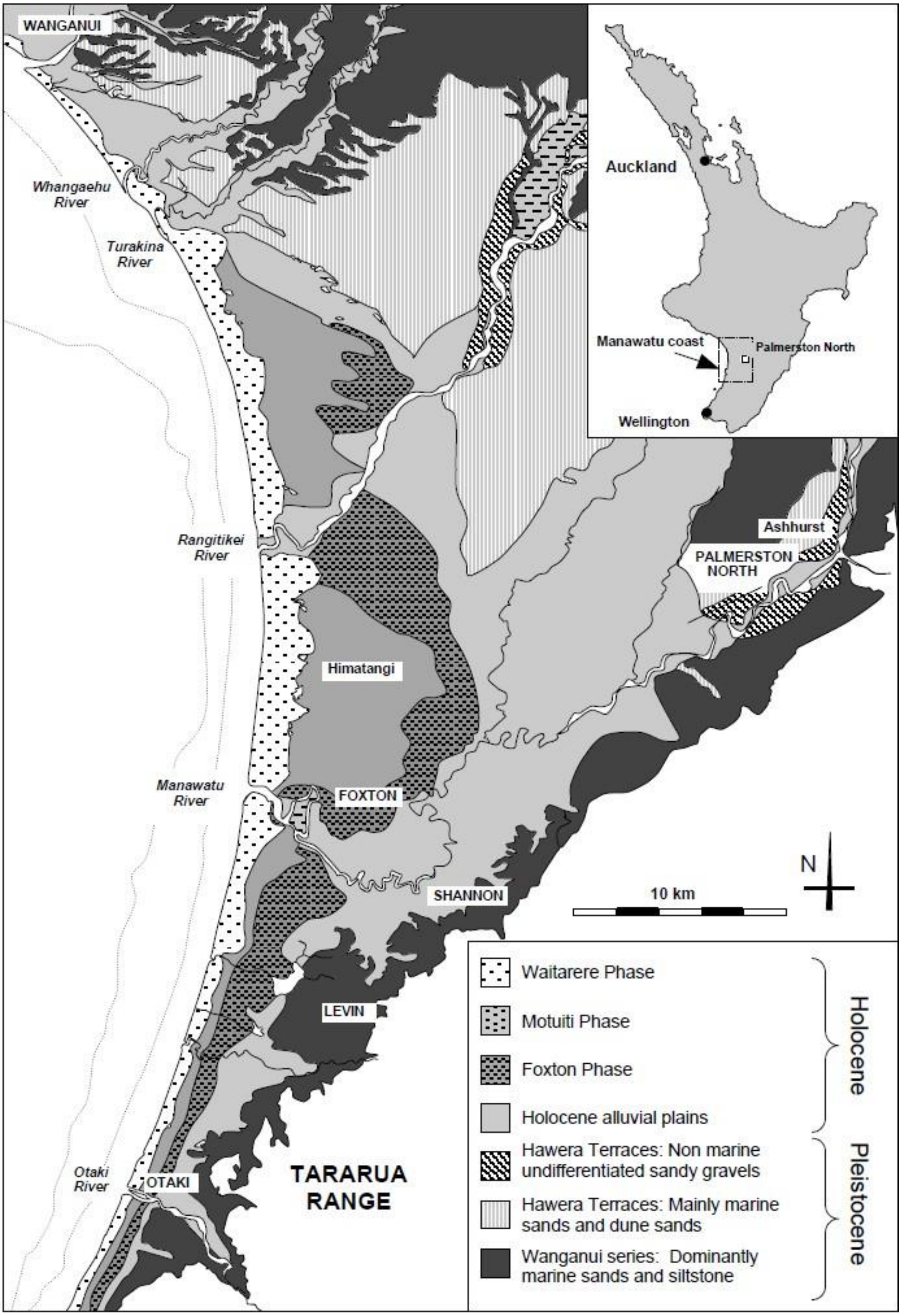
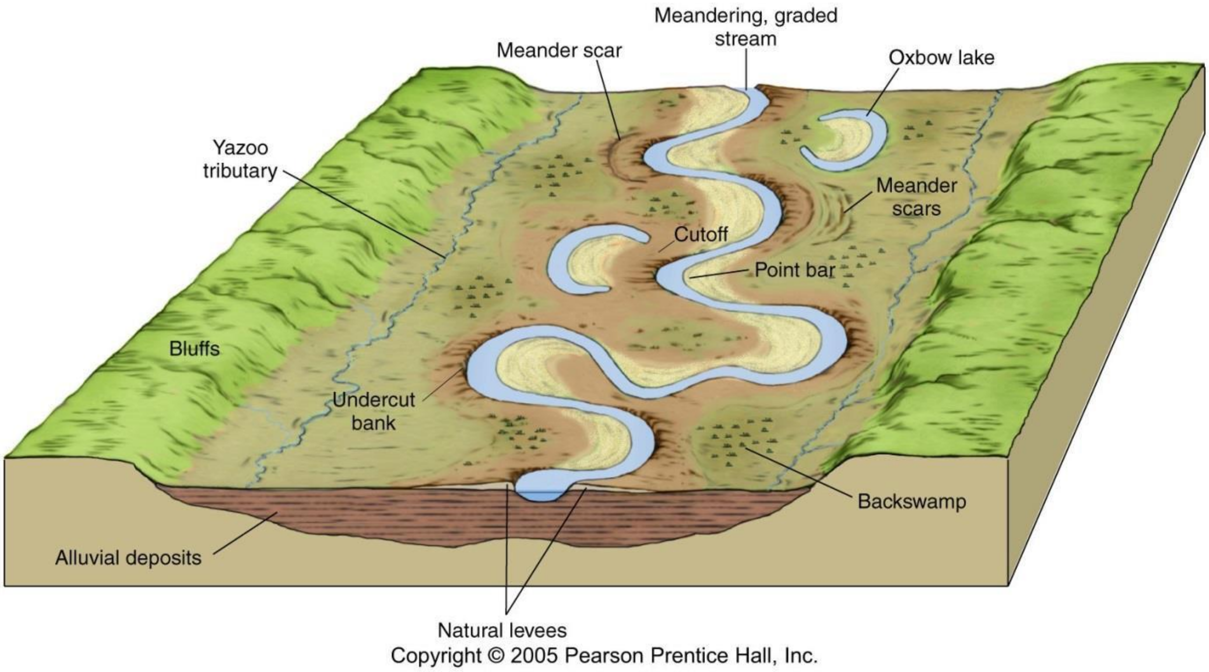
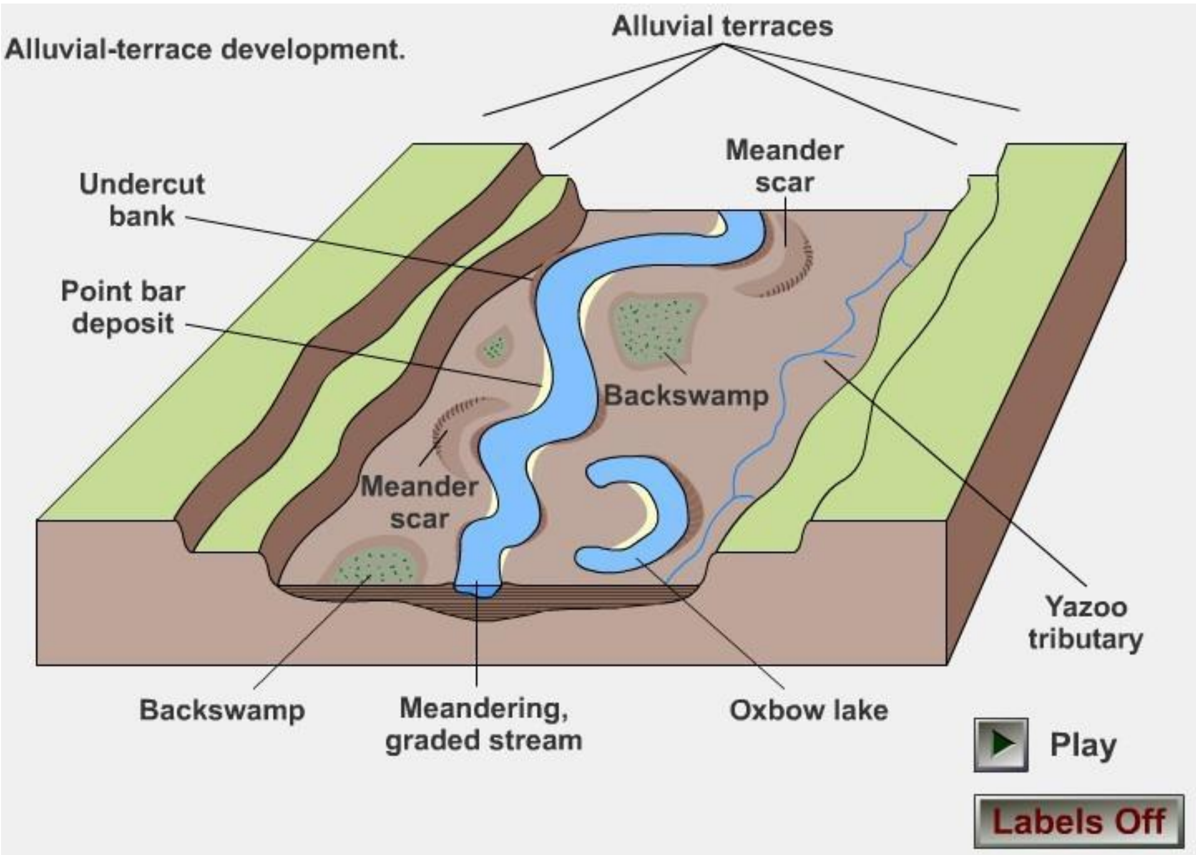


Figure 1: Quaternary geology of the Manawatu region (After Shepherd, 1987; Geological Map of New Zealand, 1:250 000, Sheet 10 (Wanganui), Sheet 11 (Dannevirke) and Sheet 12 (Wellington).

River floodplain



http://www.geographypods.com/uploads/7/6/2/2/7622863/754057079_orig.jpg



http://thebritishgeographer.weebly.com/uploads/1/1/8/1/11812015/6035222_orig.jpg?365

Stop 2 - Terraces of Manawatu

Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Measure the bedding

direction:

Make a sketch of the outcrop by naming the location, orientation marks showing the outcrop orientation, vertical and horizontal scale and show features you think important to note:

Field notes:

Manawatu floodplain

The lower Manawatu River is characterised by two discrete channel phases, and the floodplain characteristics reflect this. Between the Manawatu gorge and Opiki the channel has a relatively steep slope (0.0012), is gravel-bedded and has a sinuosity of 1.4 (Page and Heerdegen 1985). The floodplain associated with the Manawatu River comprises gravels, sands and silts and fits the classification of a medium energy non-cohesive wandering or lateral migration floodplain (Nanson and Croke 1992). Alluvium in this reach of the Manawatu River floodplain has four well defined terraces evident between Palmerston North and the gorge. These terraces have all been formed during the last glacial cycle, inset against the Tokomaru Marine Terrace, which represents the coastline during the last interglacial (OIS 5e). The highest river terrace (Forest Hill) in the lower Manawatu is associated with the (early?) Otiran cold stage (Heerdegen and Shepherd 1992). Cutting of this terrace and refilling formed the Milson terrace, which Heerdegen and Shepherd (1992) suggest correlates with the Rata terrace in the Rangitkei (OIS 3?). The Last Glacial Maximum floodplain (OIS 2) is associated with the Ashhurst Terrace, and the lowermost unit (Raukawa) is of undetermined age, but is presumed to be Holocene in age (Heerdegen and Shepherd 1992). The Holocene and modern alluvium retain a series of palaeo-meanders indicating a recent change in sinuosity of this reach (Page and Heerdegen, 1985).

From http://www.gsnz.org.nz/file_downloads/fieldtrip/MP122B_FT1.pdf

Notes:

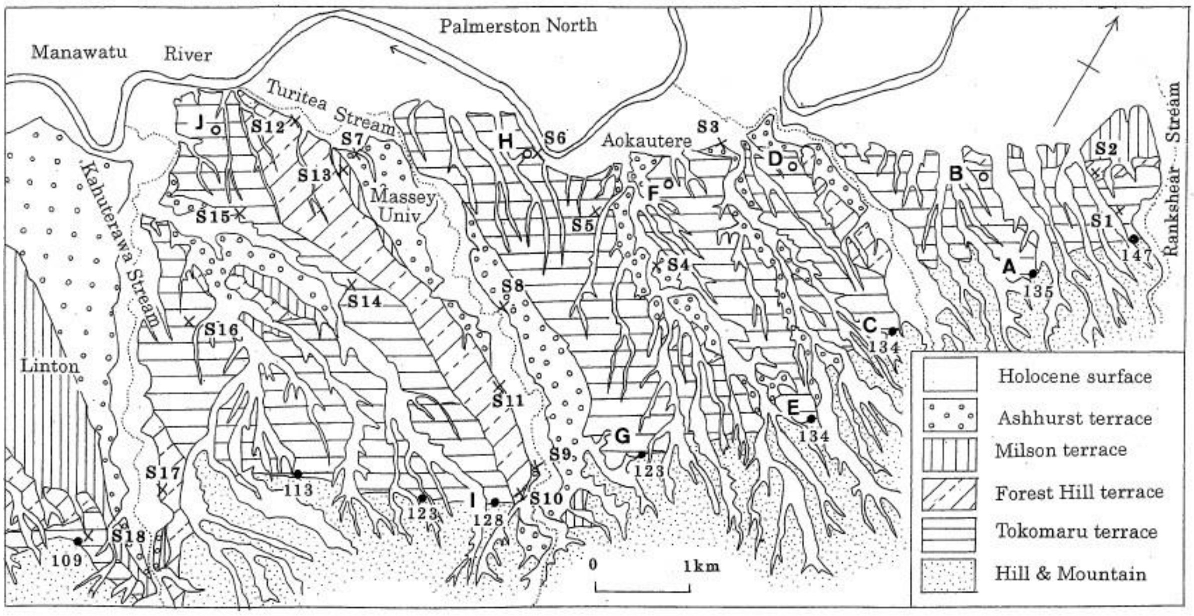


図 3　調査地域の段丘面分類図

●：旧汀線高度測定地点（数字は標高 m）　○：トコマル面下端の高度測定地点　×：柱状図作成地点

Fig. 3 Distribution of terrace surfaces in the study area

● : Measured point and altitude of Tokomaru shoreline ○ : measured point of lower edge of Tokomaru Terrace
× : locality of geologic columnars

From: https://www.jstage.jst.go.jp/article/grj2002/79/13/79_13_769/_pdf

Rangitikei river terraces

"Originally, fourteen sets of river terraces were originally mapped by Milne (1973a). These were (in order of increasing age): Kakariki, Onepuhi, Rewa, Bulls, Ohakea, Vinegar Hill, Rata, Putorino, Powera, Cliff, Greatford, Marton, Burnand and Aldworth.

However, only the major terrace sets (Ohakea, Rata, Porewa, Greatford, Marton, Burnand, and Aldworth) are considered aggradational, having formed during episodes of cool or cold climate. Each aggradational surface generated loess that was distributed onto older, adjacent surfaces. Hence, an increasing number of loess sheets with intervening paleosols (representing negligible loess accumulation during episodes of warm climate) progressively occur on older and more elevated terraces.

Seven loess's within the Rangitikei have now been recognised (Pillans 1988): Ohakea, Rata, Porewa, L4, Marton, Burnand, Aldworth and Waituna. Critical to the chronology of loess within the Rangitikei is the occurrence, near the base of the loess sequence, of Rangitawa Tephra, a widespread rhyolitic tephra dated at c. 340 ka (Pillans et al. 1996)."

From: http://www.gsnz.org.nz/file_downloads/fieldtrip/MP124B_FT7.pdf

River Terraces vs Marine Terrace of the Manawatu/Rangitikei River region

Tokomaru Marine Terrace (115 -125 ka)

Forest Hill (Manawatu) – Ohakean (Rangitikei)

Milson (Manawatu) – Rata (Rangitikei)

Ashurst (Manawatu) – Porewa or younger (Rangitikei)

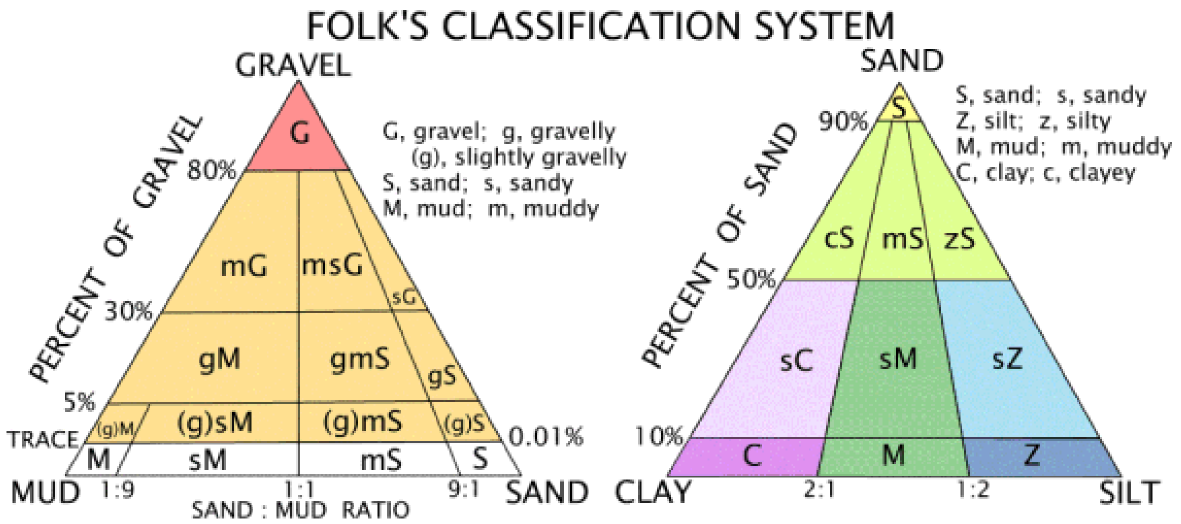
Raukawa (Manawatu)

Present day Manawatu River

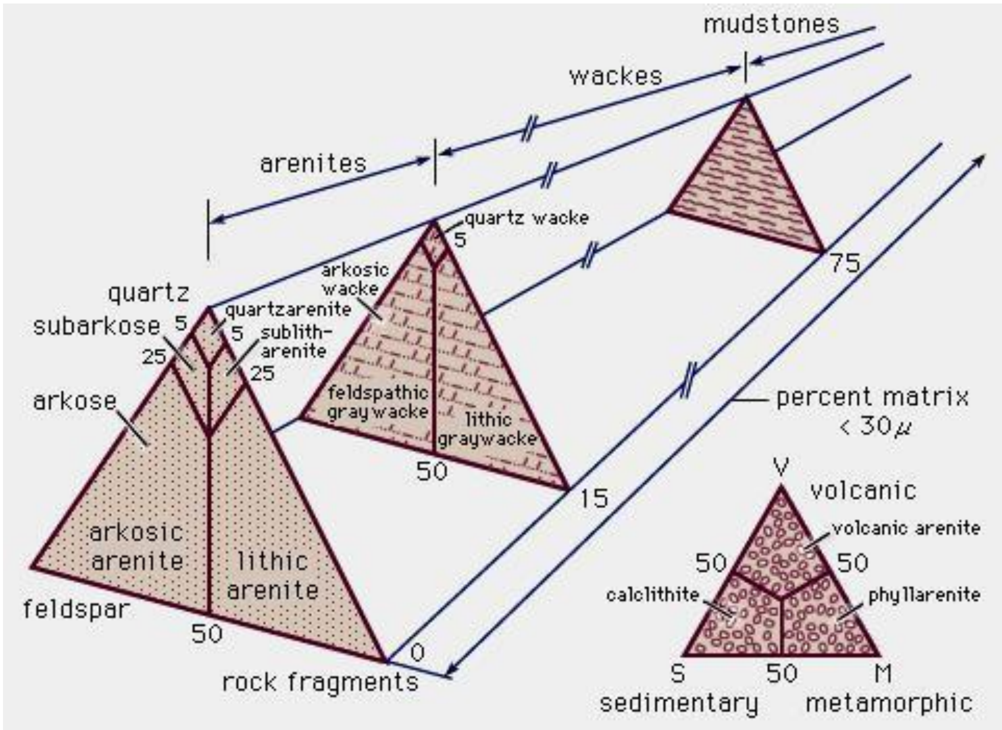
Complete the ideal section above with your line drawing

Clastic Sediments Classification

Millimeters (mm)		Micrometers (µm)	Phi (φ)	Wentworth size class		Rock type
	4096		-12.0	Boulder	Gravel	Conglomerate/ Breccia
	256		-8.0	Cobble		
	64		-6.0	Pebble		
	4		-2.0	Granule		
	2.00		-1.0	Very coarse sand	Sand	Sandstone
	1.00		0.0	Coarse sand		
1/2	0.50	500	1.0	Medium sand		
1/4	0.25	250	2.0	Fine sand		
1/8	0.125	125	3.0	Very fine sand		
1/16	0.0625	63	4.0	Coarse silt	Silt	Siltstone
1/32	0.031	31	5.0	Medium silt		
1/64	0.0156	15.6	6.0	Fine silt		
1/128	0.0078	7.8	7.0	Very fine silt		
1/256	0.0039	3.9	8.0	Clay	Mud	Claystone
	0.00006	0.06	14.0			



Sorting



Sandstone classification

Stop 3 Manawatu Gorge

Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Measure the bedding

direction if you can identify bedding:

Make a sketch of the outcrop by naming the location, orientation marks showing the outcrop orientation, vertical and horizontal scale and show features you think important to note:

Stop 4 Saddle Road section

Stop is ONLY for Extramural Students if the trip commences by vans.

Internal student (and Extramurals if we take the trip by big bus) will get explanation on the site during the bus ride.

Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Measure the bedding

direction if you can identify bedding:

Make a sketch of the outcrop by naming the location, orientation marks showing the outcrop orientation, vertical and horizontal scale and show features you think important to note:

Describe the rock units by using geological terms.

What features can you see in this view? Describe them by using proper geological terms.

Stop 4A Waipounamu Erosional Surface versus Otago Peneplain

An alternative Stop in the eastern side of the Saddle Road if the weather is nice and the view is worth to stop. Otherwise the landscape elements will be pointed out during the van and bus ride.

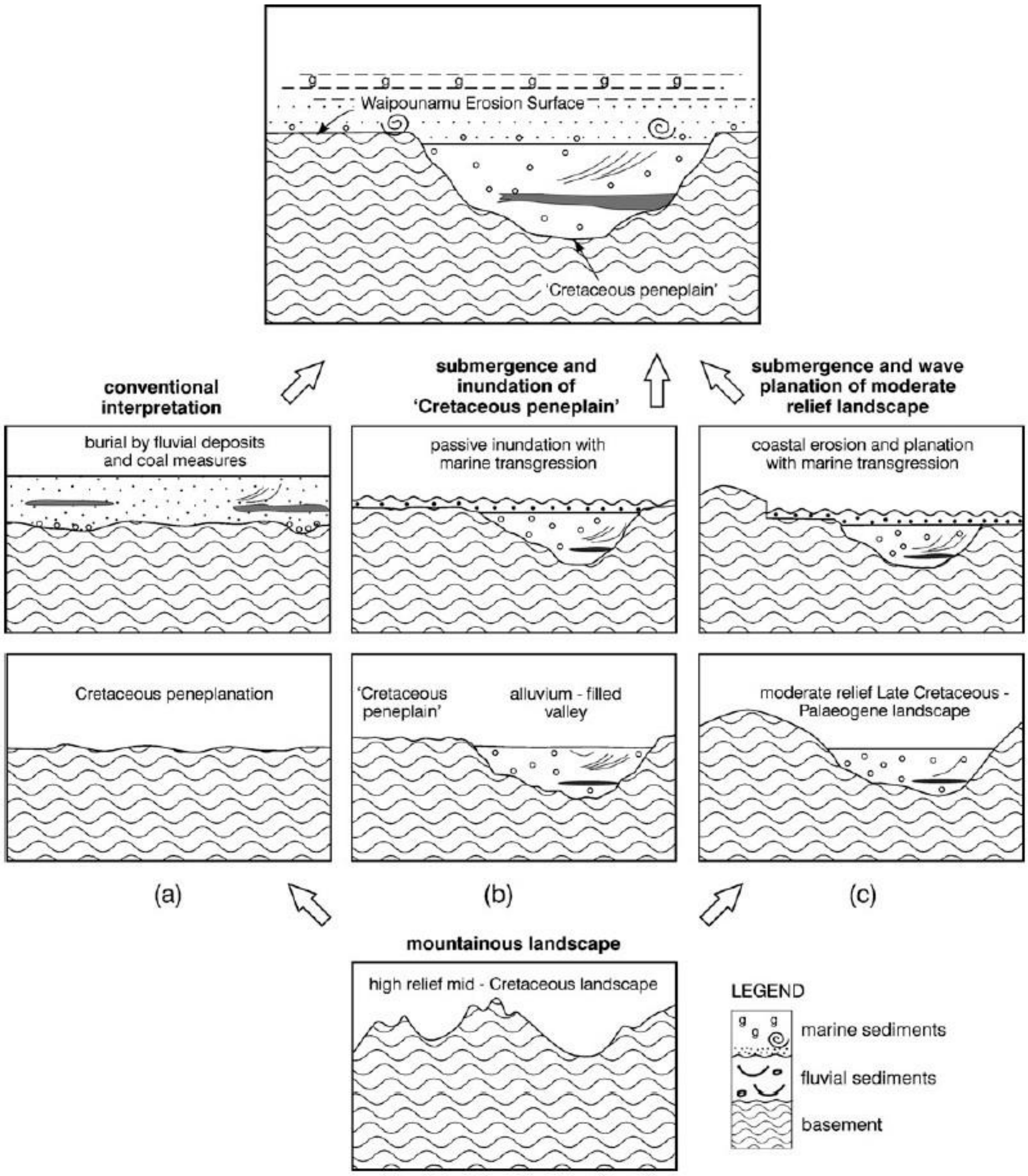
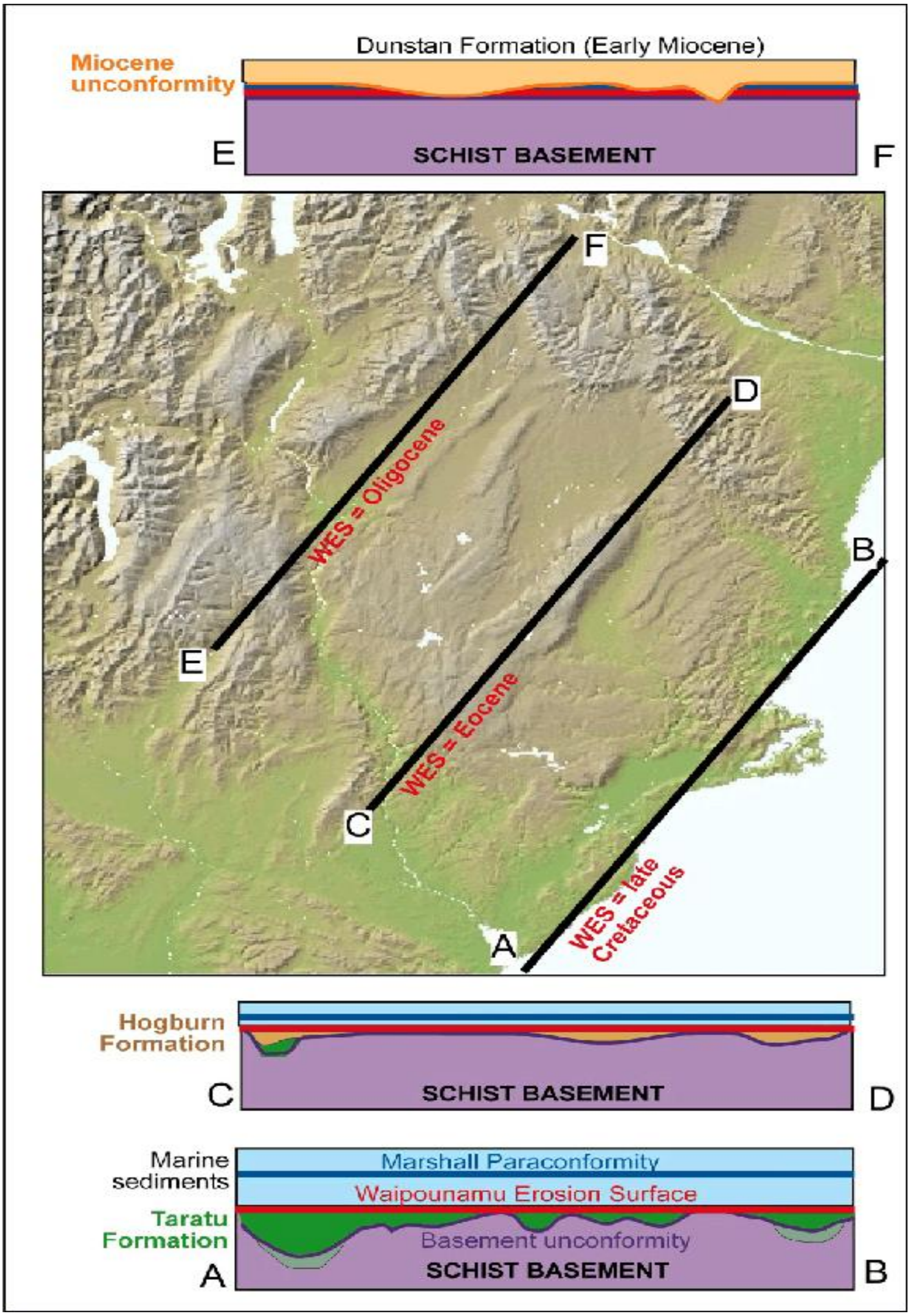


Figure 3. Spatial relationships between the 'Cretaceous Peneplain' and the Waipounamu Erosion Surface. Assuming an original high-relief mountainous landscape in Zealandia dating from middle Cretaceous break-up (at bottom), three scenarios are presented: (a) the conventional interpretation, showing peneplanation by terrestrial processes followed by deposition of a mantle of fluvial and coal-measure sediments. During subsequent subsidence, transgressive marine strata accumulated around the coastal periphery of Zealandia; (b) Cretaceous peneplanation of Zealandia is accompanied by deposition of non-marine sediment in erosional valleys draining the interior; marine transgression gradually inundates the subdued and deeply weathered continental margin; and (c) (the option preferred here) channel-fill fluvial and swamp sediments are deposited in erosional valleys within the moderate-relief Zealandia continent. Coastal erosion accompanying thermal subsidence forms extensive surfaces of marine planation upon which re-worked clastics plus fresh first-cycle basement-derived sediment is deposited. Subsidence and coastal erosion continued for at least 40 million years, the resulting transgression eventually covering Zealandia. Thus, along the present-day coast, shallow marine coarse clastic sediments of Late Cretaceous age fine upward to marl, greensand and eventually Oligocene limestone. (On diagram: g – greensand).

From: Landis et al (2008) Geol. Mag. 145 (2): 173-197

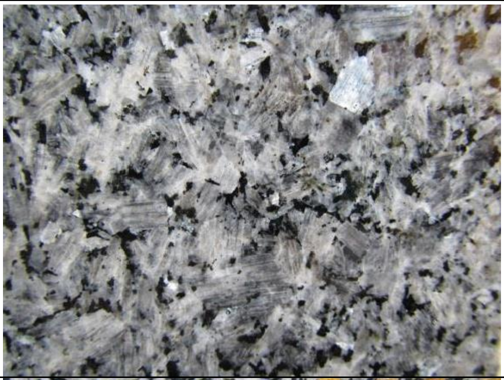
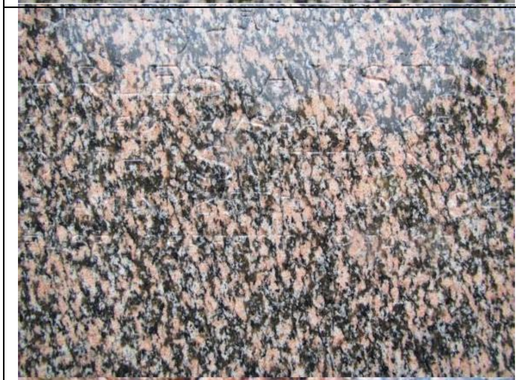


From: http://www.otago.ac.nz/geology/otago070863.png

Stop 5 Gorge Cemetery - Woodville

Write down the NZ Grid Reference of the location:

Look for and identify the rocks used for headstones below. Describe the rocks.

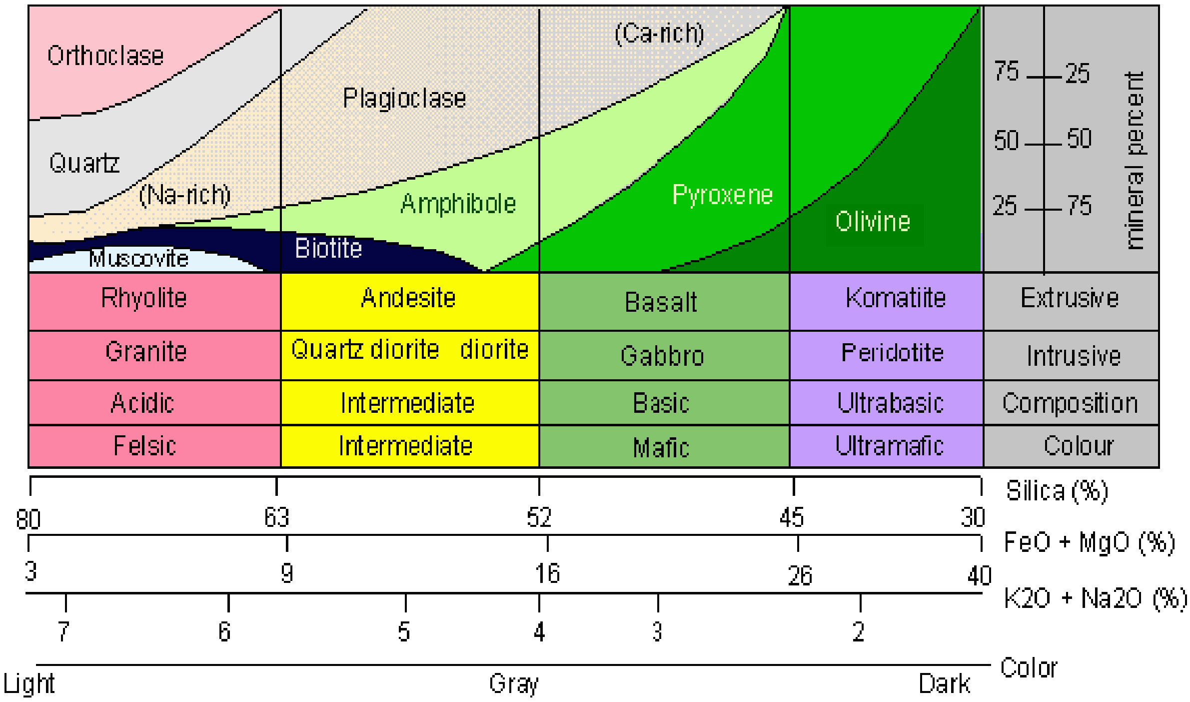
Headstone or Rocks	Description
	
	
	
	

	
	
IN LOVING MEMORY OF GOTTFRIED LINDAUER, ARTIST BORN IN PILSEN, BOHEMIA, JANUARY 5TH 1839. DIED JUNE 13TH 1926. REST IN PEACE	
	

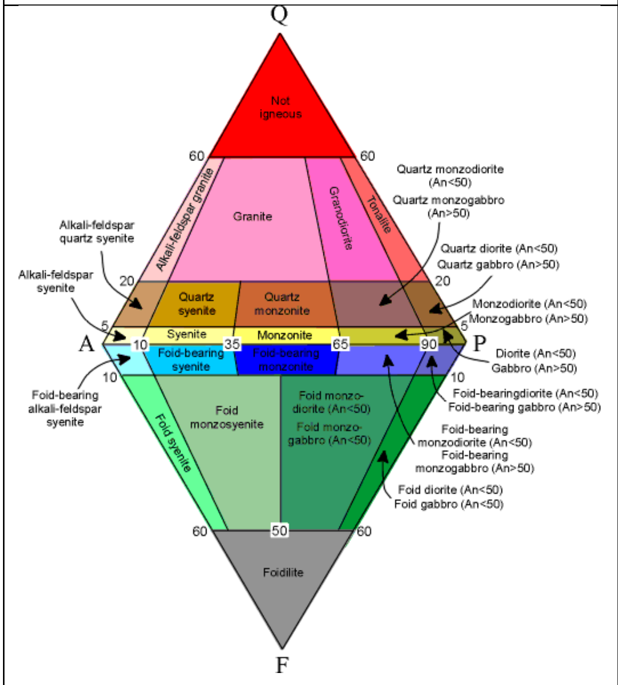
Gottfried Lindauer

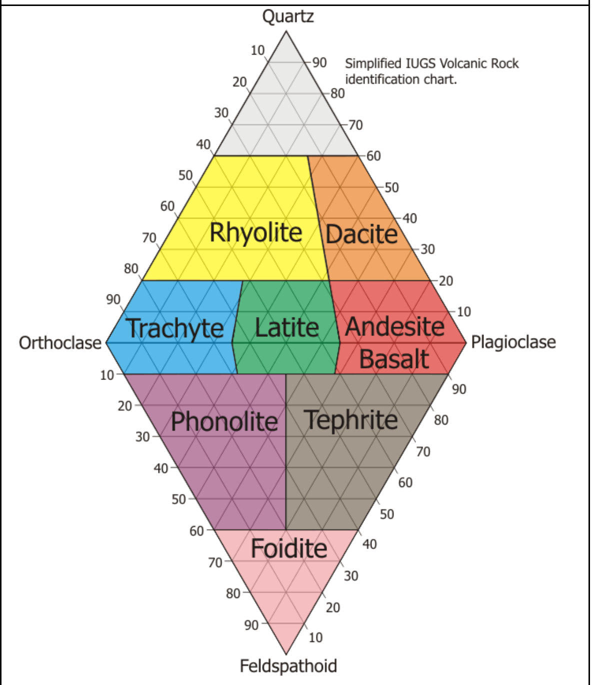
Igneous and Metamorphic Rock Classification

Guides Igneous (Plutonic vs Volcanic) Rock Classification



Plutonic (Intrusive)	Volcanic





Metamorphic Rock Classification

Rock Name		Texture	Grain Size	Comments	Parent Rock
Slate	Increasing Metamorphism	Foliated	Very fine	Excellent rock cleavage, smooth dull surfaces	Shale, mudstone, or siltstone
Phyllite			Fine	Breaks along wavey surfaces, glossy sheen	Slate
Schist			Medium to Coarse	Micas dominate, scaly foliation	Phyllite
Gneiss			Medium to Coarse	Compositional banding due to segregation of minerals	Schist, granite, or volcanic rocks
Marble		Nonfoliated	Medium to coarse	Interlocking calcite or dolomite grains	Limestone, dolostone
Quartzite			Medium to coarse	Fused quartz grains, massive, very hard	Quartz sandstone
Anthracite			Fine	Shiny black organic rock that may exhibit conchoidal fracture	Bituminous coal

From: http://science5242buffa.weebly.com/uploads/2/1/9/4/21944106/9544544.jpg?715

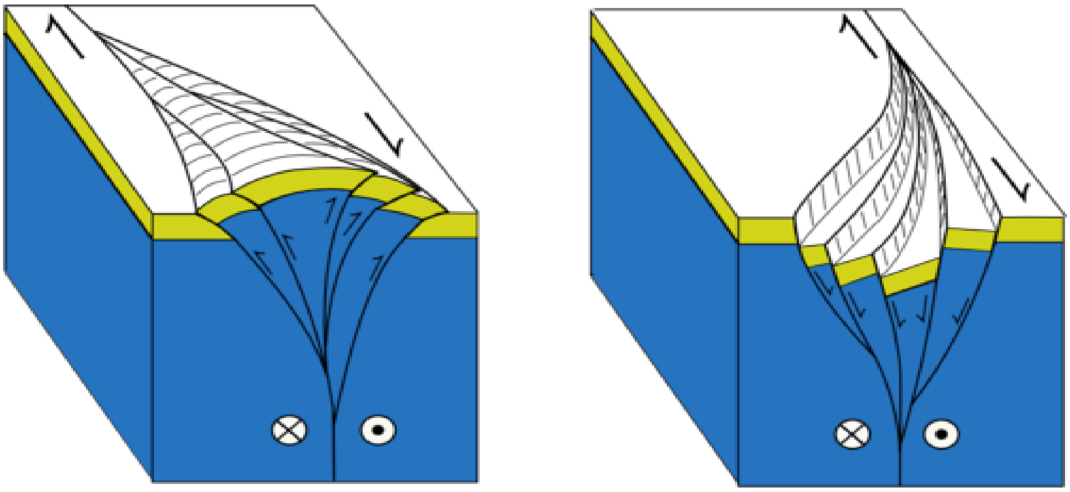
Stop 6 Wellington Fault – Tectonic horse in strike-slip fault system

"*Horse is the geological technical term used for any block of rock completely separated from the surrounding rock* ***either*** *by* ***mineral veins*** *or* ***fault planes****.*" From **Wikipedia**

http://en.wikipedia.org/wiki/Horse_%28geology%29

Write down the NZ Grid Reference of the location:

Strike-slip faults



Positive Flower Negative Flower

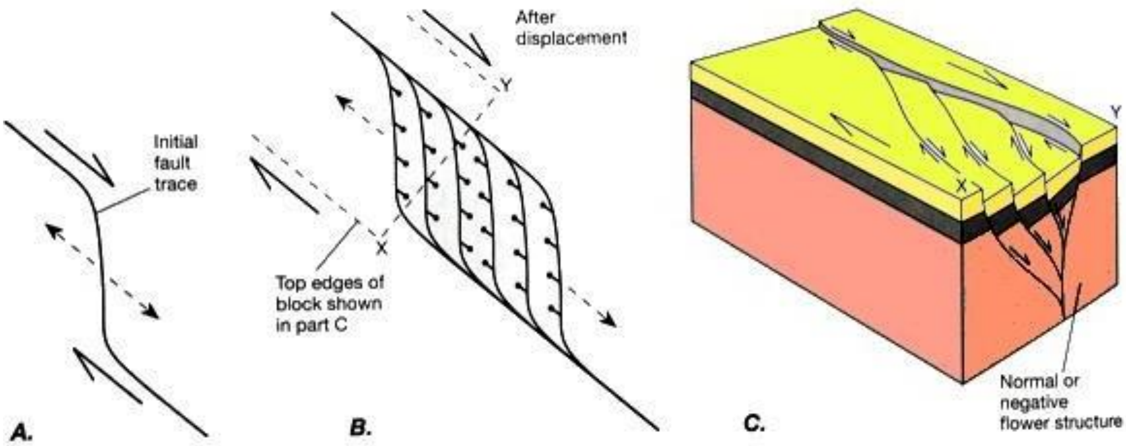


Figure 7.6 Formation of an extensional duplex at an extensional (releasing) bend. Large arrows

LUNCH STOP – Woodville

Stop 7 Loess – Soil and Volcanic Ash

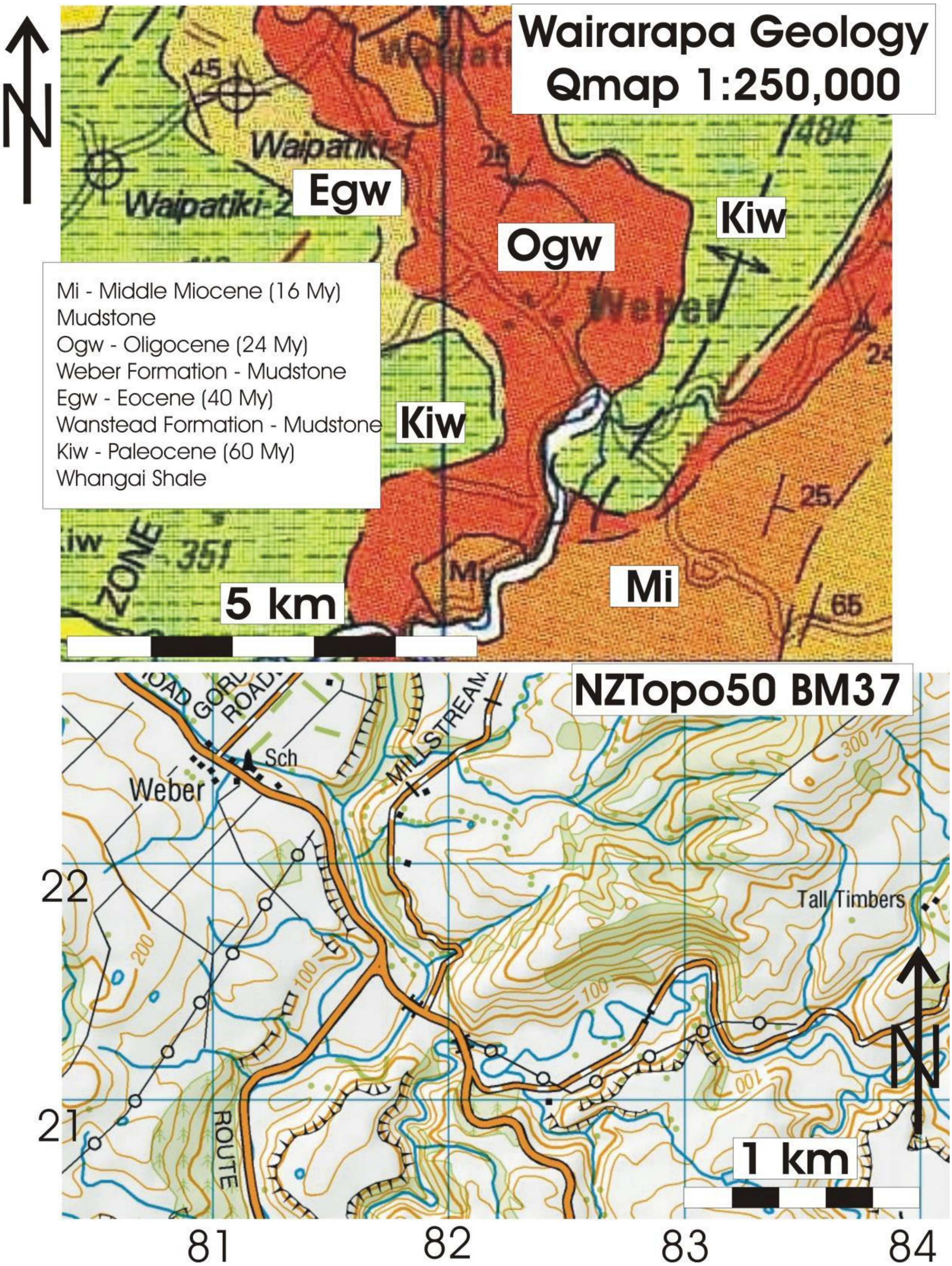
Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Measure the bedding

direction if you can identify bedding:

Make a sketch of the outcrop by naming the location, orientation marks showing the outcrop orientation, vertical and horizontal scale and show features you think important to note:

Stop 8 Whangai Shale and Weber Mudstone



Mark the Stop 8 on both maps

Write down the NZ Grid Reference of the location:

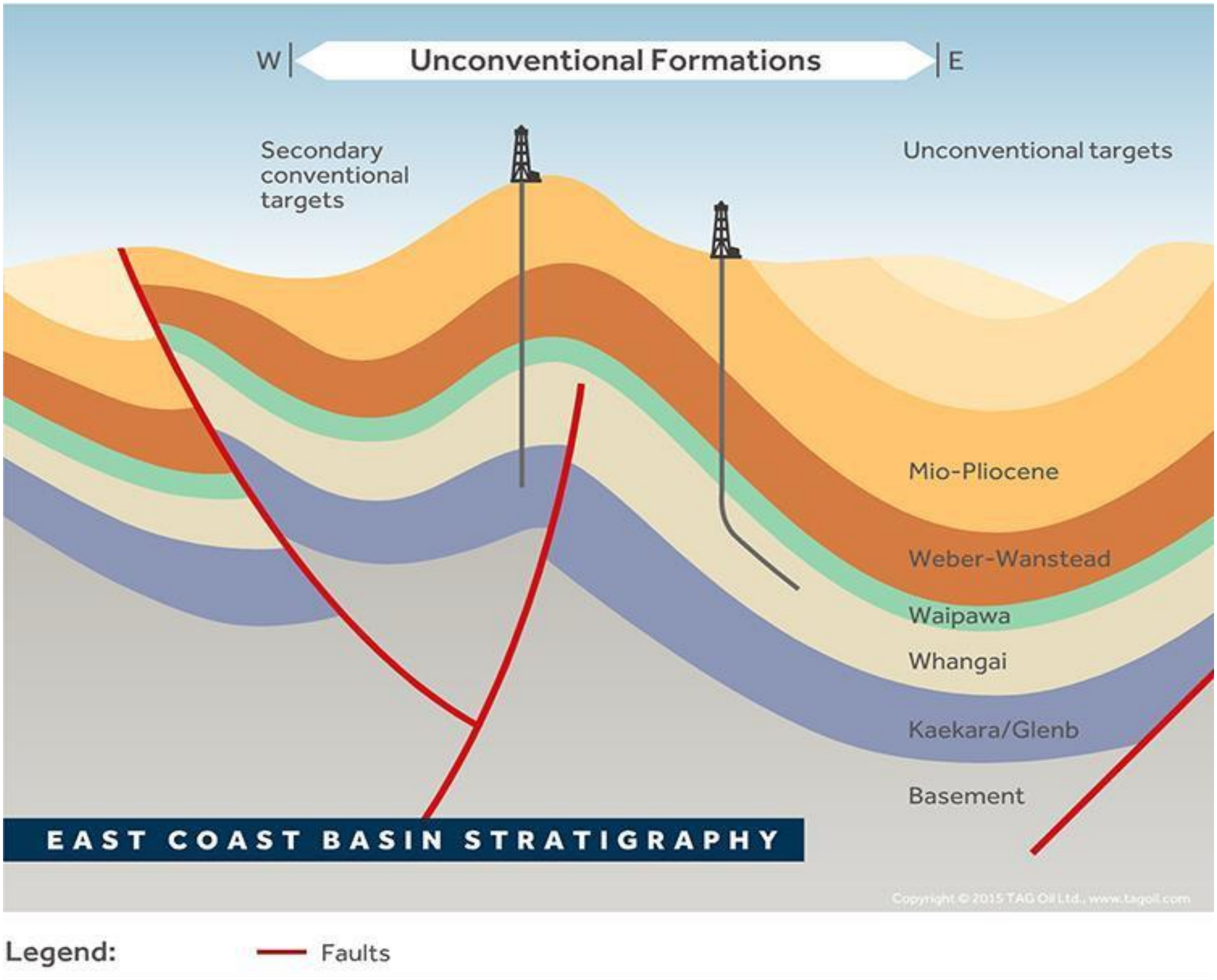
Measure/Estimate from the map the orientation of the outcrop face:

Measure the bedding direction if you can identify bedding:

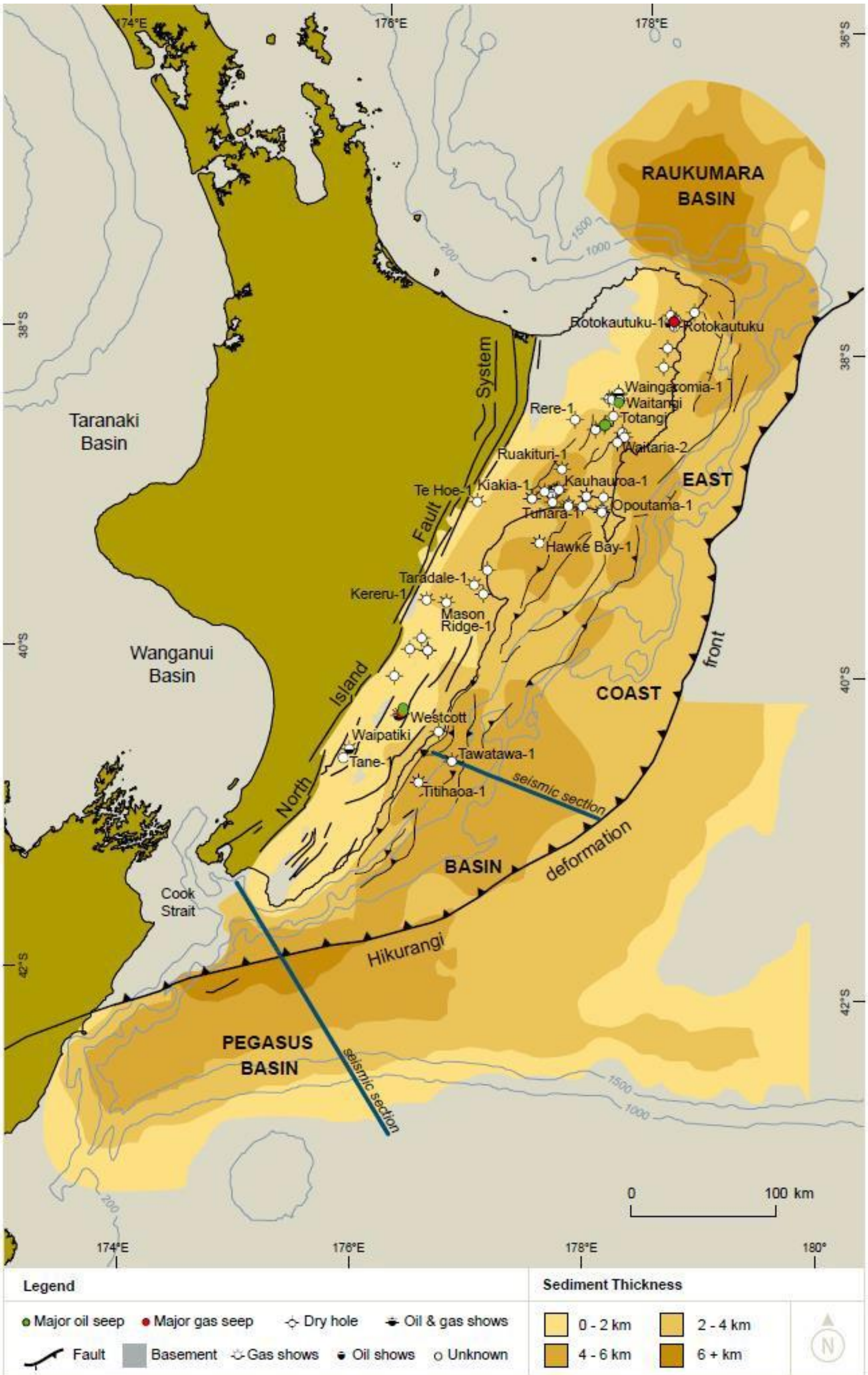
Make a sketch of the outcrop by naming the location, orientation marks showing the outcrop orientation, vertical and horizontal scale and show features you think important to note:

"**Shale** is a fine-grained sedimentary rock that forms from the compaction of silt and clay- size mineral particles that we commonly call "mud". This composition places **shale** in a category of sedimentary rocks known as "mudstones"."

From: http://geology.com/rocks/shale.shtml



From: http://www.tagoil.com/wp-content/uploads/2014/09/Unconventional_Side_ECB-Diagram.jpg



Source: https://www.nzpam.govt.nz/assets/Uploads/doing-business/nz-petroleum-basins-part-two.pdf

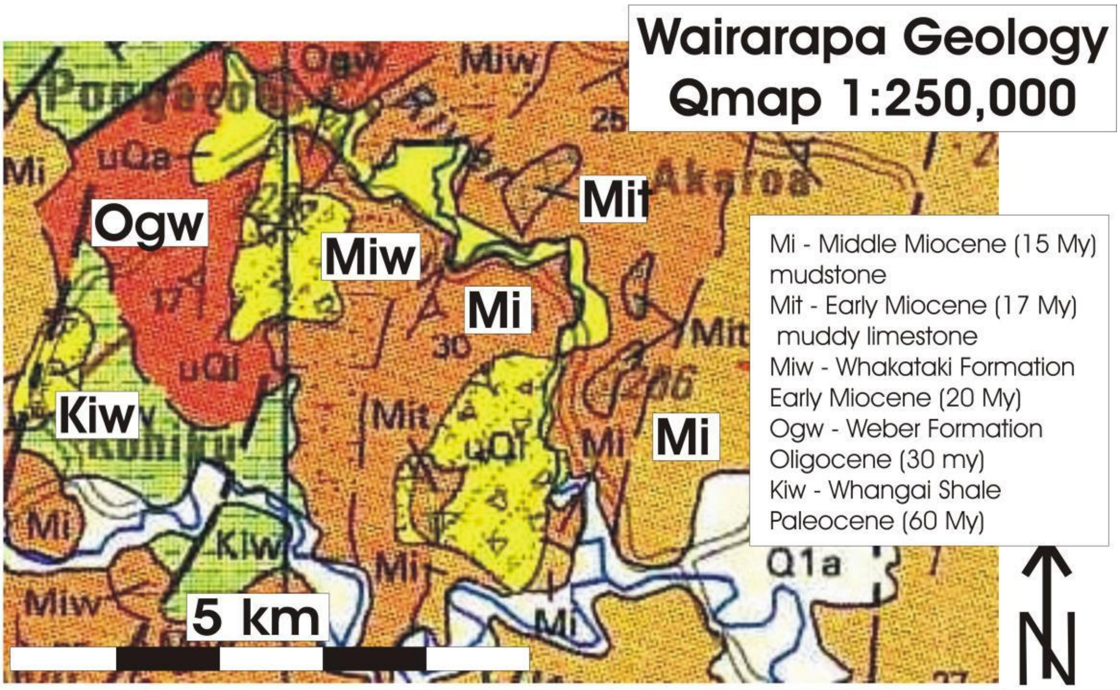
Stop 9 Pongaroa Gunclub (Alternative Stop)

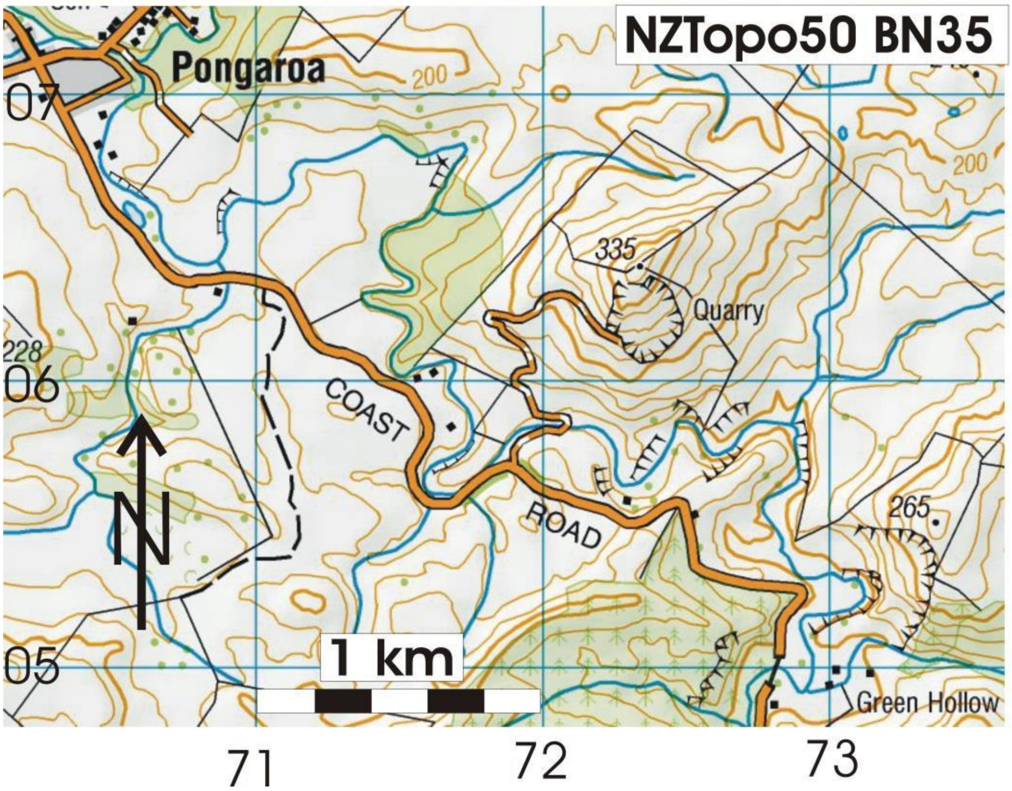
Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Identify geological

features on the outcrop face:

Stop 10 Pongaroa turbidite sequence





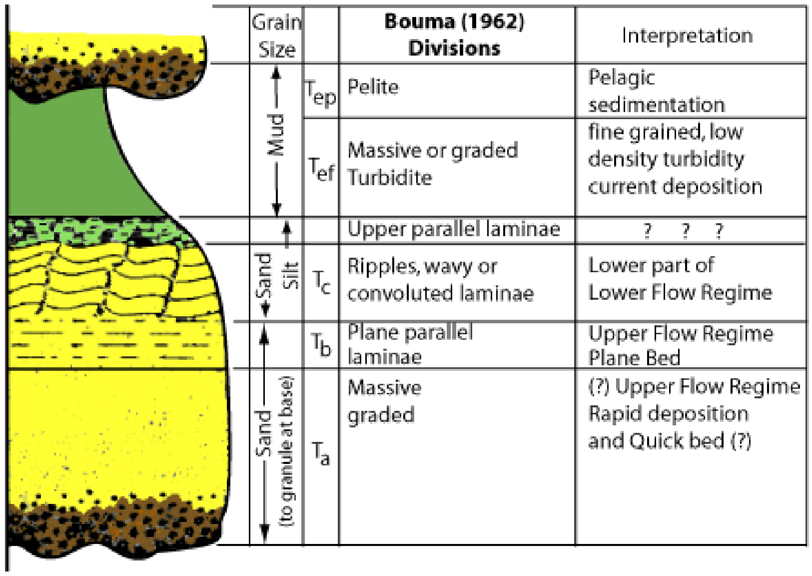
Mark the Stop 10 on both maps

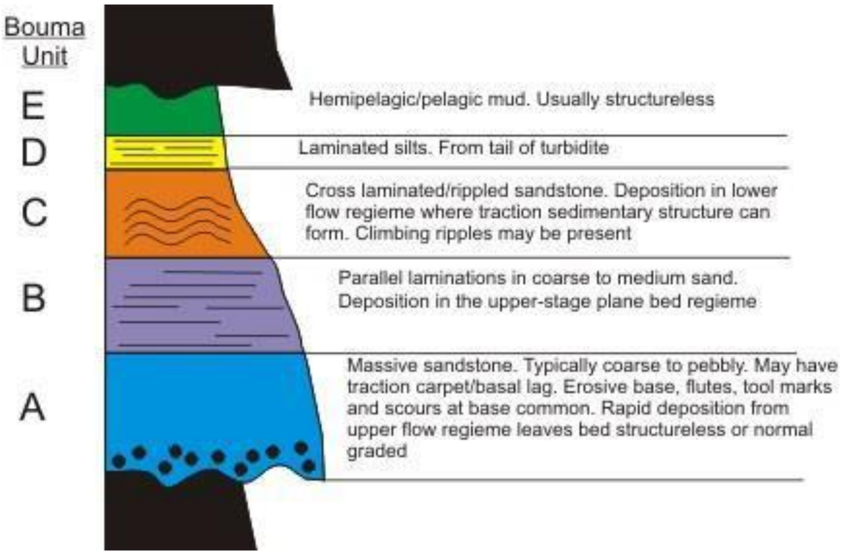
Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Identify geological

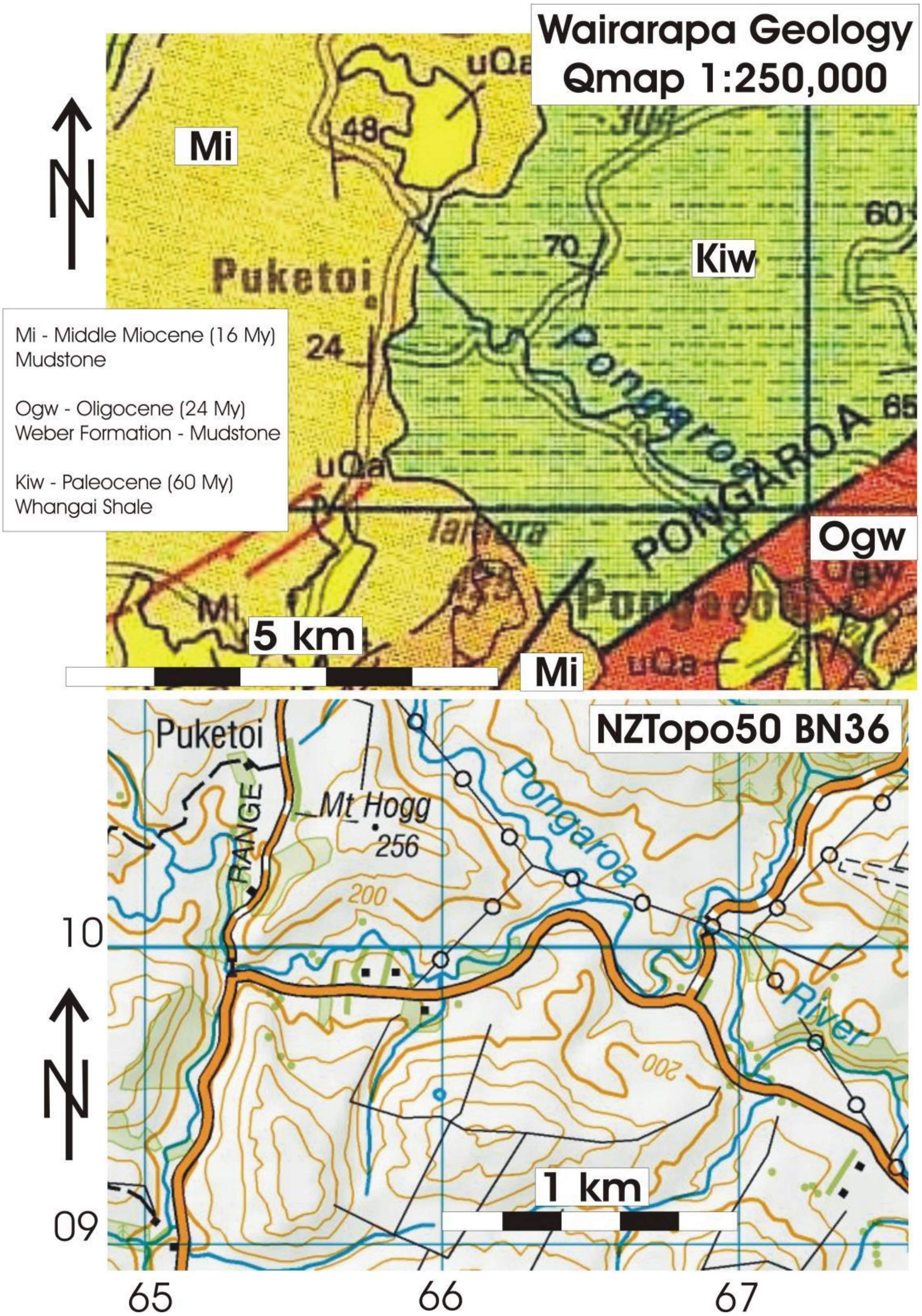
features on the outcrop face:

Bouma sequence





Stop 11 Undifferentiated massive, fossiliferous, concretionary blue- grey, calcareous, sandy mudstone (Middle to Late Miocene [15 My] marine siliciclastic units)



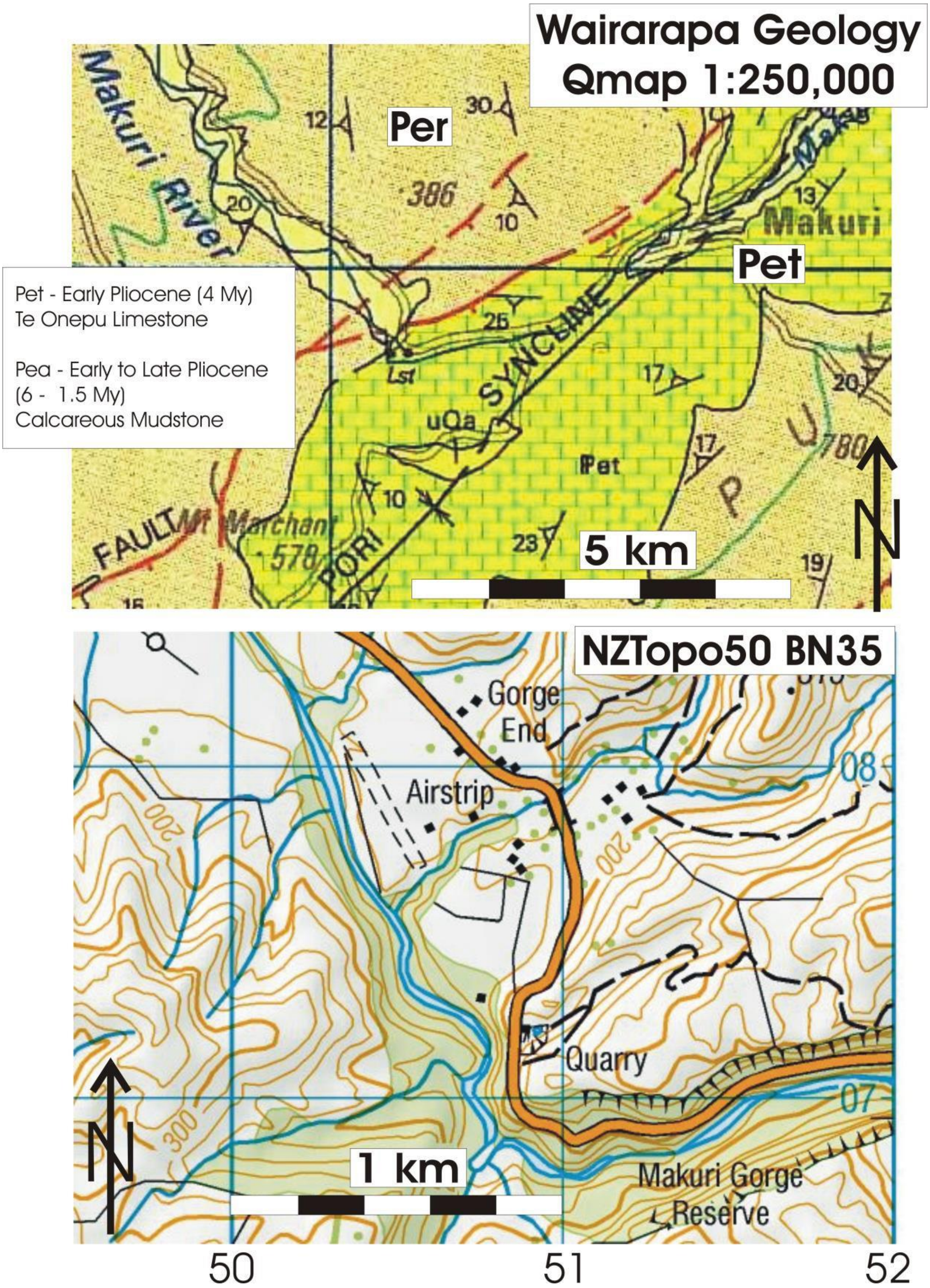
Mark the Stop 11 on both maps

Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Identify geological

features on the outcrop face:

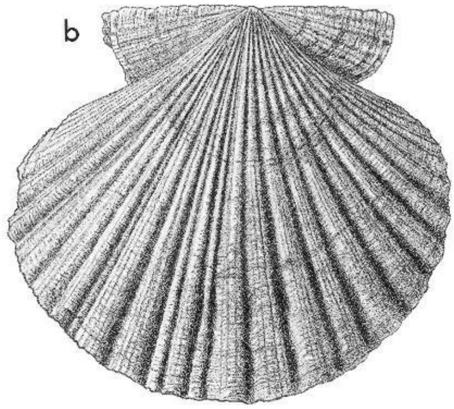
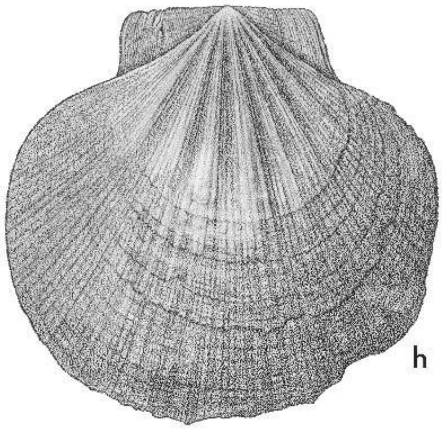
Stop 12 Makuri Limestone Quarry



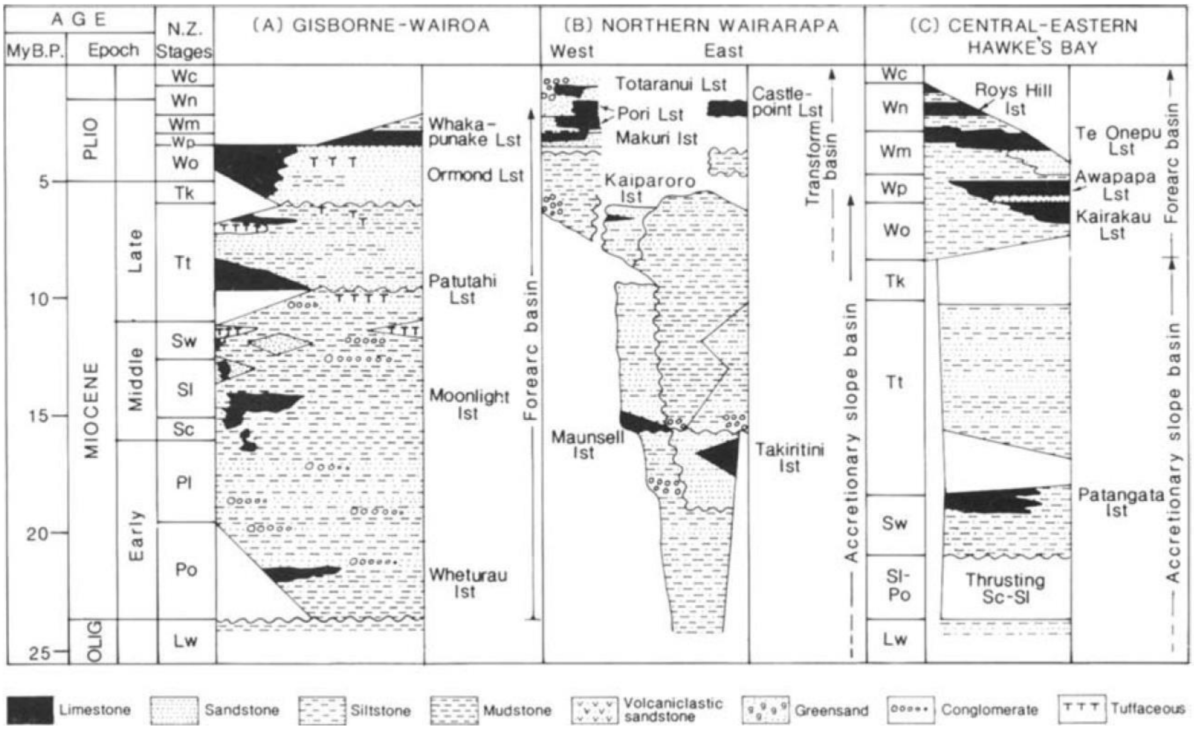
Write down the NZ Grid Reference of the location: Measure/Estimate

from the map the orientation of the outcrop face: Identify geological

features on the outcrop face:

Phialopecten (triphooki)	Towaipecten (katieae)
	

Identify the bivalves in these photos:



From: Kamp & Nelson (1988) NZJGG 31: 1-20.

NOTES: