

**Anatomy and allostratigraphy  
of  
deep-marine Mount Messenger Formation (Miocene),  
eastern-margin Taranaki Basin, New Zealand**

**Enclosures and appendices**

Thesis for partial fulfillment of Candidatus scientiarum degree in  
sedimentology/petroleum geology  
for  
**Kristian Helle**

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This volume contain enclosures and appendices to “*Anatomy and allostratigraphy of deep-marine Mount Messenger Formation (Miocene), eastern-margin Taranaki Basin, New Zealand*” which is a thesis for partial fulfillment of Candidatus Scientiarum degree in petroleum geology/sedimentology for Kristian Helle. A total of 9 enclosures and 2 appendices are included:

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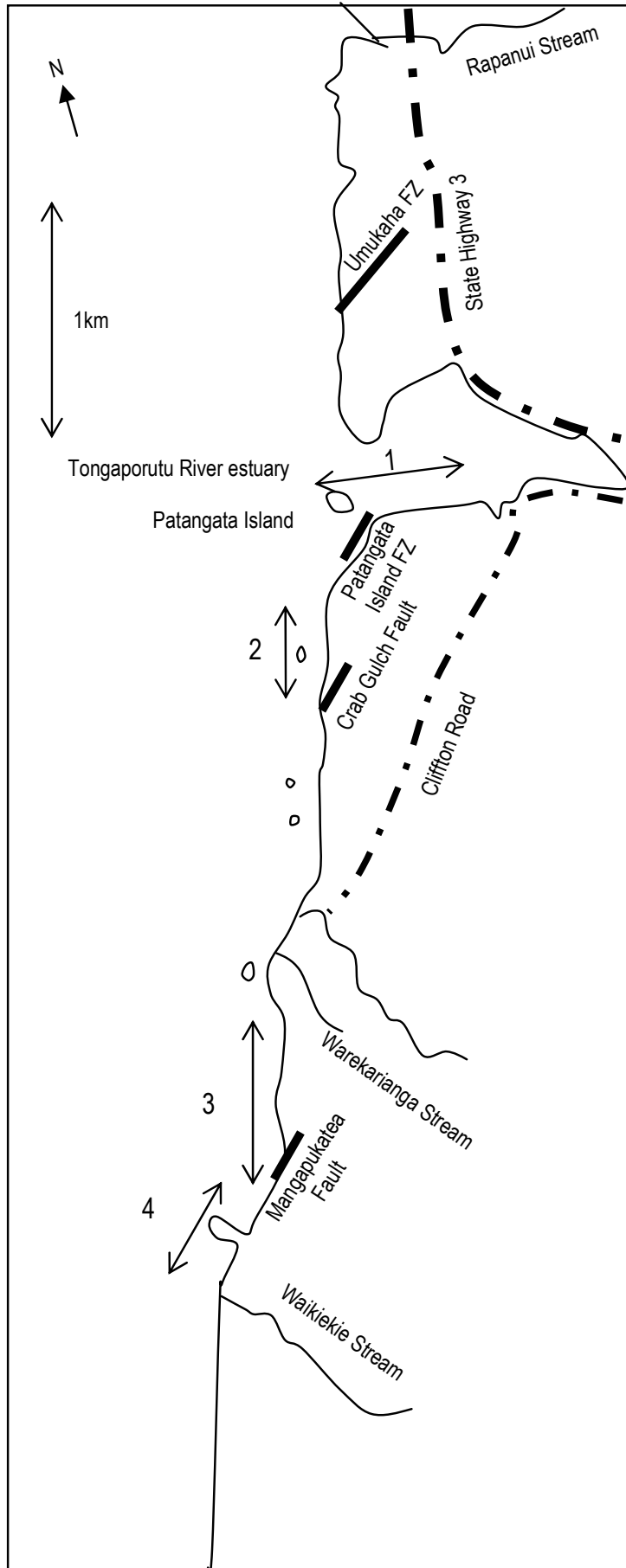
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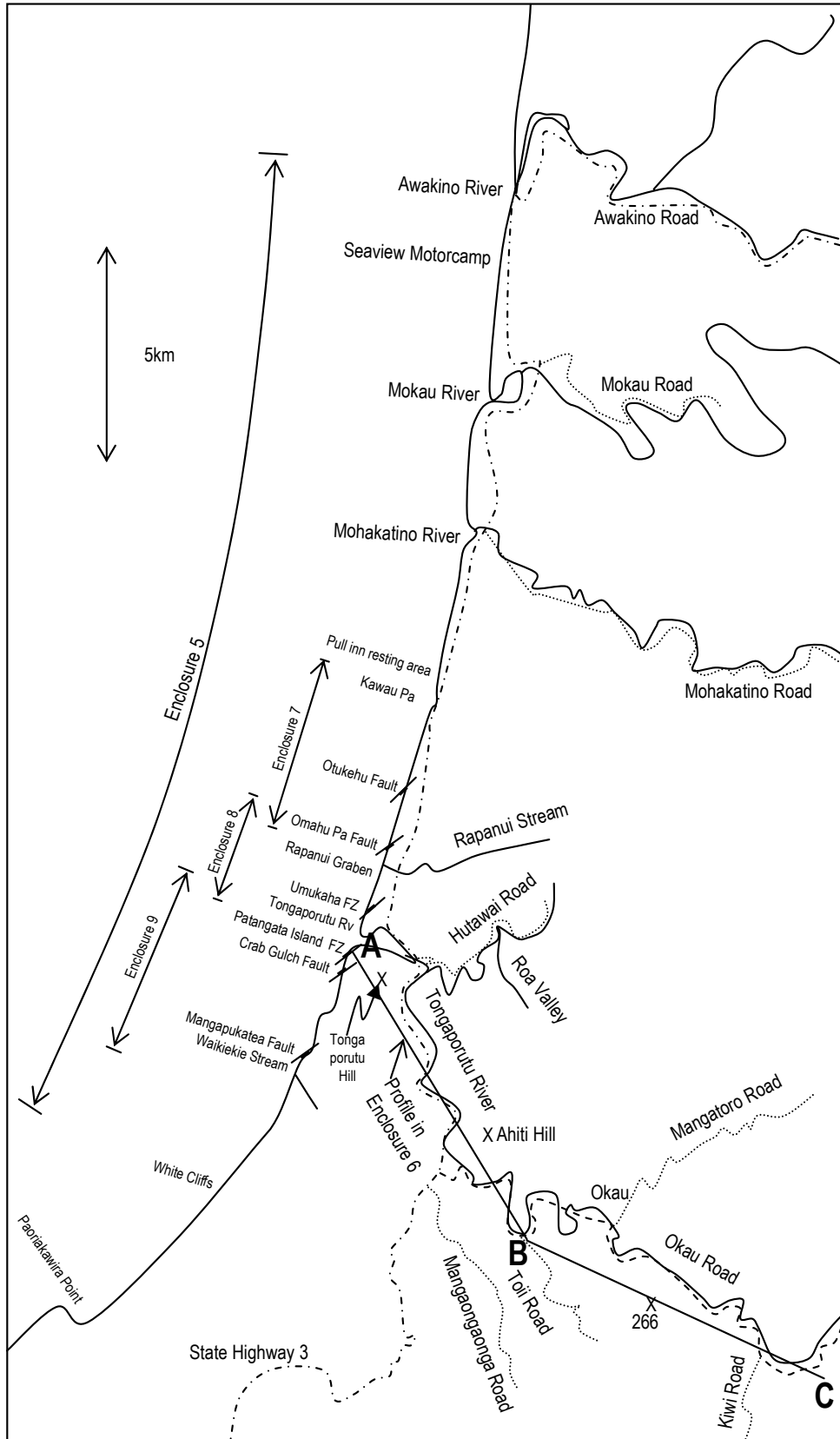
- 1. Appendix I** Detailed correlations across Omahu Pa Fault, Umukaha Fault Zone and Patangata Island Fault Zone.
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**Enclosures**



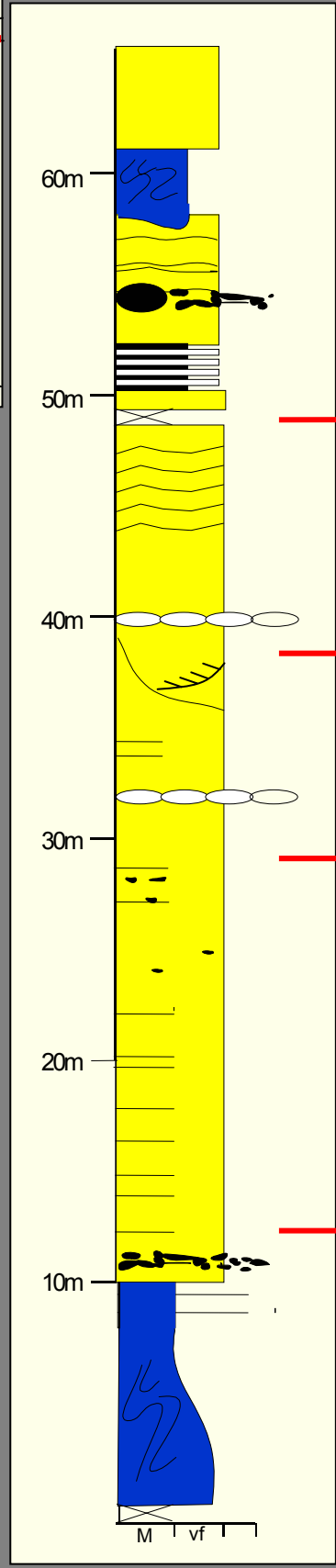
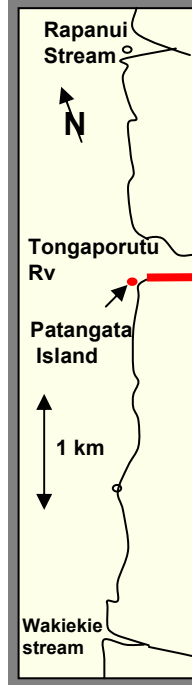
Localities of Enclosure 1-4 marked with numbers 1-4 on map. Map redrawn from King et al. (1993).





Overview of localities and position of profiles in Enclosure 5-9. Map drawn from NZMS 260 Q18 Tongaporutu Edition 1, published by Department of Land and Survey, New Zealand.



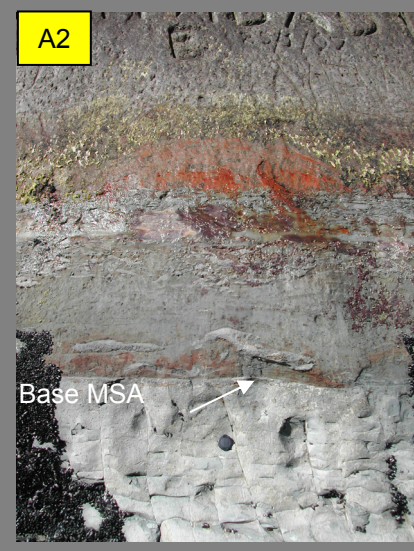
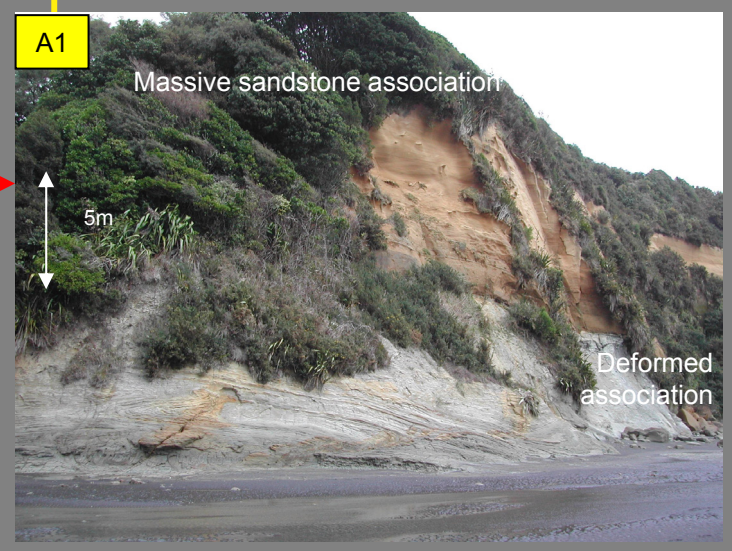


Amalgamation surfaces

Channel with climbing ripples and mudclasts

Dewatering structure

Base of MSA

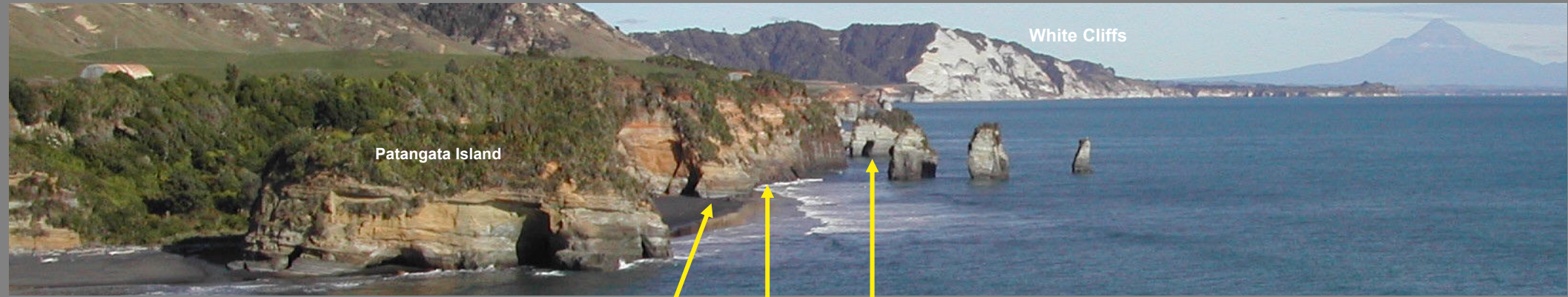
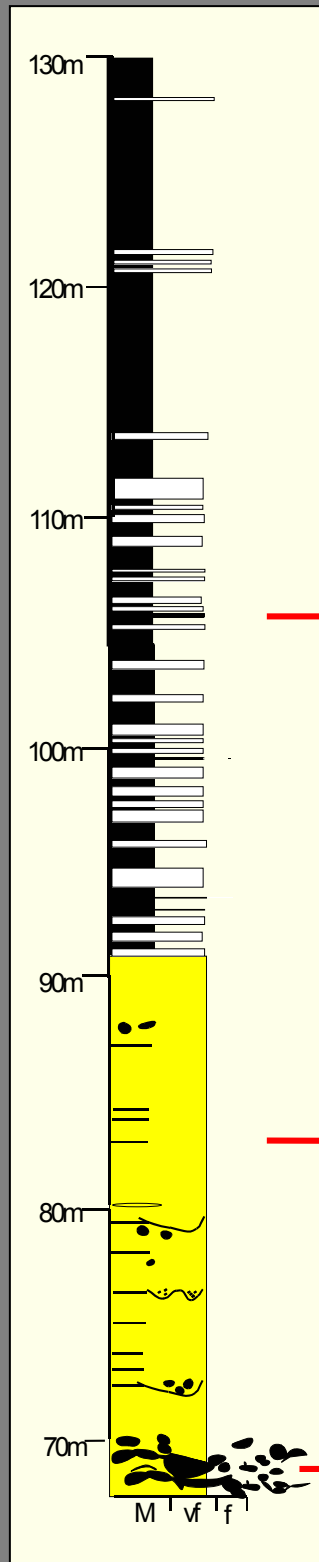
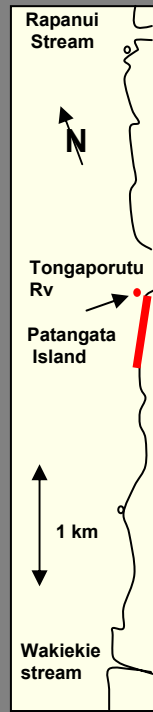


**Enclosure 1:** Massive sandstone association, southern bank of Tongaporutu River estuary. Position of panorama picture and logged section indicated by red line on map in upper left corner.  
**A:** Erosive base of massive sandstone association. Note rip-up clasts.  
**B:** Dewatering processes caused 40cm relief on mudstone lithofacies.  
**C:** Channel with climbing ripple lamination and rip-up clasts truncates thick-bedded sandstone lithofacies.  
**D:** Amalgamation surfaces.

**Legend enclosures 1-4**

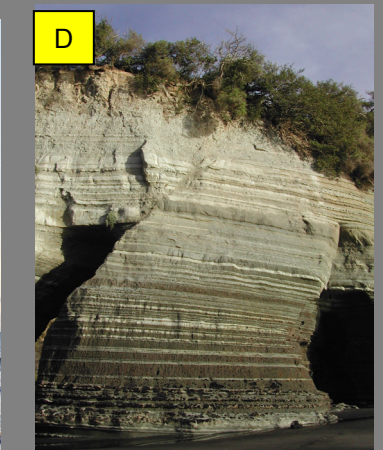
	Massive sandstone association		Concretion
	Deformed association		Climbing ripple lamination
	Heterolithic association		Ripple lamination
	Finely-laminated sandstone association		Planar lamination
			Mudstone clasts
			Scour
			Amalgamation surface





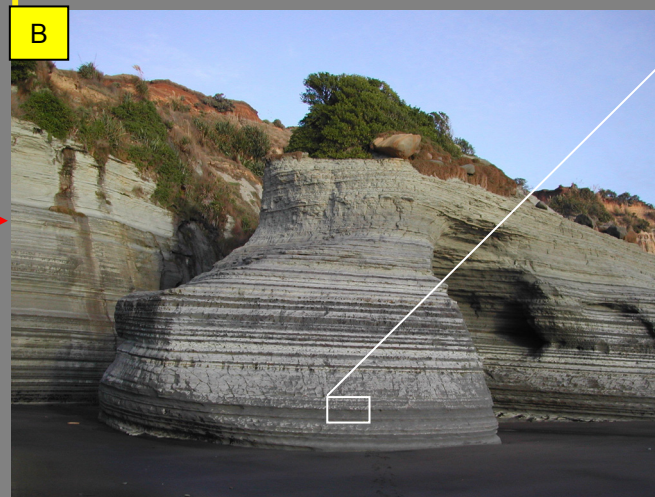
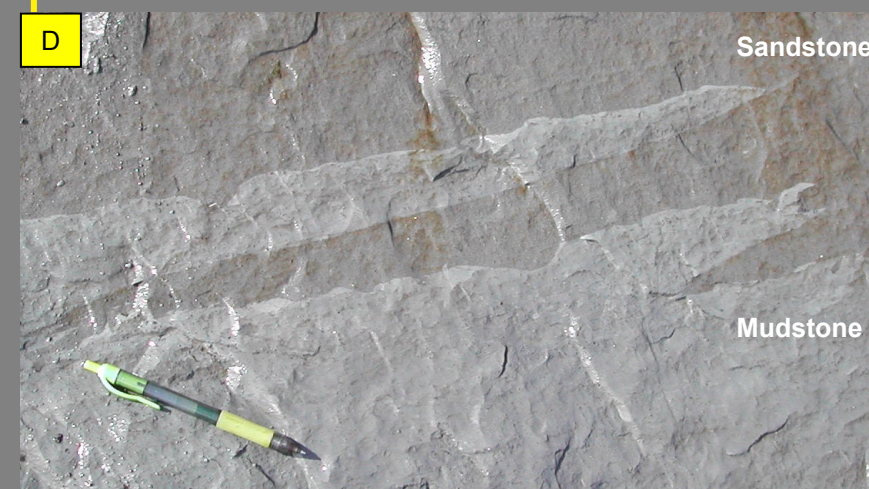
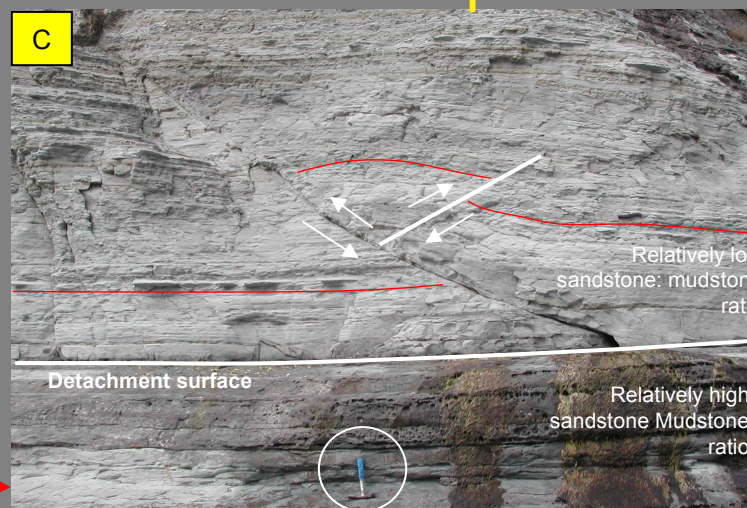
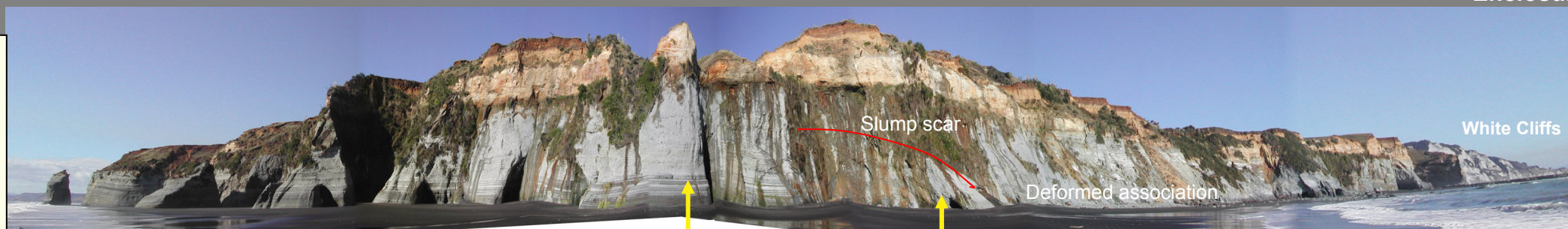
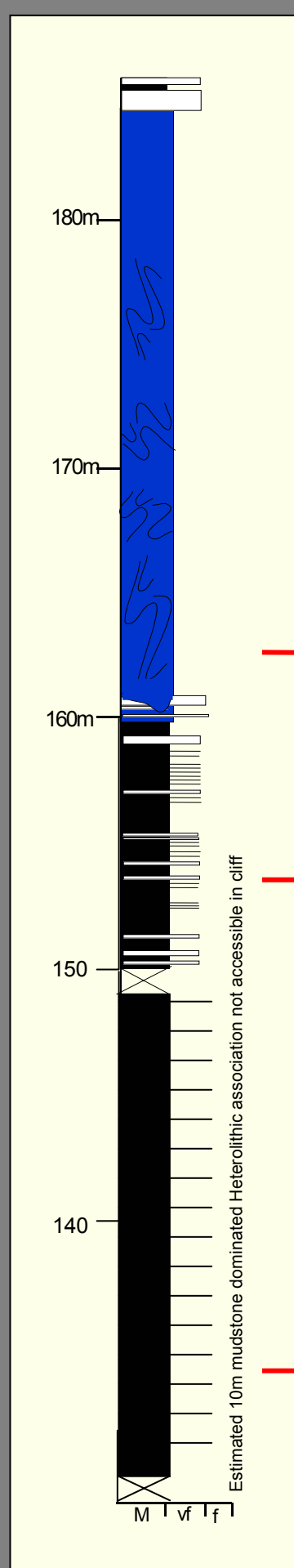
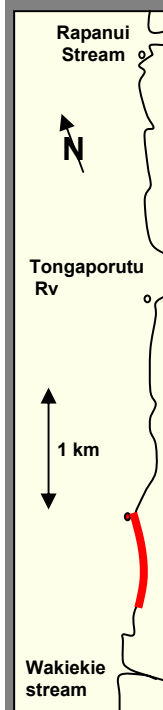
Thinning upwards from massive sandstone association to heterolithic association

Erosive relief of massive sandstone association



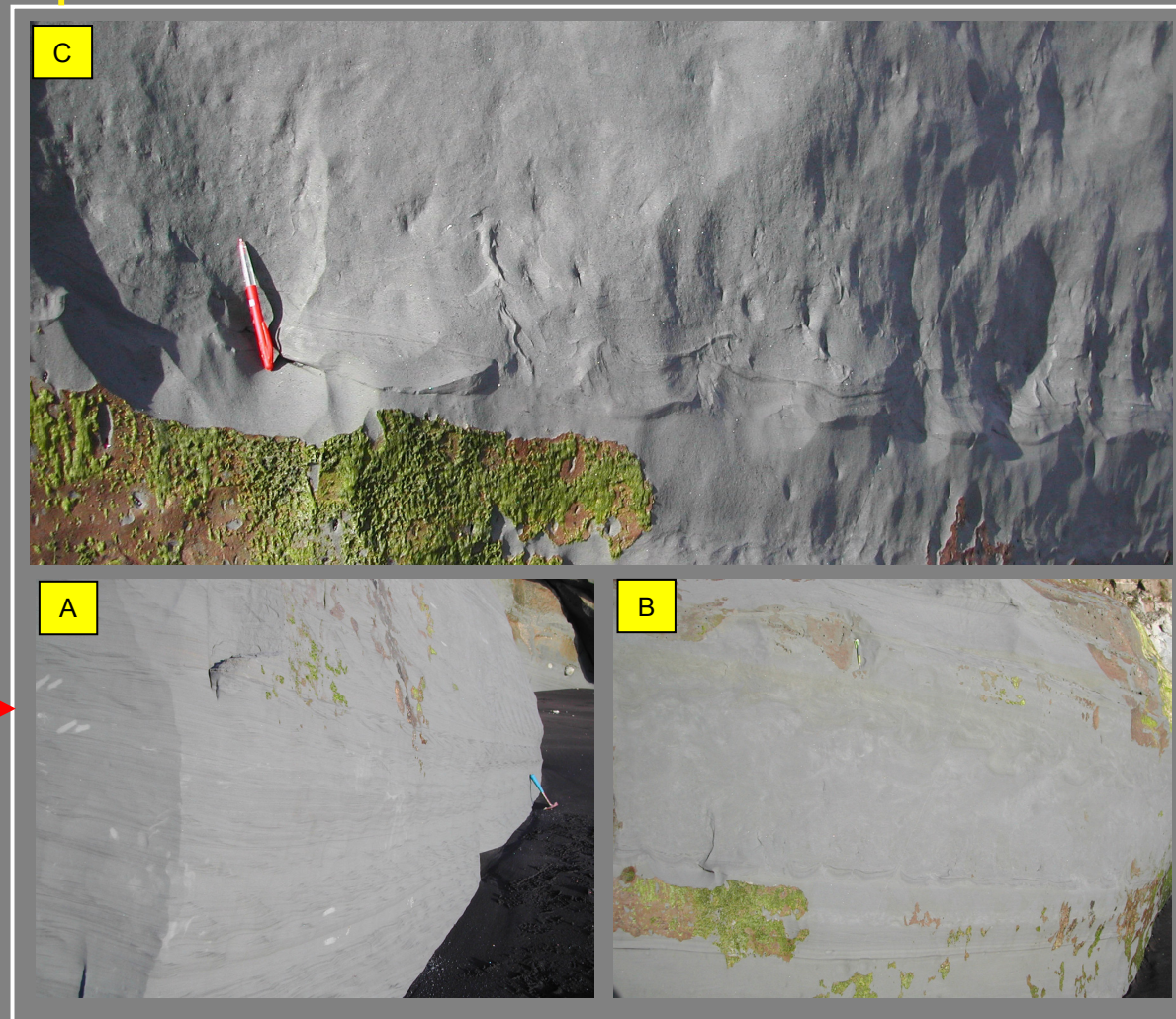
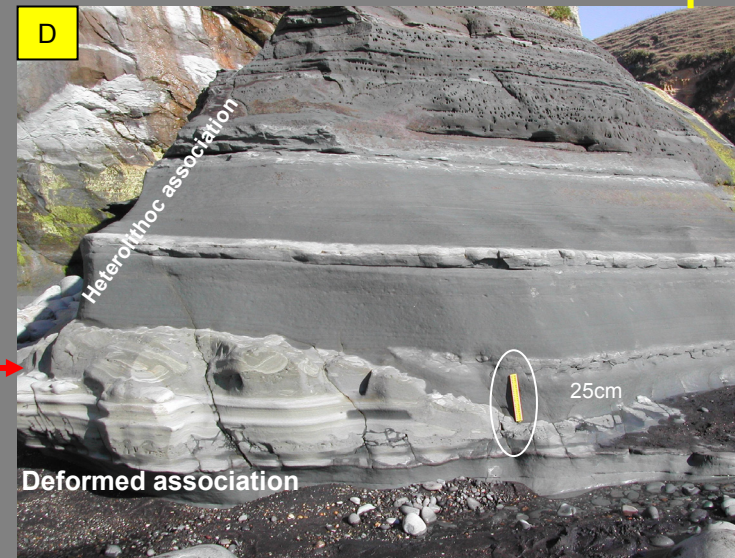
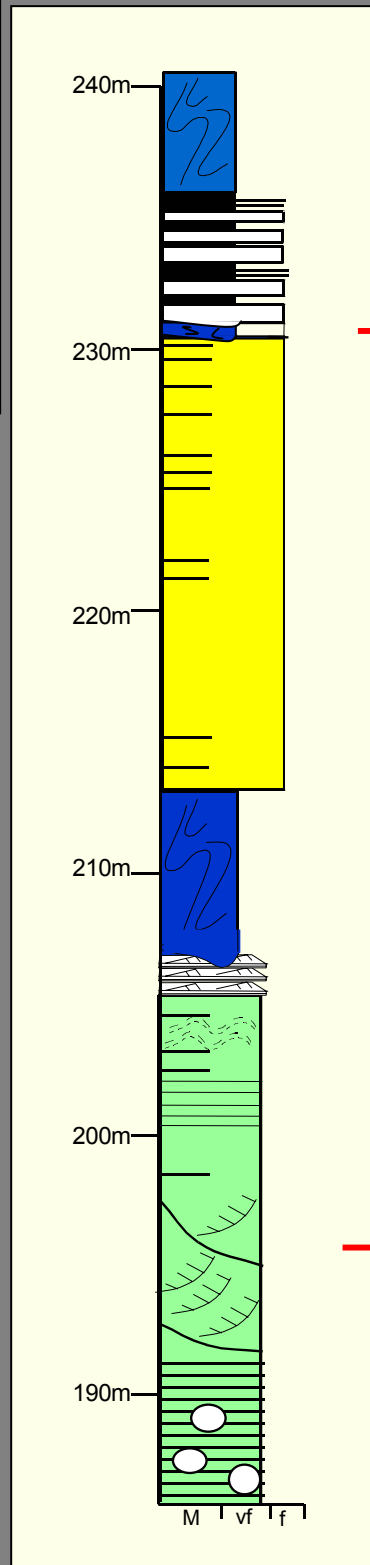
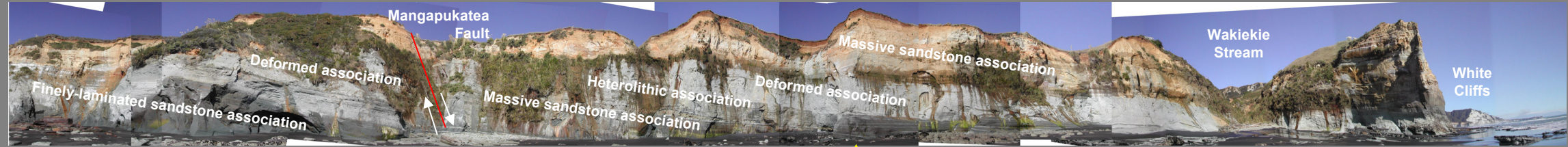
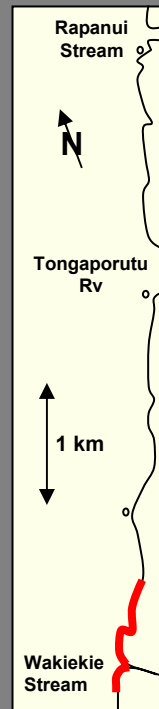
**Enclosure 2** Massive sandstone association and heterolithic association, Tongaporutu Beach.  
**A:** Ripped-up, mudstone conglomerate lithofacies. Sandstone dark colored.  
**B:** Erosive lower boundary of thick-bedded sandstone lithofacies.  
**C:** Thinning up from massive sandstone association to heterolithic association. Stack about 15m high  
**D:** Close up of thinning up succession on stack in C.  
**E:** Close up of stack in C & D, thin-bedded sandstone lithofacies, ripple laminated tops. **F:** Compensation style bedding of thin-bedded sandstone lithofacies (white arrows). Position of panorama picture and logged section indicated by red line on map in upper left corner. See Enclosure 1 for legend.





**Enclosure 3** Heterolithic association and deformed association. Sandstone dark colored.  
**A:** Beds of thick-bedded sandstone lithofacies are overall thinning upwards, with minor thinning upwards sequences superimposed.  
**B:** Heterolithic association; Mudstone lithofacies intensely bioturbated. Thin ripple laminated beds of thin-bedded sandstone lithofacies.  
**C:** Syn-sedimentary faulting caused by stress against slump scar during slump movement.  
**D:** Sand injected into mudstone due to stress against the slump scar during slump movement.  
 Position of panorama picture and logged section indicated by red line on map in upper left corner. See Enclosure 1 for legend.





**Enclosure 4** Laminated-sandstone association, heterolithic association and deformed association.

**A:** Climbing ripple lamination of finely-laminated sandstone lithofacies.

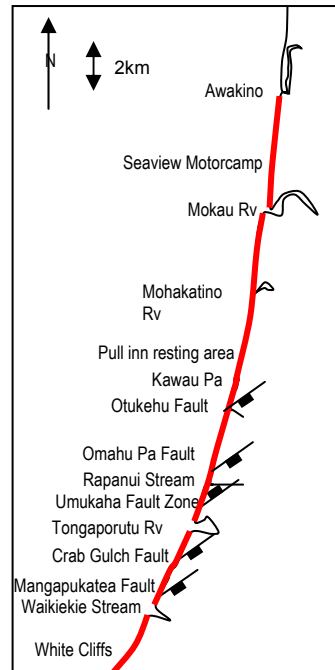
**B & C:** Dewatering structures.

**D:** Thin interval with deformed association overlain by a thin interval of heterolithic association.

**E:** To the south, the heterolithic association in D is truncated by the overlying deformed association.

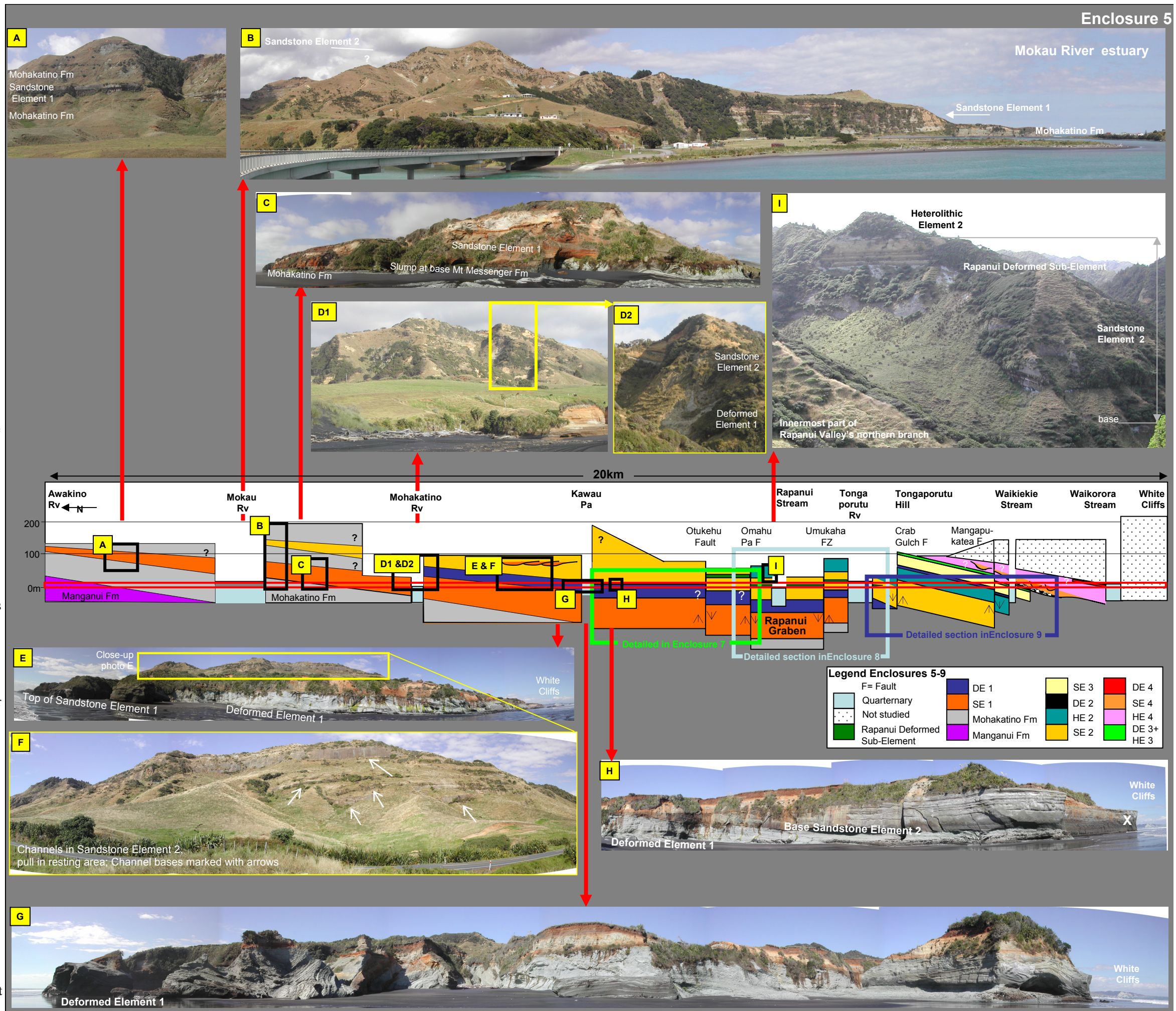
Position of panorama picture and logged section indicated by red line on map in upper left corner. See Enclosure 1 for legend.





**Enclosure 5** Profile and photos of coast near outcrops between Awakino and White Cliffs (red line on map). Inland exposures have been projected down to the coastal cliffs along strike of faults (050 degrees). Major topographical relief is included in profile. Black squares labeled A-I indicate stratigraphy shown in photos labeled A-I. Colored squares refer to detailed profiles in Enclosure 7, 8 and 9. Red frame along profile represent strata exposed in coastal cliff transect. Patangata Fault Zone is not marked in figure due to reasons of space.

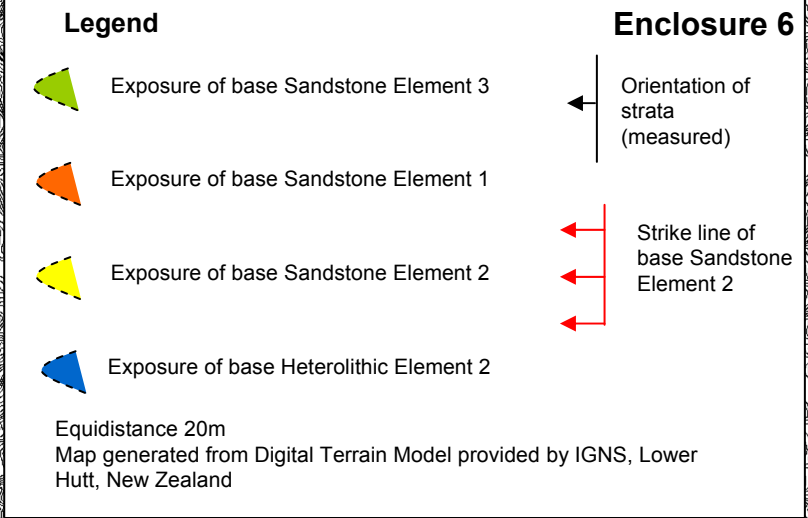
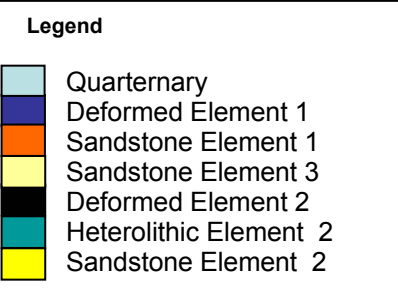
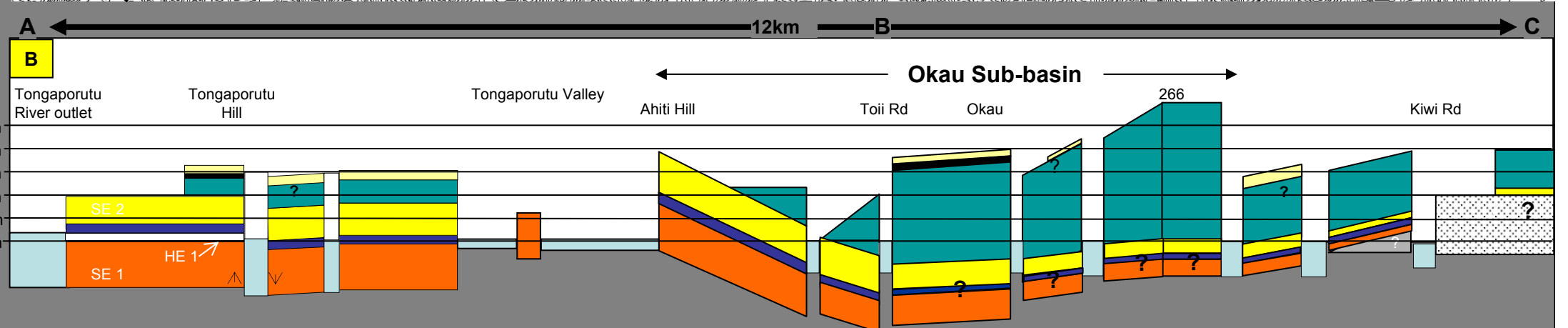
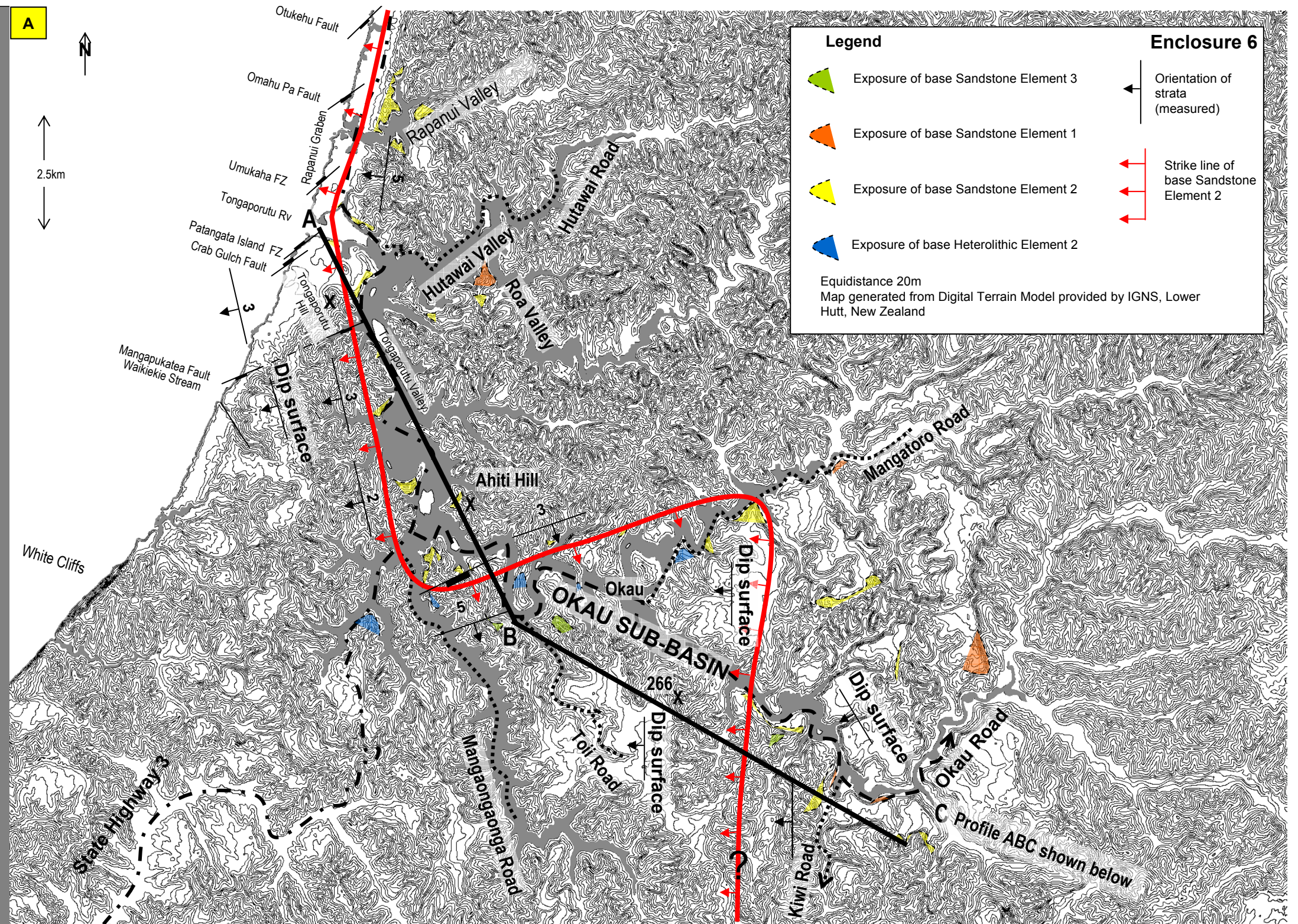
- A:** Northernmost exposure of Sandstone Element 1.
- B:** Exposures of Sandstone Element 1 and 2 at Mokau River estuary.
- C:** Coastal cliff exposure of base Mount Messenger Formation.
- D:** Exposure of Deformed Element 1 and base Sandstone Element 2 at abandoned coastal cliffs
- E:** Deformed Element 1 erosively overlies Sandstone Element 1.
- F:** Channel complex in Sandstone Element 2.
- G:** Deformed Element 1 at Kawau Pa.
- H:** Base Sandstone Element 2.
- I:** Northernmost exposure of Rapanui Deformed Sub-Element and Heterolithic Element 2.



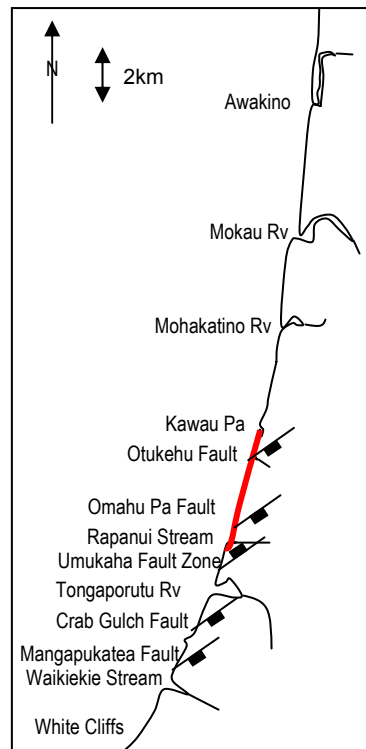


**Enclosure 6 A:** Mapped areas inland of the coastal cliff transect. Locations where lower contacts of Sandstone Element 1, 2, 3 and Heterolithic Element 2 are exposed marked on map. The strike line (marked red) of base Sandstone Element 2 construct a S-shape. Black line marked ABC on map correspond to ABC on profile.

**B:** Profile of architectural elements toward south-east. Heterolithic Element 2 thickens markedly toward the south-east to 266. East of 266, the element is markedly thinner. The element is interpreted to have been deposited in a syn-sedimentary subsiding sub-basin (Okau Sub-Basin). However, the correlation of Sandstone Element 3 from west of 266 to east of 266 is uncertain.

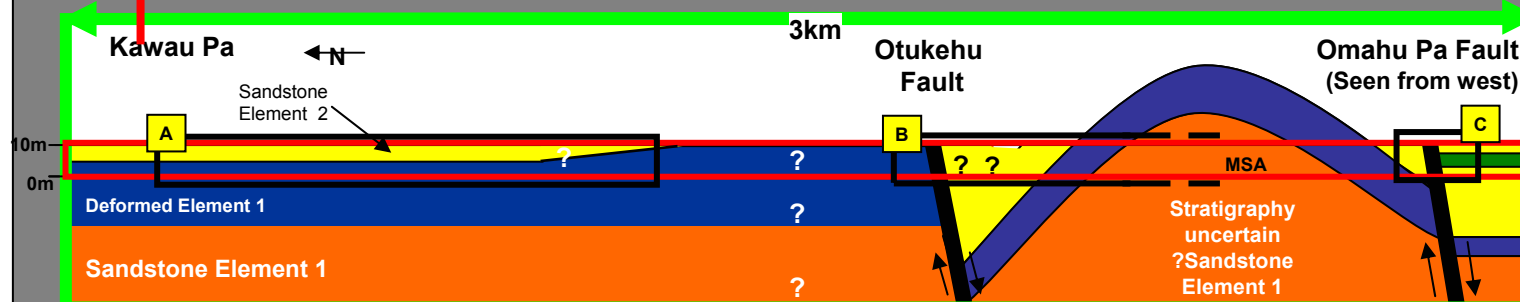




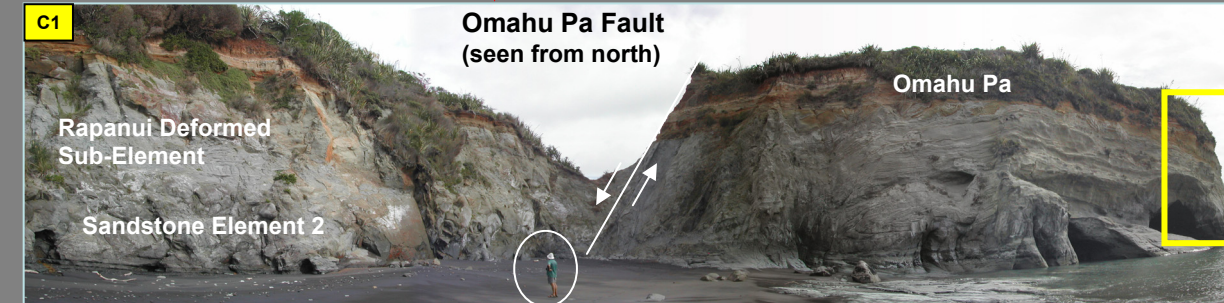
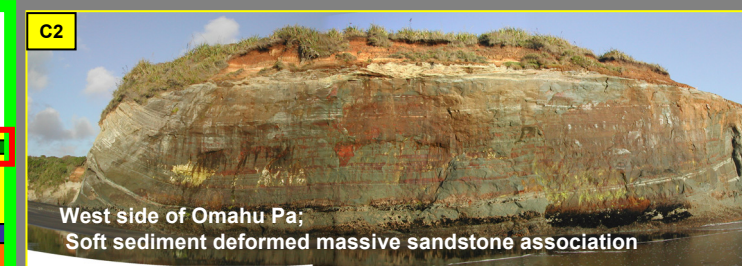


**Enclosure 7** Idealized profile of coastal outcrops between Kawau Pa and Omaha Pa Fault.

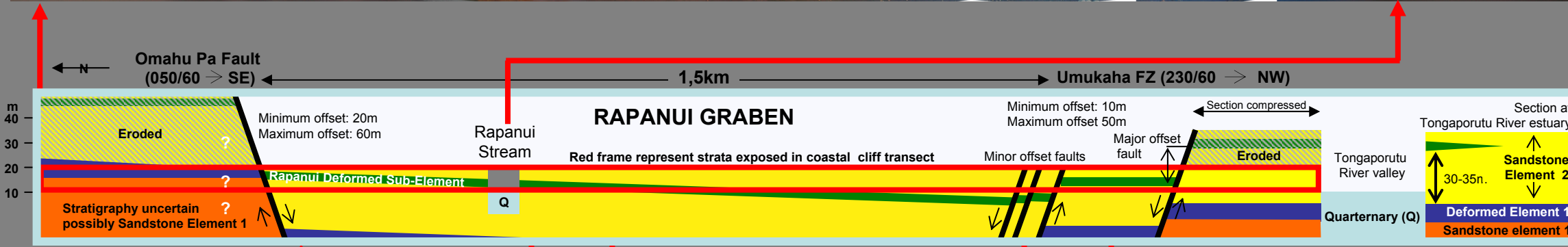
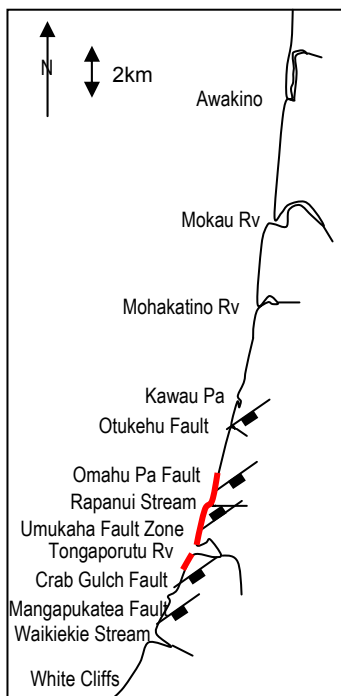
**A:** Section from Kawau Pa to Otukehu Fault is dominated by soft sedimentary deformation making stratigraphy uncertain. However, Sandstone Element 2 can be traced toward the south for 1km. X-marked cliff to the left in photo corresponds to X-marked cliff in enclosure 5 H. **B & C:** Footwall of Otukehu - and Omaha Faults both contain deformed massive sandstone association and possibly represents time equivalent strata. See Enclosure 5 for legend.



Green frame refers to green frame in Enclosure 5



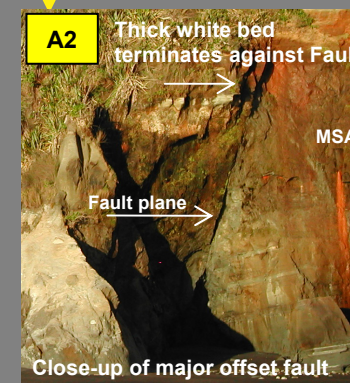




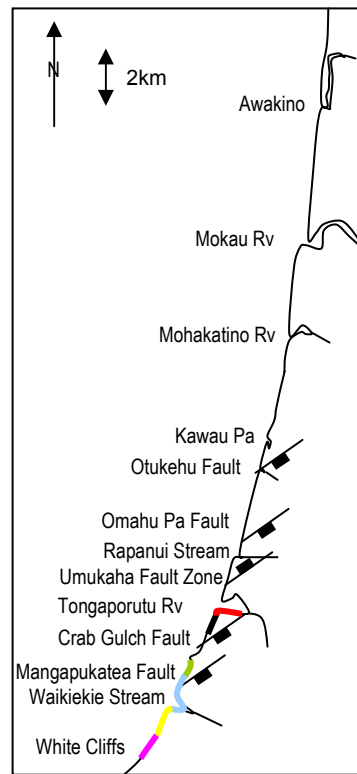
Light blue frame refers to light blue frame in Enclosure 5

**Enclosure 8** Structure and stratigraphy of the Rapanui Graben.

**A:** Umukaha FZ juxtaposes massive sandstone association and Rapanui Deformed Sub-Element.  
**B, C, D & E:** The strata can be traced from Umukaha FZ to Omahu Pa Fault.  
**E:** Omahu Pa Fault Plane.  
**F:** Omahu Pa is a block of soft sedimentary deformed strata far to big to represent the same deformed element as Rapanui Deformed Sub-Element. Omahu Pa probably exposes to Deformed Element 1. Topographical position shown with red line on map above. Red arrows indicates position of photo within coastal cliff. Yellow frames represent enlarged part in succeeding photo. Red frame along profile represent strata exposed in coastal cliffs.







**Enclosure 9** Photos from coastal cliff transect between Tongaporutu River estuary and just south of Waikiekie Stream. Color on frame of photos A-E refer to colored line on map above.

**A:** Southern bank of Tongaporutu River estuary; Stratigraphy between Deformed Element 1 and Rapanui Deformed Sub-Element exposed.

**B:** Upwards thinning from Sandstone Element 2 to Heterolithic Element 2.

**C:** Heterolithic Element 1 is erosively overlain by Deformed Element 2 which thickens towards the north.

**D:** Complex architecture of Sandstone Element 3; LSA Sub-Element and DA Sub-Element terminates against Mangapukatea Fault plane whereas MSA Sub-Element is down-faulted to beach level by Mangapukatea Fault.

**E:** Coastal exposure of Sandstone Element 4. Photo E stitched by Malcom Arnot.

**F:** Thinning up from Sandstone Element 4 to Heterolithic Element 4



Blue frame refers to blue frame in Enclosure 5



## **Appendices**

## ***Appendix I***

**Calculation of throw on Patangata Island -and Umukaha Fault Zone:** the strata at Patangata Island can be correlated across Patangata Fault Zone to Tongaporutu Beach but not to the southern bank of Tongaporutu River estuary. However, faults exposed south of Tongaporutu Beach project east of Tongaporutu River estuary and consequently the Tongaporutu River estuary -and Tongaporutu Beach sections belong to the same fault block. Patangata Island Fault Zone must therefore have an throw of more than the cliff face at the south-east side of the fault zone (10m) but less than the distance between the projection of the thick white marker bed exposed at the northern end of Tongaporutu Beach section and the same bed exposed at Patangata Island (15m) (Bed III in Figure 3.15) (distance between Patangata Island and start Tongaporutu Beach 220m, apparent N-S dip 4°).

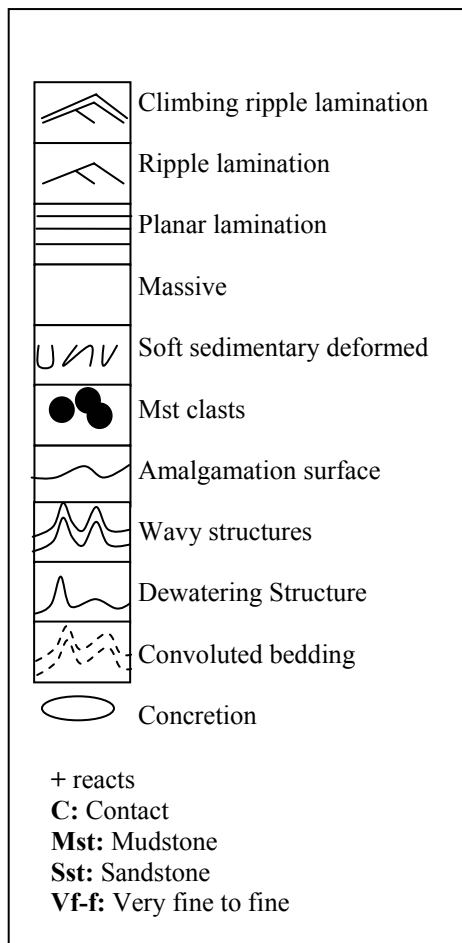
*Umukaha Fault Zone* must have a throw of more than the cliff face (i.e. 10m). Between Umukaha Fault Zone and Tongaporutu River estuary, only MSA laterally equivalent to the MSA exposed on the southern bank of the estuary is exposed. Therefore, the marker beds present on both sides of Umukaha Fault Zone exclude a throw of more than the stratigraphic thickness between Deformed Element 1 and the marker beds. This stratigraphic interval is exposed along the southern part of Tongaporutu River estuary: the stratigraphic thickness from the top of Deformed Element 1 to the base of the estuary is approximately 25m. In addition the thickness from the base of the exposure at Patangata Island to the marker beds is approximately 10m. An additional 10-15m must be added due to the throw of *Patangata Island Fault Zone* between Patangata Island and Tongaporutu River estuary section: the maximum throw of Umukaha Fault Zone is therefore likely to be between 45-50m.

**Calculation of throw on Omahu Pa Fault:** Umukaha Fault Zone juxtaposes MSA and Rapanui Deformed-Sub Element whereas Omahu Pa Fault juxtaposes a stratigraphically lower soft-sediment deformed (Sandstone Element 2) interval and Rapanui Deformed Sub-Element. This suggests a minimum additional throw on Omahu Pa Fault equal to the exposed height of the soft-sedimentary deformed block at Kawau Pa (additional 10m: total 20-45m throw).

## Appendix II

Appendix II contains sedimentary logs from the detailed study area between Tongaporutu River estuary and Waikiekie Stream. The section was logged at different scales due to the different outcrop quality at different locations. The scale of the logs in this appendix therefore varies, but is indicated on upper right corner of every page.

### Legend to sedimentary logs



Map of detailed study area between Tongaporutu River estuary and Waikiekie Stream outlet. Numbered sections refer to sedimentary logs. Map redrawn from King et al. (1993).

