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Geoscience Society of New Zealand 2011 Conference

FIELD TRIP GUIDE


St Arnaud, Lake Rotoiti, Alpine Fault


Mt Owen marble massif


Marlborough Sounds


Awaroa Bay, Abel Tasman National Park

NELSON 27 November - 1 December 2011

Geoscience Society of New Zealand


Abel Tasman National Park

Geosciences 2011

Annual Conference of the Geoscience Society of New Zealand
Nelson, New Zealand

Field Trip Guide

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Geosciences 2011

Annual Conference of the Geoscience Society of New Zealand,
Nelson, New Zealand

Field Trip 7
Tuesday 29 November 2011

Waimea – Flaxmore Fault System and Geohazards in Nelson

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Bibliographic reference:
Wopereis, P. 2011. Waimea - Flaxmore Fault System and Geohazards in Nelson. *In*: Lee, J.M. (ed).
Field Trip Guides, Geosciences 2011 Conference, Nelson, New Zealand.
Geoscience Society of New Zealand Miscellaneous Publication 130B. 19 p.

ISBN 978-1-877480-14-0
ISSN (print) 2230-4487
ISSN (online) 2230-4495

HEALTH AND SAFETY ISSUES

PLEASE READ!

There are certain inherent hazards in geology field trips especially when clambering about rocks. Caution should therefore be exercised especially at the Magazine Point field stop and at the Flaxmore Quarry stop. Caution must also be exercised when walking on the farm track locations where vehicles or machinery may be in use and the ground may be slippery. Be aware of farm animals and do not disturb.

Participants must heed and observe the warnings and time limitations imposed at certain stops by the trip leader.

Participants should carry any personal medications, including those for allergic reactions (eg. insect stings, pollen, food allergies).

The weather in November can be variable, although we hope for warm sunny conditions! Participants need to be prepared for possible wet, and/or windy conditions. The expectation is that temperatures would be in the range 15–25°C. A sunhat, sun cream, sunglasses, waterproof and windproof raincoat, and warm clothing (layers) are essential. If the weather is warm, drink plenty of water to combat dehydration.

An average level of fitness and mobility is required for this trip; there will be some clambering over rocks and some short walks (up to 0.5 km at any given stop). Underfoot conditions include hard rocky outcrops, grass, slopes, and potentially loose and slippery surfaces.

At the Flaxmore Quarry participants are required to wear hard hats and orange safety vests, which will be provided. Steel caps are not required. Lightweight boots are recommended footwear; some participants may also wish to use sturdy walking shoes.

Take care and have a safe and enjoyable field trip.

Introduction

This field trip will examine a section of the Waimea-Flaxmore Fault System between Brightwater and Nelson. It will also look at landslides and other geohazards, and aspects of Nelson urban geology. The trip will include stops to see the Port Hills Gravels (late Miocene – early Pliocene), Tahunanui Slump, Magazine Point Formation (late Oligocene – early Miocene), Bishopdale Conglomerate (Cretaceous?) and Brook Street Group (Permian). A shallow trench excavation exposing the Waimea Fault behind Richmond will be viewed. A stop will also be made at Flaxmore Quarry to inspect the Flaxmore Fault.

A geology map of the field trip area will be provided separately from this field trip guide as two A3 sheets and an accompanying legend. This map is the work of Jeff Fraser who compiled it as part of his MSc thesis entitled “A Paleoseismic Investigation of the Waimea - Flaxmore Fault System, Nelson Region” in 2005. This map is provided with permission of the author. The field trip stops are marked on the map. Paleoseismic studies from two trenches on the Waimea Fault south of the Wairoa River have revealed that there have been three earthquake ruptures of the fault in the past 20 ka.

Stop 1 Princes Drive Lookout, Tasman Heights

Princes Drive lookout is an excellent vantage point to take in the panorama looking south from Nelson with the uplifted Richmond Range on the east and the Arthur and Owen ranges on the west. The Waimea Fault follows approximately along the toe of the lower eastern foothills known as the Barnicoat Range. The Waimea Fault is part of the Waimea-Flaxmore Fault System which branches off the Alpine Fault near St Arnaud. The Waimea-Flaxmore Fault System has a number of surface traces extending ~90km northwards as far as the Whangamoa Valley north-east of Nelson. Field evidence for active fault traces tends to diminish northwards and may indicate that northern parts of the fault system rupture less frequently than southern parts of the system. Across the northwest part of the South Island ongoing compression is occurring in a WNW – ESE direction in response to movement across the plate boundary. The compression is normal to the predominant NNE-SSW direction of major faults in this part of New Zealand and since the mid-Miocene has resulted in reactivation of previously normal faults, which are now reverse in sense of direction (Sibson and Ghisetti 2010).

The Waimea Fault system separates the uplifted basement rocks of the eastern ranges of Nelson from the down-faulted Moutere Depression. This depression is infilled with a vast volume of clay-bound terrestrial gravels of the Moutere Gravel Formation (late Pliocene ~1.8-3 Ma in age) derived from the rising Southern Alps to the south and transported by rivers which once flowed northwards into the Tasman Bay area. The formation is up to 650m thick. The clasts in the Moutere Gravel are almost entirely Torlesse greywacke with minor semi-schist and there is a noticeable absence of clasts derived from the nearby Richmond, Owen and Arthur ranges, indicating that these ranges had not been significantly uplifted at the time of Moutere Gravel deposition. Evidence from two onshore petroleum wells (Ruby Bay-1 and Tapawera-1) and from seismic, gravity and magnetic surveys has revealed that a sequence of Tertiary soft sedimentary rocks underlies the Moutere Gravels within the Moutere Depression and extends to a depth of up to 1650m beneath Richmond and 1500m beneath Brightwater near the eastern margin of the depression (Anderson 1980). The Tertiary sedimentary rocks are exposed along the eastern margin of the Moutere Depression where they are outcropping to the west of the Waimea Fault. They have been described in detail by Mike Johnston (1979). Coal was mined from thin seams within the Marsden Coal Measures (Eocene) at Brook Street, Enner Glynn (east of Stoke) and near Reservoir Creek (east of Richmond).

The main NE-SW trending active faults of the Waimea-Flaxmore Fault System are from east to west the Whangamoa Fault, the Eighty Eight Fault, The Waimea Fault and the Flaxmore Fault. The Bishopdale Fault is an active west-east trending fault between the Flaxmore Fault and the Waimea Fault.

Princes Drive runs along the crest of the Port Hills which is composed of Port Hills Gravel Formation (late Miocene-early Pliocene) comprising multi-sourced gravel derived from the local Nelson ranges. The lower part of the formation tends to have more granitic clasts (presumably derived from Separation Point Batholith and Tasman Intrusives Group?) and these can be observed in road cut batters. The upper part of the formation has more volcaniclastic clasts derived from the rocks exposed to the east of the Waimea Fault (Johnston 1979). The Port Hills gravels are preserved to the west of the Waimea Fault within two synclines (Port Hills and Marsden synclines).

The Waimea Plains comprise Hope Gravel Formation (late Pleistocene) and Appleby Gravel Formation (Holocene), which collectively are up to 65m thick and contain three main aquifers (Lower Confined, Upper Confined and the Unconfined). Water from these aquifers supplies the township of Richmond and provides irrigation water for horticulture and farming. The Moutere Gravel Formation underlies the Waimea Plains beneath the late Pelistocene and Holcene gravels and also crops out on low ridges behind Richmond and Hope where it bounds the Waimea Fault and does not appear to be folded against the fault.

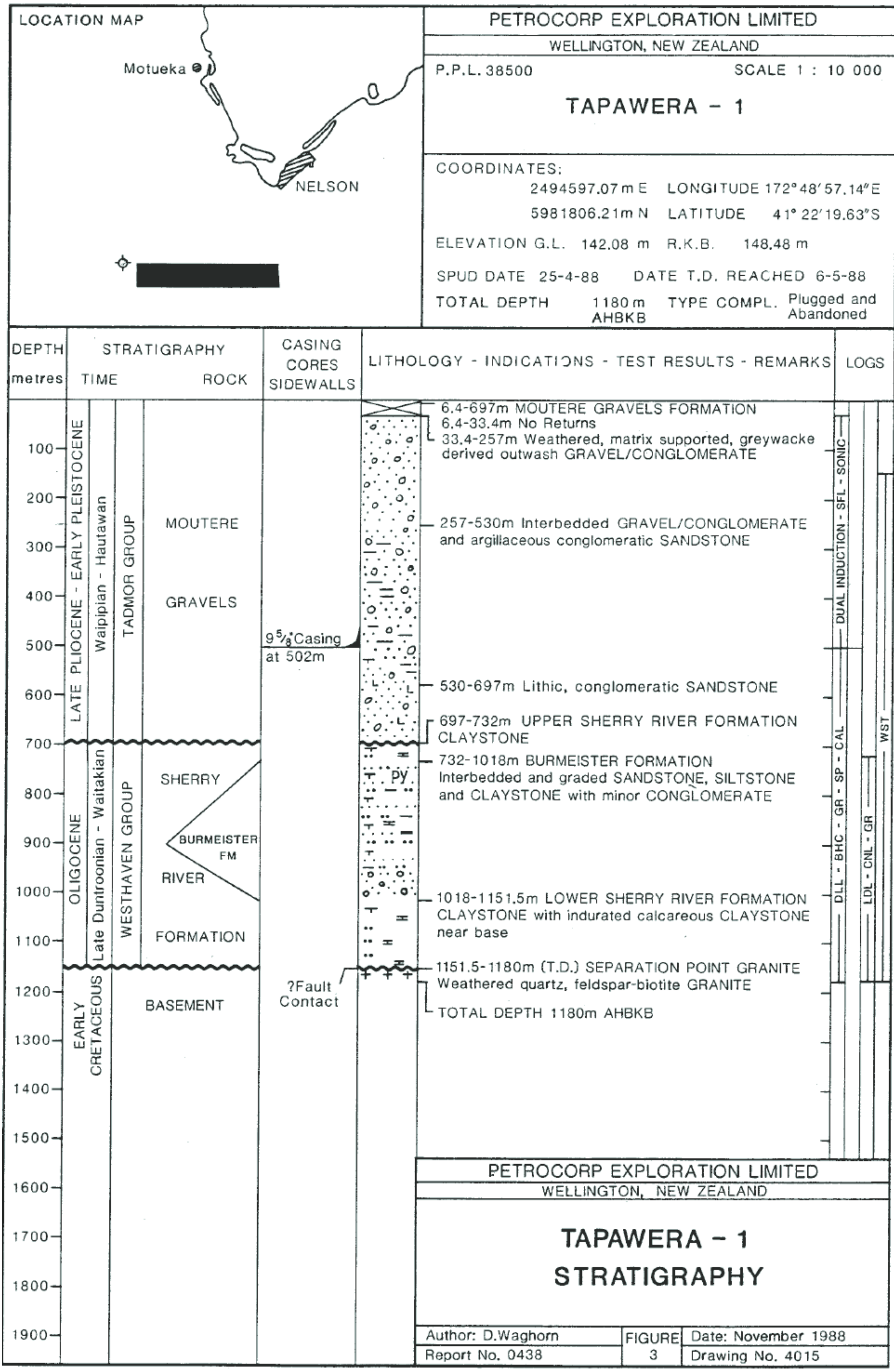


Figure 1.1 Tapawera – 1 Stratigraphy

The suburb of Stoke is built on the Stoke Fan Gravel Formation (late Pleistocene). Monaco Peninsula, Nelson Airport and the suburb of Tahunanui are built on the Tahunanui Sand Formation (Holocene) which has been deposited since the last glaciation sea level rise (circa 7,000 years BP). The Tahunanui sands and areas of hydraulic fill at Port Nelson are considered to be amongst the most liquefaction prone areas near Nelson and would be particularly vulnerable to liquefaction in a large earthquake on the Waimea-Flaxmore Fault System. A significant number of landslides have been identified along the base of the foothills behind Stoke, Richmond and Hope and some of these are likely to be have initiated by local earthquakes. Further research is required on earthquake, liquefaction and landslide hazards in the region in order to assist in emergency management and land use planning.

Stop 2 Magazine Point and Tahunanui Slump, Rocks Road

The Magazine Point Formation (late Oligocene – early Miocene) is a sequence of graded beds of sandstone, siltstone and minor igneous breccia which are exposed on the shore platform and the sea-cliffs along Rocks Road. Arrow Rock (or Fifeshire Rock) is a more resistant remnant of coarse breccia containing clasts of tonalite, syenite and green fine-grained volcanics. The sequence (probably over 1500m thick) unconformably underlies the Port Hills gravels and is steeply dipping to the south-east along the western limb of the Port Hills Syncline. The outcropping exposure is terminated against the northwest trending Stafford Fault, 1km to the north of Magazine Point. The presence of burrowing by *Ophiomorpha*, finely laminated cross bedding and macrofossils indicate a shallow (continental shelf) marine environment and the coarse breccia is likely to have been deposited by debris flows (Lewis 1980). The macrofossils include bivalves, gastropods, echinoids, corals, scaphopods and cephalopods.

A NE-SW trending fault is inferred to lie to the west of the Magazine Point separating steeply dipping Magazine Point Formation from near horizontally bedded Moutere Gravel Formation.

Figure 2.1 Strata of Magazine Point Formation, Rocks Road, Nelson

Tahunanui Slump is a large active landslide feature on the western slope of the Port Hills south of Magazine Point. The slump has approximately 120 houses built upon it and is being monitored by surveying of a network of survey pins by Nelson City Council. Several houses were damaged or destroyed in periods of localized ground movement that occurred in 1929 and 1962 when sections of the slumps moved. The initial slump failure is likely to have occurred as a consequence of undercutting of the toe of the slope by sea erosion. The trigger event for the landslide may well have been a large earthquake somewhere in the Waimea-Flaxmore Fault System. Limited geotechnical investigation on the Tahunanui Slump have revealed that the slump material is mostly silty clays, scattered gravel and some crushed carbonaceous mudstone derived from the Port Hills Gravel Formation. A number of seepage areas and springs occur within the slump and work to improve drainage has been carried out to improve stability. Nelson City Council has attached conditions to the titles of lots to limit further development and to restrict further subdivision.

Other major landslides are present in the Port Hills south of the Tahunanui Slump but are considered to be non-active (Johnston 1979).

The Boulder Bank and Haulashore Island are comprised of cobbles and boulders of granodiorite, diorite, syenite and tonalite derived from the Tasman Intrusives to the northeast and deposited as a result of long shore drift.

At the time of European settlement the Waimea River entered Tasman Bay near Rocks Road and the present day Tahunanui Beach was a sand bar. Active erosion is now occurring at the west end of the beach as the estuary channel is migrating eastwards. Erosion at the east end of the beach during the 1990s eroded away dunes and was threatening the carparks and recreational playground. This erosion problem was alleviated by constructing a low angle concrete apron below Rocks Road (with a stormwater diversion channel underneath) and also by a dune management plan that included fencing and planting.

Rockfall from the cliffs above Magazine Point onto Rocks Road is a hazard to road users and some limited remedial geotechnical work has been carried out to treat some areas of higher risk. The work has included scaling of loose rock, placing rock anchors and shotcrete.

Stop 3 Waimea Fault scarp, Hall farm, Mt Heslington Road, Brightwater

In 2005 trenching was carried out by Jeff Fraser, Mike Johnston and Andy Nicol on the Waimea Fault where it crosses the terraces of the Wairoa River. This trenching is the only trenching on the Waimea Fault that has provided dates of past earthquake events on the fault. We will park by the farm buildings and walk across the paddocks to the view the fault scarp at the sites where the trenching was carried out. Two trenches (identified as Beta and Gamma) were excavated across the Waimea Fault and have provided radiocarbon and OSL (optically stimulated luminescence) dates that constrain the ages of the last three earthquake events, bracketed to have occurred 15.3-20, 7.2-13.8 and 5.7-6.8 ka (Johnston and Nicol 2008). The sense of movement at the fault trace at Mt Heslington Road appears to be entirely reverse and there is no evidence of strike slip movement. The cumulative vertical offset related to the last three fault movements is 3.5m, indicating an average vertical slip between events of slightly more than 1m. Analysis indicates that fault rupture may be achieved during earthquakes of approximately Magnitude 7 (Johnston and Nicol 2008).

The youngest terrace of the Wairoa River (5610 – 5890 cal.years BP) postdates the last fault movement and the trace of the fault terminates at this terrace, then re-appears on the north bank of the Wairoa River where it has been mapped as extending as far north as Aniseed Valley Hill Road. LiDAR imagery flown for Tasman District Council over the area in 2011 clearly reveals the fault scarp offsetting the alluvial terraces (see Figure 4.3).

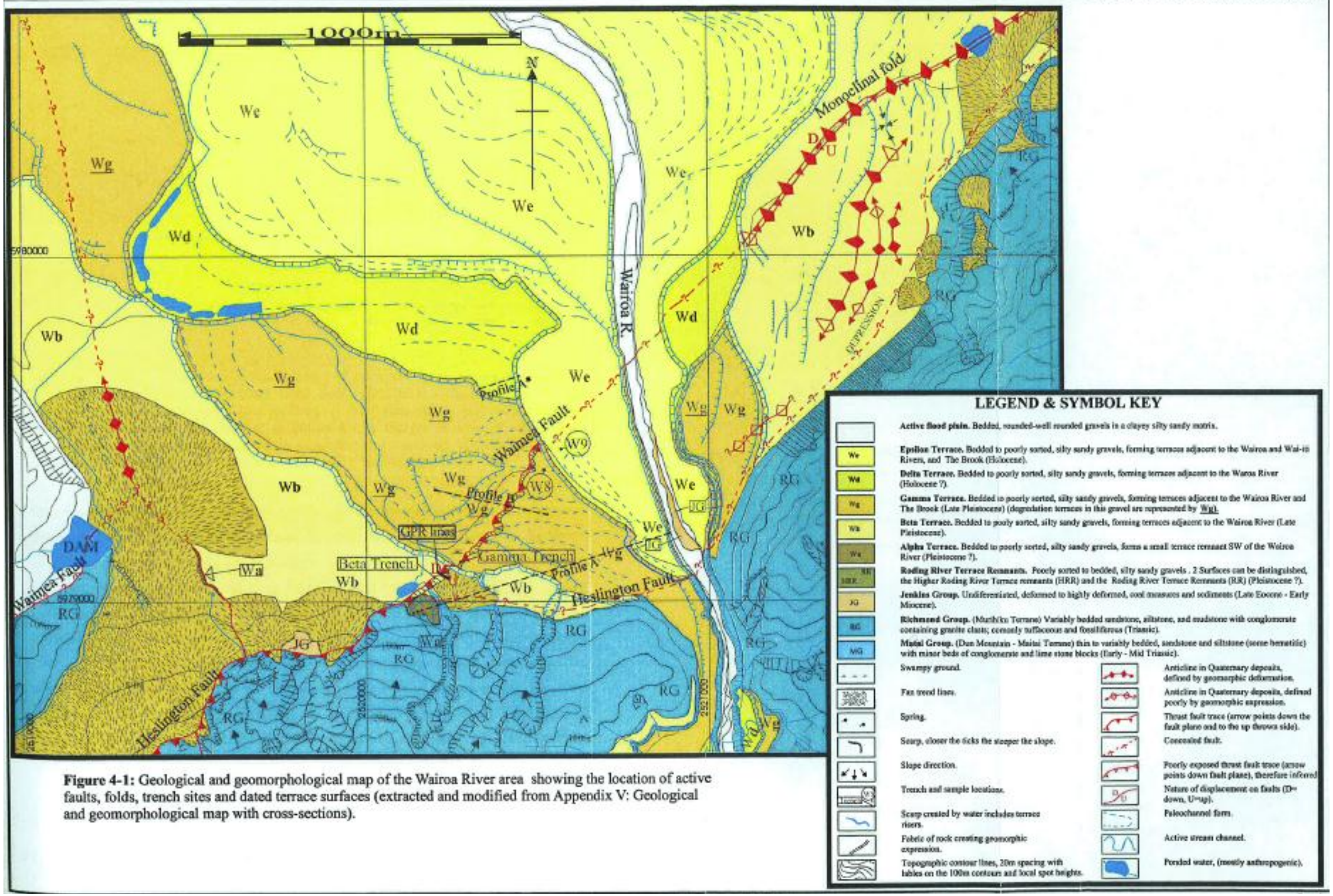


Figure 4-1: Geological and geomorphological map of the Wairoa River area showing the location of active faults, folds, trench sites and dated terrace surfaces (extracted and modified from Appendix V: Geological and geomorphological map with cross-sections).

Figure 4.1 Wairoa River Terraces Plan, Block Diagram and Beta Trench log

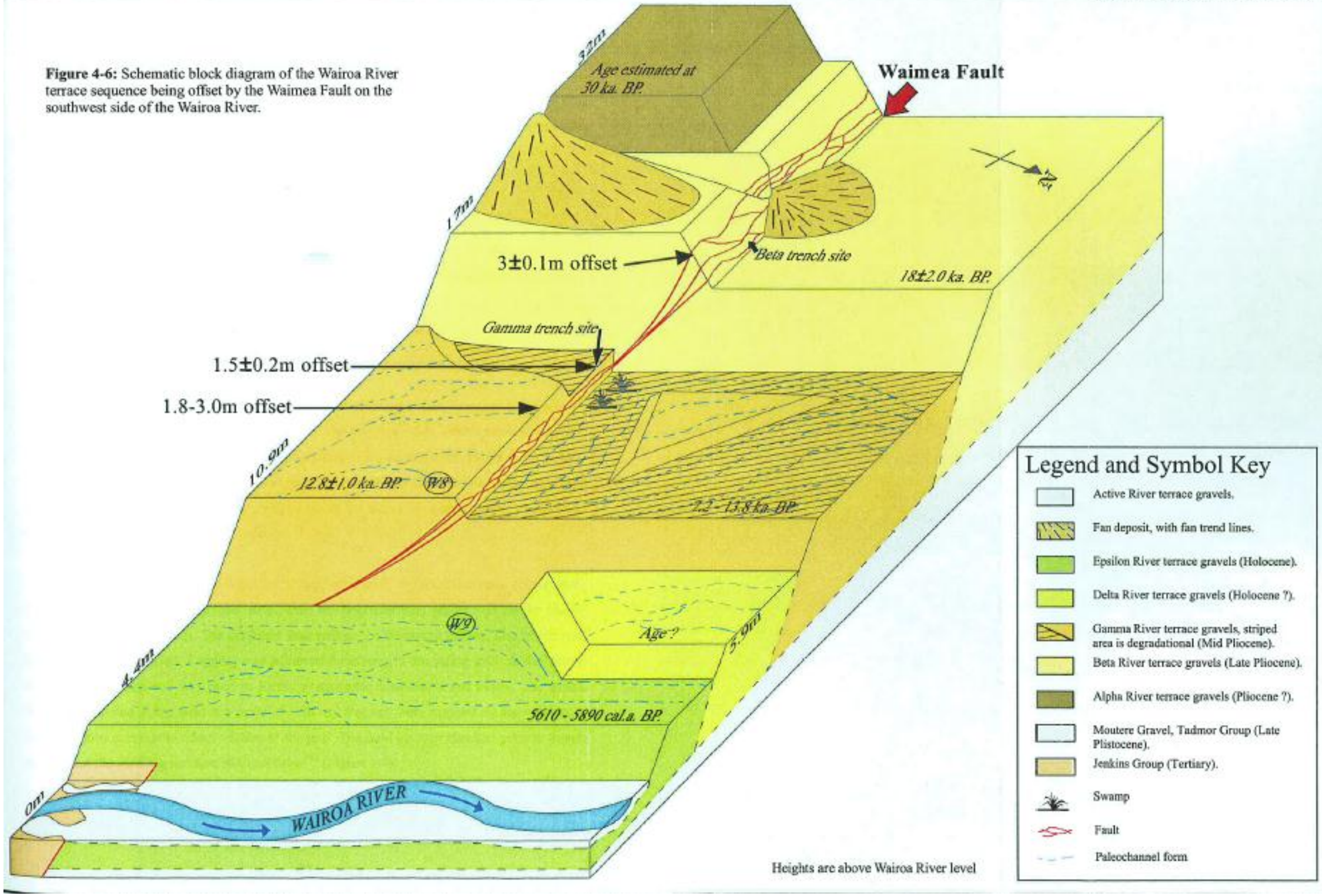
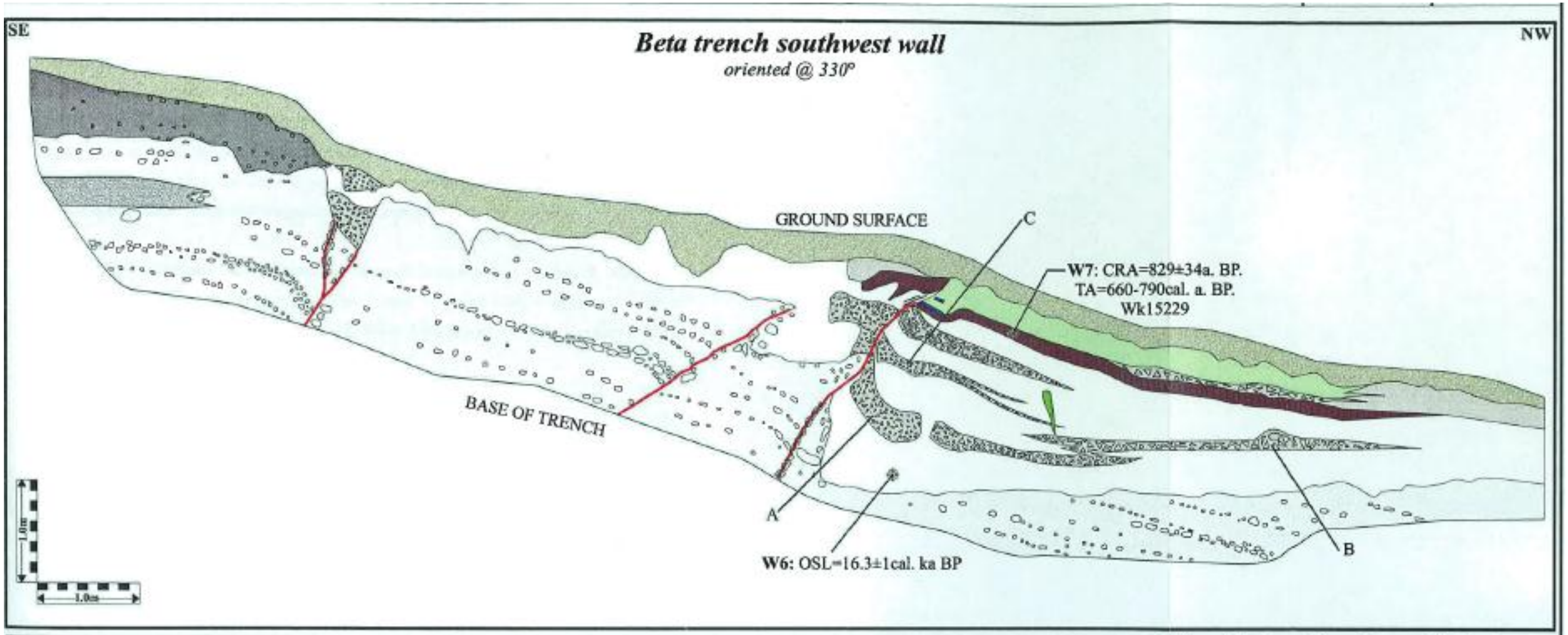


Figure 4-6: Schematic block diagram of the Wairoa River terrace sequence being offset by the Waimea Fault on the southwest side of the Wairoa River.



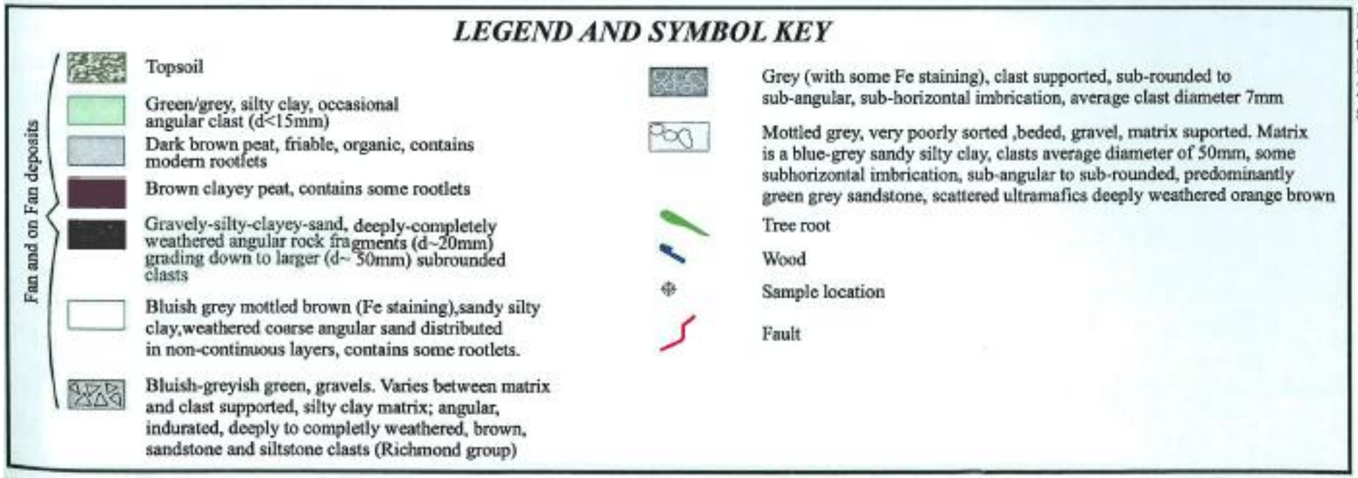


Figure 4-9: Log of the southwest wall of the Beta trench excavated across the Waimea Fault on the Beta Terrace surface west of the Wairoa River (GR: 2520200E, 5979070N). Figure 4-1 and Figure 4-8 show the location of this trench.

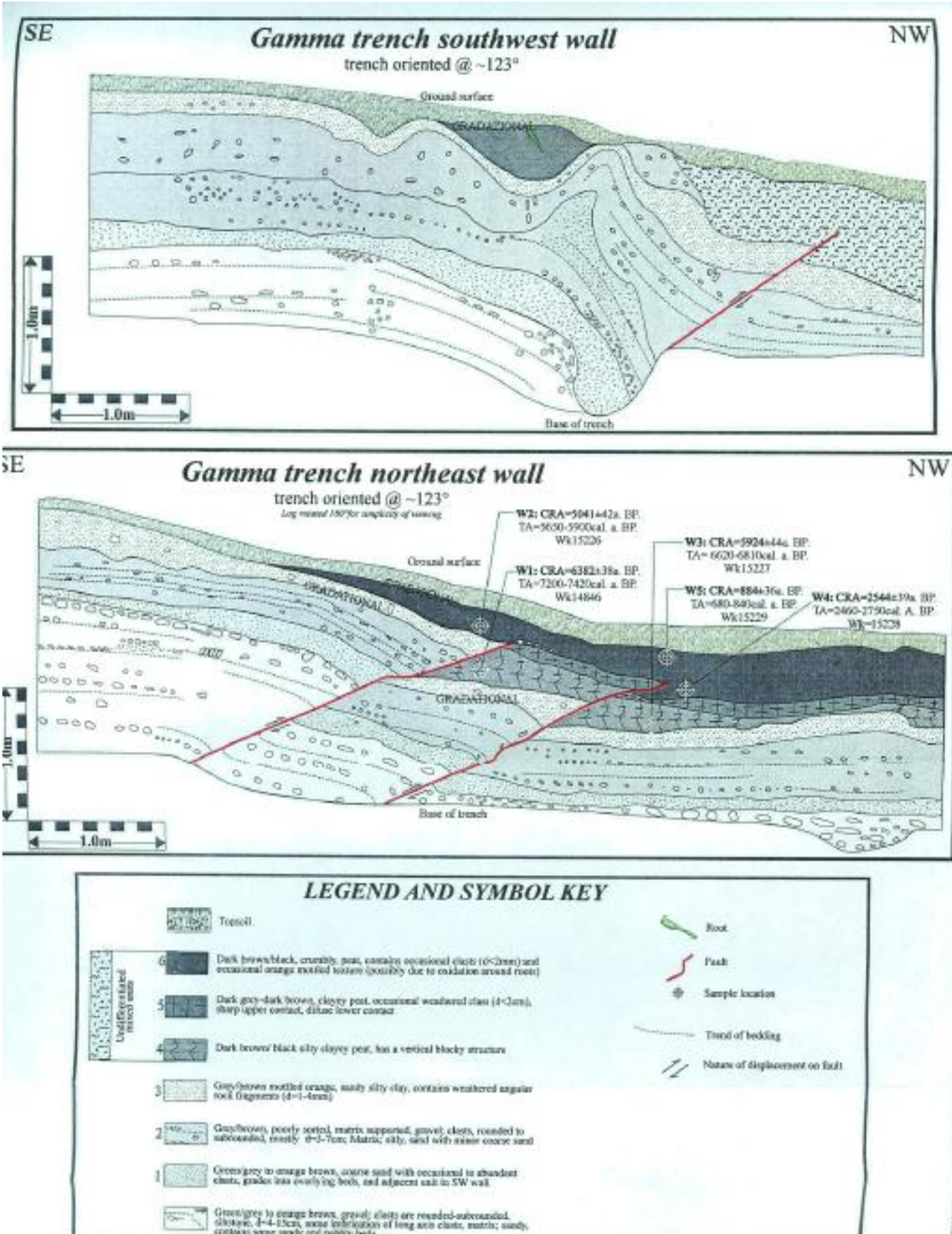


Figure 4-11: Logs of the Gamma trench excavated across the Waimea Fault on the Gamma Terrace degradational surface southwest of the Wairoa River. Both trench logs are presented from a perpendicular perspective looking approximately southwest. See Figure 4-1 for the location of the trench.

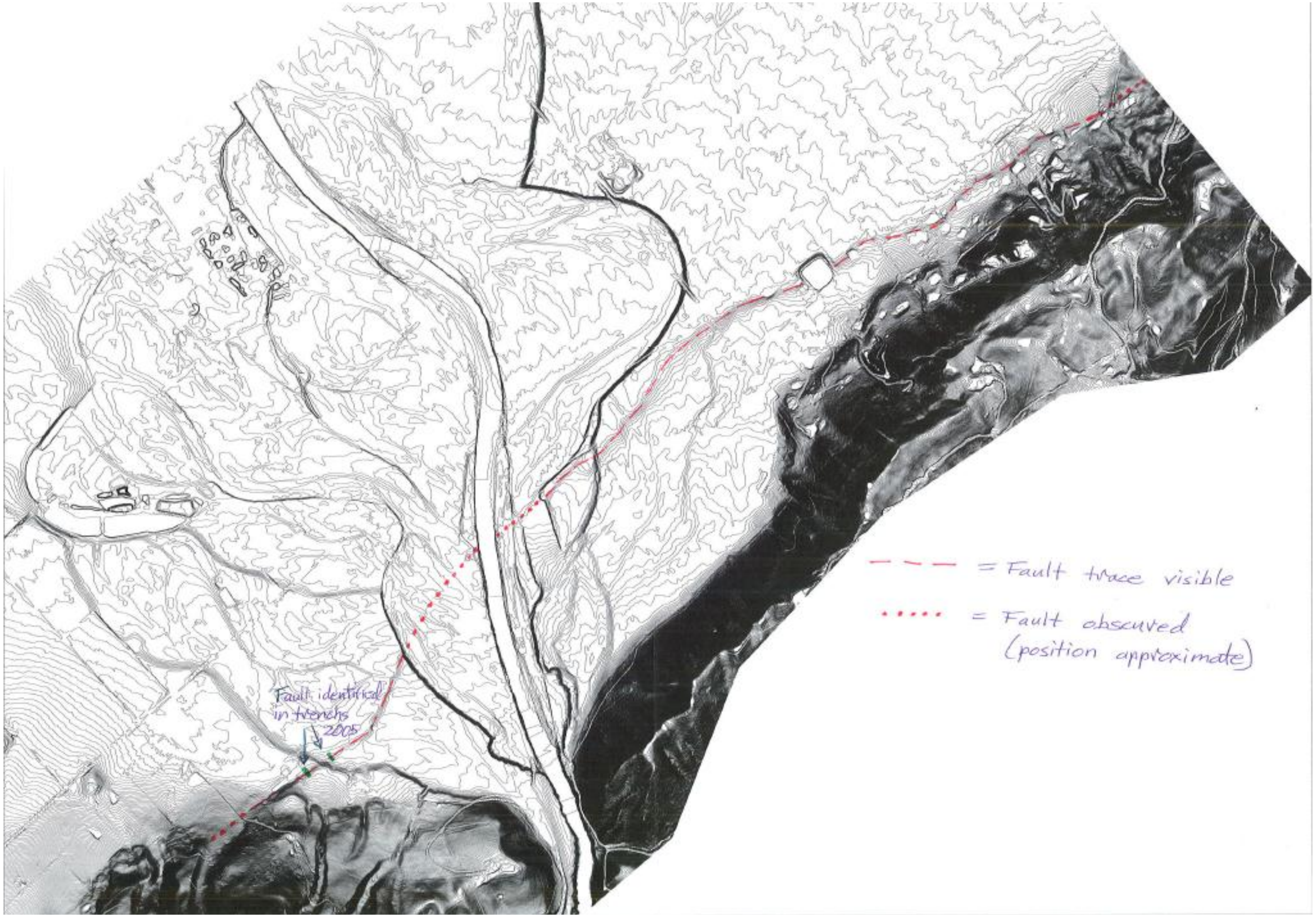


Figure 4.3 LiDAR imagery over Wairoa River Terraces with Waimea fault trace highlighted.

Stop 4 Waimea Fault Scarp, Clover Road East, Hope

Mapping by Jeff Fraser (University of Canterbury) in 2005 identified the scarp of the Waimea Fault at Clover Road East, Hope. The fault has uplifted the terrace gravels of the Hope Gravel Formation (penultimate to last glaciation) by 3 - 4m on the east side. The scarp trends northeast wards towards the foot of the Aniseed Valley Hill and diminishes in height northeastwards. The scarp is obscured by fan alluvium at Haycock Road. At Aniseed Hill mapping has identified a second strand of the Waimea Fault further up the slope which trends southwestwards towards the mouth of the Wairoa Gorge. At Aniseed Hill mapping and geotechnical investigations have identified Marsden Coal Measures between the two fault strands. Richmond Group (Triassic) sedimentary rocks crop out to the east of the eastern strand and Moutere Gravel Formation exists to the west of the western strand. A seismic traverse carried out along Clover Road East has identified a number of minor faults to the west of the Waimea Fault and mapping has identified some gentle warps of the terrace surface to the east, however this evidence is not conclusive and is open to interpretation. Tasman District Council has recently (October 2011) incorporated a new "*fault rupture risk area*" (FRRA) overlay into its Tasman Resource Management Plan which identifies a building setback zone and conditions for building, including requirements for geotechnical assessment.

Figure 4.2 Waimea Fault Scarp, Clover Road East, view towards Barnicoat Range

Stop 5 Washbourn Gardens (LUNCH STOP)

- Toilets are located beside Washbourn Gardens carpark.
- Coffee is available at Oxford Café.

Stop 6 Waimea Fault Trench, Griffin's property, Park Drive, Richmond

Trenching carried out by MWH New Zealand Ltd in 2011 during geotechnical investigations for a new access road have identified the position of the eastern strand of the Waimea Fault on the property of Mr. Rick Griffin, east of Park Drive. A band of reddish weathering Bishopdale Conglomerate is preserved against the fault and lies between the Richmond Group (Triassic) to the east of the fault and sandstone of the Marsden Coal Measures (Eocene) to the west. Mapping along the Richmond foothills above Park Drive at 1:2000 scale has revealed that the Waimea Fault is split into two strands which merge to become one fault at Kahilla Drive, 1.5km to the south.

Figure 6.1 Eastern strand of Waimea Fault exposed in trench, Griffin property, Richmond

Stop 7 Flaxmore Fault, Flaxmore Quarry, Nelson

The Flaxmore Fault is exposed in a cutting for a stormwater channel near the entrance to Fulton Hogan Limited's Flaxmore Quarry. The fault is steeply dipping at approximately 65 degrees to the southeast and has uplifted the Grampian Formation (Brook Street Volcanics Group, Permian age) over red weathering Bishopdale Conglomerate (Createaceous?). The Bishopdale conglomerate is sheared near the Flaxmore Fault. Within the quarry the indurated sedimentary rocks of the Grampian Formation are quarried for use as hard fill and roading aggregate. To the south of the quarry the Grampian Formation has been uplifted by at least 400m by the northwest trending Grampian Fault, however there is no evident trace on this fault where it crosses the Port Hills. South of the Grampian Fault the Port Hills Gravel Formation is preserved in the Marsden Syncline. Bishopdale Fault is a splay fault off the Grampian Fault and has two en echelon traces some 50m apart with both traces upthrown by about 4m on the north side (Johnston 1979).
A second quarry operated by Fulton Hogan is the York Valley Quarry located 1.5km to the southeast of Flaxmore Quarry. At this quarry augite tuff of the Kaka Formation, Brook Street Volcanics Group, provides a good quality aggregate used for roading purposes.

Stop 8 Bishopdale Formation, Bishopdale Subdivision, Nelson

Bishopdale Formation is exposed in a road cutting and in a drainage channel at Bishopdale Subdivision. The formation consists of a sheared conglomerate with rounded polished and stained clasts in a reddish clayey/silty/sandy matrix. The clasts include granite, granodoirite, dacite, green volcanics and volcanogenic sediments. Near the Flaxmore Fault the matrix is a deep red colour and contains a high proportion of montmorillonite (Johnston 1979). Poorly preserved fossils in the Bishopdale Formation at Nelson College indicate a late Eocene – Oligocene age, however the degree of weathering and the similarity to other highly weathered Cretaceous breccias and conglomerates in New Zealand suggest the possibility of a Cretaceous age.

The Flaxmore Fault splits into two strands within the Bishopdale Subdivision area. The eastern strand of the Flaxmore Fault has been located during geotechnical investigations by MWH New Zealand Ltd in 23 test pits and trenches. The sheared fault zone varied in width between 3m and 11m. The fault dips steeply to the southeast and separates highly sheared Bishopdale Conglomerate on its west side from Port Hills Gravel on its east side. Although the fault is a reverse fault it appears likely that inversion has occurred and the fault once had a normal sense of movement. Although the fault trenches exposed up to 3m thickness of gravelly clay colluvial cover over the fault strand, the soil mantle and gully deposits were not offset by the fault, indicating it has not ruptured since these Holocene deposits were formed. No organic material suitable for radiocarbon dating was found in the trenches along the eastern fault strand. The fault exposures in these trenches commonly exhibited black manganese oxide staining at the fault contact and sometimes minor tear structures parallel to the main fault.

Figure 8.1 Eastern strand of Flaxmore Fault in trench at Bishopdale Subdivision, Nelson. Red clay is sheared Bishopdale Formation and yellow material is Port Hills Gravel. Black material is manganese oxide on fault shears.

The western strand of the Flaxmore Fault is located at the western edge of the subdivision and is in a straight alignment with the main merged Flaxmore Fault that runs along the base of the Grampian Hills to the north, suggesting it is the presently active strand. Immediately to the south of the subdivision the two strands of the faults merge.

Paleoseismic investigations were carried out in 2005 in a deep trench south of Bishopdale (Fraser, Nicol and Johnston) and identified as the Bishopdale-1 trench. Although the basement rocks were offset by the fault, a paleosol layer at 4.5-5.0m depth dated at 4229-4421 calibrated years BP was not offset. The estimated timing of the last rupture is between 4.2 and 6 ka. Three prominent ridges have been dextrally offset by the Flaxmore Fault near this trench and provide a slip rate of no less than 0.05mm/year (Johnston and Nicol 2008).

The Flaxmore Fault has been mapped southwards as far as Marsden Valley Road where it is masked by the Stoke alluvial fan. Aerial photographs flown in 1995 indicate a possible fault scarp at Ngawhatu Valley Road offsetting fan gravels, however this site has been modified by housing development and the location of the fault has not been confirmed. The Flaxmore Fault has been mapped northeastwards as far as the Glen where it trends northwards into Tasman Bay.

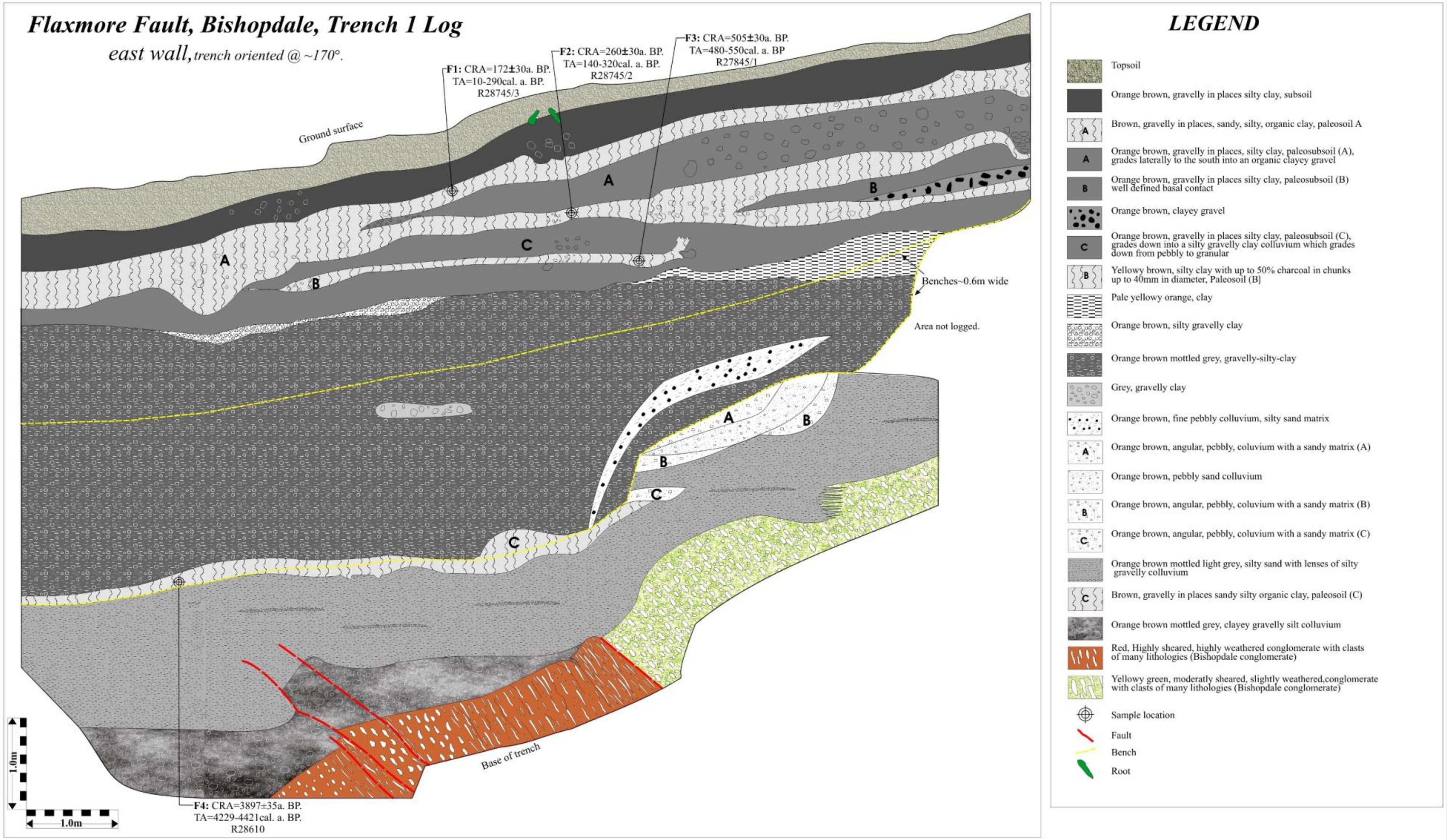


Figure 4-13: log of the east wall of Bishopdale Trench 1 excavated across the Flaxmore Fault in the floor of a small northwest draining valley in Bishopdale near Nelson City. See grid reference 2531970E, 5989130N (NZMG) Appendix 5: Engineering Geological Map and Cross-sections and Figure 4-12 shows the trench location.

Acknowledgements

Thanks for Fulton Hogan for access to Flaxmore Quarry, excavating the trench behind Richmond and supplying safety equipment. Thanks also to Selwyn and Mary Hall, Rick Griffin and Bishopdale Developments Ltd for access to their land.

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