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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

Conference Conveners
Kate Clark & Nicola Litchfield, GNS Science

Organising Committee
Kyle Bland, Carolyn Hume, Julie Lee, Dallas Mildenhall,
Anya Seward (GNS Science), and Joshu Mountjoy (NIWA)

Administration
Janet Simes, Absolutely Organised Ltd
Prepared for publication by Penny Murray

Field Trip Leaders
Malcolm Arnot, Greg Browne, Hamish Campbell,
Roger Cooper, Warren Dickinson, Neil Hartstein, Mike Johnston,
Rob Langridge, Nick Mortimer, Andy Nicol, Mark Rattenbury, Russ Van Dissen,
Karen Warren and Paul Wopereis

Geosciences 2011

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

Post-Conference Field Trip
Friday 2-Sunday 4 December 2011

Stratigraphic and Paleontologic highlights of NW Nelson, a day in the Paleozoic, a day in the Mesozoic, and a day in the Cenozoic

Leaders: Greg H Browne, Roger A Cooper and Malcolm J Arnot
GNS Science, Lower Hutt

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HEALTH AND SAFETY ISSUES

PLEASE READ!

Participants are advised that working in the field poses inherent dangers, particularly in terms of tides, rock fall, vehicles on roads and farm tracks visited etc. Cliffs can be unstable and portions may collapse or shed debris without prior warning. Hard hats will be provided. Caution should therefore be exercised when examining rocks at the base of natural or man-made cliffs. Caution must also be exercised when crossing public roads, or farm track locations where vehicles or machinery may be in use.

Participants should carry any personal medications, including those for allergic reactions (e.g. insect stings, pollen).

The weather in December can be variable with daytime temperatures around 15-25ºC. Participants need a sunhat, suncream, sunglasses, waterproof raincoat, some warm clothing mostly from wind. A water bottle should be carried at all times. An average level of fitness and mobility is required; there will be some hill walking, some clambering over rocks and some muddy stream or coastal walks. Underfoot conditions include soft muddy to sandy coastal areas, to hard rocky outcrops, grass, slopes, and potentially slippery surfaces. Participants must heed and observe the warnings and time limitations imposed by the leaders at certain stops. Due to the changing nature of the coastal sections, we cannot guarantee that conditions will be exactly as we expect them. It is recommended that a change of pants and socks be carried in the vehicles each day.

Field Trip Itinerary and Logistics

Itinerary

Day One – Friday 2 December

0800 am depart Nelson City from outside Rutherford Hotel
Stop en route in Motueka (to purchase lunch)
Locality A – Marahau overview – 10 to 10.15 am
Locality B - Takaka Hill overview – 10.30 to 10.45 am
Locality C – Cobb Valley – early afternoon
Locality D – Cobb Valley - mid afternoon

Onekaka Field Station & Collingwood Motorcamp – 6 pm

Day Two – Saturday 3 December - lowtide 1100 am

0830 am – depart Onekaka Field Station
Locality E - Northern Whanganui Inlet – 9.15 to 11.15 am

Lunch

Locality F –South Whanganui Inlet – 1 to 3 pm
Locality G – East Whanganui Inlet – 3.30 to 4 pm
Locality H – Pakawau Bush Road – 4.15 to 4.45 pm
Locality I – Collingwood, overview of Cretaceous faulting and physiography – 5.15 to 5.45 pm

Return Onekaka Field Station and Collingwood Motorcamp - 6 pm.

Day Three – Sunday 4 December – lowtide 12 noon

0830 am – depart Onekaka Field Station
Locality J – Wharariki Beach – 9.15 to 11 am
Locality K – Farewell Spit – 11.15 to 1 pm

Lunch

Drive to Nelson - 2 to 4.30 pm
Locality L – Magazine Point, Nelson City 4.30 to 5.30 pm

End of field trip – 5.30 pm

Logistics

Accommodation on Friday and Saturday nights will be at the Victoria University Field Station at Onekaka and for some, at the Collingwood Motorcamp (Ph 03 524 8149). Onekaka is about half way between Takaka and Collingwood.

We will be away from civilisation for most of the time in the field, so lunches and drinks as well as any items required in the field will need to be either purchased or brought for each day. We will provide the lunch on Saturday as we will be away from any shops that day. Breakfast for both Saturday and Sunday morning will be provided, and participants will purchase their evening meal on both of these nights. Options for eating include the pub in Collingwood (traditional Kiwi country tucker), or the Mussel Inn (a tradition in this part of the world). If people want to cook their evening meal, facilities exist at both the Onekaka and Collingwood accommodation options, but you will need to bring your own food. Cell phones will operate in many parts of the field area, but not in all areas. There are no banking facilities after leaving Takaka. EFTPOS as well as major credit cards are widely accepted, but it would pay to have a small amount of cash on hand for meals etc.

Each day involves considerable driving, much of it along winding rural gravel roads. Those that suffer from car motion sickness should bring some medication for that purpose. First aid kits will be carried by the party, and we have several qualified 1st aiders in the group. We will provide hard hats for the group.

Note that for many stops, a moderate degree of fitness is required for the walking distances involved. For any given stop this will not be more than 5 km. Several stops require walking a topographic elevation of 100-200 m. Other stops involve mudflats where wet and muddy feet can be expected. Other travel includes bush tracks, rivers, sandy beach, or farmland. Appropriate footwear is required – boots or shoes with good soles are recommended. Some stops involve sandy beaches or mudflats, where light footwear (Tevas or similar) would be fine. Have fun – this is your field trip!

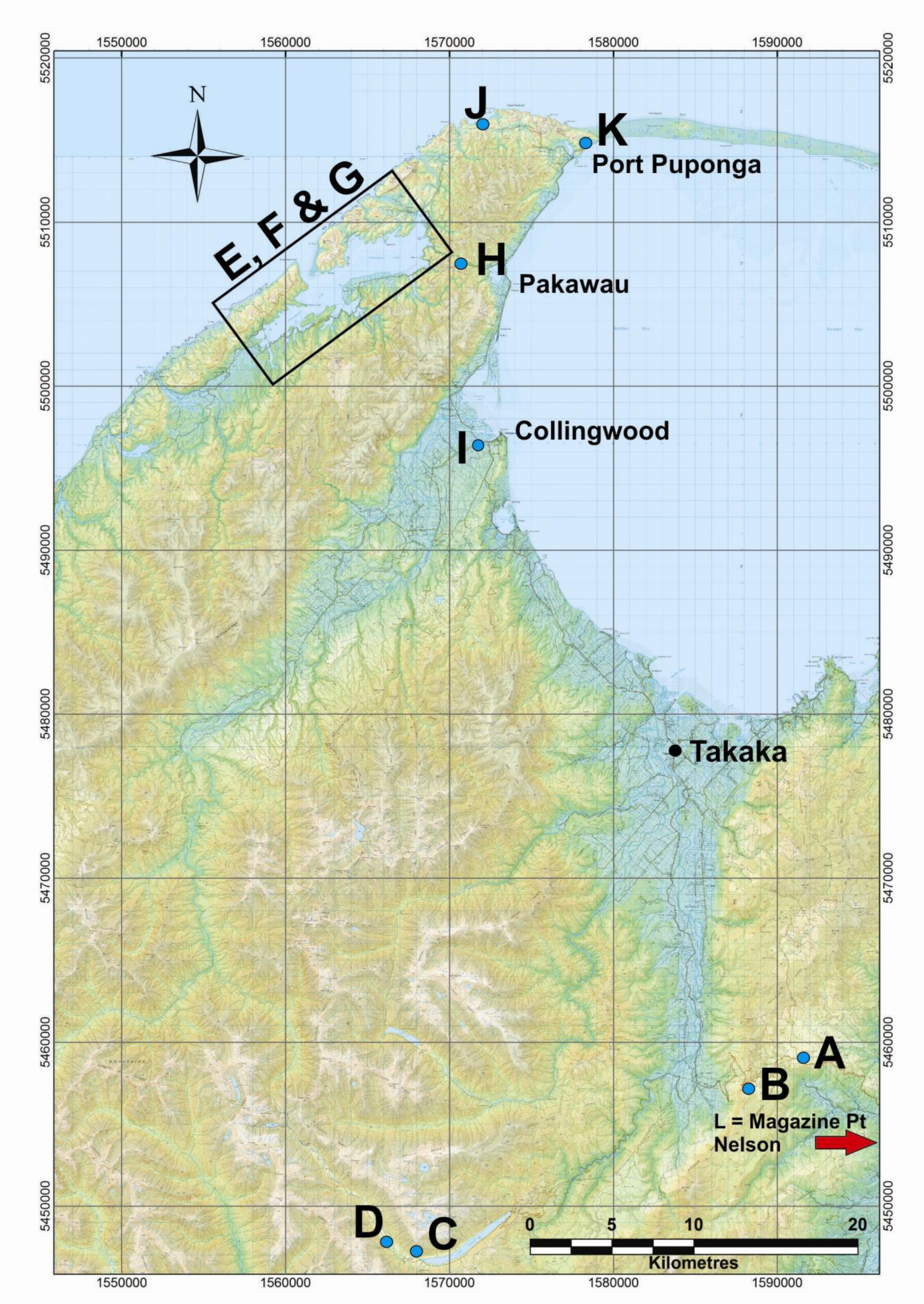

Figure 1.1 Localities to be visited on the field trip.

Geological Setting

Paleozoic Rocks

The Early Paleozoic, Western Province rocks of NW Nelson are divided into two north-south trending terranes, the Takaka Terrane (eastern) and the Buller Terrane (western), separated by the Anatoki Fault, a major Paleozoic fault with a complex history (Fig. 1.2). Day one will concentrate on successions exposed in the Takaka Terrane of Cobb Valley, which contain New Zealand's oldest rocks.

A Cambrian volcano-sedimentary arc complex (Middle to Late Cambrian), once part of the Pacific margin of Gondwana, is structurally overlain by a passive margin sequence of carbonates and siliciclastics (Late Cambrian to Early Devonian). The Cambrian succession has been folded and disrupted by faulting during at least four tectonic events, bringing together at least 12 fault slices with dissimilar stratigraphy. Cobb Valley provides a valuable transect through the heart of the Takaka Terrane, and New Zealand's Cambrian history has been largely determined from study of this area (Fig. 1.3). Because of the severe deformation and pervasive greenschist facies metamorphism, age-diagnostic fossils are extremely rare in New Zealand's Early Paleozoic rocks. Although fossils are known from several hundred fossil localities, most contain only fragmentary remains. We will visit the only Early Paleozoic locality accessible by road – Trilobite Rock in Cobb Valley.

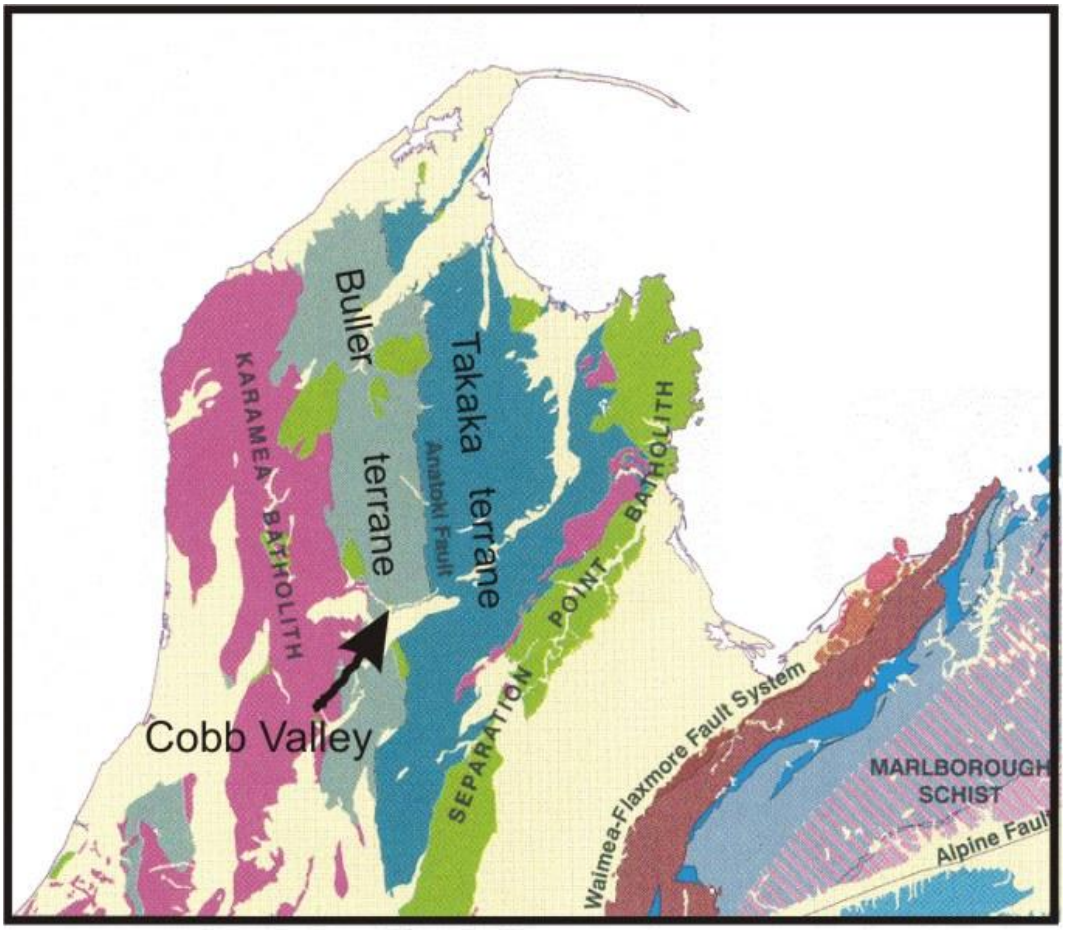

Figure 1.2 Major basement rock belts of Nelson. From Rattenbury et al. (1998, Fig. 3).

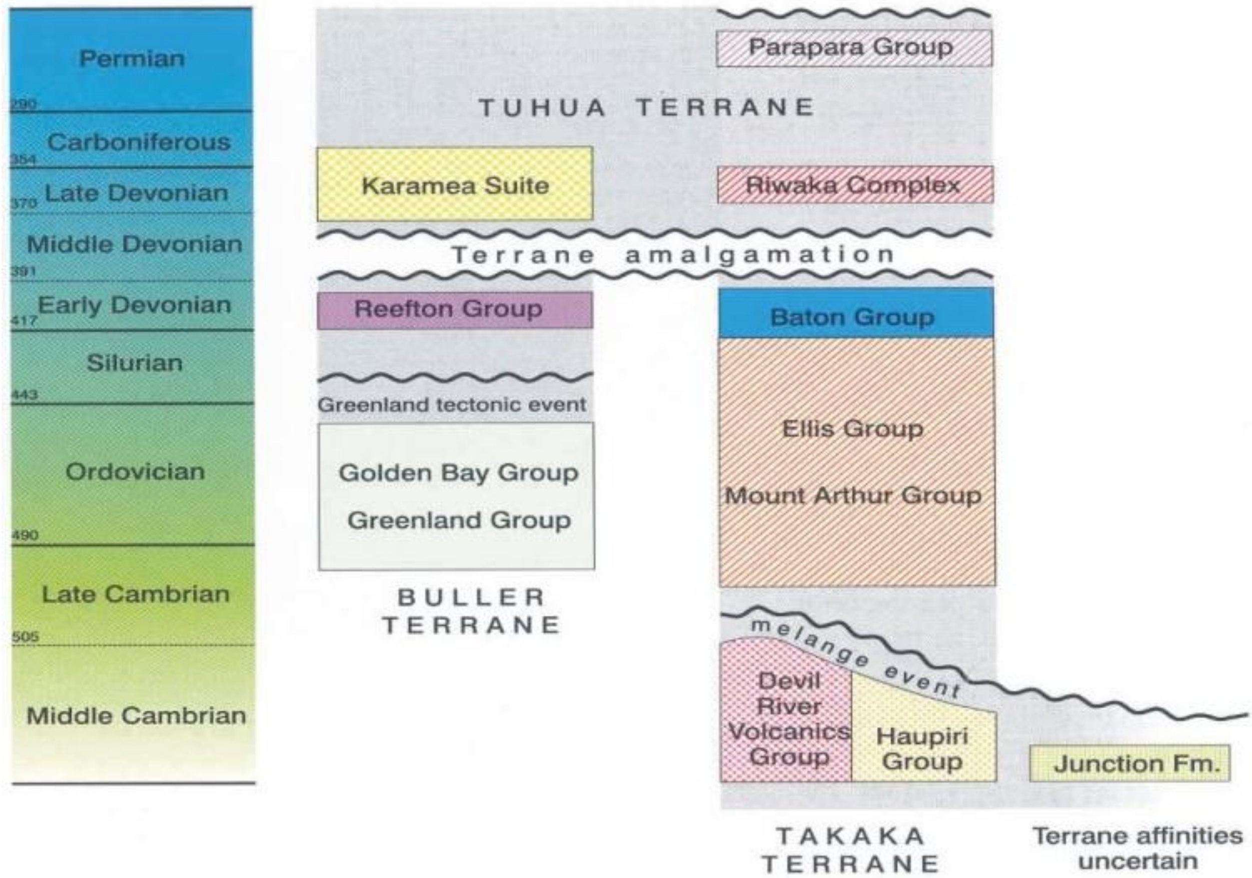

Figure 1.3 Simplified terrane successions. From Rattenbury et al. (1998, fig 10).

Mesozoic Rocks

Late Cretaceous (Haumurian) rocks are well exposed in NW Nelson, and comprise part of a rifted basin, the Pakawau Basin, formed during Cretaceous extension of the eastern Gondwana margin. This depocentre is bound by the Kahurangi Fault in the west (now offshore) and the Wakamarama Fault in the east. Day two will concentrate on Late Cretaceous sediments of the Pakawau Group, with stops to view recently discovered dinosaur footprints (Browne 2009). The Pakawau Group comprise two formations: the Rakopi Formation and the North Cape Formation. Both formations are Haumurian (Mh) or Campanian-Maastrichtian in age (Figs. 1.4 to 1.5). The lowest, conglomeratic unit of the Rakopi Formation, the Otimataura Conglomerate Member, is not particularly accessible and will not be visited. It will be viewed from a distance at Locality I. The Rakopi Formation in outcrop is primarily a fluvial succession with abundant coals, and is the prime petroleum source rock in the Taranaki Basin (Browne *et al*. 2008; Higgs *et al*. 2010).

We will spend more time examining the North Cape Formation, which in outcrop is shallow marine (beachface, channel sandstone, and estuarine). Both formations form an extensive Cretaceous coastal plain to shallow marine succession as far north as Tane-1 well, some 170 km to the north (Higgs *et al*. 2010). Although a rift basin in the Cretaceous, today the Collingwood-Whanganui Inlet area comprises a north-plunging anticline. Many of the Cretaceous faults were reactivated during subsequent Neogene deformation, and many with the opposite sense of throw.

Cenozoic Rocks

Day three is given over to the Cenozoic geology of the region examining the Kapuni Group (Paleocene to Eocene), and Oligocene Ngatoro Group. Younger Pliocene-Pleistocene sediments are exposed in the Moutere Depression east of Nelson (cf. Locality A). On this trip we will concentrate on the Paleocene Farewell Formation, a sandy and gravelly fluvial unit, Oligocene Matapo Greensand and Takaka Limestone, and near Nelson, the Oligocene Magazine Point succession.

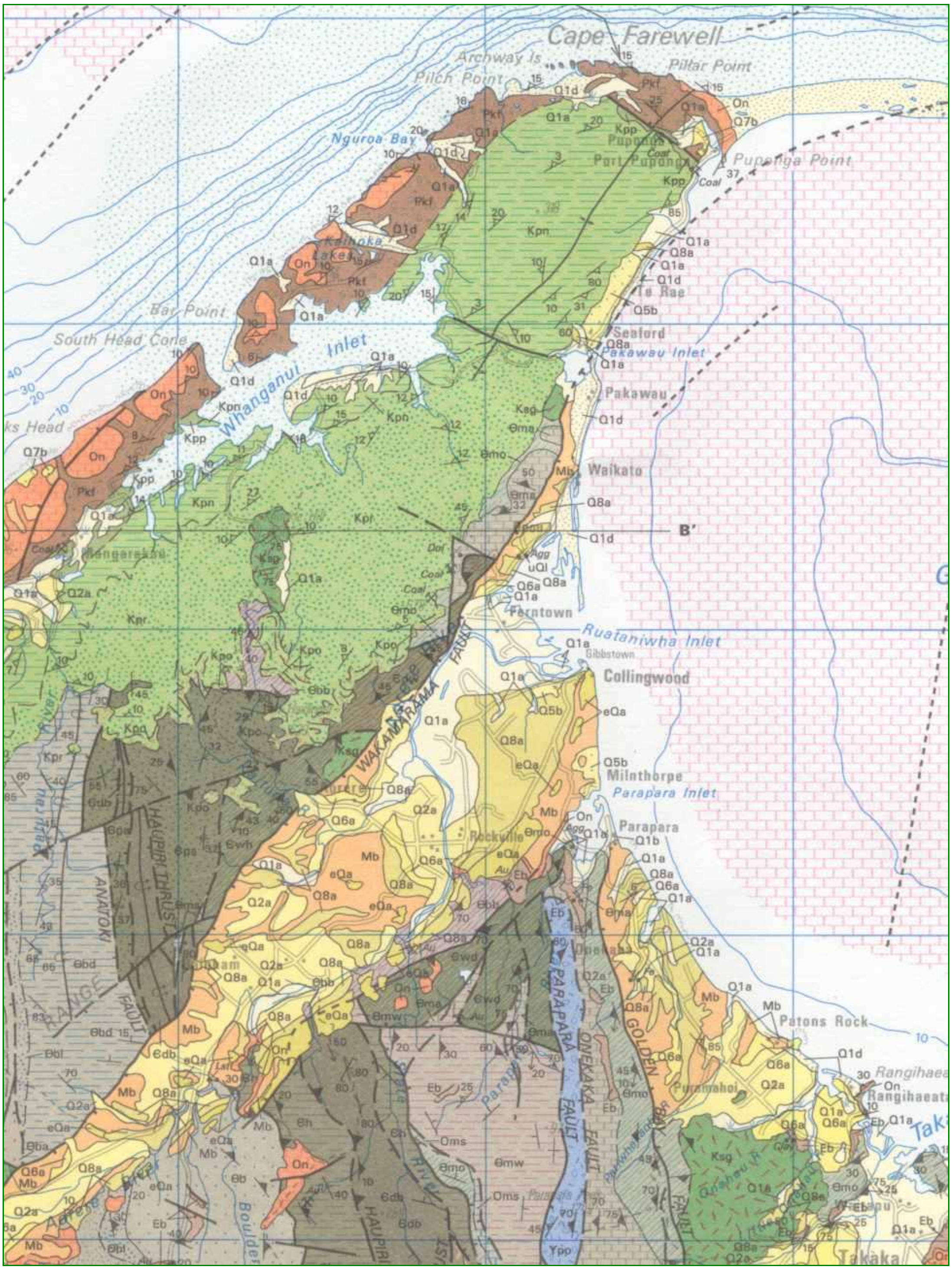

Figure 1.4 Geological map of the NW Nelson region (after Rattenbury et al. 1998).

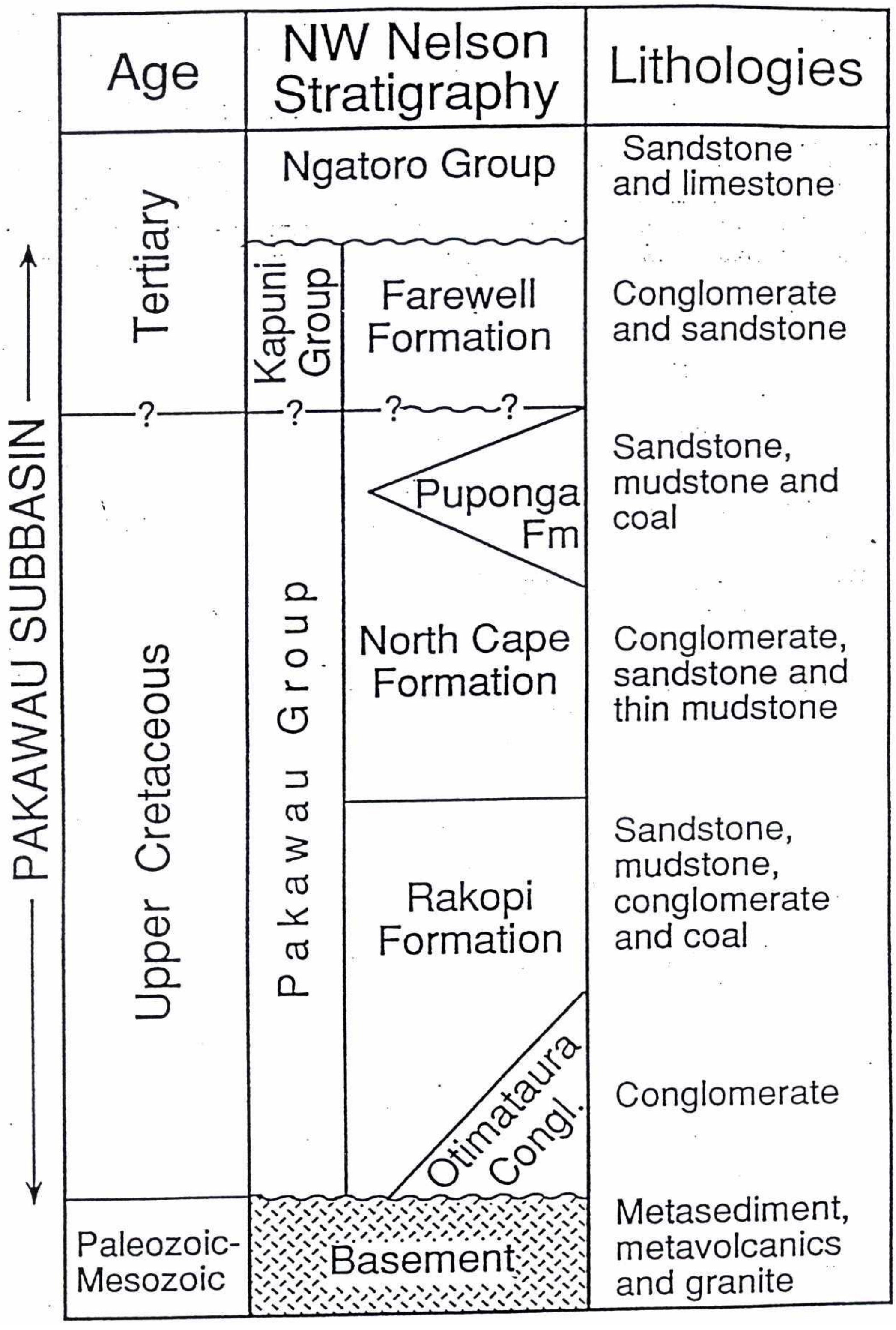

Figure 1.5 Cretaceous and early Tertiary stratigraphy of NW Nelson (after Thrasher 1992 and Wizevich *et al.* 1992).

Locality Descriptions

Day 1

Locality A: Marahau Overview

At this stop we will review the main structural aspects of the Moutere Depression and adjacent Takaka Hill, a nice analogue to the structural make-up of the southern end of the Taranaki Basin. In the distance to the east, the Paleozoic and Mesozoic terranes east of Nelson form the distant skyline, separated by the Waimea-Flaxmore Fault System, from the Plio-Pleistocene Moutere Gravels (with lenticular sands and muds) of the Moutere Depression in the foreground. Some of these sediments are well exposed in the new road diversion near Tasman and Ruby Bay. Basement terranes of the Richmond Range in the distance near Nelson City include the Brook Street, Murihiku, Dun Mountain-Maitai, and Caples terranes, aspects of which were covered on other conference field trips (cf. Campbell 2011; Rattenbury 2011 & Johnston 2011). The Waimea-Flaxmore Fault system occurs at the base of slope between the Waimea Plains and the Richmond Mountains, a system that extends from the Alpine Fault north through a series of relays to the Taranaki Fault, the major basin bounding fault between the Taranaki Basin to the west and the Wanganui Basin to the east (Stagpoole & Nicol 2008).

To the north near Marahau, are the golden sand beaches of Abel Tasman National Park amidst Cretaceous Separation Point Batholith granitic rock (Tulloch 1988; Tulloch & Rabone 1993; Muir *et al*. 1994). The batholith was a major contributor of quartz sand to the Pakawau and Kapuni groups and younger petroleum reservoirs of Taranaki (Moki and Mount Messenger formations). The Separation Point Batholith contains I-type granite and granodiorite plutons dominated by equigranular biotite granite, with minor amounts of leucocratic biotite-muscovite garnet granite (Kobe 1988; Rattenbury *et al*. 1998). Biotite-hornblende granodiorite and diorite occur in a number of plutons through the batholith. The Separation Point Batholith is dated between 109 and 121 Ma by U-Pb zircon methods (Kimbrough *et al*. 1994; Muir *et al*. 1994; 1997).

To the south, are the Ordovician to Silurian Mount Arthur and Ellis groups comprising marble (Mt Arthur Marble), schist (Pikikiruna and Onekaka schist), limestone (Summit Limestone), quartzite and quartzose sandstone (Hailes Quartzite). Surrounding us, the Mt Arthur Marble contains sparse crinoids and corals and is late Ordovician in age. The lower hill country to the east comprises the Riwaka Complex, mafic and ultramafic rocks that intrude the Ordovician to Silurian sedimentary and metamorphic units (above). They include diorite, gabbro and pyroxenite of Middle and Late Devonian age.

Locality B: Harwood Lookout

From the lookout (Harwood Lookout) is a vista west across the Takaka Syncline to the Peel Range, Tasman Mountains, Collingwood (Wakamarama Anticline) in the far distance and Golden Bay. The Takaka Syncline is floored by an Eocene carbonaceous rich succession equivalent to the Brunner Coal Measures (of the West Coast), and the Mangahewa Formation of Taranaki Basin (Leask 1993). The Pikikiruna Fault lies on eastern margin of the Takaka Valley and separates Mount Arthur Marble and Separation Point Granite (on the upthrown eastern side) from the down-faulted Paleogene sedimentary succession in the valley. To the west on the crest of the Peel Range (where we are headed) can be seen the gently dipping concordant ridge and summit features of the Waipounamu Erosion Surface. This surface is cut into basement rocks (mainly Paleozoic greywacke, shales, schists and granites) of the Takaka Terrane, a surface that has outliers of Paleogene sediments deposited on it (Cooper 1984; Rattenbury *et al*. 1998).

Locality C: Trilobite Rock

Discovered in 1950 by a Nelson engineer, Trilobite Rock is an allochthonous lens of limestone with scattered layers of trilobite fragments and other microfossils including inarticulate brachiopods, micro-molluscs, hyolithids and sponges (Henderson & MacKinnon 1981;

MacKinnon 1983, 1985). Its geological significance was recognised by Benson in the early 1950's and 16 species of trilobites have since been identified by Öpik, Singleton and Cooper (listed in Cooper 1979; 1989). Trilobites are an extinct group of arthropods, particularly dominant in marine communities in the Cambrian Period (Fig. 1.6). The Trilobite Rock assemblage indicates a late Middle Cambrian (Undillan to Boomerangian) age for the limestone. The limestone was deposited in a high energy shelf environment and the trilobites, represented only by exfoliated exuviae, include heavy shelled polymerids such as *Dorypyge*, '*Solenoparia*' and dolichometopids together with eight species of agnostids. Complete specimens are unknown. Because of metamorphism, split slabs from the outcrop generally break through, rather than around, the specimens and even complete moult fragments (such as heads, tails or free cheeks) are rare. The listed species have been identified only after specialised treatment of the host rock. This applies to all New Zealand Early Paleozoic fossils preserved in limestone. The lithofacies of the limestone contrasts strongly with that of the enclosing unfossiliferous siliceous shale of the Tasman Formation which represents a slope or basin environment. The origin of the several limestone lenses found within the shale is thought to be due to olistostromal slides, calving off a marginal shelf edge. Sedimentary breccia and conglomerate bands associated with the limestone supports this interpretation.

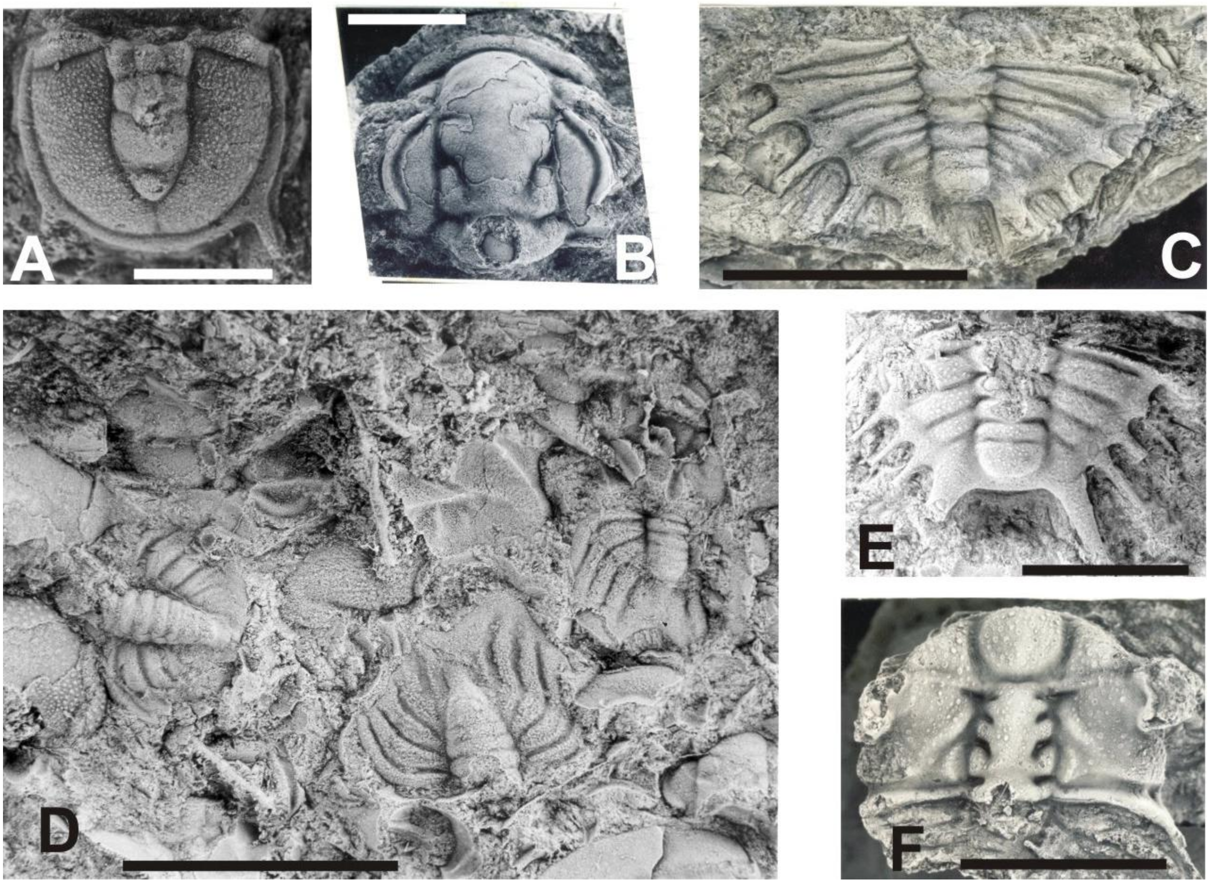

Figure 1.6 Late Middle Cambrian trilobites from Cobb Valley. A, Goniagnostus (tail); B, dilochometopid (head); Olenoides (tail); D, several kopturid tails; E; Dorypyge (tail); Nepea (head). Scale bar in A is 1 mm, and in all others is 10 mm.

Please note that we are in a DOC Reserve and collecting fossils is strictly prohibited.

Locality D: Cobb River

In Cobb River, at the camping ground near Trilobite Hut, Tasman Formation is less siliceous and contains concretionary bands and lenses. Rare trilobites include 'deep water' nepeids and agnostids of similar late Middle Cambrian age to that of the Trilobite Rock limestone. At this locality the formation shows soft-sediment deformation. To the east is the Balloon Melange, an enigmatic diamictite derived largely from a parent arkosic sandstone and siltstone (inferred to be the Junction Formation) by soft sediment deformation (Pound 1993). Regionally, the melange contains blocks of all sizes representing most other Haupiri Group units. We will examine the contact exposed in the river – is it a fault contact (Balloon Fault) between two partially consolidated formations as originally thought (e.g. Munker & Cooper 1999) or is it an intrusive contact between a diaper of subcreted and over-pressured Balloon melange and the structurally overlying Haupiri Group (Tasman Formation) as suggested in the most recent research (Jongens *et al*. 2003; Fig. 1.7)? The latter model implies that the Balloon Melange event was a major and widespread deformational episode suggesting, in turn, that it might represent the Ross-Delamerian Orogeny of Antarctica-Australia. If there is time we will also examine outcrops of the glacially striated Tasman Formation, roches moutonée in the valley floor, and clean outcrops of Balloon Melange.

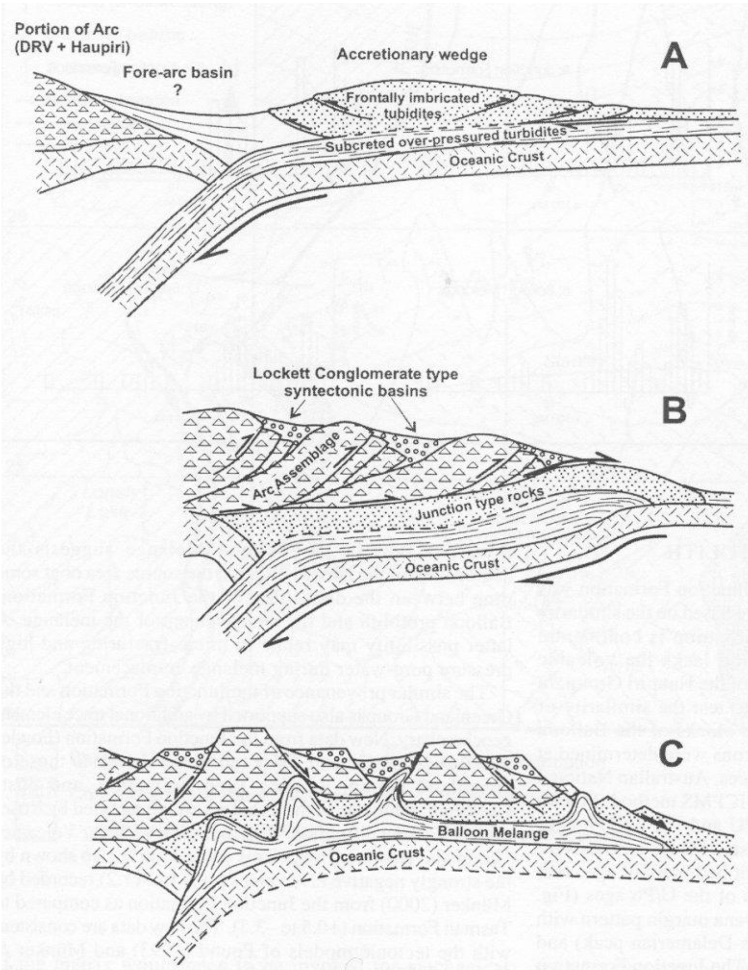

Figure 1.7 Tectonic cartoons depicting the formation of the Balloon Melange (after Jongens et al. 2003). A. Stage 1, accretionary wedge formed of Australia-Antarctica derived sediment stripped from the down-going plate, B. Stage 2, the ending of subduction and thrusting of the arc assemblage over the accretionary wedge, and C. Stage 3, over-pressured subcreted turbidites intrude upwards into thrust slab during post-orogenic relaxation (after Jongens et al. 2003).

Day 2

Locality E: Northern Whanganui Inlet

This stop involves a 20-30 minute walk to the coastal outcrop. Here we view the Late Cretaceous North Cape Formation, a Haumurian aged shallow marine sandstone unit representing intertidal, beachface, to coal swamp depositional environments (Wizevich *et al*. 1992; Bal & Lewis 1994; Stark 1996; Higgs *et al*. 2010). During the Late Cretaceous extensional tectonics related to the fragmentation of eastern Gondwana developed a number of graben in the South Island (Otago, Canterbury, Westland and NW Nelson – Bal 1994; Wizevich 1994). In NW Nelson, the Pakawau Graben was bound by the Kahurangi Fault in the west, and the Wakamarama Fault in the east. Coastal plain and marginal marine Rakopi and North Cape Formation sediments were deposited in a north-trending graben. The paleogeographic setting at least locally, was probably similar to the modern Hauraki Graben and the Firth of Thames. A coastal plain to shallow seaway bounded by periodically active Kahurangi and Wakamarama faults extended to the north, and was more fully marine in the vicinity of Tane-1 well (some 170 km north from here). Small changes in base level caused either by subsidence or sea level fluctuation, would have caused the shoreline to transgress and regress rapidly across the area, and is manifest in the rapid changes in these shallow marine-paralic facies.

At the time of North Cape Formation deposition dinosaurs roamed coastal environments, and trace fossils of their foot prints have recently been described from this, and other localities of the Whanganui Inlet area (Browne 2009). We are going to visit three of these sites today, each displaying quite different foot print morphologies.

It has been postulated that these were sauropod dinosaurs based on the rather oval morphology of the footprints. Sauropods were the largest animal to ever live, long-necked, long-tailed herbivorous quadrupeds with a relatively small head. We are not certain of the specific type of sauropod; as best we can tell, they were of the Superfamily Titanosauroidea. They had large club-like feet, and the resultant footprint can vary considerably in size and shape depending on a range of variables, including the nature of the substrate they were walking on (soft, firm, hard, wet, moist, sand, muddy sand, mud etc.), whether the animals were walking, running, stationary, variability of the footprint due to age, sex, and whether formed by the front (manus) of hind (pes) limb of the animal. Here we will view one footprint in plain view (Fig. 1.8) and one in cross sectional view. Footprints are as much as 60 cm diameter, and in cross section have similar depth of penetration into enclosing sediments.

Figure 1.8 Plan view of a dinosaur footprint. The heel of the print is to the left, and the toe to the right. At the toe portion, concentric, crenulated folds of sand suggest a relatively moist substrate at the time, in what we interpret to be beachface sediments based on sedimentologic structures in the surrounding sediment. Scale bar has 10 cm divisions.

Locality F: Southern Whanganui Inlet

Dinosaur footprints are exposed here both in plan view and in cross section. Some of the structures get up to 60 cm diameter, but most are smaller. Footprints vary considerably in size and shape. In terms of their plan view length and width, a group of footprints are less than about 15 cm diameter, and another group greater than this size. Those exposed in plan view show a sharp heel portion, and a toe end that contains small-scale fractures. This is assumed to represent the lifting of the toe from the substrate, in much the same way as a footprint on a modern beach will display clumps of sand left behind as the toe lifted from the surface. Some footprints in plan view are not oval in shape like others, and in these instances the foot may have slid forward slightly as the animal walked.

Unlike our earlier locality, here the sandy substrate was probably drier sand, but deposited in a similar beachface setting. Adjacent sediments, suggest that the environment was changing rapidly from estuarine mudflats to high energy beach, to intertidal channels, and coastal swamps in an overall regressive setting. No tracks are evident – all the footprints appear to be single or discrete features, either because of the small extent of the exposure, or due to the animals walking across as opposed to along the outcrop extent. Several morphologies are evident of footprints in cross section. Many cross sectional examples show massive or blocky sand infilling the footprint, sharp vertical margins either side of the footprints, and in one example, a rather complicated two-pronged morphology.

Locality G: Eastern Whanganui Inlet

Outcrops of North Cape Formation at this locality are characterised by intertidal flazer-bedded sandstone and siltstone which display both small vertical burrows and dinosaur footprint trace fossils. At this locality the footprints are rather different from the other two localities and not as clearly defined. Only cross sectional examples of dinosaur footprints are present, but show the same combination of sharp vertical sides, and sand infilling that is both massive, folded, and blocky.

Mud is more common of these structures, so it is thought that the sediment was mud-rich and more water logged. The resultant morphology reflects the soft and/or wet nature of the sediment, and/or that the animals were partially swimming rather than fully weight-bearing on the muddy substrate.

Locality H: Pakawau Bush Rd

The Rakopi Formation is not well exposed in outcrop, and fresh outcrop is quickly weathered. Forestry operations some fifteen years ago offered the opportunity to describe a number of freshly created forestry cuttings (described in Browne *et al*. 2008). The Rakopi Formation is the prime petroleum source rock of the Taranaki Basin (Thrasher 1991a, 1991b; Sykes *et al*. 2004), and as such is probably the most economically important formation in the country. The generally accepted view is that the Rakopi was deposited in fluvial environments, with associated overbank and lacustrine facies, but the presence of rare dinoflagellates, of glauconite, and of elevated sulphur content, indicate that at least parts of the formation were marine influenced during deposition.

Liz Kennedy as part of her MSc and PhD theses (Kennedy 1993; 1998; Kennedy *et al*. 2002; Kennedy 2003) collected well preserved leaf fossils from this site, including the first flowers from the New Zealand Cretaceous. She concluded that the Rakopi Formation was deposited in a cool to mild temperate climate with moderate rainfall in mire and lacustrine conditions. Various fluvial facies were described by Browne *et al*. (2008) – channel sands and conglomerate, lateral accretion heterolithic sandstones and siltstones, and lacustrine mudstones and overbank floodplain (Figs. 1.9 & 1.10).

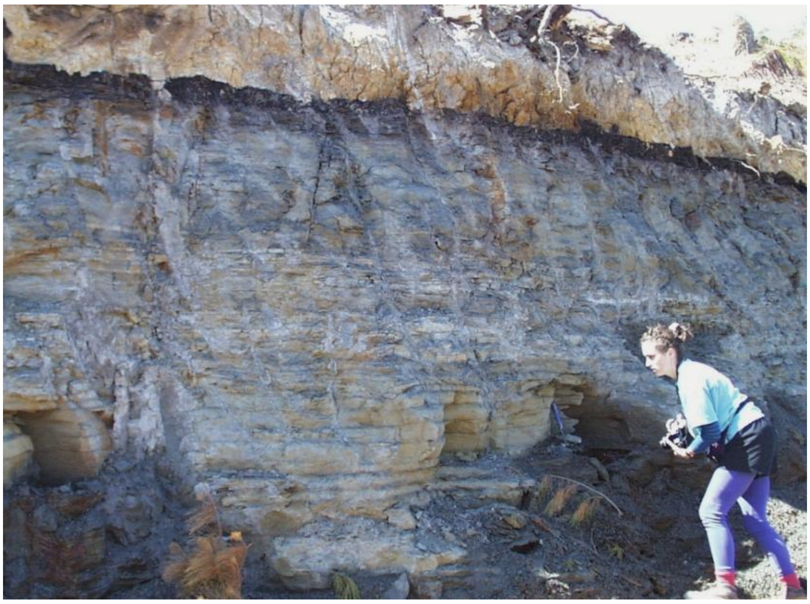

Figure 1.9 Upper part of typical fining-upward succession – laminated sandstone and siltstone, passing upward into mottled siltstone with thin sandstone interbeds, siltstones, rootlet horizons of a paleosol, then a capping coal.

Figure 1.10 Examples of angiosperm leaves from the Rakopi Formation at a locality on Pakawau Bush Road. Leaf impressions are commonly found here within pale coloured weathered fine sandstone and siltstone horizons. Seeds, conifer leaves, cone scales and numerous specimens of one type of flower were also found at this locality.

Locality I: Overview Ruataniwha Inlet, Collingwood

Collingwood is one of the better places to view the scarp of the Wakamarama Fault. The fault was an active normal fault in the Late Cretaceous, downthrown to the west, but was reactivated in the Neogene to an east-dipping reverse fault. In this regard it is similar to many Cretaceous Taranaki Basin faults that reactivated, showing a reverse sense of displacement. In this area, this was related to the convergence across the southern margin of the Taranaki Basin. During the Late Cretaceous, coarse-grained alluvial clastics were deposited west of the fault in the Pakawau Graben. Some of the basal Otimataura Conglomerate representing the initial coarse-grained clastic fill of the basin can be seen forming prominent bluffs. These conglomerates and sandstones have been interpreted as alluvial fan and braided river units, with a northward paleocurrent flow orientation (Wizevich 1994).

Day 3

Locality J: Wharariki Beach

This morning we have to wait for the tide to retreat, so we'll walk to one of NW Nelson iconic scenic attractions, Wharariki Beach. Here the spectacular coastal scenery is also spectacular geology (Fig. 1.11). Stacks, arches and headlands comprise fluvial sandstone and gravels, with thinner bedded siltstone of the Paleocene Farewell Formation. The general consensus is these sediments formed in a sandy braided river depositional system, large sandy braided rivers moving along the axis of the Pakawau Graben, fed largely from the south, with contributions also from fluvial input from the margins (Titheridge 1977). Farewell Formation is the main reservoir in the Kupe Field, a gas producing field of southern Taranaki (Schmidt & Robinson 1990; Flores *et al*. 1998; Fig. 1.12).

Figure 1.11 Wharariki Beach coastal scenery.

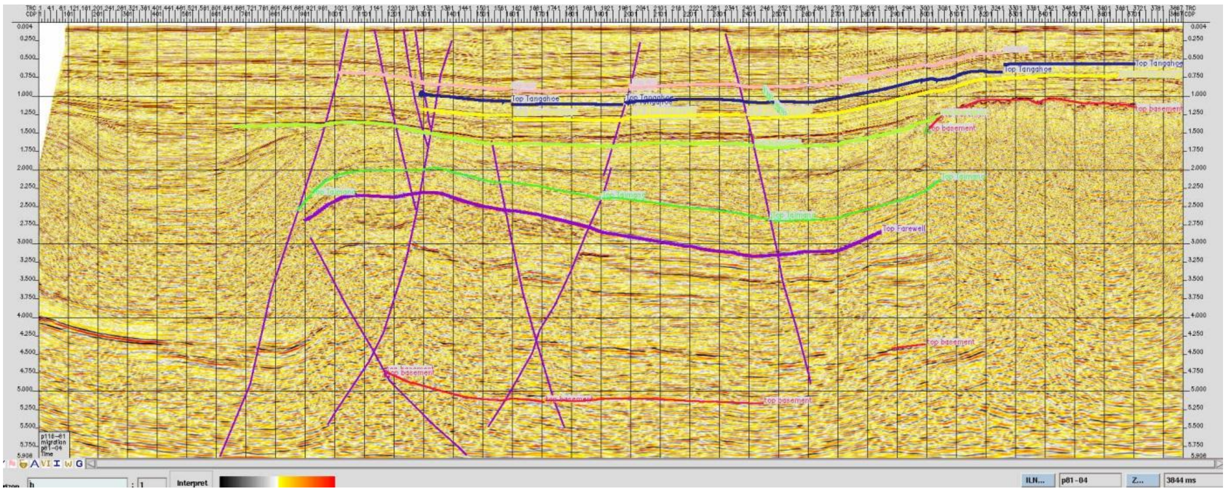

Figure. 1.12 Seismic profile through the Kupe Field, South Taranaki. The profile is oriented west-east, and crosses the Manaia Fault on the west, and the Taranaki Fault in the east. The top Farewell Formation stratigraphic interval is shown by the purple horizon in the Kupe Field area, the seismic interval of the Farewell Formation displaying discontinuous bright reflectors.

Locality K: Abel Head, Port Puponga

At the visitors centre, we'll walk south toward Port Puponga through an easterly dipping succession of Farewell Formation. The section gets better exposed toward the south as we walk obliquely across strike. We are here through a falling tide, so be prepared to get wet and muddy feet. Note this area forms part of the Department of Conservation administered farm park, so please refrain from collecting rock specimens.

The uppermost stratigraphic unit here is the poorly exposed Middle Miocene Kaipuke Siltstone that passes down into Oligocene Takaka Limestone and Abel Head Formation, in which there are some moulds and casts of irregular echinoids. Below these units are glauconitic Matapo Formation equivalents (Whaingaroan), with a rusty weathered basal unit, resting disconformably on Paleocene quartzose Farewell Formation (Fig. 1.13). The contact is well exposed at Abel Head itself at the end of the section, and represents a significant time break between the Whaingaroan and Teurian (some 20 million years). A nice section through gravelly and sandy Farewell Formation extends west as far as the road bridge at Port Puponga.

Figure 1.13 Trough cross bedded quartzose sandstone and conglomerate of the Paleocene (Teurian) Farewell Formation at Abel Head.

Locality L: Magazine Point, Tahunanui, Nelson

Watch out for irregular surfaces and hard rocks here!

If people need to catch flights, they can be dropped off at Nelson Airport on the way to Nelson. Duntroonian (Oligocene) sandstones of the Magazine Point Formation represent channelised and richly fossiliferous conglomerate, sandstone and mudstone deposited in uppermost bathyal water depths (Lewis 1980; Higgs *et al*. 2004). They are interpreted as submarine fan systems with rapid vertical and lateral variations in facies, widespread scouring and cutting out of beds. Comparable units comprise the Tariki Sandstone in Taranaki Basin.

The section dips steeply to the southeast. Magazine Point is featured in Crampton & Terezow (2010) as one of the better fossil collecting sites in New Zealand. Fossils include small solitary corals such as *Truncatoflabellum*, molluscs such as *Cyclocardia*, *Amalda* and *Austrofusus*. Numerous rather nice examples of *Ophiomorpha* exist. Magazine Point, given its proximity to Nelson, was one of the first places where fossils were collected in New Zealand. “The original specimens were collected by F Manse in the early 1800s and Ferdinand von Hochstetter in 1859, and discussed in scientific papers published by Gideon Mantell (in 1850) and Karl Alfred Zittel (in 1864)” (Crampton & Terezow 2010, p. 121).

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