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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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Field Trip 3
Tuesday 29 November 2011

Dun Mountain

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HEALTH AND SAFETY ISSUES

PLEASE READ!

Participants must heed and observe the warnings and time limitations imposed at certain stops by the trip leaders. There are several track junctions that could lead the unwary in the wrong direction. The Dun Mountain track is a popular mountain bike route and walkers should be aware that some riders travel downhill very quickly and do not always have the control that is expected of them.

The popularity of the area means that hammering of rocks close to the track should be discrete and modest. Please be mindful of others around you when hammering and wear appropriate eye protection.

As we number 26 people it is likely that there will be different speeds of ascent and for safety reasons it is important that we remain as one or possibly two groups. Please wait regularly and let people behind you catch up. In the event that someone wishes to pull out or return early it is critical that they:

1. **do not do so alone and;**
2. **pass a message/txt to the trip leader or nominated assistant indicating their intention and;**
3. **on their return to the Brook valley road leave a note/txt indicating their safe exit.**

Participants must bring their own food and water for the day and any personal medications, including those for allergic reactions (e.g. 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 cold, warm, wet, and/or dry 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. Please don't underestimate the climatic variations that are possible or the potential to get sunburnt. A change of clothing may be useful to bring and to leave in the vehicles, as would a small hand towel.

There is a toilet at Third House, about halfway along the Dun Mountain Railway, and another at the shelter near the summit of Dun Mountain. Otherwise it is a case of heading into the nearest patch of bush. Please remember that much of the route is through waterworks reserve and care must be taken to avoid polluting water courses. Railway and mining relicts are protected under the Historic Places Act.

A good level of fitness and mobility is required for this trip. The total climb is 1100 metres involving a 24 km return walk and some discomfort by the day's end is guaranteed! Lightweight boots are the recommended footwear.

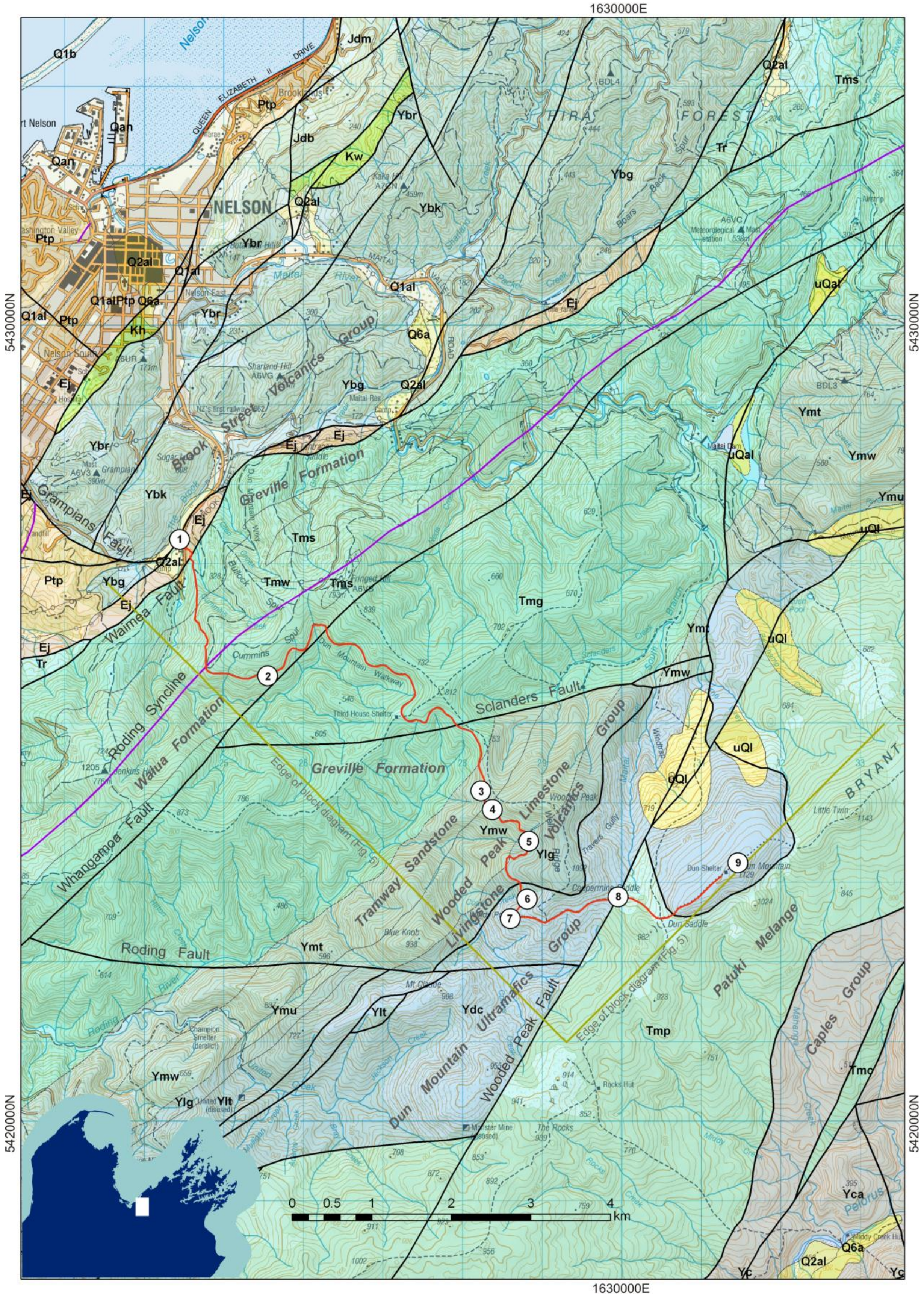

Figure 1 Locality map showing the Dun Mountain track (red line), numbered field stops and simplified geology after Rattenbury et al. (1998). The grid shown is in NZTM coordinates and grid references for the stops are listed in Appendix 1, including the now-superseded NZMG coordinates

Introduction

Dun Mountain is an accessible summit southeast of Nelson city that has figured prominently in the area's economic development and in advances in understanding of the New Zealand geology. Many eminent geologists have visited and described rocks and rock units from the area over the last 150 years. Some of these observations have had international influence, and in particular the adoption of "dunite" to describe the olivine-rich ultramafic rocks at Dun Mountain. The local stratigraphic framework, when linked to correlative rocks in southern South Island, was instrumental in proving that huge lateral displacement of the Alpine Fault has occurred.

Figure 2 View northeast showing the Dun Mountain track and Windy Point (Stop 7, lower centre), the forested Wooded Peak on the left and siltstone-dominated Patuki Melange on the right. The ultramafic rock of the Dun Mountain Ultramafics Group and parts of the Patuki Melange have restricted vegetation cover including Coppermine Saddle (Stop 8, photo centre) and Dun Mountain (Stop 9, upper centre).

Photo CN1191-11 D.L. Homer, GNS Science.

Location

The route (Fig. 1) begins in The Brook valley, 4.5 km southeast of Nelson and approximately 150 m before the Brook Valley Holiday Park entrance. A short sharp track climbs from the sign to the well-graded and benched Dun Mountain Walkway that leads to Third House Shelter. From there the route follows the upper part of the old Dun Mountain Railway to Coppermine Saddle (Fig. 2). A short climb along a less well-formed and poorly marked track then leads to Dun Saddle and a poled route from there, heads to the summit of Dun Mountain. The return journey covers 24 km and typically takes about 9 hours to complete. The climb of 1100 m is sustained and above the bushline at 800 m is regularly exposed to alpine weather conditions. Walkers should carry their own water, food and all-weather clothing. There is intermittent cell phone coverage on the lower part of the track and limited coverage on the upper part.

Geology

The route from The Brook valley to Dun Mountain climbs to a well exposed section of New Zealand's most distinctive geological unit, the Dun Mountain Ultramafics Group of Early Permian age (Fig. 1, Coombs *et al*. 1976; Kimbrough *et al*. 1992). This peridotite-dominated group and the overlying Permian mafic igneous Livingstone Volcanics Group are part of the Dun Mountain Ophiolite Belt (DMOB). The DMOB and the unconformably overlying Late Permian-Early Triassic volcano-sedimentary Maitai Group form the major elements of the Dun Mountain-Maitai terrane (Fig. 2) within the Eastern Province. These units are widely accepted to be a fault-bounded section of oceanic crust ophiolite with relict sedimentary cover deposited in a near-arc setting (Coombs *et al*. 1976; Mortimer 2000).

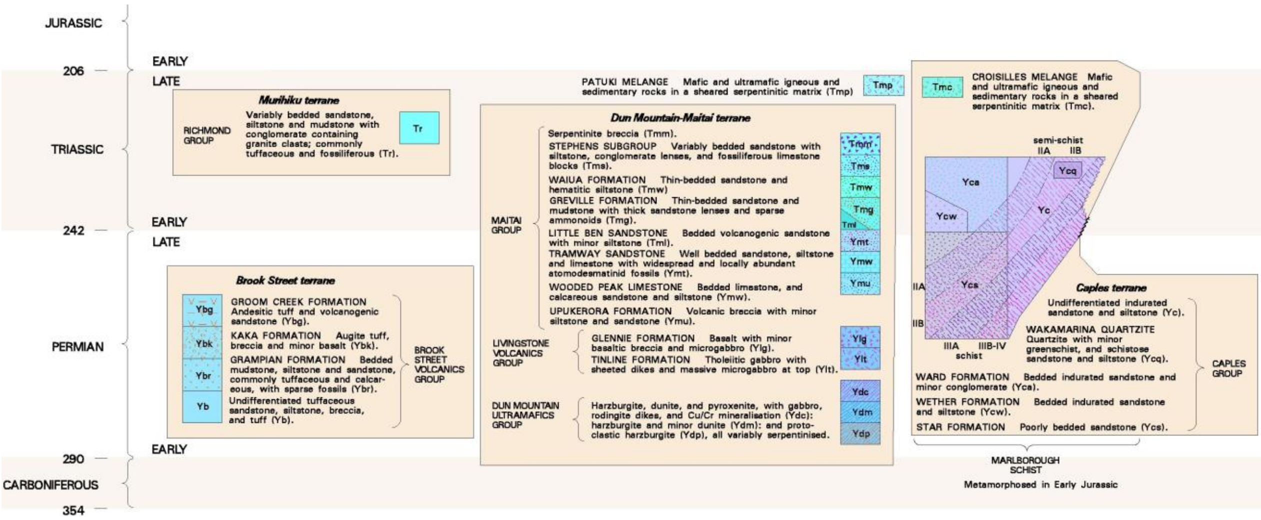

Figure 3 Geological legend for the Permian-Triassic rocks around the Dun Mountain area (after Rattenbury & others 1998).

The DMOB extends from Southland into West Otago where it is truncated by the Alpine Fault in southern Westland. Aside from a faulted wedge in the Matakitaki valley, the DMOB has been offset by the Alpine Fault 480 km to East Nelson, near Tophouse. The DMOB continues northwards through the Red Hills and the Bryant Range and across to D'Urville Island. The Junction Magnetic Anomaly is interpreted to be the buried northern extension of the DMOB through North Island, supported by the occurrence of serpentinite extruded to the surface in southern Waikato. Although the ophiolite belt is well preserved in eastern Nelson, in any one section parts of it have been faulted out. The section examined in this trip is dominated by basalt of the upper part of the mafic zone (Livingstone Volcanics), the cumulate ultramafic zone (Dun Mountain Ultramafics) and the Patuki Melange (Fig. 3).

The local stratigraphic framework has been refined many times since Hochstetter's (1864) formalising of the Maitai [Group] rocks. Notable contributions by Hector (1884), Wellman (1957), Bruce (1962) and Waterhouse (1959, 1964) amongst others have been assimilated into Johnston's (1981) 1:50 000 geological map of the area, with further refinement into a wider South Island context by Rattenbury & others (1998). Additional information on the local area geology is described in a companion field trip guide (Johnston 2011) in the Roding River catchment immediately southwest of the upper parts of the Dun Mountain track.

The Dun Mountain Ultramafics Group dominates the Red Hills and parts of the Bryant Range of east Nelson and is characterised by the reddish brown "dun" hues of the ultramafic peridotite rocks (Fig. 2). The less serpentinised rocks are typically strong and erosion-resistant forming summits, such as the Red Hills, Dun Mountain and Red Hill. The ultramafic rocks are also notable for their characteristically stunted vegetation. This may reflect relatively toxic concentrations of available nickel (Robinson *et al*. 1996) coupled with high magnesium concentrations prevent the uptake of what little calcium is available. This is particularly noticeable for southern beech (*Nothofagus fusca*) and broadleaf (*Griselinia littoralis*) that forms forests on adjacent rock units in stark contrast to the relatively barren ultramafic rocks that are dominated by tussock grasses, sedges and small shrubs (genera *Chionochloa*, *Hebe*, *Dracophyllum*, *Cassinia*, http://www.teara.govt.nz/en/1966/flora-alpine/6). This contrast has been accentuated by burning, both by Maori in search of rock (pakohe) and European exploring for copper and chrome ores.

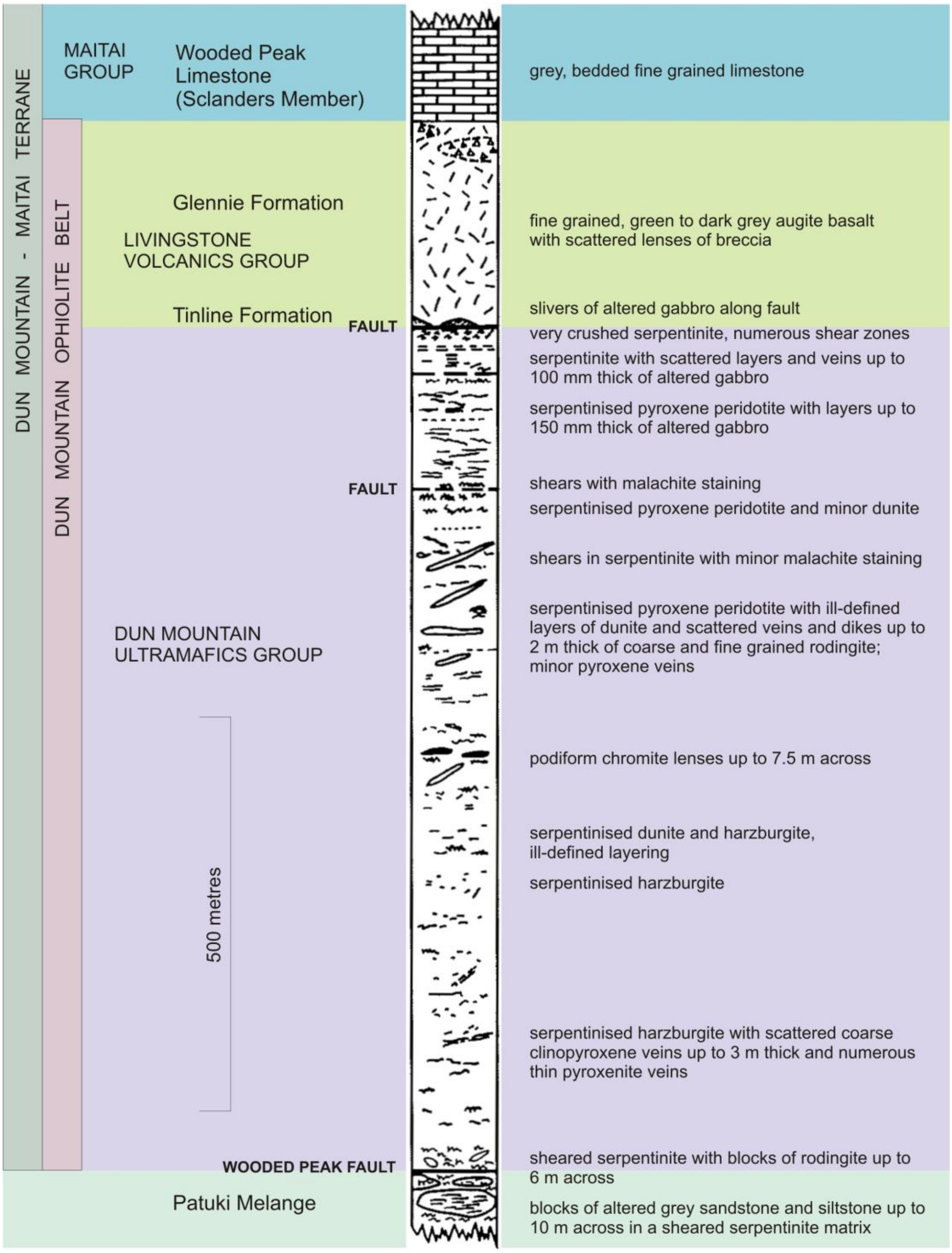

Figure 4 Stratigraphic section between lowermost Maitai Group, Livingstone Volcanics Group, Dun Mountain Ultramafics Group and the Patuki Melange on the southern slopes of Wooded Peak (after Johnston 1981).

Mining history

The area was known to Maori who extracted pakohe (metasomatised argillite) from the melange rocks north of Dun Mountain for manufacturing cutting tools. Interest in the mineral deposits around Dun Mountain began around 1852 when copper ore was found and the Dun Mountain Copper Mining Company was formed in London. Mining engineer Thomas Hacket eventually pronounced the copper lodes to be worthless but he did recommend mining chromite. An assessment by Hochstetter in 1859 was pessimistic about the economics of mining either the isolated copper occurrences or the more extensive chromite deposits. Nevertheless, the high price for chromite of £15 per ton in England led to the construction of the Dun Mountain Railway to transport the ore from the ultramafic rocks near Coppermine Saddle. The horse-drawn railway officially opened on 3 February 1862 and extended from the port, across Nelson city, then climbed from The Brook Street to nearly 900 m above sea level. The gradient on the incline section was as high as 1:18 (Brook Valley to Third House) and 1:20 for much of the remainder of the railway to Coppermine Saddle.

The Dun Mountain Railway cost £75,000 to build and between 1862 and 1864 5666 tonnes of chrome ore valued at £24,719 were extracted from east Nelson and most of this was carried by the Dun Mountain Railway. The chrome was principally used for cotton dyes and in 1861 the American Civil War stopped the export of cotton from the United States forcing British cotton mills to close. Furthermore the initially high price of chromite ore resulted in other parts of the world supplying the English market. This, coupled with the discovery of aniline dyes as a by-product from the manufacture of coal gas, led to a dramatic drop in the demand for chromite from Dun Mountain. Nevertheless, the Dun Mountain Company still had a market for chromite and in 1864 mining engineer Joseph Cock explored mountains, gullies and stream beds. He reported to the company directors that the higher grade chrome deposits were completely exhausted. The company went into liquidation and the incline part of the railway was ripped up in 1872 (the town section remained in use as a passenger tram until 1901). For more detailed information of the history of the Dun Mountain Railway see Johnston (1987, 1996, 2007).

The Dun Mountain Track

The round trip to the summit of Dun Mountain and back down takes about 9 hours with only limited time for rest or geology stops. Each stop below and some intervening landmarks have walking time targets so that the trip can be completed by the scheduled time. If there is time slippage then the trip will not be able to reach the mountain summit. The stops are shown in Figs 1 and 5 and their grid references and heights are listed in Appendix 1. Sunset occurs about 20:30 on 29 November.

Stop 1 Track start on Brook valley road [assemble by 07:50]

The start of the Dun Mountain track is marked by the “Brook Conservation Reserve” sign, 150 metres before the entrance to the Brook Valley Holiday Park. Although not exposed here, the immediate area geology is founded on Early Permian Brook Street Volcanics Group with a thin wedge of Eocene Marsden Coal Measures (Jenkins Group) occurring along the Waimea Fault, a component of the Waimea-Flaxmore Fault System, which follows this part of the valley (Johnston 1981). Bituminous coal with high volatiles and high sulphur content was extracted nearby during the 1890s from steeply dipping, and overturned, 1.5-3.3 m thick seams (Johnston 1987). Only a few thousand tonnes of coal were mined before the mine caught fire and was flooded. The nearby valley slopes are prone to slumping and buildings only 100 m north have been vacated due to the risk from slope movement.

En route to next…

The track climbs steeply until it meets the gentler gradient Dun Mountain Railway bench at "Four Corners" [08:50] at an altitude of 425 m asl. There are views to the northwest of the York Valley quarry working Brook Street Volcanics Group basaltic breccia separated from, to the south, Pliocene Port Hills Gravel by the ESE-trending Grampians Fault (Johnston 1981). Beyond is Tasman Bay flooding the northern end of the 25 km wide Moutere Depression, a complex fault angle depression between the eastern and western Nelson ranges. The track is cut into steeply dipping, Early Triassic Greville Formation of the Maitai Group. The formation is typically finely bedded grey or greenish-grey sandstone and grey mudstone, thinly laminated to very thickly bedded, with rare concretions. Although none have been found on the railway, ammonites have been collected from concretions in the nearby Maitai and Lee rivers.

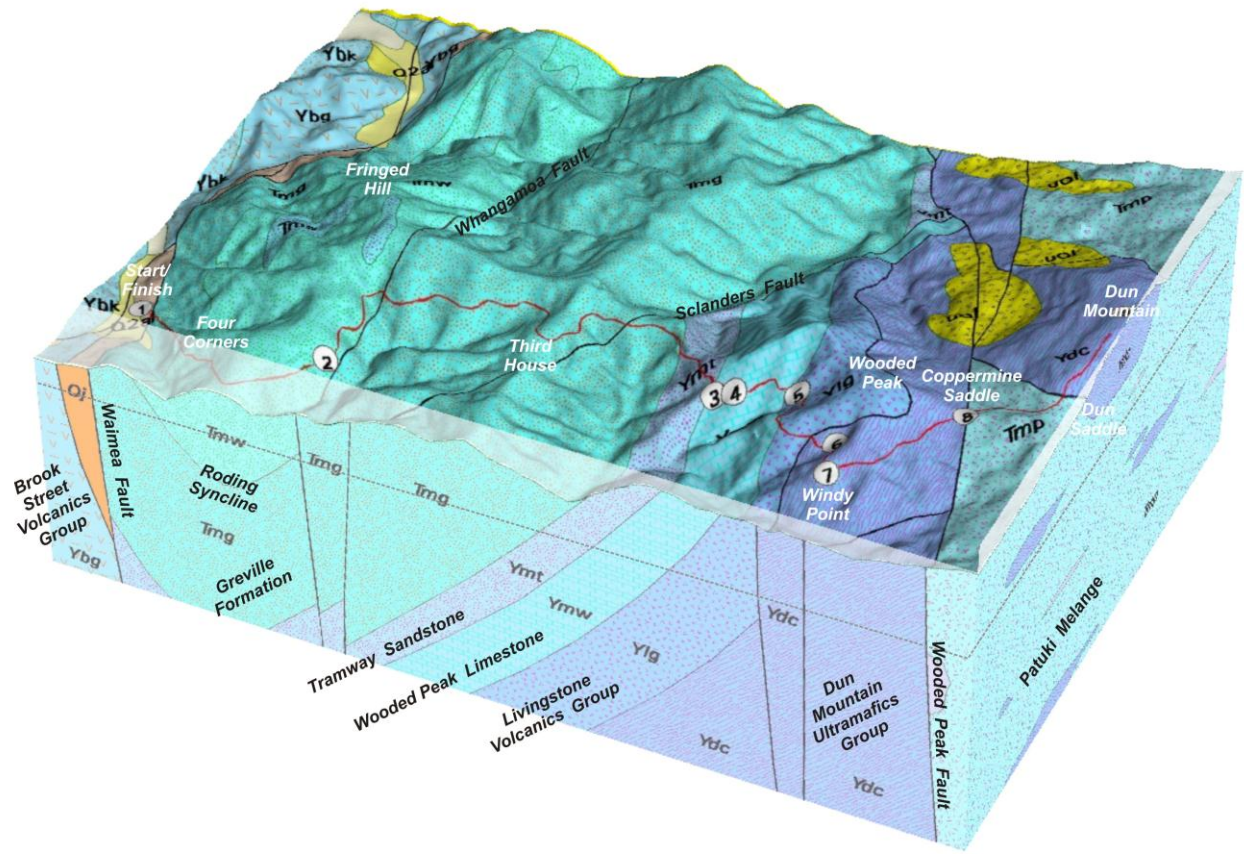

Figure 5 Block diagram showing the Dun Mountain track, key localities, numbered field stops and geological features. Adapted from Johnston (1981) and Rattenbury et al. (1998) using ARANZ's Earth Research developmental 3D modelling software.

Stop 2 Waiua Formation [08:40].

The colourful finely laminated Waiua Formation consists of green sandstone and red mudstone in contrast to the dominantly grey, but otherwise similar, underlying Greville Formation that dominates the lower half of the track. This section is extensively and closely folded (Johnston 1981) such that the two formations appear repeatedly but is overall is in the core of the Roding Syncline (Fig. 5). The Maitai Group sandstones are dominated by feldspar, with half as much quartz and minor epidote, apatite, titanite, muscovite, biotite, hornblende and chlorite. Rock fragments include felsic and intermediate volcanics and sedimentary clasts. The documented lawsonite-albite-chlorite assemblage is indicative of high pressure-low temperature metamorphism (Landis & Coombs 1967). Exposed on the crest of Fringed Hill a few hundred metres above the track in the core of the syncline is the more thickly bedded, sandstone dominated, Stephens Subgroup, the youngest unit in the Maitai Group. A basal conglomerate, with pebbles of Waiua Formation, suggests a local unconformity although generally elsewhere the subgroup is conformable. The Stephens Subgroup contains Permian fossils and this influenced thinking on the minimum age of the Maitai Group until it was realized these occurrences were allochthonous and Triassic ammonoids were discovered both in the subgroup and the Greville Formation.

En route to next…

The track follows the Dun Mountain railway gaining height slowly around the headwaters of The Brook. The Whangamoa Fault, the easternmost component of the Waimea-Flaxmore Fault System is crossed but the fault is ill-defined within the well bedded Greville and Waiua formations. Greville Formation is encountered again east of the fault. Third House [09:30] at 660 m, on the saddle between The Brook and Roding River, is a shelter constructed around remnants of the railway stables. From Third House the railway continues on a very gentle 1:70 gradient to the Junction saddle between the Roding River and South Branch of the Maitai River. The saddle (680 m) is where the ESE-trending Sclanders Fault offsets the rocks of the Dun Mountain-Maitai terrane. From the saddle the railway climbs at 1:20 around the southwest flank of Wooded Peak (1111 m) and crosses the lower units in the Maitai Group before encountering the DMOB.

Stop 3 Tramway Formation [10:15]

This is the type locality of the Tramway Formation (Waterhouse 1964), uppermost Permian, grey, thin-thick bedded sandstone of the Maitai Group. The sandstone here contains shell fragments of the bivalve *Maitaia trechmanni* (Marwick) but complete shells rare. This fossil was initially identified as *Inoceramus* leading to the Maitai Group being assigned a Triassic age and resulting in the “Maitai Problem” in New Zealand stratigraphy. The problem was partly resolved when Trechmann (1917) correctly identified the Maitai bivalves as belonging to the Permian atomodesmatinid family as well as recognising that the Maitai and Richmond Group (Murihiku terrane) rocks were not part of a continuous section but were separated by the Eighty-eight Fault. The gradational contact with the overlying Greville Formation also contains the Permian-Triassic boundary but this is not identified on the track. An intervening, laterally discontinuous, Maitai Group unit, the Little Ben Sandstone, is absent in this area.

En route to next…

From here the Tramway Sandstone grades down into the Wooded Peak Limestone, the basal unit of the Maitai Group.

Stop 4 Wooded Peak Limestone [10:25]

The Wooded Peak Limestone, named by Hochstetter in 1859, is composed of atomodesmatinid shell prisms and is divided into three members. The uppermost member is Malita Limestone (Waterhouse 1964). This is a thin bedded, flaggy limestone, usually grey with some green and pink beds, and here is about 250 m thick. Above the track is the remains of a lime kiln and quarry. Although the kiln is built of Malita Limestone it is partly lined with ultramafic boulders.

En route to next…

Further on is the underlying 170 m thick calcareous Roding Green Sandstone member (Waterhouse 1964), which was quarried for flagstones that, along with lime, were transported on the railway to Nelson. The sandstone member is followed by the lower Sclanders Limestone member up to 650 m thick (Johnston 1981). This limestone is grey and fine grained, commonly poorly bedded. The Wooded Peak Limestone overlies Livingstone Volcanics Group in this section and there is no known occurrence of the Upukerora Formation breccia that locally occurs at the unconformity (for example in the North Branch of the Maitai River).

Stop 5 Glennie Formation [10:45]

The Glennie Formation is the upper unit of the mafic Livingstone Volcanics Group of Permian age (Johnston 1981; Rattenbury *et al*. 1998). The formation is characteristically grey-green, fine grained, variably vesicular basalt with some dolerite and lenses of hematitic breccia. Some of the basalt is extrusive but pillow structures are not known. Alteration is widespread. The basalt forms the upper part of the Dun Mountain Ophiolite Belt, a slice of Permian oceanic crust that has been tectonically incorporated, with the Maitai Group, in the Eastern Province by the Early Cretaceous (Coombs *et al*.1976). In the Livingstone Volcanics Group in eastern Nelson primary minerals include plagioclase, augite, hypersthene, magnetite and very rare olivine. Some hornblende in the upper part of the group may be primary rather than secondary. The group shows three stages of metamorphism. Initially hornblende partially or totally replaced augite to form a uralite gabbro. This was followed by greenschist metamorphism with widespread replacement of plagioclase and hypersthene by albite and chlorite respectively. Finally plagioclase was replaced by hydrogrossular, epidote, prehnite and vesuvianite (Davis *et al*.1980). In Champion Creek, 5 km southwest of Stop 5, the mafic rocks contain sparse minor lenses of plagiogranite, from which zircon U/Pb data has yielded a 285 Ma or Early Permian age (Kimbrough *et al*. 1992).

En route to next…

The railway does not extend far down into the Glennie Formation and small sinkholes on the west (down slope) side of Fourth House at 810 m [10:55] show that the railway follows for a short distance along the unconformity between the Maitai and Livingstone Volcanics groups. The basal part of the Livingstone Volcanics Group, close to the faulted contact with the ultramafic rocks, is locally gabbroic, and are fault slivers of what is locally known as Tinline Formation (Johnston 1981; Rattenbury *et al*. 1998). The fault is marked by soft, very sheared serpentinite and a pronounced change in vegetation.

Stop 6 Dun Mountain Ultramafics Group, Coads Creek [11:30]

The upper part of the Dun Mountain Ultramafics Group has well-developed cumulate textures and are variably serpentinised harzburgite, pyroxenite and minor dunite. Magnesium and iron rich orthopyroxenes, along with enstatite, are dominant. Clinopyroxenes are minor other than in dikes and veins, some of which contain large crystals of diopside or cleaved masses of the more iron-rich “diallage” (Fig. 6A, Bell *et al*. 1911; Lauder 1965). Boulders of coarse grained rodingite, named from the nearby Roding River, by Patrick Marshall, are present in the creek. Rodingite is composed of green to white grossular, hydrogrossular and other calc-silicate minerals, which commonly enclose “diallage” clinopyroxene crystals. The origin of the ultramafic rocks and their context to surrounding rocks has been much speculated on with ideas ranging from early sill intrusion, volcanic extrusion, late intrusion, and tectonic emplacement. The last, as emplacement as an ophiolite (Coombs *et al*. 1976), has proved durable. The vegetation change here marks the beginning of the relatively toxic ultramafic-derived soils that are unpalatable for many plant species.

Stop 7 Dun Mountain Ultramafics Group, Windy Point [11:40]

The aptly named Windy Point at 845 m is an excellent viewpoint of the extent of the Dun Mountain Ultramafics Group highlighted by the stunted nature of the vegetation to the south, predominantly grasses and sedges with no forest. Southwest across the Roding valley the forested Wooded Peak Limestone is visible in cliffs on Blue Knob. The knobbly skyline of the Bryant Range to the southeast is in Patuki Melange with blocks of intact material, mostly sedimentary rocks with some basalt, standing proud from the weaker, serpentinitic matrix. A small excavation of a gossan 12 m below the track shows some copper mineralisation including malachite (Fig. 6D). The copper has been introduced by fluids channelled into fractured serpentinite, possibly leached from primary cumulate interlayering or, alternatively, hydrothermal extraction and deposition of metals during serpentinisation (Brathwaite & Pirajno 1993).

Figure 6 Dun Mountain Ultramafic Group rocks on the southern flanks of Wooded Peak. A: Rodingite boulder with large clinopyroxene crystals in Coads Creek. Photo: M.S. Rattenbury. B: Bright green malachite in the gossan below Windy Point. Photo: M.S. Rattenbury. C: View along the railway to Coppermine Saddle showing mine workings (upper left), the railway terminus (middle right) and a large clinopyroxene dike (lower left). Photo: M.R. Johnston. D: Chromite-rich serpentinised peridotite from mine tailings.

Photo: M.R. Johnston.

En route to next…

The 1.5 km section east from Windy Point, on a 1:66 gradient, has a variety of Dun Mountain Ultramafics Group rock types and several sites of mining activity. A 3 m thick dike of pale, fine grained rodingite (metasomatised gabbro comprising grossularite-diopside-serpentine, Lauder 1965) occurs beside the track (Fig. 6B). Talus from several mining sites shows layered chromite (Fig. 6C, 7) although the original ore-grade outcrops have been mined. Many loose specimens of chromite beside the track exhibit a podiform structure with a rodingite matrix. The best grades reached 54% chromite and the largest “seam” was about 4 m thick. Near the terminus of the railway a clinopyroxene vein up to 7 m thick has large, up to 30 cm long, interlocking cleavage planes of clinopyroxene. Just before Coppermine Saddle the terminus of the railway (875 m) is visible immediately below a recently deviated section of track. Above the track are mullock heaps from the main chromite mines on the Duppa Lode. Ore was dropped down chutes to the railway where it was loaded in wagons, which in pairs and under the control of a brakeman, descended by gravity to the Brook Valley, a trip that took two hours and fifteen minutes. Near Coppermine Saddle the track crosses a small creek that discharges from an adit and fresh samples from the clinopyroxene vein can readily be obtained from its bed.

Stop 8 Patuki Melange, Coppermine Saddle [12:30]

The Coppermine Saddle area (880 m) marks the southeast boundary of the Dun Mountain Ultramafics Group and Wooded Peak Fault contact with Patuki Melange. The melange is characterized by blocks of ultramafic rock, including rodingite, mafic and sedimentary rocks in a foliated and sheared matrix of serpentinite. The bulk of the rock originated from the Dun Mountain Ophiolite Belt (northwest) and the Caples Group (southeast) and the tectonic mixing and deformation occurred during juxtaposition of the Dun Mountain-Maitai and Caples terranes in the Mesozoic.

En route to next…

The track quality deteriorates from the saddle and care must be taken to locate standards and track markers to the east and uphill (not downhill into the Maitai catchment). The exposed rock is a mixture of serpentinite, peridotite and siltstone to Dun Saddle [13:00]. From Dun Saddle a poled route leads up solid, but serpentinised peridotite, past a shelter to the summit. At the start of the steep but short climb from the Dun Saddle, chromite layering in serpentinised dunite is exposed in a shallow prospecting trench on the west of the route.

Figure 7 Dark chromite layers in dunite of the Dun Mountain Ultramafics Group at its type locality on the southwest flank of Dun Mountain. Photo: M.R. Johnston

Stop 9 Dun Mountain [13:20]

The summit of Dun Mountain (1129 m) is an excellent viewpoint of the knobby melange country to the east and south, particularly on the west side of the Pelorus River. Dun Mountain itself is considered to be a large block of mostly variably serpentinised peridotite within the Patuki Melange. Modelling of gravity measurements indicate the block has limited depth extent (Hunt 1978). The mountain is the type locality of "dunite", the olivine-rich ultramafic igneous rock named by Hochstetter during his visit in 1859. Dunite is best exposed on the southwest spur just downslope of where the route begins to reach the broad summit of the mountain. Freshly exposed surfaces have a yellowish light grey-green appearance (Fig. 7) compared to the dark grey serpentinised peridotite. Grains and layers of chromite are widespread. In less altered peridotite distinctive thin veins of green chrome diopside cross cut the primary layering. Harzburgite, even when partly serpentinised, is readily distinguished from dunite or completely serpentinised peridotite by its rough weathered surface of protruding orthopyroxene crystals. Large slumps occur on the northwestern slopes of Dun Mountain.

En route to next…

The route now returns the same way back to the Brook valley and takes about 4 hours with limited rests. Take care between Dun Saddle and Coppermine Saddle to find the standards and track markers as the track can be poorly defined.

Finish (Stop 1). Brook Valley Road [17:30]

References

Bell, J.M.; Clarke, E. de C.; Marshall, P. 1911 The geology of the Dun Mountain Subdivision, Nelson. Wellington: Government Printer. New Zealand Geological Survey bulletin 12. 71 p.

Brathwaite, R. L., Pirajno, F. 1993. Metallogenic Map of New Zealand. *Institute of Geological and Nuclear Sciences monograph 1*.

Bruce, J.G. 1962. The geology of Nelson City area. *Transactions of the Royal Society of New Zealand, geology 1*: 157-181.

Coombs, D.S., Landis, C.A., Norris, R.J., Sinton, J.M., Borns, D.J., Craw, D. 1976. The Dun Mountain Ophiolite Belt, New Zealand, its tectonic setting, constitution, and origin, with special reference to the southern portion. *American journal of science 276*: 561-603.

Cooper, R.A., Jongens, R., Johnston, M.R. and Bradshaw, J.D. 1997. Terranes of the west and north of the South Island. *Terrane Dynamics - 97, Guidebook for Excursion B* pp B1-B42.

Hochstetter, F. von 1864. Geology of New Zealand: contributions to the geology of the Provinces of Auckland and Nelson. Translated and edited by Fleming, C.A.. Government Printer, Wellington.

Hunt, T. 1978. Interpretation of gravity anomalies over the Dun Mountain ultramafic body. *New Zealand Journal of Geology and Geophysics 21*: 413-417.

Johnston, M.R. 1980. Permian-Triassic of Nelson Regional Syncline. Fifth Gondwana Symposium Guide Book 4. IUGS Subcommission on Gondwana Stratigraphy and Paleontology. 48 p.

Johnston, M.R. 1981. Sheet O27AC - Dun Mountain (1st ed.). Geological Map of New Zealand 1:50 000, Department of Scientific and Industrial Research, Wellington.

Johnston, M.R. 1986. A3: Dun Mountain Ophiolite and the Permian-Mesozoic rocks of East Nelson. In: Houghton, B.F.; Weaver, S.D (ed.) South Island Igneous Rocks: Tour Guides A3, C2, and C7. New Zealand Geological Survey record 13, New Zealand Geological Survey, Lower, Hutt.

Johnston, M. R. 1987. High Hopes – the history of the Nelson Mineral Belt and New Zealand’s first railway. Nelson, Nikau Press 152 pp.

Johnston, M.R. 1996. Nelson's first railway and the city bus. Nelson, N.Z.: Nikau Press

Johnston, M.R. 2007. Nineteenth-century observations of the Dun Mountain Ophiolite Belt, Nelson, New Zealand and trans-Tasman correlations. Geological Society, London, Special Publications 287: 375-387.

Johnston, M.R. 2011. Field trip 4: Roding River (“Nelson Mineral Belt”) copper mineralisation and Dun Mountain-Maitai terrane stratigraphy. *In*: Lee, J.M. (ed). Field Trip Guides, Geosciences 2011 Conference, Nelson, New Zealand. Geoscience Society of New Zealand Miscellaneous Publication 130B. 17 p.

Kimbrough, D.L., Mattinson, J.M., Coombs, D.S., Landis, C.A., Johnston, M.R. 1992. Uranium-lead ages from the Dun Mountain Ophiolite Belt and Brook Street terrane, South Island, New Zealand. Bulletin of the Geological Society of America 104: 429-443.

Landis, C.A., Coombs, D.S. 1967. Metamorphic belts and orogenesis in southern New Zealand. *Tectonophysics 4*: 501-518.

Lauder, W.R. 1965. The Geology of Dun Mountain, Nelson, New Zealand; Part 2 – The petrology, structure, and origin of the ultrabasic rocks. *New Zealand Journal of Geology and Geophysics 8*: 475-504.

Mortimer, N. 2000. New Zealand’s geological foundations. *Gondwana research 7*: 261-272.

Rattenbury, M.S.; Cooper, R.A.; Johnston, M.R. 1998. Geology of the Nelson area. Institute of Geological & Nuclear Sciences 1:250,000 geological map 9. Lower Hutt. 67 p. + 1 folded map.

Robinson, B.H., Brooks, R.R., Kirkman, J.H., Gregg, P.E.H., Gremigni, P. 1996. Plant-available elements in soils and their influence on the vegetation over ultramafic ("serpentine") rocks in New Zealand. *Journal of the Royal Society of New Zealand 26*: 457-468.

Trechmann, C.T. 1917 Cretaceous Mollusca from New Zealand. Geological magazine, 4: 294-305

Waterhouse, J.B. 1964. Permian stratigraphy and faunas of New Zealand. *New Zealand Geological Survey bulletin 72.*

Appendix 1 Grid references and heights of field stops and other localities

Locality	NZTM_E	NZTM_N	NZMG_E	NZMG_N	Height
Stop 1: Track start/finish	1624528	5427439	2534525	5989143	83 m
Four corners	1624785	5425891	2534782	5987595	425 m
Stop 2: Waiua Formation	1625619	5425840	2535617	5987544	472 m
Third House	1627229	5425318	2537228	5987022	656 m
Junction Saddle	1628112	5425100	2538110	5986804	679 m
Stop 3: Tramway Sandstone	1628237	5424067	2538236	5985771	740 m
Stop 4: Wooded Peak Limestone	1628390	5424005	2538389	5985709	760 m
Stop 5: Livingstone Volcanics Group	1628823	5423761	2538822	5985465	787 m
Stop 6: Dun Mountain Ultramafics Group, Coads Creek	1628855	5423039	2538854	5984743	826 m
Stop 7: Dun Mountain Ultramafics Group, Windy Point	1628673	5422757	2538672	5984460	847 m
Stop 8: Patuki Melange, Coppermine Saddle	1629915	5422982	2539914	5984685	876 m
Dun Saddle	1630585	5422648	2540585	5984351	960 m
Stop 9: Dun Mountain summit	1631558	5423302	2541558	5985006	1129 m