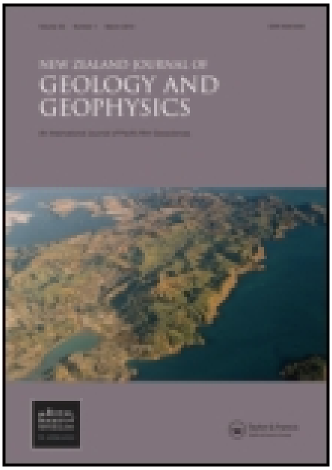

New Zealand Journal of Geology and Geophysics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tnzg20

Lower Paleozoic rocks between Upper Takaka and Riwaka, North-West Nelson

R.A. Cooper [a] [b]
[a] Victoria University of Wellington
[b] New Zealand Geological Survey , Dunedin
Published online: 09 Feb 2012.

LOWER PALEOZOIC ROCKS BETWEEN UPPER TAKAKA AND RIWAKA, NORTH-WEST NELSON

R. A. COOPER

Victoria University of Wellington*

(Received for publication, 13 August 1963)

ABSTRACT

Lower Paleozoic rocks in the southern Pikikiruna Range and adjoining area in North-west Nelson are divided into five formations and a group comprising two informal units. The Riwaka Group and the Hailes Knob Quartzite are new units that are formally defined. Fossils are rare and are poorly preserved. Corals from the Mt Arthur Marble and from a marble band on the west side of the Takaka Valley are of Uppermost Ordovician age, and from stratigraphy the full rock sequence, some 17,000 ft thick, is inferred to range from Upper Ordovician through Silurian possibly to Devonian. Metamorphic grade of rocks of the same age increases to the east, and the Riwaka Group (gneiss, diorite, and amphibolite) and the Separation Point Granite are thought to be derived from metamorphosed volcanic and sedimentary formations.

INTRODUCTION

The area mapped extends from the eastern slopes of the Haupiri and Anatoki Mountains, across the southern end of the Pikikiruna Range to Tasman Bay. It covers 92 square miles and includes parts of N.Z.M.S. 1 sheets S8, S9, S13, and S14.

The villages of Upper Takaka and Riwaka are joined by the Takaka Hill Road through the centre of the area. Upper Takaka lies near the head of the Takaka Valley—a north-trending tectonic depression—and is 14 miles south of Takaka township and 30 miles north-east of Nelson city. Except for the Takaka Valley, in which Oligocene and Miocene sedimentary rocks are preserved, lower Paleozoic rocks are exposed over the entire area. The relation of these to the main belt of lower Paleozoic sediments and metasediments of North-west Nelson is shown by Fig. 1.

With the exception of the south-western part, vertical air photographs cover the entire area (Fig. 2) and stereoscopic pairs were used extensively for structural interpretation. A base map on a scale of 3 in. to a mile was constructed from the photographs by radial plotting and the part not covered by air photographs was mapped by pace and compass traversing.

*Now with New Zealand Geological Survey, Dunedin.

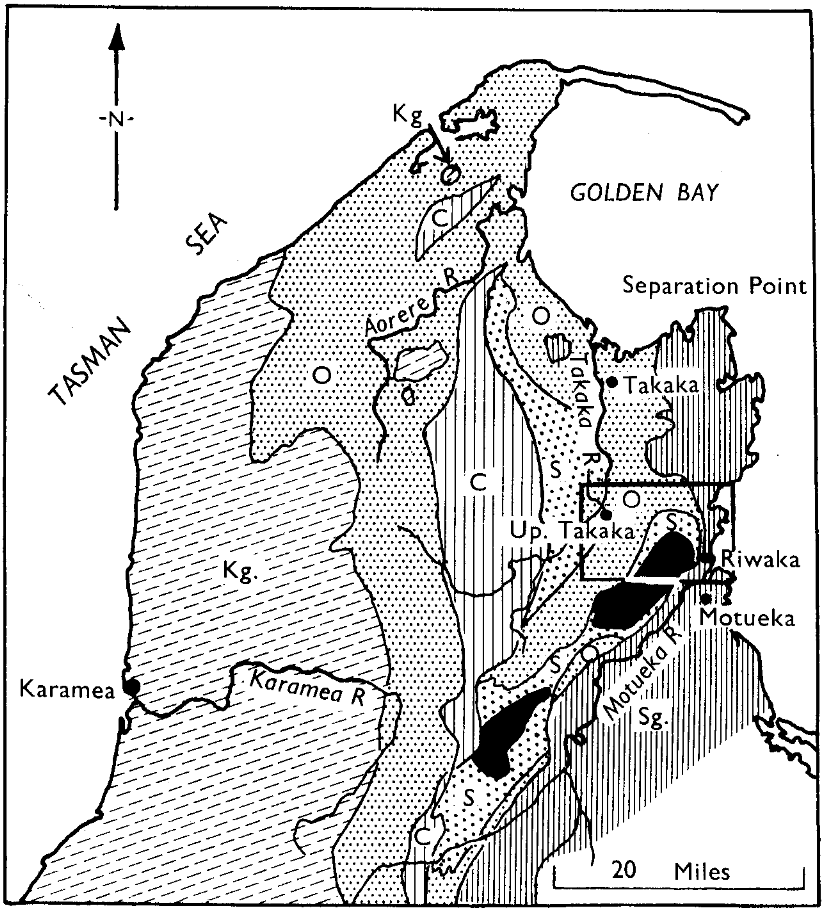

FIG. 1—Locality map of North-west Nelson showing position of mapped area (Fig. 2) and approximate distribution of Paleozoic rocks. Younger rocks not shown. Kg = Karamea Granite; C = Cambrian; O = Ordovician; S = Upper Ordovician and ?Silurian; Sg = Separation Point Granite; solid black = Riwaka Group (metavolcanics) and Wangapeka Formation, Uppermost Ordovician to ?Silurian.

PREVIOUS WORK

The earliest division of the basement rocks was made by Cox (1881), who described the section exposed on what is now the Old Takaka Hill Road, and presented a geological sketch map and cross sections of the Pikikiruna Range. Marble was considered to rest unconformably on metamorphic rocks. Cox suggested that "the cause of metamorphism of the schists is the same as that of the marble".

Park (1890) produced the first geological map of North-west Nelson.

He considered the marble of the Pikikiruna Range to be conformably overlain by hornblende gneiss and quartzites, and to be disconformably underlain by quartzites and slates. The quartzites and slates were considered to be Cambrian and the other rocks to be Lower Silurian (now Ordovician). Park considered the separation Point Granite to be a metamorphic rock and the Karamea Granite to be an intrusive rock. McKay (1879, 1892, and 1896), working in the Baton, Riwaka, and Aorere districts, largely agreed with Park's conclusions. More detailed maps, either in or near the mapped area, were made by Bell, Webb, and Clarke (1907) in the Parapara Subdivision, and by Henderson, Grange, and Macpherson (1930) in the Motueka Subdivision.

The most recent work is shown by Grindley's (1961) Golden Bay Sheet on a scale of 4 miles to an inch. The stratigraphic divisions of Park, McKay, Henderson *et al.*, and Grindley are correlated with those of the writer in Table 1.

OUTLINE OF STRATIGRAPHY

Identifiable fossils are rare and the rocks are mapped on lithology. Metamorphism increases from west to east and rocks of the same age are represented by both metamorphic and non-metamorphic formations (Table 1). The rocks of the area may be divided into four age divisions as follows:

The oldest is mica-garnet-sillimanite schist (Pikikiruna Schist) underlying the Mt Arthur Marble on the Pikikiruna Range and thought to be Middle or Upper Ordovician.

The next oldest is the Mt Arthur Marble, which contains uppermost Ordovician corals and sponges, the oldest diagnostic fossils in the area.

The third age division, thought to be uppermost Ordovician or Silurian, comprises three distinct units, two of which directly overlie the Mt Arthur Marble. These two differ strongly in degree of metamorphism and in mineralogical composition. The lower-rank unit—Haile's Knob Quartzite—consists of tuffaceous quartzites and fossiliferous slates. The higher-rank unit—lower or gneiss unit of the Riwaka Group—lies to the east in the Riwaka Syncline, and consists of 8,000 ft of quartzite, schist, and gneiss, mostly in thin alternating beds; thick interbedded quartzites are shown separately on Fig. 2. The third unit—greywacke lying to the west of the Pikikiruna Range—is of somewhat uncertain stratigraphic position.

The youngest division—the upper or metavolcanic unit of the Riwaka Group—comprises massive amphibolite and diorite with interbedded gneiss and quartzite and with increasing thickness of gneiss layers passes down into the Riwaka gneiss. It is thought to be Silurian to Devonian. Thick interbedded quartzites are shown separately in Fig. 2.

PIKIKIRUNA SCHIST

Distinctive schists underlying the Mt Arthur Marble near Pikikiruna Trigonometrical Station were named Pikikiruna Schist by Cox (1881). They are exposed in the south-plunging Pikikiruna Anticline on the western side of the Pikikiruna Range.

TABLE 1—Chart Showing Correlatives of Rocks of the Mapped Area and the Ages Previously Assigned to them. (Originally assigned age is indicated by vertical position and correlation by numbers.)

Note: "Lower Silurian" and "Upper Silurian", as used by Park and McKay, are now known as Ordovician and Silurian respectively.

Park (1890) (Collingwood & Takaka)	McKay (1879, 1892, & 1896) (Baton R., Riwaka and Aorere Valleys)	Henderson *et al.* (1930) (Motueka Subdivision)	Grindley (1961) (Golden Bay Sheet)	This Paper	Age	
			6 Riwaka Metavolcanics	6 Riwaka Group (metavolcanics)	? Devonian	Sedimentary & Metamorphic
	2 Limestone		5 Wangapeka Formation; 4 Onekaka Schist	5 Western Gwke & Marble; 3 Hailes Knob Qtzite; 4 Riwaka Group (gneiss)	Silurian	
4 & 6 Riwaka Hornblende Gneiss	1 Mica Schist and Quartzite	1, 2, & 5 Mt Arthur Series (or Upper Aorere Series)	2 Mt Arthur Marble; 1 Pikikiruna Schist	2 Mt Arthur Marble; 1 Pikikiruna Schist	Ordovician U.	
2 & 5 Aorere Series Limestone, Talc and Chlorite Schist					Ordovician M.	
(disconformity)		Lower Aorere Series			Ordovician L.	
1 Pikikiruna Series					Cambrian	
7 Granite "metamorphic" (pre-Silurian)	7 Granite	4 & 7 Granite	7 Separation Point Granite (Upper Paleozoic)	7 Separation Point Granite (Upper Paleozoic)	"Igneous"	
	6 Hornblende syenite (Devonian)	6 (in part) Dolerite and Gabbro	Rameka Intrusives (Devonian)			

The uppermost beds are 250 ft of massive, bedded, quartzite and meta-quartzite, with layers rich in garnets up to 2 mm in diameter, a few inter-bedded mica schist layers, and a few thick quartz veins. Underlying the quartzite is 200 ft of quartz-mica-garnet schist. One spectacular rock, a boulder from a stream bed half a mile east of Upper Takaka, consists almost entirely of muscovite and euhedral almandine-garnet crystals up to 2½ cm in diameter. Staurolite and sillimanite are reported by Grindley (1961). Sillimanite is a characteristic mineral of high-grade metamorphosed pelitic rocks, and as mineral lineation is relatively weakly developed in these schists, Grindley considered that they were formed under conditions of high temperature and low stress.*

Half a mile south-east of Pikikiruna Trig. muscovite-quartz-garnet schist grades into quartz-feldspar-mica gneiss similar to the gneissic phases of the Separation Point Granite.

No fossils are known from the Pikikiruna Schist, but becaue it grades up into the overlying Mt Arthur Marble it is thought to be Middle or early Upper Ordovician and to be the metamorphic equivalent of Grindley's (1961) Flora Formation.

MT ARTHUR MARBLE

The name "Mt Arthur Marble" is used for the well known marble and limestone that forms the central and western parts of the Pikikiruna Range and extends east to the Separation Point Granite. Within the mapped area the formation is well defined, having sharp upper and lower contacts. The most accessible section through the marble is along the Takaka Hill Road, from Kairuru to the summit. Black limestone lying west of the Pikikiruna Range at Sam Creek resembles black limestone on the western side of the Pikikiruna Range at Hailes Knob in lithology and fossil content, and is tentatively considered to be part of the Mt Arthur Marble.

Apart from a few discontinuous layers of graphitic, micaceous, and quartzose schist, and rare calc-silicate layers, the formation consists almost entirely of calcite. At most places, bedding planes are defined by layers of impurities. On the west side of the Pikikiruna Range the Mt Arthur Marble conformably overlies Pikikiruna Schist, and is conformably overlain by Hailes Knob Quartzite; on the east side of the range it overlies granite, and is probably unconformably overlain by the Riwaka Group gneiss.

Because of the extremely variable rank of the marble, metamorphism is considered to be due to a steep temperature gradient, and the rocks may not have been deeply buried. Rank generally increases to the north-east towards the Separation Point Granite. The low-rank zone contains black, well-bedded, highly carbonaceous limestone with a few thin quartzose and shaly beds and crops out at Hailes Knob and Sam Creek. Poorly preserved fossils are common, almost all the localities listed in Table 2 being in this zone.

The intermediate-rank zone contains light to dark grey, medium- to fine-grained marble, with few thin quartzites and graphitic schists. Crinoid stem ossicles and broken sponges are not uncommon.

*Sillimanite is largely confined to rocks north of the Takaka Hill Road near Separation Point Granite (Dr E. Ghent, pers. comm.).

TABLE 2—Lower Paleozoic Fossil Localities at Takaka Valley and Pikikiruna Range

Collection No.	Fossil Sheet No.	Approx. Grid Ref.	Fossils	Locality and Lithology	Age	Ref.
GS 744	S8/485	—	Corals, crinoids	Sparrow (limestone)	(UO)	1
V 653	S8/552	195640	Corals, crinoids, sponges, stromataporids	Sam Ck. Gorge (limestone)	(UO)	3
V 878	S8/553	253780	Indet. fossils	Mouth Dry R. (limestone)	(UO)	4
V 879	S8/554	239768	Crinoids (indeterminate)	Mouth Rameka Ck. (limestone)	(UO)	4
V 880	S8/555	185650	Corals, sponges, crinoids, stromataporids	Cotton Ck. (limestone)	(UO)	4
V 974	S8/556	282613	Sponges, ?corals (indeterminate)	Canaan Rd. (marble)	(UO)	3
V 975	S8/557	288637	Sponges, ?corals	Near Canaan Rd. (marble)	(UO)	3
V 980	S8/558	302609	Corals, crinoids	Ngarua Lime Works (marble)	(UO)	3
V 985	S8/559	—	Sponge (indeterminate)	½ mile N of Craigieburn Ck. Takaka (limestone)	(UO)	4
V 970	S13/530	192557	Corals, crinoids, stromataporids	Waitui Stm. 1 mile up gorge (thin limestone)	?O–S	3
V 971	S13/531	187596	Corals, crinoids, stromataporids	Below Trig. A, Takaka R. (thin limestone)	?O–S	3
V 972	S13/532	203535	Corals, sponges, crinoids	Dry Stm., up from bridge, Up. Takaka (limestone boulders)	(UO)	3
V 972	S13/532	203535	Brachiopods	(Quartzite boulders)	(?S)	3
V 973	S13/533	203525	Corals, sponges, crinoids	W. face, Hailes Knob (limestone)	(UO)	3
V 976	S 13/534	305570	Brachiopods	Riwaka R. (quartzite boulders)	(?S)	3
V 977	S 13/535	213510	Brachiopods	1 mile ESE of Hailes Knob (quartzite)	(?S)	3
V 978	S13/536	225550	Crinoids (indeterminate)	2 miles N of Hailes Knob (limestone)	(UO)	4
V 981	S13/537	166393	Corals, crinoids, sponges	Graham Valley (marble)	(UO?)	4
V 982	S13/538	231511	Brachiopods (indeterminate)	S. Br. Riwaka R. (quartzite)	(?S)	3
V 984	S13/539	185582	Graptolites crinoids	Takaka R. 2 miles W. Up. Takaka (shale and limestone)	(?UO)	2

Collection number: GS, N.Z. Geological Survey
V, Victoria University of Wellington

Age: O, Ordovician UO, Upper Ordovician
S, Silurian O–S, Upper Ordovician to Silurian

Ages inferred from stratigraphy are enclosed in brackets.

References:
1, Park, 1890
2, Wellman, 1962
3, this paper
4, outside mapped area.

The high-rank zone lies within 2 miles of the Separation Point Granite and contains pure coarse-grained marble, cream, white, or rarely pink. The high-rank marble commonly contains graphite specks, micaceous layers, quartz nodules, small pyrite cubes, and calc-silicate layers. A possibly economic deposit of wollastonite lies in this zone at the top of the Mt Arthur Marble, 2 miles east of Kairuru. Marble of the high-rank zone is more massive than that of the other zones and has been extensively quarried for dimension stone.

Two sets of planes intersect the high rank marble—rare sandy and micaceous layers that are considered to represent bedding and more widely distributed light and dark laminations that represent schistosity or bedding. Barely recognisable fossils occur at two localities. Marble near the granite contains thin feldspathic aplites and thin layers of coarse-grained quartz-feldspar gneiss, and is generally siliceous. Several aplites and a few prominent granitic dikes, three of which are shown in Fig. 2, occur in siliceous marble about 500 ft from the granite near Canaan Road in the north-central part of the area.

Deformation is variable but independent of rank. Trends that show prominently on air photographs were found from ground observations to represent the strike of the marble. The air photo trends have been generalised and are shown on Fig. 2 by the strike of the limestone symbol.

At the top and bottom of the marble, deformation is no greater than that of the overlying and underlying formations. The middle of the marble is deformed by numerous minor folds, by small faults, and by a few larger folds such as those near the entrance to Canaan Road. The marble appears to have flowed, being deformed most where least restrained by the adjacent formations. Structure near Canaan Road is particularly complex. Dips are moderate to gentle but strikes are extremely erratic, possibly partly due to faulting. Minor folds are irregular, with no dominant trend, and deformation appears to be the result of local rather than of regional stresses.

The syncline shown in the marble immediately west of the Pikikiruna Anticline (Fig. 2) is largely based on air photo trends. At Sam Creek, on the west side of the Takaka Valley, the marble is irregularly deformed and interrupted by small faults that are too numerous and irregular to be mapped separately.

Between the hill road section and the Motueka Lime Works ($1\frac{1}{2}$ miles north-west of Riwaka), 8 miles along the strike, the marble thins from at least 4,000 ft to no more than 100 ft. This dramatic thinning is not fully understood, but according to Grindley (1961) is characteristic of the formation. Near Kairuru, a slight angular unconformity was observed at the top of the marble, and the thinning may be due to this. Other possible causes are flow within the formation, or digestion of the lower part of the marble by the underlying granite. The upper contact shows conspicuously in the topography, and upper and lower contacts can be traced easily. Both are remarkably regular, contrasting with the complex structure within the formation.

Previously unrecorded species of corals—*Plasmoporella* cf. *inflata* Hill, *Proheliolites goldfussi* (Billings), *Favistella alveolata* (Hall)—were collected from Sam Creek by members of the Victoria University of Wellington Geology Department, and numerous poorly preserved tabulate corals

FIG. 2 (*opposite*)—Sketch map and cross-section showing solid geology between Upper Takaka and Riwaka, North-west Nelson, New Zealand.

TERTIARY

Ts = Upper Miocene sandstone
Tm = Lower Miocene mudstone
Tl = Upper Oligocene limestone

POST-SILURIAN

Sg = Separation Point Granite
Sb = Hornblendic border phase
Sd = Granite dikes (in black)

SILURIAN TO DEVONIAN

Ra = Riwaka Group—metavolcanic unit (amphibolite). Interbedded quartzites in solid black

UPPERMOST ORDOVICIAN TO SILURIAN

Rg = Riwaka Group—gneissic unit. Interbedded quartzites in solid black
Hq = Hailes Knob Quartzite
Wg = Greywacke and argillite on western side of map
Wl = Limestone band within *Wg*

UPPERMOST ORDOVICIAN

Mm = Mount Arthur Marble

MIDDLE OR UPPER ORDOVICIAN

Ps = Pikikiruna Schist

Notes: Order of superposition was determined only where arrows are shown on dip symbols. Arrows point in direction of younging.

Paleozoic fossil localities are shown by solid black circles.

The trace of the Pikikiruna Fault to the west of Hailes Knob is obscured by a thick scree of marble breccia, as shown in the section.

Thousand-yard grid squares are shown on the margins of the map.

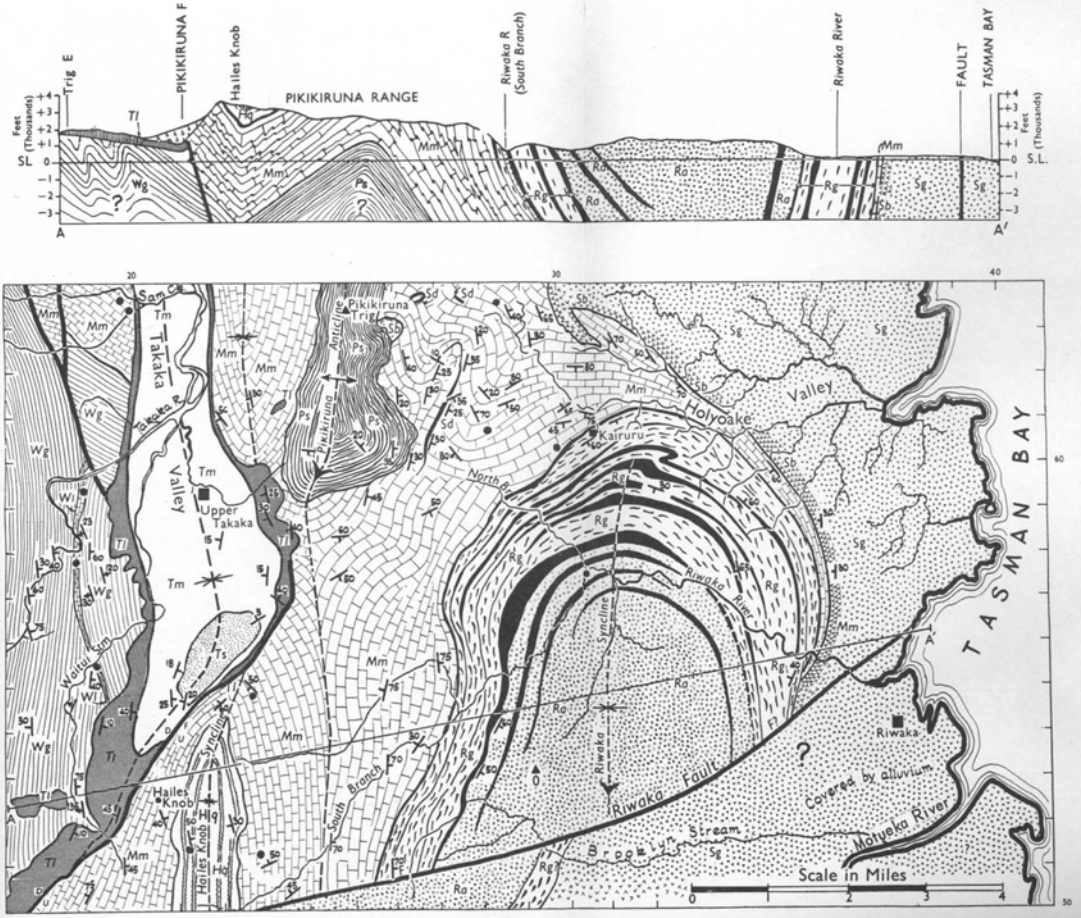

FIG. 2—Geological map and section of area between Upper Takaka and Riwaka. For explanation see facing page.

were collected by the writer at Hailes Knob. The sponge *Microspongia* sp. is abundant at both localities. The Sam Creek fauna is probably Uppermost Ordovician (Richmondian). This is in agreement with the "Upper Ordovician age" inferred for the Mt Arthur Marble by Grindley (1961), based on stratigraphy and the coral *Paleopora inordinata* Lonsd., reported by Benson and Keble (1936) from the Takaka Valley.

HAILES KNOB QUARTZITE

The name "Hailes Knob Quartzite" is proposed for grey quartzite and sandy slate conformably overlying black limestone near Hailes Knob. The rocks are confined to the core of an assymmetrical, gently south-plunging syncline—Hailes Knob Syncline—and the type section is exposed on the ridge leading south-east from Hailes Knob.

The lower 800 ft consists of grey or black quartzite, is tuffaceous in its upper part, and contains 1–6 in. quartz veins. Thin sections show rounded, even-sized, quartz grains from 0·1 to 0·4 mm in diameter. Extensive alteration gives the rock a grey colour. The upper part consists of 300 ft of tuffaceous, sandy, or graphitic slate. The rocks dip moderately and are comparatively undeformed. Together with the underlying black limestone of Hailes Knob they represent the lowest-rank basement rocks in the Pikikiruna Range.

Brachiopod fragments occur in tuffaceous sandstone and shale on the ridge leading south-east from Hailes Knob, about 800 ft above the base of the formation. Quartzite boulders with brachiopod impressions in the stream flowing south-east from Hailes Knob, and tuffaceous sandstone boulders with numerous brachiopod and crinoid impressions in Dry Stream are probably derived from the Hailes Knob Quartzite. The brachiopods are poorly preserved and could not be identified. Because it conformably overlies the Mt Arthur Marble, the Hailes Knob Quartzite is thought to be uppermost Ordovician or Silurian and the equivalent of the basal part of the Wangapeka Formation of Grindley (1961).

RIWAKA GROUP

Gneiss, quartzite, and amphibolite with rare mica schist, granite, and gabbro overlie Mt Arthur Marble in the Riwaka Syncline and form the Riwaka Group. The lower unit of the group is mainly composed of gneiss and quartzite whereas amphibolite (metavolcanics) predominates in the upper unit. Each unit is discussed separately.

Gneiss Unit

Quartz-feldspar gneiss, biotite-quartz-feldspar gneiss, and hornblende-feldspar gneiss with numerous thin, interbedded quartzites, rare amphibolites, and rarer mica schists, overlie Mt Arthur Marble on the Pikikiruna Range with slight unconformity. The gneiss is about 8,000 ft thick at the northern margin of the Riwaka Syncline, and thins to the south and east. It is well exposed on the Takaka Hill Road from Riwaka River to Kairuru.

Most of the quartzite beds are compact and white with conspicuous flecks of biotite and garnet, fairly uniform in composition, and from 10 to 100 ft thick. They are more resistant to erosion than the interbedded coarse-grained gneiss and show conspicuously on air photos. To the south and east they grade laterally into biotite-quartz-feldspar gneiss (Fig. 2). Quartzite beds south of the North Branch, Riwaka River, are mapped mainly from air photographs. Distinctive orange-weathering, green quartzite boulders in the South Branch and main Riwaka River, derived from near the middle of the formation, contain casts of highly distorted brachiopods, including a rhynchonellid.

In contrast to the quartzites, the gneissic rocks are extremely variable in composition and individual beds cannot be traced far. They are generally coarse-grained (1 to 4 mm) and strongly weathered, few outcrops yielding good hand specimens. Composition ranges from biotite-quartz-feldspar gneiss, the most acid phase, to hornblende-feldspar-gneiss, the most basic phase. Individual beds commonly contain both phases. The acid gneisses pass laterally into rocks with granitic texture that strongly resemble the Separation Point Granite. One such rock, in the Riwaka Valley, consists almost entirely of subhedral crystals of quartz and microcline, with minor biotite. Many bands are layered with alternating light and dark layers from a few inches to a few feet thick. A few bands contain probable relict cross-bedding and relict graded-bedding. The younger hornblende-feldspar gneisses are more hornblendic and massive, and grade vertically and laterally into amphibolites of the Metavolcanic unit. One amphibolite layer occurs near the base of the Gneiss unit. Biotite-garnet schists are confined to a band that immediately overlies the Mt Arthur Marble at Kairuru.

Because it overlies the marble, the gneiss unit is thought to extend up into the Silurian. The lower part of the formation is stratigraphically equivalent to Hailes Knob Quartzite lying 2 miles to the west. The fossiliferous quartzite bands are definitely of sedimentary origin. The layered gneisses suggest that part of the gneiss is of sedimentary origin, and it is thought that the formation as a whole represents metamorphosed sediments, or possibly metamorphosed sediments and volcanics.

Metavolcanic Unit

Amphibolite with minor quartzite, diorite, and gabbro overlies gneiss and occupies the core of the Riwaka Syncline. The unit is at least 4,000 ft thick.

The amphibolite is massive, dark, blue-green or black, and generally coarsely crystalline, hornblende crystals being up to 2 cm long. It is generally strongly weathered and yields a fertile soil. Average composition is 40% hornblende, 40% feldspar, with minor biotite. A typical specimen from Mt Campbell consists mostly of chloritised, calcic-andesine, with a few large crystals of altered hornblende. Thin quartzites and thin feldspathic gneissic phases are confined to the lower part of the unit. Gabbro was not seen in place but occurs as boulders in streams draining the Mt Campbell area.

No fossils are known from the unit, but because it concordantly overlies the gneiss, it is thought to be Silurian and possibly partly Devonian.

Henderson, Grange, and Macpherson (1930) considered the rocks to be intrusive, but Grindley (1961) suggested that they represent metamorphosed Devonian volcanic rocks and included them in his Riwaka Metavolcanics formation. Because of its similarity to the bands of amphibolite in the underlying gneiss, and because it contains interbedded quartzites, the unit is thought to represent metamorphosed sediments and volcanics.

"GREYWACKE" WEST OF THE PIKIKIRUNA RANGE

With the exception of the thick marble at Sam Creek, basement rocks within the mapped area west of the Pikikiruna Range consist of alternating quartzitic greywacke and quartzite, interbedded with argillite and phyllite, and a single band of black limestone.

The rocks are moderately or steeply dipping to overturned, probably isoclinally folded, and strike at about 350°. Minor folds and crenulations are not common. Estimated minimum thickness is 3,500 ft. The quartzitic greywacke and quartzite members are as much as 100 ft thick, though most are no more than 3 ft to 20 ft thick. A few are graded and most contain quartz veins from 3 to 15 in. thick. The argillite beds are up to 20 ft thick, strongly or moderately sheared and commonly show slaty cleavage. At places the argillites are phyllitic and split easily, exposing a wavy or crinkly surface, and ring when hit with a hammer. They commonly contain pyrite cubes.

The black limestone band is 50 to 100 ft thick and extends from beneath the Tertiary limestone near Waitui Stream north for 3 miles to the Takaka River, where it is cut off by a fault. It contains a few sponges, a few tabulate corals, and numerous small solitary rugose corals and stromatoporids, but otherwise resembles the black, carbonaceous Mt Arthur Marble at Hailes Knob and Sam Creek. The black limestone appears to be an interbedded layer, but it is severely deformed and may be infaulted or infolded. A 10 ft band of metavolcanics lies to the west of the marble in Waitui Stream but was not seen elsewhere.

Streptelasma sp. and *Foerstephyllum?* have been collected from the limestone at the Takaka River, and *Streptelasma* sp. from the limestone in Waitui Stream. Rugose corals, including one with an axial vortex, have been collected from both localities. Indeterminate graptolites were reported by Wellman (1962) from shale close to the marble at the Takaka River.

The rugose corals with an axial vortex suggest a Late Ordovician or Silurian age, but *Foerstephyllum* is not known in rocks younger than Ordovician. Thus the marble band is thought to be Late Ordovician; the greywackes are probably of similar or younger age. Grindley (1961) has mapped the greywackes and argillites as part of his Wangapeka Formation, which he considered to be Silurian, and the marble as infaulted Mt Arthur Marble.

SEPARATION POINT GRANITE

The name "Separation Point Granite" has been used by many writers for the granitic rocks at and near Separation Point. It is confined to the north-east and east of the mapped area and is light-coloured and deeply weathered. Average samples contain about 40% quartz, 40% feldspar (orthoclase and albite), and up to 20% hornblende and biotite, with minor amounts of apatite and muscovite. Most of the granite is coarse-grained (1 to 4 mm), granular or slightly porphyritic, with phenocrysts of orthoclase. Strongly porphyritic rocks with orthoclase crystals up to 5 cm long are associated with orbicular granite with orbs up to 20 cm in diameter in the beach cliff half a mile north of Kaiteriteri Bay.

Near the marble the granite is hornblende-rich, with gneissic or schistose foliation that is parallel to the contact. Contact rocks on the old Sandy Bay Road have fine schistosity and resemble leached calcareous schist, and in the upper Holyoake Valley there are numerous boulders of calc-silicates. Massive garnet- and garnet-actinolite-bearing rocks are common.

Park (1890) suggested that the granite is metamorphic and considered it to be "non-conformably" overlain by hornblende gneiss. Henderson, Grange, and Macpherson (1924) considered it to be intrusive. Grindley (1961) suggested that, because the granite "concordantly underlies marble for over 50 miles along the eastern highlands" and because "contacts show interlamination of marble and granite and no contact alteration or chilling", it was formed in place from granitised Ordovician sedimentary rocks underlying the marble. The writer's observations support Grindley's explanation. The age shown in Table 1—Upper Paleozoic (i.e., post-Silurian)—is that of its "metamorphism", or emplacement.

STRUCTURE AND METAMORPHISM OF THE PALEOZOIC ROCKS

Within the mapped area west of the Pikikiruna Range the rocks are inferred to form tight folds trending 340° to 360°. At only a few localities was the order of superposition directly determined from graded bedding, and at about half of these the beds proved to be overturned. Faults and minor folds are not prominent and slaty cleavage is of at least two generations.

A different pattern is shown on the Pikikiruna Range, where the rocks are mostly moderately dipping, in broad, apparently simple folds plunging south from 10° to 60°. Slaty cleavage is absent.

A major dextral transcurrent fault—the Riwaka Fault—is mapped to the north of Brooklyn Stream as displacing the axis of the Riwaka Syncline by at least 3 miles. The displacement, although uncertain, is in good agreement with that mapped on the Karamea Fault to the south-west by Henderson *et al.* (1959) and Grindley (1961). Thus the Riwaka Fault is probably the north-eastward extension of the Karamea Fault.

Quartzite, phyllite, and limestone at Hailes Knob and the rocks to the west of the Pikikiruna Range are typical products of low-grade regional metamorphism probably caused by deep burial. Other rocks of the

Pikikiruna Range are of medium to high grade. The Mt Arthur Marble, although almost pure calcium carbonate, provides a rough measure of metamorphic grade and conveniently extends across the Range. Fine-grained limestone, overlain by quartzite and shale, lies in the south-east of the Range, and coarse-grained wollastonite-bearing marble, overlain by quartzite and gneiss, lies near the granite. This rapid increase in metamorphic grade is thought to be caused by a steep temperature gradient associated with the Separation Point Granite rather than by deformation under high confining pressure. It is possible that the high temperature that produced the metamorphic rocks of the Riwaka Syncline also caused granitisation of rocks underlying the marble.

Petrological study and chemical analyses are needed before more definite statements concerning the origin of metamorphic rocks can be made.

ACKNOWLEDGMENTS

The writer would like to thank Mr and Mrs Ralph Hope of Upper Takaka and Dr and Mrs R. Roborgh of Riwaka for their hospitality. Dr Roborgh first drew the writer's attention to the brachiopod-bearing boulders from the Riwaka River. Thanks are also due to Drs H. W. Wellman, P. Vella, and J. Bradley for helpful discussion and assistance in the preparation of this paper.

REFERENCES

BELL, J. M.; WEBB, E. J. H.; CLARKE, E. DE C. 1907: The Geology of the Parapara Subdivision. *N.Z. Geol. Surv. Bull 3.*

BENSON, W. N.; KEBLE, R. A. 1936: The Ordovician Rocks of New Zealand. *Geol. Mag. 73 (6)*: 241–51.

COX, H. S. 1881: On Certain Mines in the Nelson and Collingwood Districts, and the Geology of the Riwaka Range. *N.Z. Geol. Surv. Rep. Geol. Explor. 1879–80,* [*13*]: 1–11.

GRINDLEY, G. W. 1961: Sheet 13—Golden Bay. "Geological Map of New Zealand, 1 : 250,000," N.Z. Dep. Sci. Indust. Res., Wellington.

HENDERSON, J.; GRANGE, L. I.; MACPHERSON, E. O. 1924: Motueka Subdivision. *N.Z. Geol. Surv. Annu. Rep 18*: 4–6.

HENDERSON, J.; GRANGE, L. I.; MACPHERSON, E. O. 1930: Geological Maps of Takaka, Flora, Kaiteriteri, and Motueka Survey Districts. (To accompany *N.Z. Geol Surv. Bull 35.*)

HENDERSON, J.; GRANGE, L. I.; MACPHERSON, E. O. 1959: The Geology of Motueka Subdivision. *N.Z. Geol. Surv. Bull. 35.* (Compiled by G. C. SHAW.)

MCKAY, A. 1879: The Baton River and Wangapeka Districts, and Mount Arthur Range. *N.Z. Geol. Surv. Rep. Geol. Explor. 1878–79,* [*12*]: 121–31.

MCKAY, A. 1892: On the Crystalline Limestones and so-called Marble Deposits of the Pikikiruna Mountains, Nelson. *N.Z. Geol. Surv. Rep. Geol. Explor. 1890–91, 21*: 38–43.

MCKAY, A. 1896: The Geology of the Aorere Valley, Collingwood County, Nelson. *Append. J. House Repres. N.Z., C.–11*: 4–27.

PARK, J. 1890: On the Geology of Collingwood County, Nelson. *N.Z. Geol. Surv. Rep. Geol. Explor. 1888–89, 20*: 186–243.

WELLMAN, H. W. 1962: New Graptolite Localities in New Zealand. *N.Z. J. Geol. Geophys. 5*: 642–45.