Transactions of the Royal Society of New Zealand
Vol. 77, Part 2, pp. 306–312, 1 Text Figure, Plate 36.

Pillow Lava at Red Rock Point, Wellington.

By H. W. WELLMAN, N.Z. Geological Survey.

[*Read before the Wellington Branch, October 30, 1946; received by the Editor, October 3, 1947; issued separately, February, 1949.*]

Abstract.

A PHOTOGRAPH is presented showing pillow lava at Red Rock Point, Wellington. The lava forms part of a continuous but steeply dipping and overturned section composed chiefly of indurated sandstone and siltstone (greywacke and argillite), but with conspicuous grey, red, and green tuffaceous siltstone bands with radiolarian cherts adjoining the pillow lava. The rock sequence is illustrated by a columnar section and a tentative Triassic age is adopted for the whole in spite of *Torlessia mackayi* occurring in the youngest beds.

Introduction.

Locality: Red Rocks Point is near Sinclair Head on the northern shore of Cook Strait, two and a-half miles west of the Island Bay tram terminus, and five miles south-west of Wellington City. The rocks are well exposed at the coast, both in an elevated shore platform and in 100 ft. cliffs.

Previous description: The pillow lavas and red and green rocks at Red Rock Point are in striking contrast with the seemingly uniform greywackes and argillities that form the bulk of the Wellington Peninsula. The rocks have already been described by McKay (1879, 1888) and in greater detail by Broadgate (1916); but pillow lava was not recognised by either of them. In his first report McKay referred to the rocks as " red and green slates, containing nests of calc spar and manganese ore, beneath which are slaty beds, with sandstones and some thin beds of conglomerate. . ." In his second report (1888, p. 67), he stated:

> "At Red Point, on Cook Strait, these rocks are finely exposed in the sea cliff, and consist of grey, red and green slates, the green and red colours over a thickness of some 30 ft. being so disposed as to afford slabs of variegated slate of great beauty, capable of being used for ornamental purposes. Succeeding these are grey and red cherts, 15 ft. to 20 ft. thick; a flinty jasper rock, veined yellow and white, and a varying thickness of a remarkable rock consisting of a mixture of granular limestone, serpentine, and a brown jasperoid rock; beneath which, on the west side, there is a varying thickness of a finely crystalline volcanic rock, of a leek-green colour, in which numerous cavities of irregular form have been filled with carbonate of lime."

Broadgate made a detailed field and laboratory examination of the rocks exposed at Red Rocks Point and illustrated his report by a plan and cross-section. The names he used for the rocks are the same as those used by McKay in 1888, but by mistake he applied some of them differently. They differ also from those used in this report. (See table below).

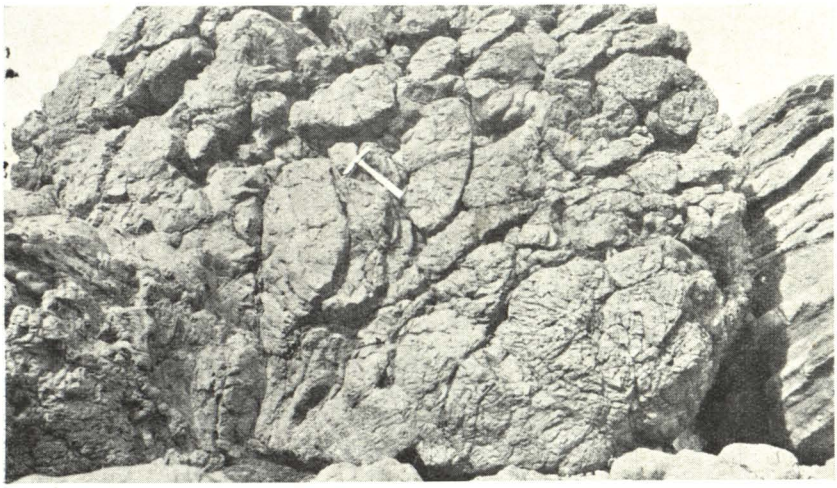

Photo. Maxwell Gage.

Pillow Lava Boulder, Red Rock Point, Wellington.

[*To face page* 306

Stratigraphy.

General: The first impression given by the section at Red Rocks is one of complexity, for all the beds dip east at high angles with considerable variations in strike, but detailed examination of the limited section described in this report shows no repetition of beds and no evidence of significant faulting. The beds are all indurated, the sandstone and siltstone being similar to the greywacke and argillite that forms such a large proportion of the undermass of New Zealand. As the beds all dip at high angles it cannot be assumed without other evidence, as McKay appears to have done, that the beds have not been overturned and that younger beds still overlie older ones. As there is no fossil evidence to give the true stratigraphic order, the top and bottom of the beds have to be distinguished by internal evidence. The only useful criterion so far found is in the numerous alternations of sandstone and siltstone bands on the west side of the section. The bulk of these sandstone bands grade westward into siltstone but are abruptly adjoined by siltstone to the east. This consistent sedimentary relation has been interpreted as meaning that the top of the section lies to the west and that the whole section has been overturned. This overturning has been accepted in this report and column (Fig. 1) and the terms used later to indicate superposition refer to the original, and not to the present order of the beds. The following table indicates the four groups now recognised, with Broadgate's equivalent names shown alongside:—

This report	Broadgate, 1916, p. 77, FIG. 2.
West side (top)	
(4) Alternating indurated bands of siltstone and sandstone.	Argillite and greywacke.
(3) Variolitic pillow lavas. Thin radiolarian cherts.	Diabase tuff.
(2) Red and green tuffaceous siltstone.	Red and green argillite.
(1) Jointed indurated sandstone with numerous quartz veins.	Grey chert (altered greywacke)

(1) *Jointed Sandstone:* The oldest bed is a very uniform closely jointed medium sandstone (greywacke), highly indurated and penetrated by numerous small irregular quartz veins and with no traces of bedding planes. The sandstone is at least 300 ft. thick, the base being to the east of the area examined. This bed was termed a " grey chert " by Broadgate, who mistook it for rocks termed " cherts " by McKay. McKay's cherts are thin-bedded radiolarian cherts interbedded with the red and green siltstone and mistaken for a quartz reef by Broadgate.

(2) *Red and green tuffaceous siltstone and thin-bedded chert:* The oldest bed of this group is a 20 ft. band of tuffaceous siltstone weathering dove-grey and finely cleaved, so that it tends to break into elongated prisms; bedding planes are ill defined. Ellipsoidal calcareous concretions up to 3 ft. in major diameter and 6 in. to 1 ft. in minor diameter are not uncommon in this bed but were not seen

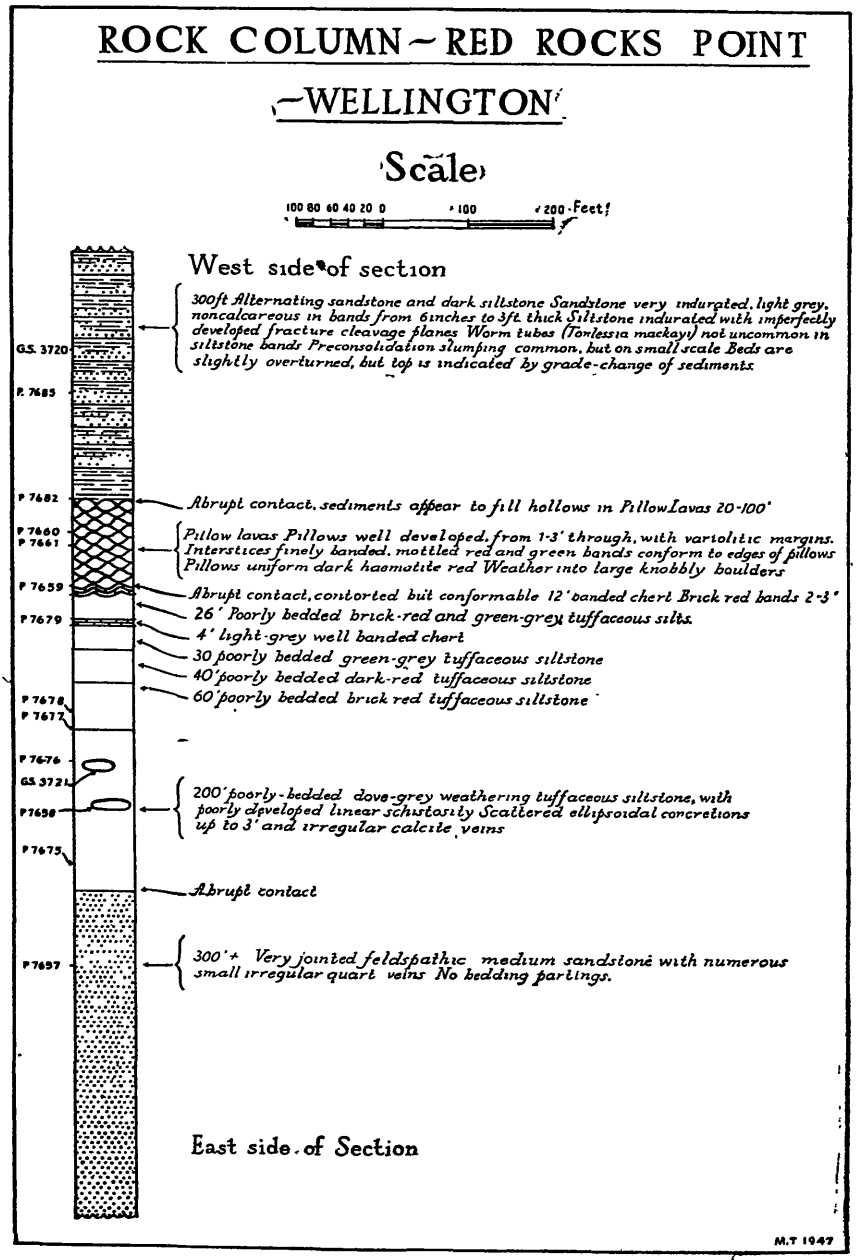

FIGURE 1.

elsewhere. The concretions weather more rapidly than the enclosing siltstone and can be easily and cleanly detached from their matrix. Several organic but otherwise indeterminate round bodies (G.S. 3721) up to 0·25 in. through were collected from one of these concretions.

The contact between this bed and the jointed sandstone (1) is abrupt and clearly defined, dipping east at 50°. There appeared to be no way of finding the true stratigraphic order of the beds in this part of the section, but as they all dip east, and as the upper part of the section is considered to be overturned it is inferred that this part of the section is overturned also.

The dove-grey-weathering, tuffaceous siltstone is succeeded by thick alternating bands of red and green-grey tuffaceous siltstone with which are interbedded two narrow bands of thin-bedded chert. The upper tuffaceous beds are more brightly coloured, but otherwise similar to the dove-grey-weathering tuffaceous siltstone. The analyses given below show that the difference in colour is due to differences in the degree of oxidation of the iron compounds, the red siltstones being more highly oxidised than the green.

Two chert beds in the stratigraphic upper part of this group are separated by 26 ft. of red and green siltstones. The upper band is 12 ft. thick and is brick red in colour, the lower is 4 ft. thick and is mottled light- and dark-grey. Both beds consist of two-to-three inch bands of impure chert and both show bands that are so closely and complexly folded as to suggest that they were deformed while soft and gelatinous.

The chert in thin section shows poorly preserved radiolaria, and provides a further example of the not uncommon association of radiolarian cherts and pillow lavas. The chert is represented in the Geological Survey collection by P.7659, and P.7679, the red, green and grey tuffaceous siltstone by P.7675, P.7676, P.7677, and P.7678 and a calcareous concretion from the grey siltstone by P.7658.

The tuffaceous beds are so fine grained that their mode of origin cannot be determined microscopically and their tuffaceous origin is inferred from indirect field evidence and from their chemical composition. The field evidence is, (a) that irrespective of colour they are distinct from normal argillites, and (b) that they are closely associated with volcanic rocks. At Red Rock Point the tuffaceous beds were deposited immediately before the outpouring of pillow lava, and similar beds, also closely associated with volcanic rocks, have been reported by McKay from many places in Wellington, Marlborough, and Canterbury. Similar but older rocks, also associated with volcanics, are known from the Te Anau Series of Southland, and from the rocks east of the Maitai limestone near Nelson, and at d'Urville Island. Using the analyses on p. 81 of Broadgate's report, the average composition of the very similar red and green tuffaceous siltstones can be compared with that of a typical argillite and a pillow lava. They are intermediate with regard to most of the significent constituents, thus:—

	Al_2O_3	$FeO+Fe_2O_3$	CaO	Na_2O	K_2O	SiO_2	MgO
Pillow lava	13.98	9.84	10.27	3.56	1.69	48.62	1.36
Average red and green tuffaceous silts	17.94	7.85	1.18	2.70	3.37	59.60	2.51
Typical argillite	19.03	7.36	0.16	2.02	4.21	57.89	1.47

If it be assumed that the tuffaceous beds are a mixture of volcanic material with the composition of the pillow lava and non-volcanic material with the composition of the typical argillite, then the above figures give a range of 12 – 40 per cent. and an average of 26 per cent. of volcanic material in the tuffaceous beds. The anomalous higher value of SiO_2 in the tuffaceous beds can be explained by supposing a small admixture of chert to have been deposited with them.

No explanation is offered for the significantly higher value of MgO.

(3) *Variolitic pillow lavas:* The pillow lava forms a compact and easily recognisable bed without interbedded sediments. At the seaward margin of the rock platform the pillow lava flow is no more than 20 ft. thick, but it thickens inland and at the top of the cliff where last examined it is at least 100 ft. thick. In the cliff face the rock breaks along joint-planes and the pillows do not stand out in relief but, on the rock platform, weathering has removed the filling from between the pillows and their individual form is well shown (Plate 36). They are from 1–3 ft. in diameter, and some are surrounded by a thin margin showing variolites that range up to 0·25 in. in diameter. The interior of the pillows is irregularly jointed and very fine grained and shows no trace of either phenocrysts or amygdales. The filling appears to be highly altered and shows fine pistachio-green and dull red bands sub-parallel to the margins of the pillows. The base of the lavas has an undulating surface formed by the curved surface of the individual pillows, the underlying cherts appearing to have been deformed by the outpouring of the lava to fit the curved base of the pillows.

The pillow lava is represented in the Geological Survey collection by specimens P.7682, P.7683, P.7684, P.7660, and P.7661.

(4) *Thin alternating bands of sandstone and siltstone. 300 + ft.* These beds form the rock-cut platform at the west side of the measured section. They consist of well-bedded alternating medium sandstone and siltstone in bands from 6 in. to 3 ft. thick.

Although the beds are slightly overturned no definite post-consolidation faults were seen. Bedding faults associated with thin quartz veins are common and are usually confined to the less competent siltstone bands. Minute 0·125 – 0·5 in. pre-consolidation step faults are widespread and obscure the details of the sedimentation picture. A diligent search for fossils revealed only the compressed tube of *Torlessia mackayi* (Bather), (G.S. 3720), a fossil not uncommon in the siltstone bands.

Age and correlation: In his first paper McKay (1879) correlated both the red and green rocks and their associates with the Maitai Series; but in his second paper (1880) he separated the rocks into two groups, correlating the red and green rocks with the Triassic Wairoa Series, and the *Torlessia mackayi* beds more doubtfully with the Carboniferous Maitai Series. In the absence of satisfactory fossil evidence, correlation can be made only on the basis of lithology by those having a good field knowledge of the rocks in many parts

of New Zealand. McKay was fortunate in this respect and his lithologic correlations cannot be lightly dismissed.

The term Maitai Series, although clearly defined by Hochstetter, has subsequently been used to include other rocks; but the writer prefers to restrict its use to its original meaning, that is, to the Maitai limestone (with *Maitaia*), and to the overlying " grey, red, and green Maitai slates." When Maitai Series is used in this restricted sense it can be shown that none of the beds described from Red Rock Point resembles any of these beds in the Maitai Series. In spite of the remarks made by McKay (1888, p. 62), the red and green rocks, which probably form the basis of the original correlation, show little resemblance with the " red and green slates " at Nelson, for the Nelson rocks are finely laminated, being composed of alternating red and green bands each no more than a quarter of an inch thick. Moreover, the underlying " grey slates " are finely laminated indurated mudstones and siltstones with few sandstone bands; and no rocks of this type have been described from Red Rocks Point. It has also to be noted that no intrusive or extrusive rocks are known *within* the Maitai beds as defined above, so that the presence of the pillow lavas is not evidence for correlation by lithology.

The apparent absence of *Maitaia* from the Wellington district is also evidence against correlation, for the fossil is widely distributed in the Maitai limestone and in the underlying beds.

In his second paper, McKay (1888), basing his argument on *Monotis salinaria* and *Mytilus problematicus* in similar beds at Ashley Gorge, Glentui Creek, and the upper Okuku River, classed the lava and red and green siltstones as Triassic Wairoa Series. He mentioned that the fossil *Torlessia mackayi* has not been found in Maitai rocks (and it is as well to mention that it has not been subsequently found there); but partly in deference to the earlier classification he still classified the fossiliferous beds to the west of the lavas as Carboniferous Maitai Series. If the overturning assumed in this report is correct, then the beds with *Torlessia mackayi* must be younger than the lava, and if the lava is Triassic, *Torlessia* can be no older.

It would be unwise with the information at present available to make further attempts at correlation; but it should be pointed out that the problem is far from insoluble, provided lithology is uniform over wide areas, and this as yet has not been disproved. The problem is most likely to be solved by the building up of detailed columns into one complete composite column covering all the rocks involved, and by making full use of all the scanty fossil evidence available. It was with this ultimate object in mind that the present paper was written.

Analyses.

The following analyses already given by Broadgate (1916, p. 81) were made by the Dominion Laboratory, the names given to the rocks are those used in this report and not those used by Broadgate.

	1	2	3	4	5
SiO_2	70.20	57.89	58.70	61.10	48.62
TiO_2	0.66	1.00	0.93	0.95	1.66
Al_2O_3	13.53	19.03	18.29	17.60	13.98
Fe_2O_3	1.68	4.48	1.99	3.84	7.68
FeO	3.24	2.88	6.03	3.85	2.16
MnO	n.d.	0.04	n.d.	n.d.	n.d.
MgO	1.48	1.47	2.96	2.07	1.36
CaO	1.80	0.16	1.30	1.07	10.27
Na_2O	2.04	2.02	2.63	2.78	3.56
K_2O	3.18	4.21	3.30	3.45	1.69
CO_2	n.d.	nil	n.d.	n.d.	n.d.
P_2O_5	n.d.	0.26	n.d.	n.d.	n.d.
SO_3	n.d.	0.11	n.d.	n.d.	n.d.
Moisture at 100°C.		1.15			
Organic matter and combined water	2.03	5.65	4.11	3.42	8.22
	99.84	100.35	100.24	100.13	99.20

(1) Feldspathic indurated sandstone (greywacke), Red Rock Point, east end section.

(2) Typical "argillite," Muritai (Point Arthur), Wellington.

(3) Green tuffaceous siltstone, Red Rock Point, Wellington.

(4) Red tuffaceous siltstone, Red Rock Point, Wellington.

(5) Pillow lava, Red Rock Point, Wellington.

References.

Broadgate, F. K., 1916. The "Red Rocks" and associated beds of Wellington Peninsula. *Trans. N.Z. Inst.*, vol. 48, pp. 76–86.

Hochstetter, F. von, 1867. *New Zealand, its Physical Geography, Geology, etc.*

McKay, A., 1879. The Geology of the Neighbourhood of Wellington. *Reports of Geological Explorations during 1878–79*, no. 12, pp. 131–5.

——— 1888. On the Tauherenikau and Waiohine Valleys. Tararua Range. *Reports of Geological Explorations during 1887–88*, no. 19, pp. 58–67.