The Petrography of Some Jurassic Conglomerates at Kawhia, New Zealand

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[*Read before the Auckland Institute, December 16, 1953, received by Editor, January 4, 1954.*]

Abstract

ON the southern shores of Kawhia Harbour and along the outer coast between Urawitiki Point and Parikawau a number of conglomerate horizons are exposed within a succession of approximately 21,500ft. of fossiliferous Jurassic greywackes and argillites. The pebbles forming the conglomerates represent a wide range of rock-types, including keratophyres, altered andesites, and high grade schists, the latter belonging to a series of Lower Paleozoic rocks now found exposed only in the South Island.

INTRODUCTION

Within the Jurassic geosynclinal sediments of the Kawhia district there are ten bands of conglomerate which alternate with sandstones and argillites containing marine fossils and plant remains. These conglomerates were noted by McKay (1884), Trechmann (1923, pp. 254-256), and by Henderson and Grange (1926, pp. 32–34), but they were not studied in any detail until Bartrum (1935) described sections of pebbles collected from Ururoa Point.

The conglomerates studied by the writer occur at a number of horizons throughout the Jurassic sequence from the top of the Aratauran to the lower part of the Puaroan, and they are present also in rocks of all the intermediate stages (Ururoan, Temaikan, Heterian, Ohauan). The positions of the various horizons have been recorded in a stratigraphic chart (Fig. 1). Conglomerates are best developed at Waiharakeke, Ohaua Point, Totara Point, Urawitiki Point, Ururoa Point, Arawhero, Te Angina, Parapara, Rimurapa, and Parikawau (Fig. 2). The beds maintain regular thickness throughout their visible outcrop, and in general they are only four to five feet thick. At Te Angina and at Rimurapa conglomerate is developed in massive beds whose thickness is about thirty feet, and the constituent boulders are well-rounded and measure up to six inches in diameter. At Totara Point and at Ohaua Point sandstones and argillites are interbedded with conglomerates having thickness of five hundred feet and of one hundred feet for the respective conglomerate horizons.

From a study of three hundred thin sections it has been possible to recognize thirty-seven rock types among the pebbles. Of the eight hundred pebbles collected from the conglomerates, pebbles of igneous rock comprise approximately 92 per cent. of which 15 per cent are plutonic The remaining 8 per cent. consist of metamorphic rocks (5 per cent.) and of sedimentary rocks (3 per cent.).

DESCRIPTION OF ROCK TYPES

Some of the pebbles studied, especially those of acid composition, which have been found to be identical with rocks described by Bartrum (1935) will not herein

Vol. 82, Part 2, pp. 223–230, Plates 10–11, 2 Text-figs., September, 1954.

System	Series (of J. Marwick 1953)	Stage	Thickness	Character of Rocks. Area East of Te Arawi.	Character of Rocks. Faulted Block West of Te Arawi. (Described by Mason, 1952)
UPPER JURASSIC	Oteke	Puaroan	2,600	Mudstone Sandstones and grits Mudstone Conglomerate (Waiharakeke)	
	Kawhia	Ohauan	7,300	Sandstones and mudstones Bands of conglomerate and sandstone (Ohaua Point) Sandstone with Ohauan fossils (Kowhai Point)	
		Heterian	2,600	Sandstone with Heterian fossils (Heteri) Conglomerate (Totara Pt.)	Conglomerate (Parapara) Conglomerate (Te Angina, Rimurapa)
		Temaikan	1,600	Sandstone with Temaikan fossils. (Captain King) Sandstone with plant remains Sandstone with *Meleagrinella* Conglomerate (Urawitiki Pt.)	Sandstone with Temaikan fossils. Sandstone. Conglomerate (Parikawau).
LOWER JURASSIC	Herangi	Ururoan	3,000	Sandstone with *Dactylioceras* Conglomerate (Ururoa Point) Sandstone and argillite with *Pseudaucella marshalli*.	
		Arataurian	2,600	Conglomerate (Arawhero) Sandstone and argillite with *Otapiria marshalli*.	
UPPER TRIASSIC	Balfour	Otapirian	2,000	Sandstone and argillite with Otapirian fossils.	
		Warepan	1,000	Sandstone and argillite with *Monotis richmondiana*.	
		Otamitan	2,600	Andesite intrusion. Sandstone and argillite with *Mytilus problematicus*.	
				Andesite intrusion (Te Arawi)	

FIG. 1. Approximate Stratigraphic Position of Conglomerate Beds.

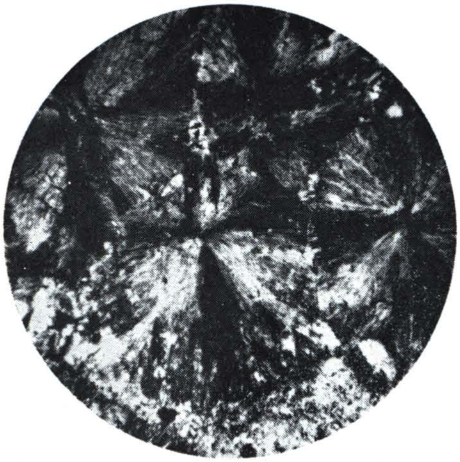

FIG. 1.—Rhyolite (2280). Large spherulites in a microgranular groundmass. Crossed nicols, × 15.

FIG. 2.—Keratophyre (2298). Small phenocrysts of albite in a trachytic groundmass. Crossed nicols, × 15.

FIG. 3.—Andesite (2249). Amygdules filled with zeolite and quartz. Crossed nicols, × 15.

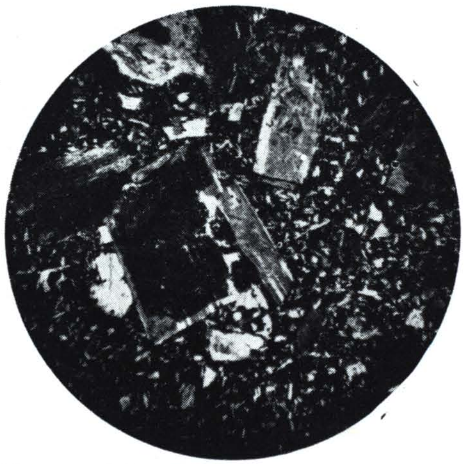

FIG. 4.—Meta-andesite (2272). Andesine phenocrysts partially replaced by analcite (dark.) Crossed nicols, × 15.

FIG. 5.—Meta-andesite (2371). Clear secondary albite rims altered original feldspar phenocrysts. Crossed nicols, × 15.

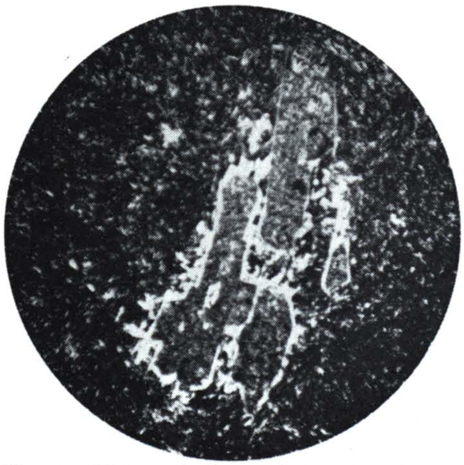

FIG. 6.—Meta-andesite (2271). Altered feldspar phenocrysts rimmed with clear secondary albiclase. Crossed nicols, × 15.

Facing page 224]

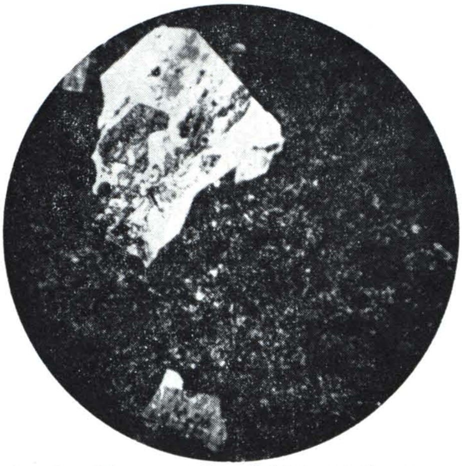

FIG. 1.—Meta-andesite (2240). Albite phenocryst partially replaced by orthoclase. Crossed nicols, × 15.

FIG. 2.—Actinolite - quartz - albite - epidote - chlorite-schist (2181). Actinolite in radiating acicular prisms. Ordinary light, × 24.

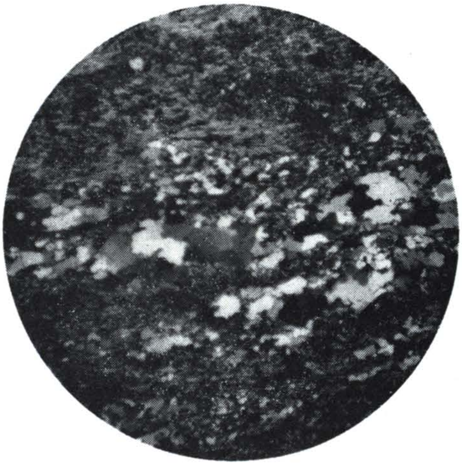

FIG. 3.—Quartz-muscovite-chlorite-epidote-schist (2185). Crossed nicols, × 15.

FIG. 4.—Quartz-albite-biotite-garnet-schist. (2189). Small crystals of garnet (black) scattered throughout the rock. Crossed nicols, × 15.

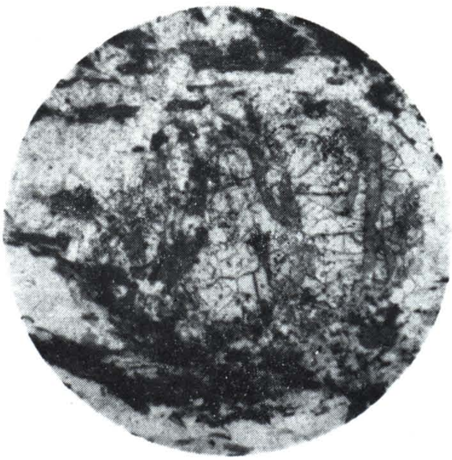

FIG. 5.—Quartz - andesine - biotite - garnet - schist (2190). Large shattered garnet crystal and a biotite-rich band. Ordinary light, × 24.

FIG. 6.—Gneissic Granite (2192). Green hornblende partly replaced by biotite (dark). Ordinary light, × 30.

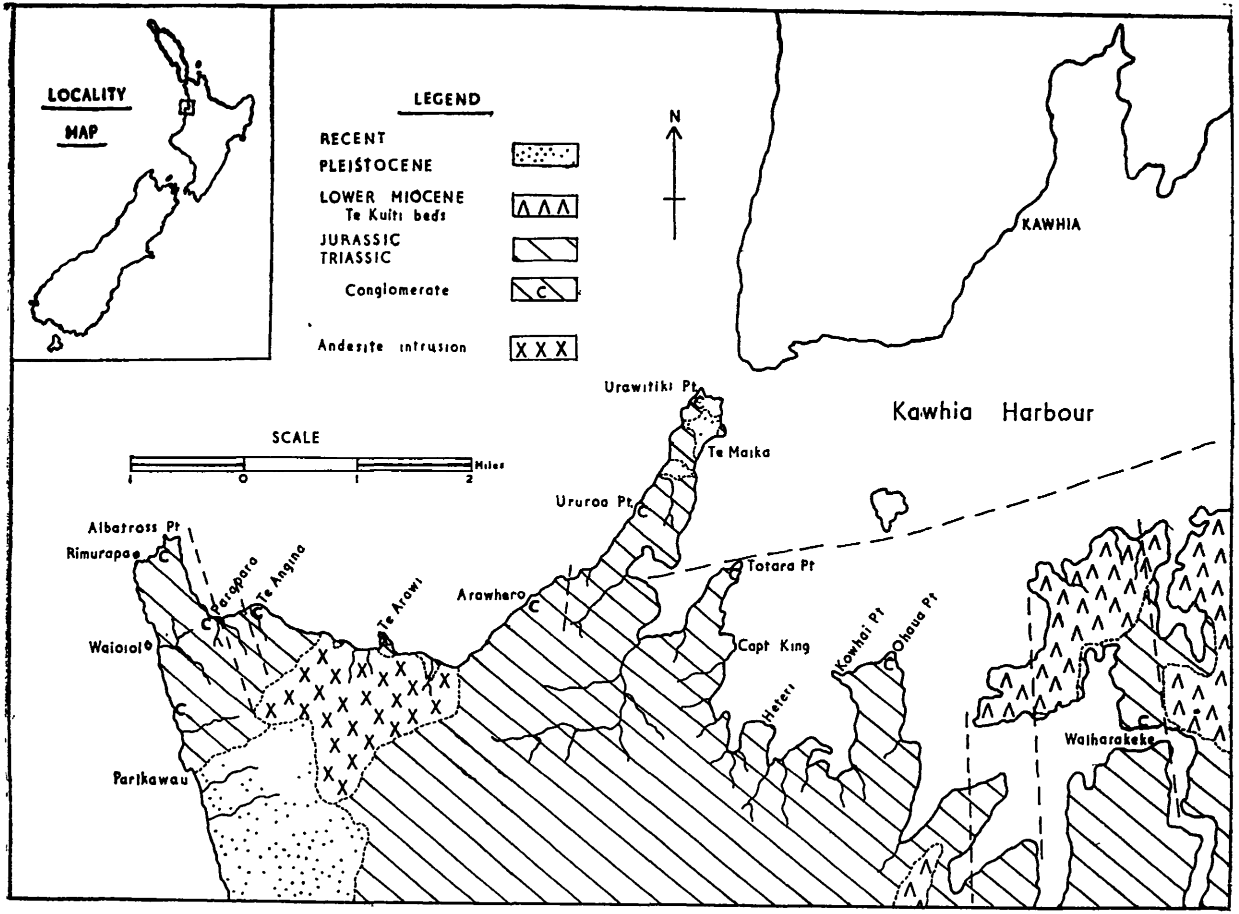

Fig. 2 Map showing location of conglomerate beds

Geology after Henderson and Grange N. Z Geological Survey Bulletin No 28 be described in detail. Serial numbers given after the name of each rock type refer to thin-sections in the collection of the Geology Department at Auckland University College.

Plutonic Rocks

Hornblende-granite, 2135–6, 2150–3, 2199, 2200, 2242, 2278; collected at Arawhero Point, Ururoa Point, Urawitiki Point, Totara Point, Te Angına.

Biotite-granite, 2137, 2154-5, 2201, 2302, 2378; Arawhero Point, Ururoa Point, Urawitiki Point, Ohaua Point, Waiharakeke.

Soda-granite, 2156; Ururoa Point. The dominant feldspar in·this rock is albite.

Microgranite, 2303–4; Ohaua Point.

Hornblende-granodiorite, 2157, 2203, 2305–6; Ururoa Point, Urawitiki Point, Ohaua Point.

Diorite, 2227, 2307; Parikawau, Ohaua Point.

Hypabyssal Rocks

Quartz-porphyry, 2278; Te Angina.

Granodiorite-porphyry, 2138, 2158–9, 2205, 2243, 2312–9, 2359, 2380; Arawhero, Ururoa Point, Urawitiki Point, Totara Point, Ohaua Point, Parapara. Waiharakeke.

Aplite, 2204, 2308; Urawitiki Point, Ohaua Point.

Granophyre, 2309–11, 2379; Ohaua Point, Waiharakeke.

Dolerite. 2160, 2202; Ururoa Point, Urawitiki Point.

Syenite-porphyry, 2320; Ohaua Point.

Volcanic Rocks

Rhyolite, 2139, 2244, 2280, 2322–8, 2360–2; Arawhero Point, Totara Point, Te Angina. Ohaua Point, Parapara. These rocks show fine flow structure with a microspherulitic and microgranular groundmass. Plumose axiolites and large spherulites enclosing crystals of microperthite have been developed in some cases. (Plate 10, Fig. 1).

Dacite, 2163-4, 2206-10, 2228, 2245, 2329–37, 2365–6, 2381–2; Ururoa Point, Urawitiki Point, Parikawau, Totara Point, Parapara, Ohaua Point, Waiharakeke.

Trachyte, 2283; Te Angina.

Quartz-keratophyre, 2140, 2165; Arawhero Point, Ururoa Point.

Keratophyre, 2141–2, 2166–8, 2171, 2213, 2215, 2232, 2246, 2285–9. 2239–42, 2385; Arawhero Point, Ururoa Point, Urawitiki Point, Parikawau, Totara Point, Te Angina, Ohaua Point, Waiharakeke.

Pebbles of keratophyre are abundant, and contain numerous phenocrysts of albite and a few large crystals of oligoclase set in a fine-grained trachytic groundmass (Plate 10, Fig. 2). Although most of the albite is unusually fresh there is nothing to indicate replacement of an earlier formed plagioclase, and this suggests that the albite was primary in origin. Rare phenocrysts of colourless augite also occur, but the original ferromagnesian phenocrysts are mostly represented by pseudomorphs of chlorite. The extremely fine-grained nature of the groundmass renders it difficult to determine any variation in the feldspar laths, but they were identified as albite in rare instances. Small grains of epidote, calcite, chlorite and magnetite are very abundant.

Andesite, 2172–5, 2217–8, 2233–5, 2249–69, 2292–5, 2349–51, 2367–9, 2386–7; Ururoa Point, Urawitiki Point, Parikawau, Totara Point, Te Angina, Parapara, Ohaua Point, Waiharakeke

The andesites contain phenocrysts of oligoclase or andesine feldspar, colourless augite or a pale-green diopsidic variety usually very altered, and occasionally hypersthene. The groundmass has a pilotaxitic texture consisting of laths of feldspar, mainly oligoclase, with small patches of calcite, granular epidote, chlorite, and magnetite dust Many of the pebbles, particularly those from Totara Point, are highly amygdaloidal and the cavities have been filled with a variety of secondary material including quartz, fibrous epidote, chalcedony, chlorite, calcite and zeolites (Plate 10, Fig. 3).

Meta-andesite,* 2177–8, 2237, 2240, 2271–2, 2296, 2370–1, Ururoa Point, Parikawau, Totara Point, Te Angina, Parapara.

These rocks appear to be andesites which have undergone alteration by a process of soda metasomatism In certain sections (2177, 2272, 2370) the original feldspar has been partially replaced by analcite (Plate 10, Fig 4) and in others (2178, 2237, 2271, 2371) albitisation is indicated by a narrow rim of clear albite ($Ab_{90}An_{10}$) or albiclase ($Ab_{85}An_{15}$) surrounding the weathered original feldspar (Plate 10, Figs 5 and 6) In both cases the original feldspar is either oligoclase or andesine and usually it has undergone considerable alteration to chlorite and epidote Occasionally the host feldspar has been completely replaced by albite, which in turn has been partially replaced by orthoclase (2240, 2296; Plate 11, Fig. 1). A similar sequence of feldspathisation affecting an intrusion of granodiorite is described by Leedahl (1952, pp. 52–58) who considers it is due to potash metasomatism accompanying or following albitisation

The meta-andesites also contain a few crystals of weathered oligoclase, about $Ab_{75}An_{25}$, which appear to have escaped secondary replacement, and rare phenocrysts of a pale green diopsidic augite undergoing alteration to epidote, chlorite, calcite, and iron-ore One notable section (2178) contains chloritic pseudomorphs in which cross-fractures are so outstanding as to suggest replacement of original olivine. The groundmass is pilotaxitic in texture and consists of tiny microlites of feldspar (albiclase to oligoclase) with abundant chlorite, epidote, and iron-ore.

SEDIMENTARY ROCKS

Greywacke, 2302, 2389; Ohaua Point, Waiharakeke

METAMORPHIC ROCKS

Pebbles of metamorphic rocks are abundant only at Ururoa Point, and several of these resemble the schists of Central and Western Otago (Hutton, 1940) and South Westland (Turner, 1933). A series of partially reconstituted greywackes and schists is representative of the zones of regional metamorphism described by Turner (1938) and covers the range from Chlorite I sub-zone to the Oligoclase Zone

* The term meta- is defined by Holmes (1920, p. 154) as "a prefix used before the names of igneous rocks to signify that the mineral and chemical composition of the latter have been modified by alteration."

Chlorite I schist, 2223, 2241, 2353–6, 2373–5, 2390; Urawitiki Point, Ohaua Point, Parapara, Waiharakeke.

Reconstitution is indicated by undulatory extinction and mortar structure of the quartz, and by alteration of the plagioclase feldspar to clinozoisite and sericite. Ferromagnesian minerals have been altered to chlorite and epidote and strings of magnetite are abundant.

Quartz-feldspar-epidote-chlorite-schist, (Chlorite 2 sub-zone), 2179-80, 2391; Ururoa Point, Waiharakeke.

Distinct schistosity is exhibited by these rocks, but they lack foliation. Some sheared and fractured clastic grains still remain, but crystalloblastic material is abundant. Quartz and albite are the main constituents, with accessory chlorite, epidote, and magnetite.

Actinolite-quartz-albite-epidote-chlorite-schist, (Chlorite 2 sub-zone). 2181–2; Ururoa Point.

Pale-green actinolite is abundant in these rocks, and in one section forms radiating sprays of acicular prisms sometimes set at considerable angles to the schistosity (Plate 11, Fig. 2). Quartz and a small amount of albite occur in small sutured grains with accessory chlorite, epidote, clinozoisite and iron-ore.

Quartz-epidote-chlorite-schist, (Chlorite 4 sub-zone), 2183; Ururoa Point.

This rock is schistose and coarsely foliated. Epidote is the dominant constituent with quartz, chlorite, abundant iron-ore, and a few weathered grains of feldspar.

Quartz-chlorite-clinozoisite-schist, (Chlorite 4 sub-zone), 2184; Ururoa Point.

Layers rich in large sutured grains of quartz alternate with others rich in chlorite and iron-ore. Clinozoisite is abundant in certain bands and epidote. sericite, apatite, and long prisms of blue-grey tourmaline also occur.

Quartz-muscovite-chlorite-epidote-schist, (Chlorite 4 sub-zone), 2185, Ururoa Point.

Certain bands enriched in quartz with a few kaolinised grains of feldspar alternate with laminae rich in epidote, chlorite, muscovite, and iron-ore. The chlorite is of two types, green pennine and a brown variety. (Plate 11, Fig. 3).

Quartz-actinolite-epidote-chlorite-schist, (Chlorite 4 sub-zone), 2186; Ururoa Point.

Quartz, in large sutured grains, is the dominant constituent of certain layers, permeated by strings of epidote, chlorite, and a little calcite. Alternating with these are bands rich in actinolite, epidote, and chlorite, with fairly abundant magnetite.

Quartz-epidote-clinozoisite-chlorite-muscovite-garnet-schist, (Chlorite 4 sub-zone), 2187; Ururoa Point.

Layers rich in small sutured grains of quartz, with rare weathered grains of feldspar, abundant clinozoisite, and a little chlorite and muscovite, alternate with layers rich in larger sutured grains of quartz and abundant epidote, permeated by long strings of iron-ore. Garnet is evenly distributed as small infrequent subidiomorphic crystals.

Albite-quartz-calc-muscovite-schist, 2188; Ururoa Point.

Albite, quartz, and calcite are the dominant constituents of this rock with accessory chlorite and muscovite.

Quartz-albite-biotite-garnet-schist, (Biotite Zone), 2189; Ururoa Point.

Leucocratic layers with sutured grains of quartz and feldspar alternate with layers rich in biotite and iron-ore. Epidote and clinozoisite are abundant in certain bands with accessory muscovite and calcite. Small garnet crystals are fairly evenly distributed (Plate 11, Fig. 4). Retrogressive metamorphism is indicated in this rock by sericitisation of the feldspar and chloritisation of the biotite.

Quartz-andesine-biotite-garnet-schist, (Oligoclase Zone), 2190–1; Ururoa Point.

Large shattered garnet crystals occur in these rocks, the cracks being filled with chloritic material (Plate 11, Fig. 5). Layers rich in sutured grains of quartz and weathered andesine alternate with bands rich in flakes of biotite and iron-ore, with accessory clinozoisite and apatite. The biotite has been slightly chloritised and this, with sericitisation of the feldspar, indicates retrogressive metamorphism.

Quartz-oligoclase-biotite-muscovite-schist, (Oligoclase Zone), 2147; Arawhero.

A fairly coarse-grained schistose rock with quartz and feldspar as the main constituents, the latter consisting mainly of oligoclase and a small amount of microcline. Small flakes of muscovite and greenish-brown biotite are scattered throughout the rock in sub-parallel arrangement.

Quartzite, 2376; Parapara.

The rock consists almost entirely of interlocking grains of quartz which have been fractured and granulated.

Gneissic granite, 2192; Ururoa Point

The main constituents of this rock are quartz and weathered feldspar forming a coarse mosaic with some tendency towards graphic intergrowth. Brown pleochroic biotite is abundant in small flakes replacing strings of chloritic alteration products. Patches of green hornblende are also partly replaced by biotite and granular epidote (Plate 11, Fig. 6) Apatite is an abundant accessory mineral.

Hornblende-plagioclase-biotite-quartz-gneiss, 2193; Ururoa Point.

A greenish-brown variety of hornblende is abundant in this rock, with flakes of yellowish-brown biotite, iron-ore, and accessory sphene. The plagioclase is acid andesine and there is a small amount of quartz. The rock is similar to the hornblende-gneisses of Doubtful Sound described by Turner (1939, p. 574).

Oligoclase-quartz-gneiss, 2194; Ururoa Point.

Affinities with the feldspathic gneisses of Doubtful Sound (Turner, 1939, p 580) are shown by this rock. It consists of oligoclase, a small amount of quartz, flakes of reddish-brown biotite, some blue-green hornblende, and granular epidote Sphene and apatite occur as accessory minerals.

CONCLUSION

The existence of a land-mass west of New Zealand during the Jurassic period was postulated by Benson (1923, p. 40), and it is probable that the pebbles in the Jurassic conglomerates at Kawhia and other localities were derived from such a landmass. Wellman (1952, p. 16) suggested that the Lower Paleozoic rocks of the South Island continued northwards along a line parallel to the west coast of the North Island and formed the western margin of a major Jurassic geosyncline. The fossiliferous beds and associated conglomerates at Nelson, Southland and west Auckland were deposited along this margin of the geosyncline. In the South Island the Paleozoic rocks are very varied in type, and derivation from an adjacent landmass composed of similar rocks would explain the rich assembly of rock types in the Kawhia conglomerates

Acknowledgments

This petrographic description comprised part of the writer's thesis for the Honours degree at Auckland University College.

Grateful acknowledgment is made to Dr R N. Brothers for his assistance in determining the composition of some feldspars with the universal stage. The writer would also like to thank Professor A. R. Lillie for helpful advice and Mr. E. J. Searle for taking photomicrographs

References

Bartrum, J. A., 1935. Metamorphic Rocks and Albite-Rich Igneous Rocks from Jurassic Conglomerates at Kawhia. *Trans. Roy Soc N.Z.*, Vol 65, pp 95–107

Benson, W. N, 1923. Palaeozoic and Mesozoic Seas in Australasia. *Trans. N Z. Inst*, Vol. 54, pp 1–62

Henderson, J. and Grange L I, 1926. The Geology of the Huntly-Kawhia Subdivision. *N.Z. Geol Surv. Bull.*, No. 28, (N.S.)

Holmes, A., 1920. *Nomenclature of Petrology.* London, Thomas Murby and Co

Hutton, C. O., 1940. Metamorphism in the Lake Wakatipu Region, Western Otago New Zealand. *D.S.I R. Geol. Memoir*, No 5.

Leedahl, G. P., 1952. The Cluanie Igneous Intrusion, Inverness-shire and Ross-shire. *Q.J.G.S.*, Vol. cviii, pp. 35–63.

McKay, A., 1884 On the Geology of the Kawhia District *Rep Geol. Explor*. No 16, pp 140–148.

Marwick, J., 1953. Divisions and Faunas of the Hokonui System (Triassic and Jurassic) *N Z. Geol. Surv. Pal. Bull.*, No. 21

Mason, A. P., 1952. A Note on the Geology of the Albatross Point District. Kawhia *Rec Auck. Inst Mus.*, Vol. 4, pp 153–157.

Trechmann, C., 1923 The Jurassic Rocks of New Zealand *Q J G S*, Vol 79, pp 246–286.

Turner, F J., 1933 The Metamorphic and Intrusive Rocks of Southern Westland *Trans N.Z. Inst.*, Vol. 63, pp 178–284.

——— 1938. Progressive Regional Metamorphism in Southern New Zealand. *Geol Mag*, Vol 75, pp. 160–174.

——— 1939. Hornblende-Gneisses, Marbles, and Associated Rocks from Doubtful Sound Fiordland, New Zealand. *Trans. Roy. Soc. N.Z.*, Vol. 68, pp. 570–598

Wellman, H. W., 1952. The Permian-Jurassic Stratified Rocks. *Symposium sur les series de Gondwana publie par le XIXe Congres Geologique International*, Alger, pp. 13–24