Some Tertiary Igneous Rocks from the Ocean Beach–Matapouri Coastal Region, Northland

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Abstract

SOME intrusive rocks, mainly alkaline, of Lower Tertiary age, are described for the first time. These are thought to be the oldest igneous rocks in the region (excluding spilitic rocks contemporaneous with sediments of the Waipapa Group).

Further descriptions of quartz–diorite porphyry and hypersthene granodiorite of the Wairakau Andesites are also presented. These rocks are shown to have a possible age ranging from pre-Whaingaroan (Lower Oligocene) to Quaternary.

INTRODUCTION

THE rocks described here were collected from the coastal region north-east of Whangarei, between Ocean Beach and Matapouri (Fig. 1). Some of the rocks have been described previously by Ferrar (1925) and Allen (1951) but additional work is presented in this paper.

On field relations and mineralogy the rocks may be placed in two groups:

1. Miscellaneous intrusives, hitherto undescribed and the oldest of the two groups.
2. Wairakau Andesites comprising, in this region, quartz-diorite porphyry and hypersthene granodiorite.

MISCELLANEOUS INTRUSIVES

Occurrence and Field Relations

These rocks occur as three dykes seen cutting only rocks of the Waipapa Group (?Permian). They appear to have suffered only minor faulting and shearing, as shown by the displacement of two parts of one dyke at N20/066956, and minor shearing on another, at N20/065929, with the shear joints passing into the surrounding Waipapa rocks.

Microscopic Features

Techniques used in determinations of plagioclase compositions were those of Slemmons (1962) and Michel-Levy (Kerr, 1959); depending on the method used

the names follow the composition in parentheses. The determination of chemical composition of pyroxenes from optical properties was done by using data given by Deer *et al.* (1963a, p. 28, 132). All specimen numbers refer to the petrology collection of the Geology Department, University of Auckland.

Olivine nephelinite: Specimens 11152 and 10529 are from a small dyke, at N20/066956, approximately 4ft wide, which intrudes sandstones of the Waipapa Group. In thin section the rock is porphyritic with phenocrysts, approximately 1.0mm in length, of augite with the following optical properties:

$$2V_\gamma : 52°–56° \text{ (four measurements)}$$
$$\beta = 1.700 \pm 0.002$$

These correspond to a composition of $Mg_{34}\,(Fe^{2+}+Fe^{3+}+Mn)_{24}Ca_{42}$. Many of the augite phenocrysts show replacement by calcite. A small amount of corroded olvine also occurs as phenocrysts in 10529. The groundmass contains abundant granular ore together with diopsidic augite, patches of calcite and small pools of fibrous zeolite. The fibres of the zeolite show parallel extinction and length-slow orientation and the mineral is probably natrolite (Deer *et al.*, 1963b). Abundant nepheline is also present in small subhedral crystals in the groundmass and in irregular veinlets; the identification of this mineral has also been confirmed by X-ray diffraction (Miss P. M. Black, personal communication). The nepheline is often closely associated with calcite and zeolite; the latter mineral often occurs in fibrous bundles radiating from fine-grained irresolvable cores which may be nepheline undergoing alteration to zeolite.

Microgabbro: Specimen 11169 is from a dyke, approximately 2ft wide, at N20/064933. In thin section the rock is intergranular, with small grains of diopsidic augite, less than 0.3mm in length, with the following optical properties:

$$2V_\gamma : 46°–49° \text{ (six measurements)}$$
$$\beta = 1.680 \pm 0.002$$

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These properties denote a composition $Mg_{54}(Fe^{2}+Fe^{3}+Mn)_{8}Ca_{38}$. Abundant laths of plagioclase, up to 0.3mm long, have a composition of labradorite, An_{65}–An_{68} (Michel-Levy and Slemmons). Granular ore and calcite occur throughout the groundmass, and quartz in minor amounts. Calcite is also common in pools with quartz and occasionally analcime. Pools of fibrous zeolite were also seen; this appears similar to the zeolite in 11152 and 10529 and is probably natrolite. Mineralogically the rock appears to be an altered microgabbro.

Camptonitic lamprophyre: Specimens 11171 and 11172 are from a dyke 20ft wide occurring at N20/065929. Specimen 11171, from the main body of the dyke, in thin section contains phenocryst, less than 2.5mm long, of brown hornblende with the following optical properties:

Pleochroism: X = pale brown-pink, Y = red-brown, Z = red-brown

$2V_{\alpha}$: 74°–78° (five measurements)

$\alpha = 1.670 \pm 0.002$

$\gamma = 1.677 \pm 0.002$

These properties suggest either kaersutite or basaltic hornblende (Deer *et al.*, 1963a, pp. 315–327). From the information available it cannot be determined which of the two possibilities is correct, but the feldspar mineralogy suggests that the more alkaline variety kaersutite is present.

Phenocrysts of augite, up to 1.5mm in length and less abundant than the amphibole, have the following optical properties:

$2V_{\gamma}$: 40°–42° (five measurements)

$\beta = 1.700 \pm 0.002$

These properties suggest a composition $Mg_{38}(Fe^{2}+Fe^{3}+Mn)_{28}Ca_{34}$. Some augite crystals have reaction rims of the brown amphibole.

The augite and amphibole crystals are surrounded by an interlocking mass of coarse subhedral feldspar crystals comprising approximately 60 per cent of the mode. No quartz is present. Much of the feldspar is altered, is dusty in appearance, and contains fine chlorite, rendering specific identification of the feldspar difficult. The plagioclase is albite–oligoclase, An_{10} (Michel-Levy), and staining with sodium cobaltinitrite indicates that the amount of potash feldspar is only slightly less than that of the plagioclase. Small grains of ore are abundant and apatite is present in accessory amounts.

Specimen 11172 was collected from a vein, varying from ¼in to 3in in thickness, which cuts the main dyke. Such veins are quite numerous, have the same general disposition as the dyke, and show some offsetting along small shear joints. This specimen is finer grained than 11171 but has a similar mineralogy. This dyke is considered by the writer to be a lamprophyre with camptonitic affinities, following the terminology of Williams *et al.* (1954).

None of the three intrusions appears to have had any effect on the mineralogy of the surrounding sandstones and sample 11155, collected 1ft from the olivine nephelinite at N20/066956, shows no alteration attributable to contact metamorphism.

Age

These intrusions cut only rocks of the Waipapa Group, which are of probable Permian age. Allen (1951) has shown that olivine nephelinite (termed limburgite by him) at McLeod's Bay, Whangarei Heads, underlies basal conglomerates of the Whangarei Series (now known as Motatau Group, of Landon age). Black and Brothers (1965, p. 68), however, state that the flow occurs within, rather than underlying, the basal conglomerate, and they state the age of the conglomerate to be Waitakian. Allen (1951) gave the age of his Whangarei Series (Motatau Group) as Waitakian to Whaingaroan, while on foraminiferal evidence basal rocks collected by the writer from the Motatau Group near Kauri Mt are older than Southland Series and probably either Landon or Lower Pareora in age (Mr N. de B. Hornibrook, personal communication). Thus it does not seem justifiable to give the olivine nephelinite at McLeod's Bay an age as precise as Waitakian unless the flow definitely lies within the basal conglomerate and the latter can be shown to be of undoubted Waitakian age.

Allen (1951) and Black and Brothers (1965) regarded the McLeod's Bay olivine nephelinite as similar to that occurring at Pukenamu, one mile from the olivine nephelinite described by the writer. On petrologic evidence it seems reasonable to correlate all three occurrences of olivine nephelinite and to date them tentatively as post-Waipapa Group and older than Landon or Lower Pareora Series (Oligocene).

1. Quartz–diorite porphyry, on coast east of Kauri Mt (Ferrar, 1925, p. 74, No. 6).

2. Quartz–diorite porphyry, on coast north-east of Kauri Mt, N20/071923, specimen 10519. Analyst: T. H. Wilson.

3. Hypersthene granodiorite, south side of Ngunguru Estuary (Ferrar, 1925, p. 74, No. 7).

4. Hypersthene granodiorite, Tahere (Ferrar, 1925, p. 74, No. 8).

5. Hypersthene granodiorite, on coast south of Matapouri, N20/032153, specimen 10520. Analyst: T. H. Wilson.

The other two dykes, microgabbro and camptonitic lamprophyre, are more closely related petrologically to the olivine nephelinites than to the quartz–diorite porphyry of the Wairakau Andesites or the Pukenamu tuff breccia cone of the Parahaki Volcanics, which are the only other igneous bodies in the district. Further, shear joints in the camptonitic lamprophyre pass into the surrounding Waipapa rocks but similar features are not seen in the Wairakau Andesites. For these reasons these intrusions are thought to be older than the Wairakau Andesites and are considered tentatively to have the same age as the olivine nephelinites.

Intrusives of the Wairakau Andesites

The name Wairakau Series was first used by Bell (1909) and later, in the same year, by Bell and Clarke (1909) for andesitic breccias, tuff beds, lavas and dykes, with rare carbonaceous sandstones, occurring in the Whangaroa district. Ferrar (1925) extended the term to include semi-basic intrusions, with subsidiary andesitic lavas and agglomerates in the Whangarei region which showed petrologic similarities with the rocks at Whangaroa. The name was retained by Allen (1951), but Thompson (1961) renamed them the Wairakau Andesites.

Occurrence and Field Relations

Rocks of the Wairakau Andesites occur sporadically throughout this coastal region but are most abundant in the vicinity of Kauri Mt, where they consist of intrusions of quartz-diorite porphyry cutting rocks of both the Motatau and Waipapa Groups, together with lesser amounts of hornblende andesite. North of Horahora there are scattered dykes and intrusions of hypersthene granodiorite. None of the intrusions show any evidence of deformation. The rocks are discussed in two groups: (1) quartz-diorite porphyry; (2) hypersthene granodiorite. The hornblende andesites described by Ferrar (1925) are not dealt with.

Quartz-diorite Porphyry

Occurrence and microscopic features: This rock is exposed in several localities on or near the coast about Kauri Mt and intrudes both Waipapa and Motatau rocks. At the northern end of Ocean Beach a series of dykes, previously unrecorded, intrudes rocks of the Motatau Group. Specimen 11139, from the most southerly dyke (N20/065899), shows in thin section abundant zoned phenocrysts, up to 2.0mm across, of plagioclase with rims of An_{54} to An_{55} (four measurements, Slemmons) and all with optical properties transitional between plutonic and volcanic plagioclases. Calcite, pseudomorphous after hornblende, is common with the pseudomorph margins fringed with granular ore. Calcite also replaces some of the plagioclase. The groundmass consists of abundant laths of andesine, An_{45} (Michel-Levy), quartz, and small grains of ore.

Specimen 11284 comes from the largest of the dykes (N20/066905) in the Ocean Beach locality. In thin section are seen phenocrysts, up to 1.75mm long, of chloritised hornblende and lesser numbers of biotite flakes up to 0.75mm in length. Corroded phenocrysts of quartz, less than 2.0mm across, are also common but are not as abundant as zoned phenocrysts, up to 3.0mm across, of plagioclase with margins of An_{41} to An_{44} (three determinations, Slemmons). In the groundmass, which is highly altered and contains much secondary calcite, the predominant mineral is andesine, An_{40} (Michel-Levy), with lesser amounts of orthoclase and quartz and a little chloritised green hornblende. Other specimens from the dykes are highly altered and much calcite, apparently secondary, is present together with abundant secondary chlorite.

In all the specimens of quartz-diorite porphyry from this district, that were examined by the writer the potash feldspar is present only in the ground mass and the amount is difficult to estimate. Similar difficulty occurs in estimating the amount of groundmass quartz present. Norms of the rocks (Nos. 1 and 2, Table I) show that up to one-sixth of the total normative feldspar is orthoclase. However, the amount of modal orthoclase is certainly less than this, as up to 6 per cent (molecular percentage) of the orthoclase end-member has been determined in andesine (Deer *et al.*, 1963b, pp. 114–115). On this basis the name quartz-diorite porphyry is considered more suitable for these rocks than the term quartz porphyrite used by Ferrar (1925).

The rock of the larger bodies of quartz-diorite porphyry lying east and north-east of Kauri Mt is fresher than that of the dykes. Specimen 10519 contains phenocrysts, up to 1.75mm in length, of green-brown hornblende showing resorption and with the following optical properties:

Pleochroism: X = pale brown, Y = greenish brown, Z = pale green

$\alpha = 1.652 \pm 0.002$

$\gamma = 1.670 \pm 0.002$

$2V_{\alpha} = 80°–90°$ (six determinations)

These properties suggest a range in composition between $Mg_{65}(Fe^{2+}+Fe^{3+}+Mn)_{35}$ and $Mg_{75}(Fe^{2+}+Fe^{3+}+Mn)_{25}$ (Deer *et al.*, 1963a, p. 296). The remaining mineralogy is similar to that seen in the dyke rocks. Plagioclase phenocrysts are common and frequently show oscillatory zoning. One phenocryst has a core of An_{40} and a rim of An_{47} (Slemmons), while three other phenocrysts have rims of An_{45}, An_{43}, An_{47} (Slemmons). The groundmass of 10519 consists of plagioclase laths of indeterminable composition, with quartz, granular ore, hornblende, and biotite.

An analysis (No. 2) of 10519 is given in Table I together with an analysis (No. 1) given by Ferrar (1925) of similar rock nearby.

Effects on intruded sediments: The effect of the intrusions on the Waipapa and Motatau rocks has not led to any notable assemblage of contact-metamorphic minerals. In 11147, collected from Motatau rocks in contact with a dyke (11284), it is seen in thin section that the sedimentary character has been almost entirely lost owing to recrystallisation of abundant calcite.

The Motatau rocks surrounding the most southerly of these dykes, at the northern end of Ocean Beach (N20/065899), are intensely deformed and markedly reconstituted. However, it is likely that much of the deformation was due to movement, prior to intrusion of the dyke, on a large fault of unknown displacement which lies only 50 yards to the south and which may continue across to Parua Bay some four miles away (Allen, 1951). The deformed sedimentary rocks in thin section show considerable shattering and are often reconstituted to a fine-grained almost irresolvable mineral assemblage (e.g., 11138). Quartz grains may be identified, secondary calcite is ubiquitous in all specimens, and fine chlorite and siliceous organic tests are also seen (e.g., 11135). A fine fibrous mineral present in irregular patches in 11136 was shown by X-ray diffraction to be a chlorite with a diffraction pattern resembling that of penninite.

At the north end of Ocean Beach the quartz-diorite porphyry is considered to have given rise to veins of chalcopyrite–pyrite–bornite–sphalerite–quartz (11143, 11144) in argillaceous limestones and non-calcareous sandstones of the Motatau Group. Most veins are less than an inch thick, usually occur along zones of shearing, and generally consist of calcite and pyrite. However, specimen 11143, collected at N20/065902, is more unusual in its mineral assemblage, as given above, and in its occurrence as a system of close veins exposed in the centre of a small shingle beach where they are clearly visible at low tide striking out to sea. Many of these veins cross-cut one another and the whole system probably occupies a zone of shattering. The occurrence of this system of veins was first noted by Ferrar (1925, p. 79) who gave an assay.

Discussion: Ferrar (1925) showed that the andesitic rocks of the Whangarei region fall into two broad groups: (1) normal andesites and (2) acidic andesites. He showed by chemical analyses that the latter rocks contain a higher percentage of silica than the normal andesites and generally show moderate amounts of modal quartz. He also considered that the hornblende andesite at Kauri Mt was the effusive equivalent of the quartz-diorite porphyry. The analyses given by Ferrar support his views, as does the new analysis of quartz-diorite porphyry presented by the writer. This evidence does not support the view of Brothers (p. 23, *in* Thompson and Kermode, 1965) who placed the Kauri Mt granodiorite in the Parahaki Volcanics.

Hypersthene Granodiorite

Occurrence and microscopic features: These rocks, termed porphyrite dykes by Ferrar (1925), are here referred to as hypersthene granodiorite on the basis of their mineralogy and chemical analyses. They are found as small scattered intrusions from Horahora northwards to Matapouri and are only seen intruding rocks of the Waipapa Group.

Specimen 10520 is from a dyke (N20/032153), 30 to 40ft wide. A visual estimation of the modal composition (weight per cent), after treating with sodium cobaltinitrite to stain the potash feldspar, is: quartz, 15; potash feldspar, 10; plagioclase, 50; with mafic minerals comprising the bulk of the remaining 25 per cent. The plagioclase is labradorite, An_{60} (Michel-Levy), and is both normally zoned and unzoned. Some of the potash feldspar shows highly irregular perthitic structures and is often intergrown with quartz. The bulk of the mafic minerals consists of hypersthene which is sometimes rimmed with clinopyroxene. The pyroxenes frequently show partial alteration to green fibrous uralite and to non-fibrous green amphibole, which are in turn often replaced by green-brown biotite. Optical properties of the hypersthene are:

$$2V_{a} : 50°–52° \text{ (four measurements)}$$
$$\gamma = 1.698 \pm 0.002$$
$$a = 1.692 \pm 0.002$$

These properties indicate a composition of $Mg_{60}(Fe^{2+}+Fe^{3+}+Mn)_{40}$. The plagioclase is normally zoned and cores of two crystals are An_{73} and An_{81} while rims of three other crystals are An_{40}, An_{43}, An_{39} (Slemmons); the optical properties are transitional between plutonic and volcanic plagioclases. The rock shows considerable chloritisation. A chemical analysis (No. 5) of 10520 is given in Table I.

Specimen 11197 is from a small knoll at N20/996065; this is the locality of the rock for which Ferrar gave a chemical analysis (No. 3, Table I). In thin section the rock is similar to 10520 except that less uralite and green amphibole and more biotite (in flakes less than 0.5mm long) are present. Optical properties of the hypersthene are:

$2V_\alpha$: 45°–55° (five measurements)

$\gamma = 1.695 \pm 0.002$

$\alpha = 1.687 \pm 0.002$

These properties suggest a composition of $Mg_{65}(Fe^{2+}+Fe^{3+}+Mn)_{35}$, which is similar to that for the hypersthene in 10520. Abundant ore is present in the groundmass and there is much fine chlorite throughout.

Specimens from other localities are very similar to those already described. Specimen 11251 occurs capping a hill (N20/021112) behind Tutukaka and closely resembles 11197. However, 11250, from the same locality, is finer grained; the plagioclase is labradorite, An_{60} (Michel-Levy), and the hypersthene shows very little replacement. Presumably the finer grained rock cooled more quickly than the main body of rock and escaped the late magmatic alteration which occurred elsewhere and formed such products as uralite.

The hypersthene diorites have not greatly altered the Waipapa Group rocks which they intrude. Sandstone (11261) in direct contact with a dyke (10520) shows much fine chloritisation and limonitic staining, but sandstone (11262) collected only four yards from the contact of the same dyke is unaltered.

Discussion: These scattered rocks are clearly of the same type, derived from a common magma. They appear to have been emplaced as small intrusive bodies and no evidence of any effusive rocks can be found. The existence of uralitised pyroxene indicates that the magma cooled sufficiently slowly to permit late-stage magmatic alterations to occur.

Two chemical analyses, reported by Ferrar (1925), are included in Table I (Nos. 3 and 4). One new analysis (No. 5) is given. The two analyses given by Ferrar are similar, and on this evidence he classed these rocks with the porphyrites and normal andesites in his Wairakau Series. However, the new analysis presented here is somewhat different from those of Ferrar (1925), although the high content of water in the analyses tends to invalidate chemical comparison and also causes the norms to be of doubtful value. Nevertheless the analyses suggest that the rocks are granodiorites, and this view is borne out by the petrographic evidence available.

The exact relationship of these rocks to other rocks of the Wairakau Andesites is uncertain but petrologic evidence seems to relate the hypersthene granodiorites to the Wairakau rocks rather than to any other group in the Whangarei region.

Age of the Wairakau Andesites

Bell and Clarke (1909) considered their Wairakau Series at Whangaroa to be of Miocene age, and this age was retained by Ferrar (1925) for the Wairakau Series in the Whangarei region.

At Kauri Mt quartz-diorite porphyry of the Wairakau Andesites intrudes beds of the Motatau Group, and hence at that locality the intrusives are post-Landon or post-Pareora in age. Brothers (*in* Thompson and Kermode, 1965, p. 23) places these intrusives in the Parahaki Volcanics which are also regarded as Miocene but younger than the Wairakau Andesites (Allen, 1951). Nevertheless, as already mentioned, the writer considers that the petrologic evidence does not support Brothers's view. At McLeod's Bay there is further evidence that the quartz andesites are older than rocks of the Motatau Group (Allen, 1951).

The upper age limit of the Wairakau Andesites is uncertain. Onerahi chaos-breccia rests on the slopes of Mt Hikurangi, which was included in the Wairakau Andesites by Ferrar (1925) but in the Parahaki Volcanics by Thompson (1961). At Whangarei Heads the normal andesites intrude Onerahi rocks (Ferrar, 1925; Allen, 1951); the latter rocks have been mapped as chaos-breccia by Thompson (1961) but are not mentioned as such by Kear and Waterhouse (1966). The Onerahi chaos-breccia is considered by Kear and Waterhouse (1966) to have been emplaced between the Waitakian–Otaian (Oligocene to Lowest Miocene) and the Quaternary; the only formations known to overlie it are Quaternary alluvium and Quaternary basalts (Kerikeri Volcanics). Thus, in the Whangarei region the Wairakau Andesites have a possible age from pre-Whaingaroan (Lower Oligocene) to Quaternary.

Parsons (1966) has shown that at Whangaroa tuffs with plant remains, and contained within Wairakau breccias, are Nukumaruan (Pleistocene) in age but it is not yet known if all the breccia at Whangaroa has a similar age. It seems likely, however, that the Wairakau Andesites of Northland were emplaced over a very long period.

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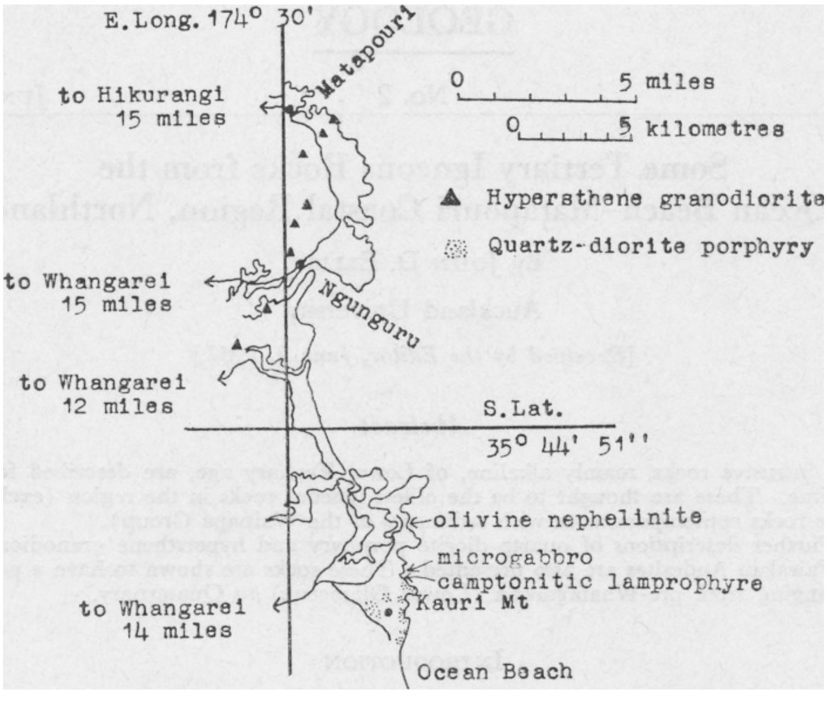

FIG. 1.—Ocean Beach–Matapouri Coastal Region, Northland

	1	2	3	4	5
SiO_2	59.86	61.8	58.46	57.40	62.0
Al_2O_3	16.02	16.3	16.85	16.37	16.7
Fe_2O_3	1.25	3.1	0.90	2.08	1.8
FeO	3.42	3.3	5.79	4.64	3.9
MgO	2.61	4.0	2.26	2.28	2.5
CaO	6.05	5.2	5.32	5.76	2.4
Na_2O	3.59	2.9	2.89	2.85	3.6
K_2O	1.83	1.1	2.19	2.45	1.1
H_2O+	1.75	0.2	3.09	2.99	3.0
H_2O-	0.53	0.5	1.23	1.62	1.3
CO_2	1.89	nil	0.04	0.10	nil
TiO_2	0.76	0.6	0.86	0.92	0.8
P_2O_5	0.17	0.5	0.05	0.25	0.3
S	trace		nil	0.02	
NiO	0.04		trace	0.07	
MnO	0.04	0.2	0.12	0.05	0.2
SrO	0.02		0.04	0.02	
BaO			0.05		
Totals	99.83	99.7	100.14	99.87	99.6

C.I.P.W. NORMS

	1	2	3	4	5
Q	19.08	23.7	14.58	14.34	26.52
or	10.56	6.67	12.79	15.01	6.67
ab	30.39	24.63	24.63	24.10	30.39
an	17.24	22.24	26.41	24.46	10.01
C	1.84	2.14			5.92
di				1.36	
hy	10.33	12.9	14.5	10.45	10.95
mt	1.86	4.41	1.39	3.02	2.55
il	1.52	1.22	1.67	1.67	1.52
ap	0.34	1.34		0.67	0.67

TABLE I.—CHEMICAL ANALYSES.