TRANSACTIONS

OF THE

ROYAL SOCIETY OF NEW ZEALAND

EARTH SCIENCES

VOL. 8 | No. 7 | 27 AUGUST 1970

Description and Correlation of Holocene Volcanic Formations in the Tarawera-Rerewhakaaitu Region

By J. W. COLE

Victoria University of Wellington.

[*Received by the Editor, 8 October 1969.*]

Abstract

THE Rerewhakaaitu, Waiohau, Kaharoa, and Tarawera Formations of Vucetich and Pullar (1964) are redefined as "volcanic" formations each with several members:

FORMATION	MEMBER
Tarawera	Rotomahana Mud
	Tarawera Basalt
Kaharoa	Wahanga Rhyolite
	Lahar Breccia
	Ruawahia and Tarawera Rhyolites
	Flow Breccia
	Kaharoa Tephra
	Crater Rhyolite
Waiohau	Flow Breccia
	Waiohau Tephra
	?Plateau Rhyolite
Rerewhakaaitu	?Koa Rhyolite
	Rerewhakaaitu Tephra

Correlation within tephra members and between tephras and pyroclastic or lava flow members is based on mafic minerals. Precise source vents for each member are located on Mount Tarawera.

INTRODUCTION

THE stratigraphy and approximate sources of Holocene tephra deposits of the Rotorua–Bay of Plenty–Gisborne region have been described by Vucetich and Pullar (1964). This paper describes the lithology and mineralogy of the Rerewhakaaitu, Waiohau, Kaharoa, and Tarawera Formations in the Mount Tarawera–Rerewhakaaitu region and locates their sources more precisely. Correlation is also made between pyroclastic deposits and several rhyolite domes and flows on Mount Tarawera, allowing the rhyolites to be identified as members within formations. It has thus been necessary to change each formation from an ash or pyroclastic formation to a volcanic formation.

The term "pyroclastic" is used to describe both clastic ejecta which have been erupted explosively (airfall deposits) and ejecta which may have resulted from small nuée ardente eruptions (ash-flow deposits), and the terminology of Fisher (1961) is used for the description of pyroclastic rocks of a particular grain size. The term "tephra" is restricted to airfall deposits, as implied in Thorarinsson's (1954) definition.

Published by the Royal Society of New Zealand, c/o Victoria University of Wellington, P.O. Box 196, Wellington.

Trans. R. Soc. N.Z., Earth Sciences, Vol. 8, No. 7, *pp. 93–108, 4 figs., 1 pl.*

METHODS OF CORRELATION

The section of Holocene tephra at Democrat Road, Rerewhakaaitu (N86/934824)* of Vucetich and Pullar (1964) was taken as a standard for the region, and the sequence at each unknown section was compared with it. Once tephras were identified, samples were taken vertically at 15cm intervals from selected localities of the Rerewhakaaitu, Waiohau, Kaharoa, and Tarawera Formations. Mafic mineral contents were determined and found to be distinctive for each tephra. This method was then used to confirm correlation in areas where field determinations were difficult, and to correlate tephras with pyroclastic or lava-flow rocks of the same formation.

DESCRIPTIONS OF FORMATIONS

Type or standard sections of the pyroclastic members of the four formations described were taken where they were 1½–2m thick; a convenient thickness for examining vertical changes in lithology and lateral variation around the vent.

Rerewhakaaitu Formation

The type section of the Tephra Member (Rerewhakaaitu Ash of Vucetich and Pullar, 1964: 57) is in Democrat Road, Rerewhakaaitu (N86/934824, Fig. 2, Section 3).

	Thickness (cm)
Brown ash with lapilli up to 5cm in diameter (buried soil)	15–37
Shower-bedded fine ash, coarse ash and lapilli	52–74
Distinct lapilli bed	7–13
Shower-bedded coarse ash and lapilli	25–37

The Tephra Member is exposed in the "pumice washes" on the south side of Mount Tarawera, where it is up to 50m thick. It is weakly shower-bedded and contains many blocks of pumiceous rhyolite and partly expanded obsidian in a matrix of coarse ash.

The Koa Rhyolite Member is apparently interbedded with the Tephra Member on the south-west side of Mount Tarawera. No standard section can be given, but there is an outcrop of the rhyolite at the head of one of the pumice washes to the south of Koa Trig (N77/960908).

Mineralogy: The Rerewhakaaitu Tephra Member contains a mixture of two types of lapilli (Table II); pumice and obsidian with a low crystal content (Type A); and pumice and obsidian with a high crystal content (Type B). The volumes of each are approximately equal.

Type A: The crystal content averages 3 percent and consists of small resorbed crystals of plagioclase (0.5–1mm in diameter), hypersthene, and magnetite. The glass is pumiceous with some granophyric aggregates in it.

Type B: The crystal content averages 19 percent and includes plagioclase, quartz, hornblende, and biotite. Both plagioclase and quartz are large (up to 3.5mm) and are often surrounded by a rim of small feldspar microlites. The quartz is usually strongly resorbed. Mafic minerals are green hornblende and biotite, which are of medium size ($<$ 1mm), and are often intergrown together or with plagioclase. The biotite is commonly more strongly pleochroic around the margin than in the centre. The glassy groundmass is full of small laths of plagioclase with some small biotite flakes and hornblende crystals. In the crushed lapilli and ash both types A and B contribute mafic minerals, so that biotite, green hornblende, hypersthene, and magnetite are present in approximately equal amounts (Table III).

The major rock type of the Koa Rhyolite Member resembles pumice of Type A with a few small crystals of plagioclase and hypersthene. However, large "xeno-

* New Zealand Grid Reference (North Island Sheet 86).

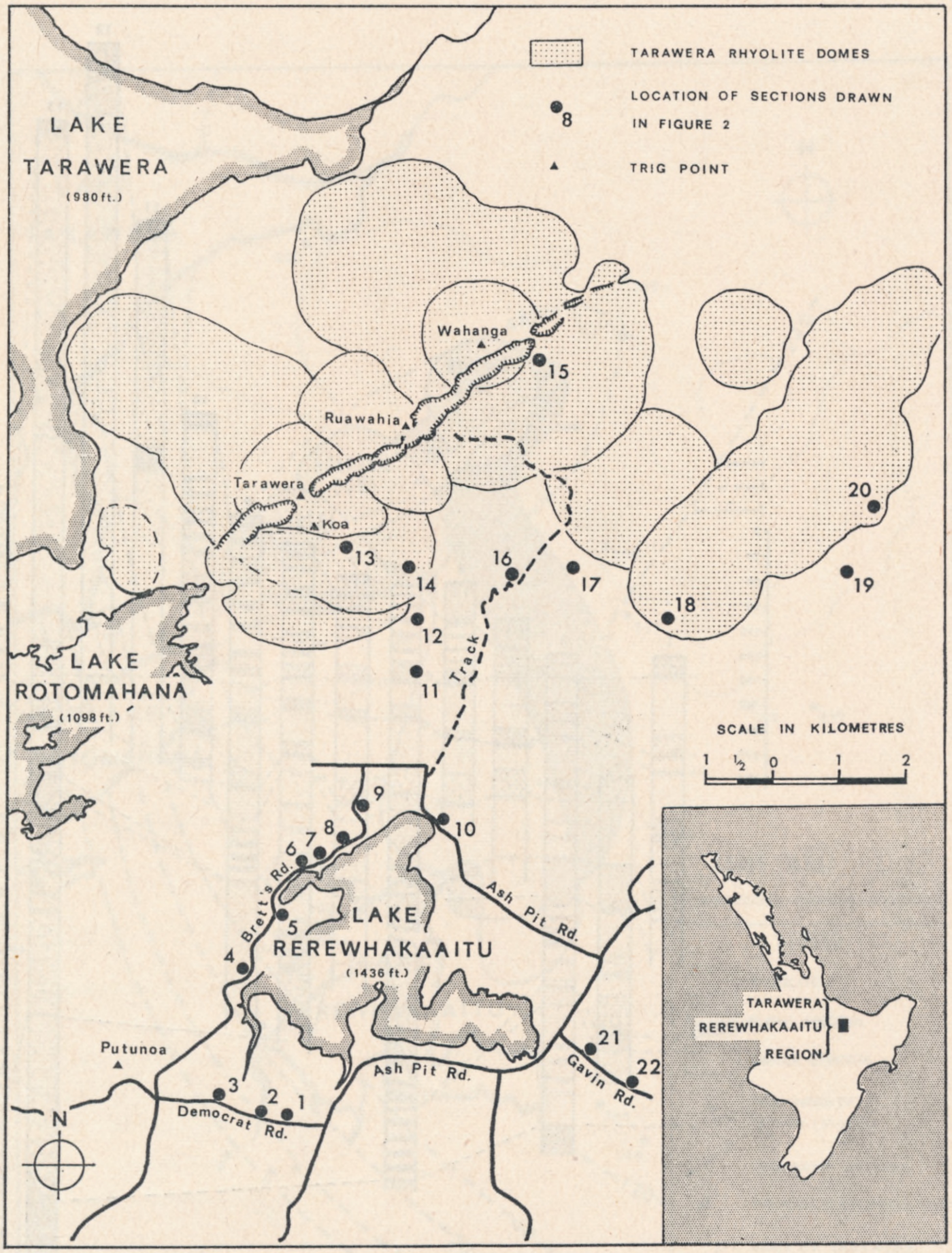


FIG. 1.—Map of the Mount Tarawera–Rerewhakaaitu region, showing locations of sections given in Figure 2.

crysts" of Type B pumice are common within the lower parts of the rhyolite dome, and in places the two types are in almost equal proportions.

Waiohau Formation

The Waiohau Tephra Member (Table I) was first described by Vucetich and Pullar (1964: 55) from the thick deposits in the Waiohau district, 18 miles to the

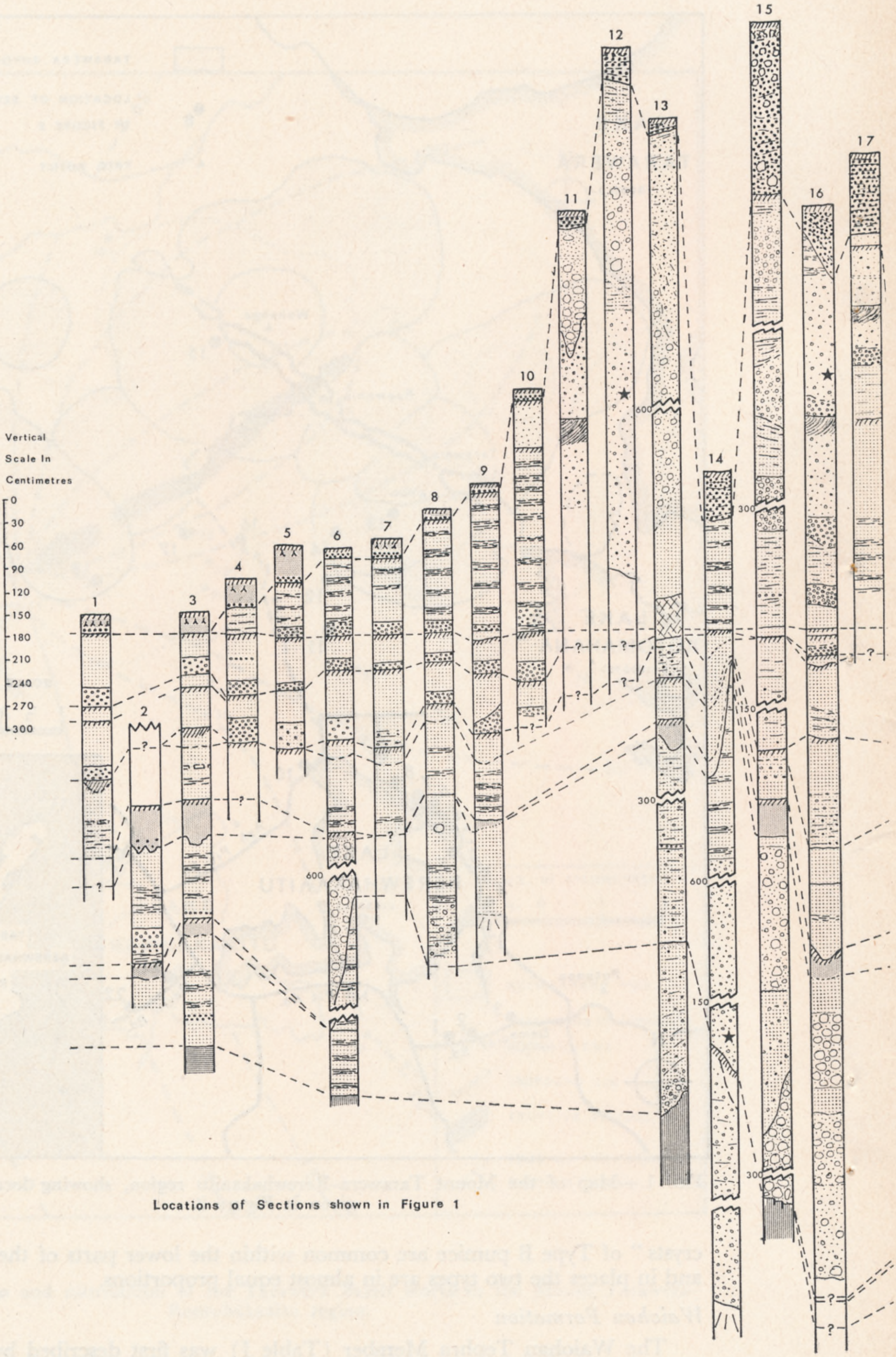
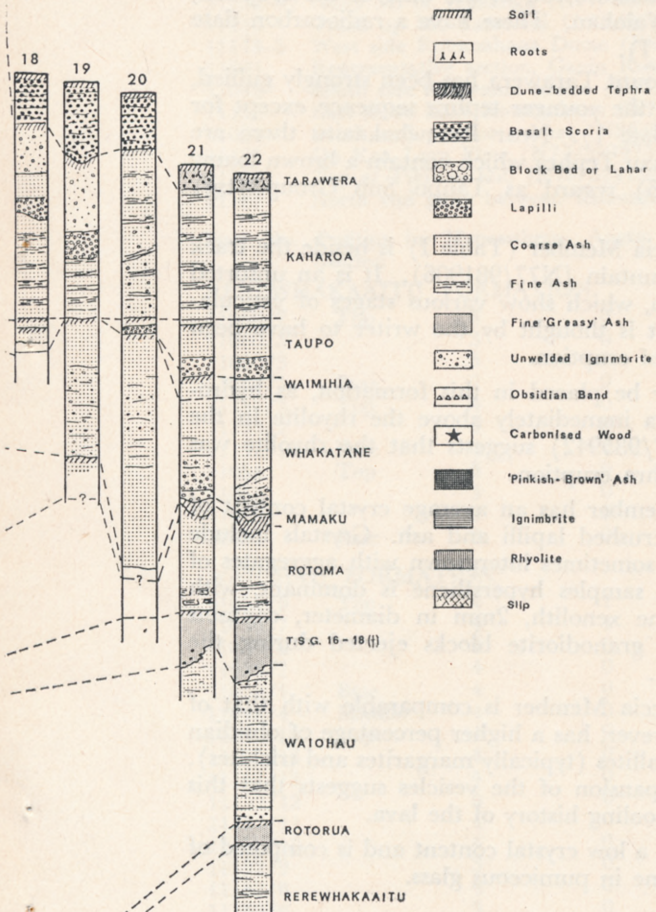


FIG. 2.—Sections of Holocene pyroclastic formations in the Mount Tarawera–Rerewhakaaitu



region. T.S.G., Taupo Sub-group.

east of Tarawera. Their type section, however, is at Democrat Road, Rerewhakaaitu (N86/934824, Fig. 2, Section 3).

	Thickness (cm)
Light-brown ash with a few lapilli and some obsidian (buried soil)	22
Shower-bedded pumice and obsidian with some rhyolite lapilli	30–67
Shower-bedded coarse and fine ash	37
Ash grading into pumice lapilli	15–25
Obsidian lapilli bed	2– 5
Pumice lapilli	5

In the pumice washes to the south of Koa Trig (N77/964914) Waiohau Tephra is over 20m thick (Plate 1). The base is exposed in a shallow depression cut into the underlying Rerewhakaaitu Tephra Member. Charred logs, probably the remains of trees that were growing on the Rerewhakaaitu soil at the time of the eruption, occur about 15cm above the base of the Waiohau. These have a radiocarbon date of 11,250 ± 250 years before 1960 (Table I).

The top of the Waiohau Tephra on Mount Tarawera has been strongly gullied, and on the southern side of the mountain the younger tephra sequence except for the Kaharoa is present in the gullies (Plate 1). Near Rerewhakaaitu there are shallow depressions in the top of the Waiohau Tephra which contain a brown loamy ash that Vucetich and Pullar (1964: 46) regard as Taupo Sub Group (tsg) Members 16–18.

The standard section of the Flow Breccia Member (Table I) is beside the track from Rerewhakaaitu to the top of the mountain (N77/981906). It is an unsorted breccia containing large blocks of obsidian, which show various stages of vesiculation, in a matrix of coarse to fine ash. It is thought by the writer to have been deposited from a small nuée ardente type of eruption.

Plateau Rhyolite Member can possibly be placed in this formation, as hydrothermal alteration of the Waiohau Tephra immediately above the rhyolite in the gully to the south-east of Wahanga (N77/985942) suggests that the rhyolite was extruded only a short time before the tephra eruption.

Mineralogy: The Waiohau Tephra Member has an average crystal content of less than 4 percent for both blocks and crushed lapilli and ash. Crystals include small fragments of quartz and plagioclase sometimes intergrown with aggregates of hypersthene and hornblende. In crushed samples hypersthene is dominant, with some green hornblende (Table III). One xenolith, 2mm in diameter, contains quartz and feldspar, very similar to the granodiorite blocks ejected during the Kaharoa eruption (Ewart and Cole, 1967).

The mineral content of the Flow Breccia Member is comparable with that of the air-fall tephra. The Flow Breccia, however, has a higher percentage of obsidian blocks, and the glass of these is full of crystallites (typically margarites and trichites). Distortion of the flow banding by the expansion of the vesicles suggests that this expansion was a secondary feature in the cooling history of the lava.

The Plateau Rhyolite Member also has a low crystal content and is composed of small crystals of plagioclase and hypersthene in pumiceous glass.

Kaharoa Formation

There is a standard section of the Tephra Member (Table I) at Gavin Road, Rerewhakaaitu (N86/001826, Fig. 2, Section 22):

	Thickness (cm)
Fine ash, yellow-brown at top (buried soil)	15
Fine to coarse ash alternating with white pumice lapilli, some rhyolite obsidian, and basalt (2 units)	50
Fine ash	5
Shower-bedded coarse ash and lapilli, a few thin bands of fine ash	35

Fine and coarse ash, alternating with pumice lapilli, some rhyolite, obsidian, and basalt (3 main units)	55
Fine grey ash	5

The Tephra Member thins rapidly to the south-west away from Mount Tarawera and is not recorded in the section at N86/934824 (Fig. 3). At Bretts Road, Rerewhakaaitu (N86/944854, Fig. 2, Section 5), it is much thinner than at Gavin Road, and the sequence is markedly different:

	Thickness (cm)
Black ash, grading downward into dark brown ash (buried soil)	10
Coarse ash with thin bands of pumice, rhyolite, and obsidian	60
Pumice lapilli	10

Towards Mount Tarawera the Tephra Member thickens and includes a Flow Breccia Member, about 200cm of which is exposed in a section by the track from Rerewhakaaitu to the top of the mountain (N77/981906, Fig. 2, Section 16):

	Thickness (cm)
Shower-bedded ash and lapilli (pumice, obsidian, rhyolite, basalt)	15–60
Fine to coarse unsorted pink ash, with a few lapilli up to 50mm. Some cross bedding at top (Flow Breccia Member)	120–180
Lapilli and blocks up to 75mm	30–45
Shower-bedded coarse to fine ash of pumice, rhyolite, and obsidian (four main units)	60
Coarse lapilli and blocks, mainly pumice	22–30
Fine ash	22–37
Coarse ash	1

The Flow Breccia Member occurs only near the source vent and is very similar to deposits surrounding rhyolite volcanoes in Japan (Aramaki, 1963). Cross-bedding is common at the top of the member, probably due to wind action on the material after the eruption.

The Lahar Breccia Member occurs at the top of the Kaharoa sequence to the north-east of Lake Rerewhakaaitu. It consists of blocks of pumiceous rhyolite in a matrix of coarse ash. Blocks of the same rhyolite are also scattered over the ground surface. The deposit can be traced up to the southern flank of Ruawahia Dome, Mount Tarawera, and probably originated as a lahar from the talus front at the margin of this dome. The material on becoming saturated with water shortly after the eruption became unstable and flowed down towards Lake Rerewhakaaitu.

Crater Rhyolite Member is exposed in the deepest crater of the line of vents across Mount Tarawera and probably represents the first activity of the Kaharoa eruption (Cole, in press). It is overlain by the Kaharoa Tephra Member, which is in turn overlain by Ruawahia, Tarawera, and Wahanga Rhyolite Members. These members are also exposed in the walls of the craters.

The age of the formation, found by dating a sample of carbonised wood from within the Tephra Member, is 930 $\pm$ 70 years before 1960 NZ170, Grant-Taylor and Rafter, 1963: 140).

Mineralogy: All members of the Kaharoa Formation have very similar mineralogy. The four rhyolite members vary in colour from pink to grey in hand specimen. They have a high percentage of phenocrysts (average 24 percent) of quartz, plagioclase, and biotite, which are often shattered. Tarawera Rhyolite Member in addition has crystals of hypersthene and hornblende, but these may be derived from Koa Dome through which it was extruded.

The Kaharoa Tephra Member close to the presumed vent resembles the Ruawahia Rhyolite Member. Blocks of obsidian and pumiceous rhyolite contain large crystals of quartz, plagioclase, and biotite (maximum diameter 3mm). Pumice from around Lake Rerewhakaaitu has a lower total crystal content (Table II) and includes a few small xenoliths of basalt, which contribute occasional augite and olivine crystals to the ash and lapilli.

The Flow Breccia Member has the same "primary" rhyolite pumice as the Tephra Member, but has in addition blocks of ignimbrite, granodiorite, and basalt. The granodiorite blocks when coated with ash superficially resemble rhyolite.

The Lahar Breccia Member has blocks of pumiceous rhyolite identical with that of Ruawahia in a matrix of coarse to fine ash. Crushed samples of this member show a similar mafic mineral assemblage to the Tephra Member.

Tarawera Formation

On Mount Tarawera the Basalt Member (Table I) is shower-bedded, with layers of coarse basalt lapilli interbedded with layers of basaltic ash. The size of the lapilli increases towards the eruptive vents, where there are large blocks up to 20cm diameter. The following sequence occurs in a section exposed to the south of Wahanga Dome (N77/985942):

	Thickness (cm)
Blocks of pumiceous rhyolite up to 30cm, with some basalt	90
Basalt with a few blocks of rhyolite	150
Basalt and rhyolite (maximum size 10cm)	30

In the Rerewhakaaitu basin small fragments of rhyolite are scattered throughout the basalt scoria. On the north and west sides of Lake Rerewhakaaitu the Tarawera Basalt passes laterally into the Rotomahana Mud, a fine grey muddy ash which is

TABLE I.—Holocene Volcanic Chronology in the Tarawera–Rerewhakaaitu Region.

Formation	Members	14C Age (years before 1960)	Reference to Age
Tarawera	Rotomahana Mud	74	
	Tarawera Basalt	(Eruption in 1886)	
Kaharoa	Lahar Breccia		
	Wahanga Rhyolite		
	Ruawahia Rhyolite		
	Tarawera Rhyolite		
	Flow Breccia		Vucetich and Pullar
	Kaharoa Tephra	940 ± 70	(1964: 45)
	Crater Rhyolite		
Taupo	Upper Taupo Pumice		
	Taupo Lapilli	1,770 ± 80	Healy (1964: 42)
	Rotongaio Ash		
	"Putty Ash"	1,830 (approx.)	Healy (1964: 37)
	Hatepe Lapilli	1,900 ± 70	Healy (1964: 27)
Waimihia		3,430 ± 50	Healy (1964: 36)
Whakatane			
Mamaku			
Rotoma			
	Brown greasy ash		
	(? T.s.g. 16–18)	8,860 ± 1,000	Healy, 1964
Waiohau	Flow Breccia		
	Waiohau Tephra	11,250 ± 250	Unpublished date
	? Plateau Rhyolite		N.Z. 14C No. 568
Rotorua			
Rerewhakaaitu	? Koa Rhyolite		
	Rerewhakaaitu Tephra	14,700 ± 400	Vucetich (1968)
	Older Tephras		

Tephra exposed in the walls of a gully to the south-east of Koa Trig (N77/964914). Height of section approximately 13m.

Table II.—Modal Analyses of the Rerewhakaaitu Formation.

	Rerewhakaaitu Tephra Member (Pumice of Type A)			Rerewhakaaitu Tephra Member (Pumice of Type B)			Koa Rhyolite Member	
Thin Section No.	11116	11160	11165 (1)	11165 (2)	11159	11156	11163	11088
Glass or groundmass	98.3	97.5	96.7	80.5	81.2	82.0	95.8	94.0
Quartz	—	—	—	3.8	2.8	2.8	0.1	0.6
Plagioclase	1.3	2.5	3.2	12.0	13.5	13.1	3.9	3.1
Biotite	—	—	—	3.0	2.0	1.2	—	0.2
Hypersthene	0.3	—	—	0.1	0.2	—	0.1	0.3
Hornblende	—	—	—	0.1	0.2	0.7	—	0.3
Magnetite	0.1	—	0.1	0.5	0.2	0.2	0.1	1.5
Xenoliths	—	—	—	—	—	—	—	—
Total crystal content	1.7	2.5	3.3	19.5	18.9	18.0	4.2	6.0
Plagioclase/quartz ratio	—	—	—	3.1	4.8	4.7	39.0	5.16
Vesicular (V) or Spherulitic (S)	S	V	V	V	—	V	V	V

Specimen numbers refer to rocks and thin sections kept in Geology Department, Victoria University of Wellington, Collection.

TABLE II.—Cont.

WAIOHAU FORMATION.

	Waiohau Tephra Member	Waiohau Flow Breccia Member		Plateau Rhyolite Member	
Thin Section No.	11152	11153/4	11153/7	11138	11134
Glass or groundmass	98.1	94.0	95.7	93.0	94.9
Quartz	0.3	1.6	1.2	1.5	0.6
Plagioclase	1.5	3.6	2.6	5.3	4.2
Biotite	—	—	—	—	—
Hypersthene	0.1	0.7	0.4	0.1	0.2
Hornblende	—	—	—	—	—
Magnetite	—	0.1	0.1	0.1	0.1
Xenoliths	—	—	—	—	—
Total crystal content	1.9	6.0	4.3	7.0	5.1
Plagioclase/quartz ratio	5.0	2.3	2.16	3.52	7.0
Vesicular (V) or Spherulitic (S)	V	—	—	V	S

TABLE II.—Cont.

KAHAROA FORMATION.

	Kaharoa Tephra Member					Crater Rhyolite Member	Ruawahia Rhyolite Member		Tarawera Rhyolite Member		Wahanga Rhyolite Member
Thin Section No.	11169	11142	11030	11064	11065	11149	11046	11036	11101	11102	11067
Glass or groundmass	94.7	83.3	66.6	62.5	68.0	71.1	75.5	72.8	76.0	69.1	75.2
Quartz	1.3	4.6	13.5	13.5	9.3	9.7	7.2	8.7	7.2	10.5	9.6
Plagioclase	3.1	9.5	16.3	19.4	21.0	16.6	13.3	15.1	13.2	17.1	11.0
Biotite	0.3	2.2	3.6	4.2	1.6	2.3	2.5	3.0	3.1	1.7	4.2
Hypersthene	0.3	—	—	—	—	—	—	—	—	0.3	—
Hornblende	—	0.2	—	—	—	—	—	—	0.1	0.5	—
Magnetite	0.1	0.2	—	0.4	0.1	0.3	1.5	0.4	0.4	0.8	—
Xenoliths	0.2	—	—	—	—	—	—	—	—	—	—
Total crystal content	5.4	16.7	33.4	37.5	32.0	28.9	24.5	27.2	34.0	30.9	24.8
Plagioclase/quartz ratio	2.4	2.06	1.21	1.44	2.26	1.71	1.87	1.75	1.83	1.63	1.15
Vesicular (V) or Spherulitic (S)	V	V	—	V	V	S	S	S	V	S	S

TABLE III.—Mafic Mineral Contents of Pyroclastic Members of Rerewhakaaitu, Waiohau, and Kaharoa Formations.

Key to Symbols: 4 : > 50%
3 : 26–50%
2 : 11–25%
1 : < 10%
0 : Absent

Localities:

11060	Type section, Democrat Road (N86/934824).
11152	Near head of large pumice wash (N77/964908).
11051–5	Head of small pumice wash (N77/936914).
11164	"Moat" between Tarawera and Rerewhakaaitu domes (N77/954913).
11059	Type section, Democrat Road (N86/934824).
11048	Bretts Road (N86/946861).
11154	East of fissure (N77/994952).
11139–42	Gully SE of Wahanga (N77/985942).
11153	Track up Mt Tarawera (N77/981906).
11173–5	West side Rotomahana Dome (N86/955899).
11061	Representative section, Gavin Road (N86/993831).
11043	South side Ruawahia coulée (N77/969927).
11132	East shore Lake Rotomahana (N77/930903).
11050	South end pumice washes (N86/963887).
11121	On Koa Lava Flow (N77/957973).
11168	Top of Tikitere Hill (N76/829134).
11167	North end gully between Ruawahia and Wahanga domes (N77/965950).

Spec. No.	Position in Section	Hypersthene	Augite	Pale Hornblende	Green Hornblende	Brown Hornblende	Biotite
REREWHAKAAITU FORMATION							
11060/7	Top	3	0	1	2	0	4
11060/5		3	0	0	3	0	3
11060/3		3	0	0	3	0	3
11060/1	Base	2	0	0	3	0	4
11152/3	Top	4	0	1	2	0	2
11152/2		4	0	0	2	0	2
11152/1	Base	4	0	0	2	0	2
11054	Top	3	0	0	3	0	3
11053		3	0	0	2	0	4
11052		3	0	0	3	0	1
11051	Base	3	0	0	3	0	1
WAIOHAU FORMATION							
11059/9	Top	4	1	0	1	0	0
11059/7		4	1	0	1	0	0
11059/5		4	0	0	1	0	0
11059/2		4	0	0	1	0	0
11059/1	Base	4	0	0	3	0	1
11048/4	Middle	4	0	0	1	0	0
11152/15	Top	4	0	0	1	0	0
11152/14		4	0	1	2	0	1
11152/13		4	0	0	1	0	1
11152/12		4	0	0	0	0	0
11152/11		4	0	0	0	0	0
11152/10		4	0	0	2	0	0
11152/9		3	0	1	3	1	1
11152/8		4	0	0	3	1	1
11152/6		3	0	0	3	1	0
11152/4	Base	4	0	1	2	0	0
11055	Middle	4	0	0	1	0	1
11154/3	Middle	4	0	0	1	0	0
11154/2	Middle	4	0	0	1	0	0
11164/2	Middle	4	0	1	1	0	0
11164/1	Base	4	0	0	2	0	0
11140	Near Top	4	0	0	2	0	0
11139	Base	4	0	0	0	0	0
11153/11	Top	4	0	0	2	0	0
11153/7		4	0	0	2	0	0
11153/3		4	0	0	2	0	0

11153/1	Base	4	0	0	2	0	0
11175	Middle	4	0	0	2	0	0
11173	Middle	4	0	0	1	0	0

KAHAROA FORMATION

Spec. No.	Position in Section	Hypersthene	Pale Hornblende	Green Hornblende	Biotite	Olivine	Augite
11061/6	Top	1	0	1	4?	1	1
11061/3		1	0	0	4	1	1
11061/1	Base	2	0	1	3	2	2
11142/6	Middle	2	1	1	4	0	1
11043	Middle	1	0	1	4	0	1
11132	Middle	2	1	1	3	0	2
11050	Middle	2	1	2	4	0	2
11121	Middle	1	1	1	4	1	1
11168/2	Near Top	2	0	1	4	0	1
11168/1	Near Base	2	1	1	4	0	0
11167	Middle	1	1	1	4	0	0

TABLE IV.—Modal Analyses of Basalt from Tarawera Formation.

	1	2
Thin Section No.	11032	11074
Groundmass:		
General	77.6	79.8
Feldspar	17.1	15.6
Olivine	5.3	4.6
Pyroxene	g	g
Magnetite	g	g
Xenocrysts:		
Plagioclase	0.7	1.5
Xenoliths:		
Andesite	—	0.8

g — mineral included in " general groundmass ".

thickest around Lake Rotomahana. The basalt and the mud alternate in some sections (e.g., N86/944854, Fig. 2, Section 5).

Mineralogy: The primary product of the Tarawera eruption is the high-alumina basalt of the Basalt Member. This contains a few medium-sized crystals of quartz, plagioclase, biotite, augite, and olivine, all of which are regarded as xenocrysts. The primary groundmass consists of small laths of plagioclase (average composition An_{62}), crystals of olivine ($<$ 0.15mm diameter), augite, and hypersthene ($<$ 0.1mm) in a dark basaltic glass. Two modal analyses of the basalt are shown in Table IV.

There is considerable variation in the lithology of the Tarawera Basalt from the eruptive fissure to the limits of ejection. In the fissure the basalt is solid to slightly scoriaceous, but immediately surrounding the fissure it is highly scoriaceous (vesicle space $>$ 50 percent) and usually oxidised to a bright red-brown colour. In some places the scoria has welded together, but in thin section it appears as lapilli in a matrix of crushed basalt. The size of the scoria decreases away from the vent until around Lake Rerewhakaaitu the basalt occurs as lapilli in coarse ash.

The Rotomahana Mud Member contains largely comminuted fragments of altered lake sediments and volcanic glass, with occasional lapilli of basalt scoria. The main constituents of the tephra are the clay minerals allophane, kaolin, montmorillonite, and illite, with a few crystals of pyroxene, sericite, and biotite (New Zealand Soil Bureau, 1968).

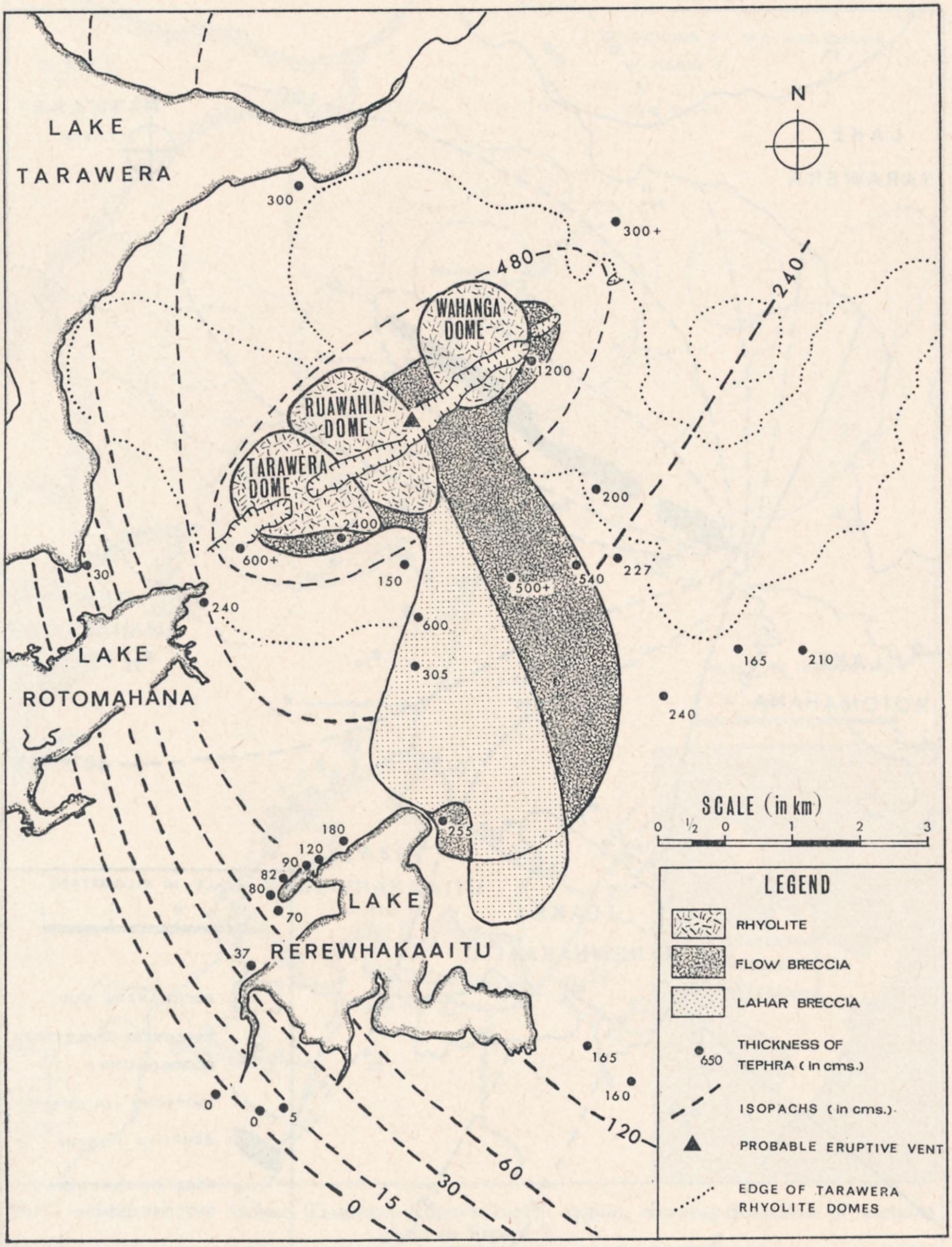


FIG. 3.—Thickness and distribution of the Kaharoa Formation in the Mount Tarawera–Rerewhakaaitu region.

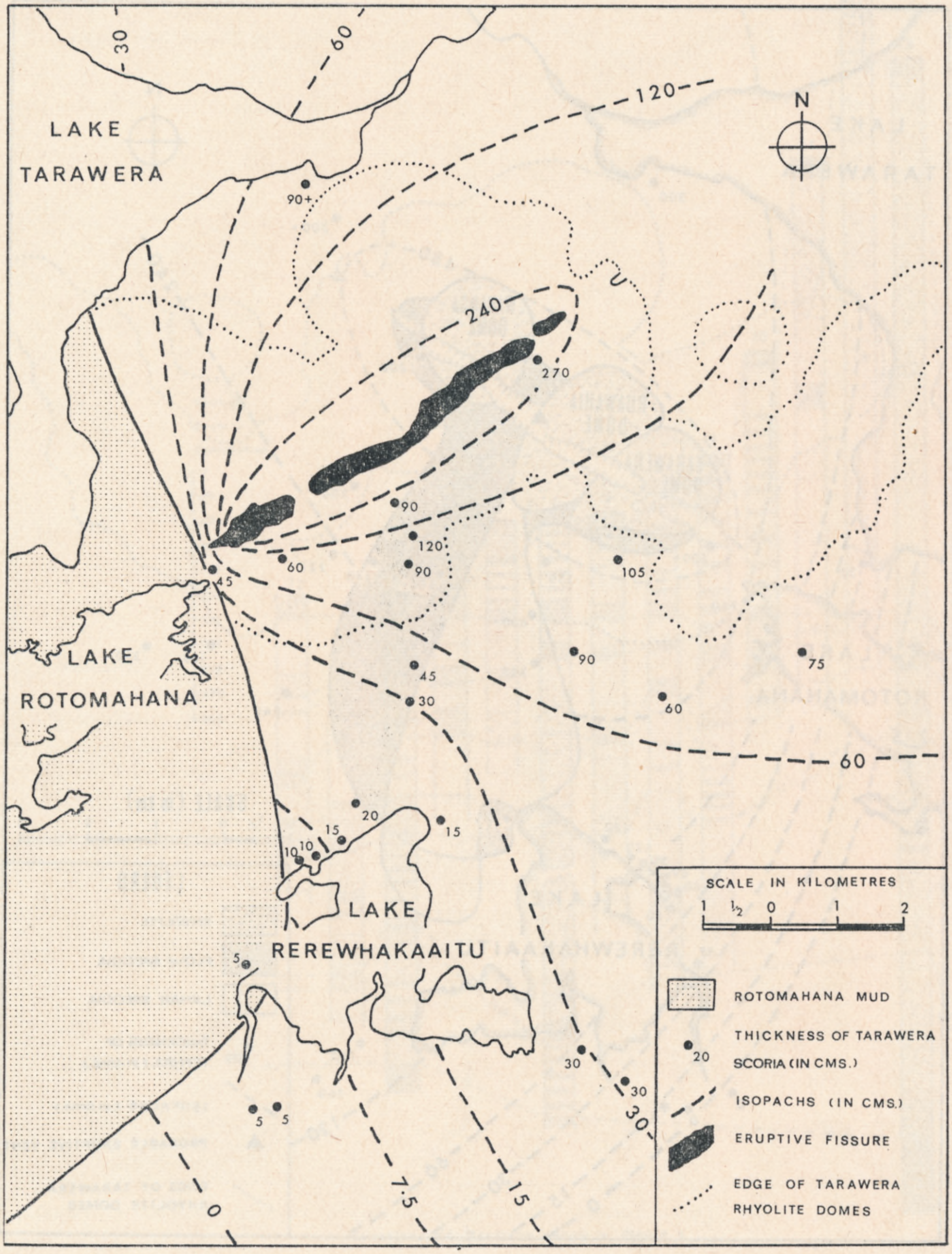


Fig. 4.—Thickness and distribution of the Tarawera Basalt scoria in the Mount Tarawera–Rerewhakaaitu region.

Source of the Pyroclastic Rocks

It is easy to find the vents for the most recent eruptions, but it becomes more difficult for the older ones. The vents for the Tarawera Formation are known exactly, as the craters are still clearly visible (Figure 4). As the eruption was seen, the sequence of events is described in detail.

The position of the vent or vents for the pyroclastic members of the Kaharoa Formation is less certain. The isopachs (Figure 3) and grain-size variations make the most likely site to the east of Ruawahia Trig, where the later Tarawera eruptive craters are widest.

The sources of the Waiohau and Rerewhakaaitu Formations are even more difficult to establish. Both are thickest in the gullies to the south-east of Koa Trig (N77/964914) and the similarity of mineral content between the two types of Rerewhakaaitu tephra (A and B) and the Rotomahana and Koa Domes respectively suggests that the Rerewhakaaitu Tephra Member came from the same vent as the domes. The stratigraphic relationship further suggests that after most of this tephra was erupted the vent was filled by Koa Dome, a sequence common in rhyolite eruptions. The volcanic rocks of the Waiohau Formation, which are younger than those of the Rerewhakaaitu Formation, are thought to have come from a vent close to the site of Crater Dome (N77/955915).

Conclusions

Pyroclastic deposits can be correlated over a wide area by comparison of their stratigraphic position and lithology, provided that the sections are not more than a kilometre apart. Correlation becomes difficult close to the vent, where lithology changes rapidly. For example, pyroclastic flow deposits of the Kaharoa Formation are interbedded with Kaharoa Tephra around the vent (Figure 2), thus markedly increasing the thickness. In such places it is useful to have an alternative method of identification. Characteristic mineral content has proved successful around Tarawera for the airfall tephra. The method has also been used to correlate airfall tephra, pyroclastic flow deposits, and rhyolite domes of the same formations. Radiocarbon-dated tephra members have provided a chronology for the eruptive history of the Tarawera Complex.

Acknowledgments

This study was a part of a Ph.D. project undertaken at Victoria University of Wellington and financed by a New Zealand Government Commonwealth Scholarship. During the course of the study Mr C. G. Vucetich and other members of the Geology Department have spent much time discussing the subject, and for their help the author is most grateful.

References

Aramaki, S., 1963. Geology of Asama volcano. *J. Fac. Sci. Univ. Tokyo* 2(14): 229–443.

Cole, J. W., in press. Structure and eruptive history of the Tarawera Volcanic Complex. *N.Z. Jl Geol. Geophys.*

Ewart, A.; Cole, J. W., 1967. Textural and mineralogical significance of the granitic xenoliths from the central volcanic region, North Island, New Zealand. *N.Z. Jl Geol. Geophys.* 10: 31–54.

Fisher, R. V., 1961. Proposed classification of volcaniclastic sediments and rocks. *Geol. Soc. Am. Bull.* 72: 1409–14.

Grant-Taylor, T. L.; Rafter, T. A., 1963. New Zealand natural radiocarbon measurements 1–4, *Radiocarbon* 5: 118–62.

Healy, J., 1964. Stratigraphy and chronology of late Quaternary volcanic ash in the Taupo, Rotorua, and Gisborne districts. *N.Z. geol. Surv. Bull. n.s.* 73, pt. 1.

New Zealand Soil Bureau, 1968. Soils of New Zealand, part 2. *New Zealand Soil Bureau Bull.* 26.

Thorarinsson, S., 1954. The eruption of Hekla, 1947–1948, part 2(3): The tephra fall from Hekla on March 29, 1947: 1–68, Reykjavik.

Vucetich, C. G.; Pullar, W. A., 1964. Stratigraphy and chronology of the late Quaternary volcanic ash in the Taupo, Rotorua, and Gisborne districts. *New Zealand geol. Surv. Bull. n.s.* 73, pt. 2.

Vucetich, C. G., 1968. Soil-age relationships for New Zealand based on tephro-chronology. *Proc. 9th Congress I.S.S.S.*: 121–130.

Dr J. W. Cole,
Department of Geology,
Victoria University,
P.O. Box 196,
Wellington.

Printed by Otago Daily Times Ltd., Dunedin, New Zealand.