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1980/26. Petrography of Triassic acid pyroclastic rocks and rhyolite near Bicheno

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Abstract

Extensively altered, rather poorly welded ash-fall tuffs of rhyolitic to rhyodacitic composition occur both *in situ* within the Upper Parmeener Supergroup and as loose talus at five localities up to twelve kilometres apart in the vicinity of Bicheno, eastern Tasmania. A tuff layer about 0.8 m thick was intersected in drill core, and all five localities may represent the same stratigraphic horizon. The rocks contain phenocrysts (5-15%) of embayed quartz, kaolinised feldspar and altered vermiculite in a devitrified matrix (85-95%) of quartz and kaolinite in which may be discerned relict glass shard and bubble structures. In some localities, the vermiculite has been thermally exfoliated, suggesting heating to in excess of 300°C during the intrusion of nearby Jurassic dolerite. Rhyolite pebbles within Pleistocene river gravel and Triassic conglomerate, and of probable Triassic derivation, are also described.

INTRODUCTION

Triassic acid pyroclastic and rhyolitic rocks were discovered and collected by C.A. Bacon in 1979 during an Honours project, except for Sample 47850 which was collected by P. Sansom of the Shell Company.

The Triassic sequence in which the pyroclastic rocks occur is a flat-lying fluvial sequence of sandstone, siltstone, mudstone and coal measures, thinning to the south. It rests on an irregular basement of Devonian adamellite, against which it is faulted out to the east. It is capped by a dolerite sill over much of the area. Further north, drill core intersected probably disconformably underlying Permian marine rocks and a basement of Mathinna Beds. Further details of the local geology and sedimentology are given in Bacon (1979).

Forsyth (*in prep.*) listed a microflora belonging to the *Craterisporites rotundus* zone in a *Dicroidium* bearing siltstone occurring in the Denison Rivulet not more than 50 m stratigraphically below the pyroclastic rocks, suggesting correlation with the Ipswich Coal Measures and therefore probably Karnian in age (Forsyth, *in prep.*).

Locality of specimens

University of Tasmania No.	*Field No.*	*AMG Reference*	*Field occurrence*
47845	Bi 45	EP989619	pyroclastic outcrop
47846	Bi 3A/66.7 m	EP981618	pyroclastic, 0.8 m in core
47847	Bi 77*d*	EP997567	pyroclastic talus
47848	Bi 77*c*	EP997567	pyroclastic talus
47849	Bi 80	EP995566	pyroclastic talus
47851	DRPL	FP014686	pyroclastic outcrop
47842	Bi 130	FP025646	rhyolite pebble
47850	Bi 109A	FP028601	conglomerate float

These localities are shown in Figure 1. Diamond drill hole Bi 3A is summarised in Figure 2 (from Bacon, 1979).

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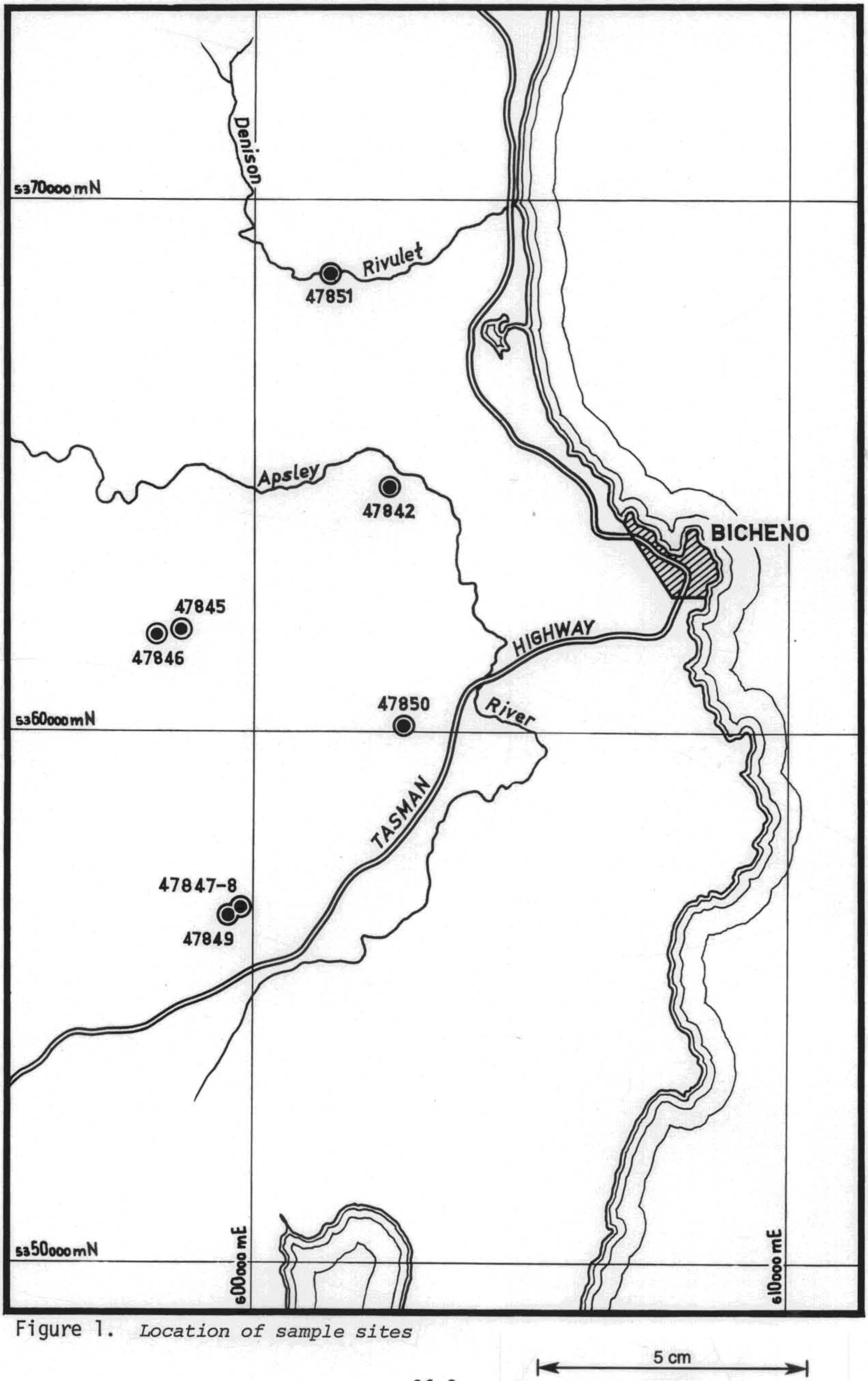

Figure 1. *Location of sample sites*

PETROGRAPHY

Welded tuff

Specimens 47845, 47846, 47848, 47849 and 47851 are lithologically very similar rocks, with only minor variations in grain size, mineral abundance, degree of alteration and development of lamination. Although texturally similar, 47847 is a much darker coloured rock, probably because of ferruginous staining during weathering.

47845. This is a hard, fine grained rock with an off-white to buff colour. It consists of abundant (10%) but small (< 1 mm) phenocrysts of altered biotite (vermiculite), kaolinised feldspar and quartz in a matrix of devitrified glass (90%). Accessory minerals include traces of hematite and zircon. The rock displays a well developed, wavy to streaky, horizontal and planar lamination, defined by variations in the colour, composition and grain size of the matrix, the abundance of phenocrysts and, to a lesser extent, alignment of elongate phenocrysts. Orange-red patches of ferruginous staining occur in fractures and on weathered surfaces.

The larger phenocrysts are those of relict vermiculite (< 1 mm, commonly about 300 µm). They appear to have formed from the hydrothermal alteration of biotite and are themselves altered to colourless, cryptocrystalline clay minerals. Colour ranges from deep brandy-brown to pale yellow-brown in the more altered examples. Pleochroism is absent or very weak, with absorption sometimes slightly greater parallel to the cleavage. Birefringence is moderate, with anomalous green or blue-green predominating, to probably very low in more altered grains. Extinction is parallel. The mineral is optically negative and uniaxial or biaxial with a very small 2V. The shape of the phenocrysts range from euhedral or subhedral pseudohexagonal basal sections to distorted, rectangular laths and ragged anhedra. Most are rounded or embayed, suggesting corrosion whilst within the magma before eruption, perhaps due to decreasing water pressure. Many are distorted, with a curved or radiating cleavage and wavy or sweeping extinction. Parting along the cleavage is common. These features are attributed to thermal exfoliation of the vermiculite, which requires heating to at least around 300°C (Deer, Howie and Zussman, 1962). This was probably caused by the intrusion of Jurassic dolerite, which crops out 5-10 m stratigraphically above on the hillside.

The most abundant phenocrysts are altered feldspars. These include oriented laths (typically 200 µm x 400 µm), oblong lozenges and numerous smaller (100-200 µm) anhedra. A few show rounded embayments and signs of resorption into the magma. All are completely altered to a very fine (2-10 µm) matrix, probably largely of kaolinite and quartz, with low birefringence and frequently wavy extinction.

Quartz occurs as scattered, small (100-300 µm), roughly equidimensional anhedra and subhedra. Some phenocrysts have concave sides, again suggesting magmatic embayment. Extinction is rarely wavy. Some phenocrysts have been cracked *in situ*, with the fragments crystallographically oriented, whilst there are also a few aggregates of small angular phenocrysts, going to extinction separately.

Small quantities of anhedral to subhedral, almost opaque to very deep red hematite grains (50-100 µm), and traces of minute zircon and opaques are present as accessories. In one sample, a zircon inclusion occurs within hematite.

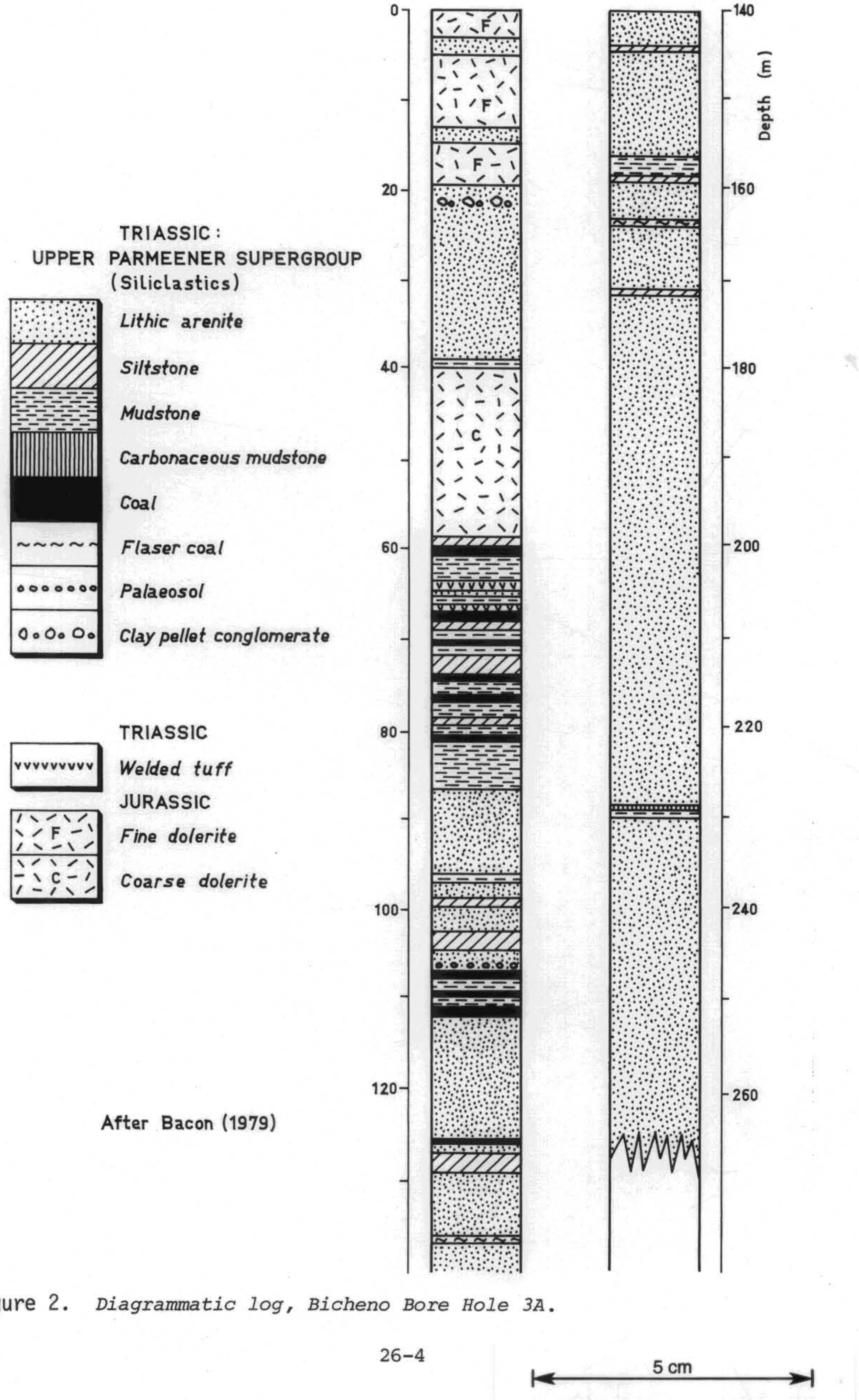

Figure 2. *Diagrammatic log, Bicheno Bore Hole 3A.*

The matrix is a devitrified glass, now altered to a colourless to pale grey cryptocrystalline mixture, probably largely consisting of silica and clay minerals (*e.g.* kaolinite and smectite). Within it may be discerned colourless, sometimes flattened, crescent-shaped to rarely circular structures a few hundred microns long, and sometimes apparently fused together. These represent broken, deformed shards and unburst bubbles of devitrified volcanic glass. They tend to be oriented parallel with the pervasive, wavy lamination, which is also defined by a crude, thin, lenticular banding in composition, colour and grain size of the matrix, and by alignment of elongate phenocrysts.

The relict, somewhat deformed vitroclastic texture indicates that the rock is a rather poorly welded ash-fall tuff formed by aerial deposition of ash following explosive volcanic activity. Weak compaction resulted in some welding and deformation of glass shards whilst the ash was still hot, and accentuated the largely depositional lamination.

47846. The core is of a rock similar to that of the nearby outcrop (47845), but much of it has a faint green tint, and lamination is less pronounced. Minor irregular dark streaks a few centimetres long cut the lamination and may have been produced by later diagenesis.

In thin section, the rock is much finer grained than 47845. Phenocrysts of relict vermiculite, kaolinised feldspar and quartz are less abundant (5%) and rarely more than 300 µm long. Vermiculites are paler in colour and more altered, but are not thermally exfoliated. The matrix, also more altered, contains numerous tiny (100 µm) laths of kaolinised feldspar. Glass shards are much less abundant and generally smaller.

The finer grained nature of this rock, compared with 47845, is attributed to aeolian sorting, being formed from finer material that took longer to settle from the air after the respective eruptions or eruption.

47847. This is a fine-grained dark grey rock with a reddish-orange tint. Numerous but very small (generally < 300 µm) grains of quartz and feldspar, and larger (500 µm - 1 mm) altered relict vermiculites are scattered within a streaky well laminated yellow-brown matrix of devitrified glass.

The relict vermiculites have been exfoliated and later altered almost beyond recognition. Cleavage, where distinguishable, is usually curved and deformed. Many grains have completely altered to almost colourless, cryptocrystalline clay minerals and are recognised only by their relict cleavage. Others still retain a pale brown colour, wavy extinction, length fast character and vague lath-like or hexagonal forms. Some appear to have disrupted the surrounding matrix during exfoliation and expansion.

Relict feldspar occurs as equi-dimensional to lath-like, mostly subhedral and completely kaolinised grains, sometimes with embayed margins. Quartz occurs as scattered, isolated angular anhedra and subhedra, typically only 50 µm across, and sometimes with slightly wavy extinction. Small quantities of zircon and opaques are present.

The matrix of devitrified glass is thoroughly altered and stained, and relict shards are rarely distinguishable. The well developed and somewhat crenulate lamination is defined by slightly coarser, lighter coloured lenticular bands alternating with narrow, very fine, darker, wavy and anastomising bands that may have been produced by later alteration by inter-lamellar water.

Although the degree of alteration and staining makes comparison difficult, the phenocrysts are still smaller than in 47846 and the lamination is much more finely developed. This rock may represent the more fine-grained ash which settled relatively later and was hence then cooler.

47848 and 47849. These are almost indistinguishable samples collected from localities only 200 m apart, and will be described together.

They are hard, fine grained, off-white to greenish tinted rocks, very similar in hand specimen to 47845 except perhaps slightly more weathered. Abundant (15%) phenocrysts of kaolinised feldspar and lesser relict vermiculite and quartz are contained in a devitrified glass matrix (85%).

The relict vermiculites, less common than in the other rocks, are mostly ragged and contorted pale brown to almost colourless relicts up to one millimetre across. A few deformed hexagonal basal sections are recognisable. They show signs of thermal exfoliation, and have been thoroughly altered to cryptocrystalline clay minerals.

Kaolinised feldspars are larger (50-500 µm, but typically about 300 µm) and more abundant than usual. They are mostly equidimensional, sometimes embayed anhedra and less often subhedral laths. Small (mostly < 200 µm) sometimes embayed angular anhedra of quartz are sparingly scattered throughout the rock. Zircon and opaques are accessory constituents, occurring in trace quantities only. Fused crescent-shaped shards and round bubbles of devitrified clay are clearly discernable in the microcrystalline to cryptocrystalline matrix of clay minerals.

These are the coarsest and most poorly laminated rocks of those examined here.

47851. This is a rather coarse and poorly laminated welded tuff similar to 47848 and 47849.

Yellow-brown to almost colourless deformed laths and relict basal sections of vermiculite are much more abundant and less altered than in those rocks. They retain a good cleavage and, in some, high birefringence, but have been thoroughly exfoliated, often to twisted, elongate vermiform grains with radiating cleavage and sweeping extinction.

Mostly equidimensional kaolinised feldspar anhedra are rarer than in 47848 and 47849. Small, scattered angular quartz anhedra and subhedra are also present.

The matrix consists of largely cryptocrystalline clay minerals. The analysis (800285) suggests minor carbonate is also present. Only a few relict shard and bubble structures are discernable, suggesting that the matrix was originally mostly fine grained vitric ash.

Rhyolite

47842. The hand specimen, a portion of a rough elongate pebble with about a 100 mm long axis, is a fine grained, pale yellow-grey to beige-coloured rock. The rock consists of phenocrysts of altered sanidine (5%), typically 1 mm long, enveloped in a matrix of abundant, small (rarely > 100 µm, grading to a few microns) quartz grains and straw-yellow, cryptocrystalline devitrified glass (vitrophyric texture). The quartz grains are rounded to elongate, oriented with their long axes parallel, and mutually aligned, forming a very well developed and macroscopically visible flow lamination, which is also defined by minor compositional (colour) variations in the devitrified glass.

The flow lamination parts and curves to wrap around each sanidine phenocryst. These are frequently embayed, euhedral to subhedral laths, oblongs, and squat six-sided lozenges, rarely < 500 μm and up to two millimetres long. Most are partly altered, especially along the cleavages, to dark cryptocrystalline clay minerals (saussurite).

Some ghost structures within the matrix have a fibrous appearance suggestive of completely altered biotite. There is also a fine (< 10 μm) sprinkling of inconspicuous opaque grains throughout the matrix.

47850. Angular blocks of conglomerate were found in ploughed paddocks and, although not *in situ*, have not been transported any great distance.

Bacon (1979, p. 32) described the rock as 'composed of large, well rounded equant to elongate lithic clasts set in a medium grained lithic arenite. The large clasts, up to 10 cm in diameter, are: quartzite, both white and pink with rare inclusions of garnet, black siltstone and three varieties of volcanic rock fragments. Two of the volcanic fragments are welded tuff or ignimbrite, and the third variety resembles rhyolite. All the volcanic clasts are weathered and the glass is devitrified. The conglomerate may represent a channel deposit.'

ANALYSES OF WELDED TUFF

Analyses of welded tuffs are given below.

Field number		-	Bi 45	Bi 77*d*
Slide number*		47851	47845	47847
Registered number†		800285	800286	800287
	SiO_2	70.60	78.60	77.10
	TiO_2	0.35	0.19	0.67
	Al_2O_3	14.30	12.00	13.00
	Fe_2O_3	0.83	0.91	0.05
	FeO	1.40	0.29	0.71
	MnO	0.06	<0.01	<0.01
	MgO	0.45	0.20	0.15
	CaO	1.40	0.08	0.11
	Na_2O	0.40	0.05	0.05
	K_2O	2.50	1.30	3.60
	CO_2	0.70	-	-
	H_2O+	4.40	4.00	3.90
	H_2O-	1.90	1.80	0.66
	Total	99.27	99.42	100.00

* University of Tasmania catalogue
† Department of Mines, Launceston
800285 - Average of three similar analyses
800286 - Average of two similar anlayses
800287 - Average of two similar analyses

The rocks are rhyodacitic (800285) to rhyolitic (800286, 800287) in composition (*cf*. Joplin, 1964). Alteration has resulted in high H_2O+ values and depleted the rocks in alkalis (especially sodium) and possibly also calcium, as feldspars, the glassy matrix and later the biotite/ vermiculites are degraded to kaolinite and other clay minerals. Potassium is somewhat better retained, and its abundance may be a function of the abundance and degree of alteration of biotite/vermiculite.

H_2O+ is sufficient to account for almost all the Al_2O_3 as kaolinite, suggesting that the devitrified matrix, which forms 80-90% of each rock, is mineralogically largely a kaolinite mineral plus silica.

PARTIAL ANALYSES OF RELICT VERMICULITE WITHIN WELDED TUFF

A polished thin section of sample 47845 was prepared and four partial analyses of relict vermiculites within it were obtained using the University of Tasmania's electron microprobe.

	47845/1	47845/2	47845/3	47845/4
SiO_2	53.48	53.86	53.15	71.49
TiO_2	2.98	2.59	4.40	2.64
Al_2O_3	41.33	41.16	39.90	23.93
Fe as FeO	0.82	0.86	1.03	0.68
K_2O	1.29	1.43	1.37	1.11
Total	99.90	99.90	99.85	99.85

Elements sought but not detected (< 0.2%) were Na_2O, MgO, MnO, CaO and Cr_2O_3. The totals are recalculated to near 100% and are of no significance. All analyses were performed using a small area (∿ 100 μm square) scan.

Analyses 1 to 3 show that the relict vermiculites have a comparison close to kaolinite (Al_2O_3 45.90%, SiO_2 54.10%, anhydrous). Although a small amount of interlayer potassium has been retained, it is no higher than in the rock as a whole (analysis 800286). Titania is in excess over iron, and is probably present as minute particles of anatase derived from the alteration of ilmenite, rather than substituting in the kaolinite lattice. Iron could be present as Fe^{3+} substituting for Al, but at this stage of alteration it is more likely to have been expelled from the lattice to have formed oxides. Under the microscope, these particular grains are subhedral basal sections or twisted exfoliated laths with sweeping extinction. Although masked by the orange-brown colour, birefringence appears to be low, and a basal section gave a biaxial negative figure. These characteristics are consistent with complete alteration of the vermiculite to kaolinite.

Analysis 47845/4 is close to three-layered dioctahedral phyllosilicates such as pyrophyllite (ideally Al_2O_3 29.79%, SiO_2 70.21% anhydrous). Although the particular grain is too poorly crystalline to determine optically, it is probable that it is similar to the less altered grains with high birefringence and very small 2V. The mineral is therefore considered to be close to the smectite beidellite (roughly $NaAl_6 \cdot AlSi_{11}O_{30}(OH)_6 \cdot nH_2O$) which, like montmorillonite, is well known as an alteration product of tuffs and volcanic ash. Furthermore, the prolonged action of water on smectite minerals tends to leach and hydrate them to kaolinite (Deer, Howie and Zussman, 1962; p. 240-241).

Thus four stages are envisaged in the alteration of the original magmatic biotite:

(*a*) alteration of biotite to vermiculite. This probably occurred by hydrothermal action within the volcanic ash, soon after deposition, at temperatures of less than 200°C.

(*b*) thermal exfoliation of vermiculite (>300°C) caused by intrusion of Jurassic dolerite.

(*c*) low temperature leaching of Mg and addition of Al from the matrix, to form the smectites, montmorillonite and (finally) beidellite.

(*d*) further leaching and weathering of beidellite to the form kaolinite.

CONCLUSIONS

It is probable on stratigraphic and petrologic evidence that samples 47845 and 47846 and 47847, 47848 and 47849 represent the same horizon. It is possible that the more dacitic outcrop to the north (47851) is also the same horizon. Minor lateral or vertical variations in grain size and mineralogy are attributable to aeolian sorting of ash. The lateral extent of the horizon, which may be stratigraphically useful, is unknown. Although tiny clastic fragments of volcanic material in the Late Triassic of Tasmania have been found to be of widespread occurrence (*e.g.* Lewis and Voisey, 1938; Spry, 1962) this is the first reported discovery of *in situ* pyroclastic rocks.

Reworked rhyolite pebbles in the district are thought to be derived from associated Late Triassic flows, but these have not been found *in situ*.

Recently reported alkali olivine basalts near St Marys (Calver and Castleden, *in press*) are older (Middle Triassic) and not closely related.

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