The Sequence of Tertiary Volcanic and Sedimentary Rocks of the Mount Warning Volcanic Shield

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Abstract—In this paper the writer presents the sequence of volcanic and sedimentary rocks in the Mount Warning volcanic shield and also attempts to analyse some aspects of their origin and depositional environment.

The shield is composed of basalts which issued from a vent now represented by the Mount Warning central complex. Interbedded in the basalts on the flanks of the shield are a number of local rhyolite flows and associated pyroclastics which were delivered from subsidiary vents, the plugs of which are still evident. Also interbedded are lacustrine sediments which were derived principally from basement country rocks and which give some indication of the age of the shield and of subsequent earth movements.

The oldest Tertiary rocks in the area appear to be the volcanic domes around Woodenbong and Mount Barney. However, an argillaceous sedimentary sequence actually forms the basal member of the pile. Then follows 800 feet of basalt which is overlain by an excellent 200-foot marker band of agglomerates, tuffs, brecciated rhyolite and an associated polymictic conglomerate.

Above this, there is over 2,800 feet of basalt which contains thick intercalations of rhyolite and acid tuff in four distinct localities, namely the Binna Burra, Mount Lindesay and Canungra areas and the Nightcap Range. These all appear to be on the same stratigraphic horizon.

Introduction

Previous work on the Mount Warning Shield has been incomplete mainly due to the influence of the interstate boundary, whereby a quarter of the shield area lies in Queensland and the remainder in New South Wales. Richards (1916), working on the Queensland section, recognized the presence of the rhyolite bands but he erroneously correlated the two acid levels and demarcated Lower (basic), Middle (acid) and Upper (basic) Divisions of volcanic rocks. He also included the acid and alkaline plugs to the west in his Middle Division. This concept has prevailed for almost half a century and was accepted by Tweedale (1951), who worked in the Binna Burra area in Queensland, in part by Crook and McGarity (1956), who carried out surveys in the Minyon Falls area, N.S.W., and by McElroy (1959), who has just completed a survey of the New South Wales section of the Clarence-Moreton Basin.

Bryan (1959), using chemical analyses, correlated the Lower Division of Richards with the Silkstone Formation at Ipswich in Queensland. Recently, Solomon (1959) has elucidated the geology of the central complex of Mount Warning and also has made observations on the geomorphology of the shield and the erosion caldera.

The 1800-square-mile shield embraces the McPherson Range (which constitutes the New South Wales-Queensland border), the Tweed Range and its southerly extension, the Nightcap Range. On the dissected northerly fall of the McPherson Range are the Springbrook and Lamington Plateaux, much of which are set aside as national parks. Both parks are readily accessible by trafficable roads to Christmas Creek, the Lost World, O'Reilly's, the Darlington Range, Binna Burra, the Numinbah Valley and Springbrook and there is also an excellent network of tracks through both reserves.

The Tweed Range is included for the most part in the Wiangaree and Mebbin State Forests and the Nightcap Range in the Whian-Whian State Forest. The southern part of the shield gives way to the gently undulating northern slopes of the Richmond Valley, the lateritized basalt soils of which support an intense dairying industry.

The greater part of the shield above the Hillview Rhyolite level is thickly covered with wet sclerophyll and rain forests. In the Tweed Range and the western part of the Lamington Plateau access is extremely difficult and visibility severely restricted in heavy rainforest. Any investigator of these areas needs to be an expert bushman or a member of a party.

This survey, from the very nature of the terrain of the area, is necessarily on a regional scale. Much of the area of the McPherson and Tweed Ranges and the Lamington Plateau was mapped during excursions with members of the University of Queensland Bushwalking Club. Within the erosion caldera seven traverses were made up the escarpment. The outer portions of the shield remnants were examined by road traverses, principally, some short foot traverses being made into unserved areas.

Geomorphology

The present disposition of the lavas depicts a rough concentricity about Mount Warning with a 120-degree sector denuded from the
coastal side and a core of seven miles radius partly removed to form a central erosion caldera. The average radius of the outcrop area is about 30 miles, but outliers of basalt over 40 miles from the central plug indicate that the shield originally was of much larger areal extent. The maximum thickness of the pile at any one point is 3,400 feet at Mount Hobwee (3,960 feet) on the caldera rim. On the opposite side of the caldera in the Nightcap Range the thickness is only 2,600 feet, while at Mount Lindesay, a distance of 33 miles from Mount Warning, the thickness is also 2,600 feet. These figures indicate that the shield lavas flowed a considerable distance in a westerly direction at least; this will be discussed further later in this paper.

The most conspicuous physiographic feature of the area is the erosion caldera in which the three arms of the Tweed River have carved out a gigantic amphitheatre, some fourteen miles diameter, almost perfectly symmetrically disposed about the 3,793 feet spire of Mount Warning. Most of the floor of the caldera is below the 400 feet contour, so that the masses of the McPherson, Tweed and Nightcap Ranges, rising in an almost continuous precipitous wall to heights of three and four thousand feet, form an impressive scene. Observations on this unusual topographic pattern prompted Professor Dorothy Hill (1951) to suggest first that it was an erosion caldera and that Mount Warning might be the focus of a volcanic shield. A description of the caldera and the possible mechanisms of its formation have been adequately discussed by Solomon (1959).

Peripherally from the caldera rim, erosion trends are radial, resulting in a digital pattern of spurs and canyons that persists to the outer edge of the shield remnant. The only major exception to this is the upper part of the Richmond River where there is a superimposed north-south drainage pattern due to late Tertiary differential uplift in the Richmond Range area.

**Basement and Tectonic Environment**

The Mount Warning central stock lies exactly on the boundary between Lower Palaeozoic sediments to the east and Mesozoic basal volcanics to the west. That there is at least a steep unconformity surface between the two is shown by steeply dipping Mesozoic strata around Chillingham. However, there is little evidence for a faulted junction as might be suggested from such a position of the plug, though this may well be the case and such a line of possibility would certainly warrant investigation by any future worker on the Mesozoic rocks in this area.

Much of the eastern Palaeozoic massif formed a basement high for the Tertiary lavas, up to 1,000 feet above the general level of the Mesozoic basement. Section A–B shows that no lavas covered some Palaeozoic areas till the second basalt episode.

To the west, the dominant basement structures are the Beaudesert Syncline (Reid, 1922; Morton, 1923), and the Overflow Anticline, the latter being persistent from Flinder's Peak in Queensland to west of Casino, at least, in New South Wales. These structures are secondary folds of the main Clarence-Moreton Basin (McElroy, 1959) (=Moreton Offshoot Basin, Whitehouse, 1955). Their pre-Tertiary existence is shown by Section A–B wherein there is demonstrated the considerable unconformity between the Mesozoic and Tertiary strata.

The Overflow Anticline formed a slight basement high due to its core of more resistant Marburg Formation sandstone, inliers of which occur in the basalt around Grevillea in the Upper Richmond area. On the other hand, the Beaudesert Syncline was an area of lower relief and it is over this structure that the greatest thickness of the lowest basalt was deposited. Other local highs, now often exposed as inliers, existed in the area, e.g. near the head of the Albert River, the area to the north of Nimbir and at Bexhill, near Lismore.

**The Tertiary Deposits: (i) Trachytes and the Mount Barney Complex**

Around Woodenbong there are a number of trachyte domes with limited associated flows. Of these, Glassy and Dome Mountains offer the only evidence of age relationship. Trachytic lava and tuff from the former extends to the north and north-east over Jurassic Walloon Coal Measures and at several points along the Richmond River above Grevillea similar lava underlies the lowest basalt. In some occurrences there is a conglomerate associated with the lava indicating lacustrine deposition. The shield basalts of the Richmond Range appear to have flowed around Dome Mountain though the exact relationship is obscured by a profuse growth of rain forest.

The Mount Barney intrusive complex (Stephenson, 1959) is most probably of the same age. It is pre-Chinghee Conglomerate (see later) in age, since that stratum contains an abundance of boulders of granophyre, obviously
derived from the Mount Barney central stock, the only local occurrence of that rock type.

In Cabnibble Creek, nine miles south-east of Beaudesert, a small laccolithic mass of trachyte underlies the lowest basalt and intrudes Jurassic Walloon Coal Measures. Due to soil development no actual contacts with the basalt can be observed to ascertain its relationship to the Lamington sequence. However, there appears to be no disturbance of the basalt, indicating a pre-shield age for the intrusion.

The Tertiary Deposits: (ii) The Lamington Group

The Lamington Group embraces the sequence of interbedded lavas, pyroclastics and sediments which is excellently exposed in the Lamington Plateau. The total thickness of the group is 3,400 feet at Mount Hobwee on the eastern edge of the plateau. The name replaces Lamington Volcanics (Stephenson, Stevens and Tweedale, 1960).

The Numinbah Valley Formation

This name is introduced for a sequence of brown and white shales and mudstones that occurs beneath the lowest basalt along the eastern slopes of Turtle Rock in the Numinbah Valley. The beds are up to 100 feet thick and contain abundant dicotyledonous leaf impressions.

Beds of similar lithology and floral content occur in a small outcrop beneath the lowest basalt to the south-east of the Cabnibble trachyte. This outcrop was discovered in 1959 by N. H. Simmonds of the Queensland Geological Survey. Apparently equivalent leaf-bearing strata have been noted by the writer below the basalts on the McPherson Range, ten miles west of Coolangatta.

Three miles south-west of Beaudesert near the Mount Lindesay Highway an oil bore encountered shales which contained the freshwater gastropod Melania sp. (Ball, 1924). The area is covered by 100 feet of alluvium but the nearest rock outcrop is the lowest basalt of the Lamington sequence. The shales are therefore considered to be equivalents of the beds described above.

The Albert Basalt

This name is proposed for the lowest basalt of the volcanic pile since its maximum thickness of 800 feet is attained and its full sequence exposed along the valley of the Albert River. The relationship with both the underlying Numinbah Valley Formation and the overlying Hillview Rhyolite can be seen in Cabnibble Creek, a tributary of the Albert River.

The formation is a readily defined unit as far south as Wiangaree in New South Wales, where in the southern part of the Wiangaree State Forest both the Hillview Rhyolite and the associated Chinghee Conglomerate lens out. Eastward it becomes very thin, below the Hillview Rhyolite in the Beechmont Range and it does not extend over most of the Palaeozoic basement high that runs beneath the Springbrook Plateau. Similarly, to the south, in the Tweed Range the sequence thins to 300 feet in the Mebbin State Forest. It probably extends to the Lismore area (whereby it could be the lower part of McElroy's, 1959, Lismore Basalt), though the writer believes that this area may have been a "high" during early shield times and may not have been covered by the Albert Basalt sequence (see later).

Thus the first lavas from the Mount Warning vent filled a shallow depression coincident with the Beaudesert Syncline and flowed over an undulating surface to the north and west, piling up to the east against the high of Palaeozoic sediments and possibly having limited extent to the south.

The Hillview Rhyolite

This name covers a band of agglomeratic tuffs and brecciated rhyolite that is well exposed in the Hillview area in the valley walls of Christmas and Chinghee Creeks. The band shows marked outcrop in the escarpment known as Hillview Cliffs.

In the type area the basal member is up to 50 feet of acid agglomeratic tuff containing boulders of rhyolite up to one foot in diameter. Eastward of the type locality, particularly around the head of Christmas Creek, a considerable amount of accessory boulders is included. These comprise Palaeozoic sediments, granophyre and basalt cobbles to three inches diameter.

The tuff always appears white or buff coloured in outcrop and can be readily traced at the 1,100-feet contour from the type area to the Beechmont Range where it occurs in the 1,000-1,100-foot interval. It is well exposed around Canungra Creek and in the Coomera Valley where it sometimes occurs in cliffs very much resembling those of Triassic sandstones. The tuff there shows well-defined bedding which is accentuated by limonitic staining and contains numerous pebbles of basalt and rhyolite. The band extends to the Canungra...
area, where it outcrops at 1,050 feet on the southern slopes of Mount Tamborine.

Overlying this there is up to 150 feet of brecciated and often silicified rhyolite, though in some cases up to 50 feet of basalt may intervene, e.g.: in the Neglected Mountain area. This rhyolite member does not extend eastward of the Canungra Range but west of there it forms a more prominent marker band forming low buff coloured cliffs and changes of slope. Westward from the Richmond Gap the rhyolite becomes bluish white in colour and extremely silicified. This is attributed to leaching by groundwater since all this area is covered by luxuriant rain forest. Further west, at Mount Glennie, the tuff member has thinned out but the rhyolite reaches a maximum thickness of at least 200 feet and an elevation of 2,000 feet.

Occasionally pitchstone or pitchstone breccia is associated with the rhyolite; up to ten feet of this rock type is exposed in Christmas Creek, under Buchanans Fort, and in Chinghee Creek.

Both the tuff and the rhyolite can be traced to the vicinity of Mount Lion near Wiangaree. The band occupies the 900-1,000 feet contour interval in that area but it lenses out to the south-east. It is not shown in the face of the erosion caldera nor in any of the high areas south or west of Wiangaree.

No vents have been found, proximal to its outcrop, that could have been responsible for the tuffs and lavas of the Hillview Rhyolite. However, the westerly increase in thickness of the brecciated rhyolite suggests an origin in this direction, whereby the rhyolite plug, Mount Gillies, may have been the effusive centre. Since the tuff is water sorted, of fairly uniform thickness and contains much varied, accessory material, no direct indication can be gained of its source; most likely it also came from the north-west.

The Chinghee Conglomerate

This is a new formational name in print, though the horizon has been referred to as such, verbally, for quite some time. The lacustrine formation consists of alternating beds of coarse argillaceous current bedded sandstones and polymictic conglomerates with boulders up to two feet diameter. Boulders consist of Palaeozoic sediments, rhyolite and granophyre, the last being similar to that of the Mount Barney central stock (Tweedale, 1951). A maximum thickness of one hundred feet is attained at the head of Chinghee Creek, six miles south of Hillview. There, a basalt intercalation occurs near the top, indicating that deposition possibly occupied only a short time interval, being merely a torrential accumulation between successive lava flows.

The Chinghee Conglomerate consistently overlies the Hillview Rhyolite, overlaps it to the south-east and outcrops in the caldera escarpment at 800 feet elevation. However, it is only about twenty feet thick at The Pinnacle on the Tweed Range and it lenses out by the southern end of the Wiangaree State Forest, on that range. Argillaceous lenses in the formation contain dicotyledonous leaf impressions, very similar to present-day Eucalyptus laminae.

The presence of the coarsest grade of material in the Chinghee Range-Richmond Gap area suggests that this area is adjacent to the principal contributory to the lacustrine depression. It is noted that the area of outcrop of the formation coincides with the southern extension of the Beaudesert Syncline. Thus it might be claimed that a downwarping of the late Mesozoic structure commenced prior to the deposition of the Hillview Rhyolite and that by the time of the Chinghee Conglomerate the subsidence produced sufficient gradient to attract rudaceous sediment of boulder dimensions (see Tertiary Earth Movements). Since the only granophyre in existence in the vicinity is in the central stock of Mount Barney some contribution to the depression from the west must be assumed.

The Beechmont Basalt

Formational status is hereby given to 900 feet of basalt which overlies the Chinghee Conglomerate and is capped by the Binna Burra Rhyolite (see later). The name is taken from the Beechmont Shelf where the basalt and the consecutive acid bands can be seen in the one section on the eastern wall of the Coomera Valley.

In that area the Binna Burra Rhyolite lenses out at 2,000 feet elevation just north of Binna Burra and along the western wall of the Coomera gorge. Thus westward in the Lamington Plateau there is no marker to divide the Beechmont Basalt from the succeeding basalt formation (the Hobwee Basalt) until Glennies Chair is reached, 30 miles distant. On this mountain and on Mount Lindesay nearby, 700 feet of basalt between the Hillview and Mount Lindesay Rhyolites (see later) is considered by the writer to be Beechmont Basalt equivalent.

Similarly, to the south, the Binna Burra Rhyolite ceases at Point Lookout on the Tweed
Range at 1,800 feet elevation. Therefore south of this the only marker is the thinning Chinghee Conglomerate, and, south of its termination in the Wiangaree State Forest there is 3,300 feet of unbroken basalt succession equivalent to the three basalt divisions of the Lamington area.

A unique feature of the formation is the prevalence of lenses of diatomite, shales and conglomerates, the latter containing pebbles to six inches long of granophyre, rhyolite and Palaeozoic sediments. Two such lenses, up to fifteen feet thick, one of which contains dicotyledonous leaf impressions, occur on the road to O'Reilly's Guest House and Tweedale (1951) has described others in the Beechmont and Darlington Ranges.

**The Lismore Basalt (McElroy, 1959)**

This formation comprises half the outcrop area of the shield deposits. Though predominantly basalt, it contains conglomerates, shales, diatomites and opal (the latter at Tintenbar, near Bangalow). Interbedded shales in the Nimbin area have yielded fish remains, as yet undescribed (C. Shipway, Qld. Geol. Surv., verbal communication). The sequence reaches a maximum thickness of 600 feet in the Nightcap Range, where it is overlain conformably by the Nimbin Rhyolite (see later).

The exact relationship between the Lismore Basalt and the Albert and Beechmont Basalts is not established due to the lensing out of the Hillview Rhyolite-Chinghee Conglomerate marker in the Tweed Range and to the disconnection of the overlying Binna Burra and Nimbin Rhyolites. As mentioned previously, the Albert Basalt may not have flowed as far as the Nightcap Range; thus the Lismore and Beechmont Basalts may be somewhat equivalents. The included sedimentary beds and the respective thicknesses of the formations support this correlation (see also under Nimbin Rhyolite below).

**The Binna Burra Rhyolite**

This is a new formational name for a sequence of aerially distributed tuffs and rhyolite that overlies the Beechmont Basalt in the Binna Burra area, from which place the formation is named. The maximum thickness is 1,000 feet in the central part of the area in the vicinity of the junction of the Ship's Stern and Beechmont Ranges.

Detailed work in this area has been done by Tweedale (1951) who recognized up to 300 feet of lower rhyolite tuff overlain by 700 feet of rhyolite lava. Locally at Mount Roberts (Binna Burra) the lava is overlain by over 200 feet of upper tuff which is identical with that of the lower member. However, at this point the lava is thinning out and it terminates in the southern end of the Beechmont Shelf.

Tweedale considers that the presence of glass shards in the tuffs is sufficient evidence of aeolian deposition. The present writer agrees and wishes to draw a contrast with the bedded, accessory tuffs of the Hillview Rhyolite sequence.

The tuff members are of very limited areal extent, the lower being somewhat symmetrically distributed about two rhyolite plugs (Egg and Charraboomba Rocks) which are quite obviously the points of origin of the whole Binna Burra Rhyolite sequence. The rhyolite member extends to the Beechmont Shelf in the north, Point Lookout and "The Buggams" in the south and eastward to the Springbrook Plateau and Mount Cougal. At Springbrook it is underlain locally by obsidian. To the west it thins out in the western wall of the Coomera gorge (Coomera Crevise being incised in the lava) at an elevation of 2,000 feet.

**The Mount Lindesay Rhyolite**

Here again a new name is introduced for a sequence of tuffs, agglomerates, obsidian and rhyolite that forms the cliffs on Mount Lindesay and also on the nearby Mount Glennie. On Mount Lindesay the sequence is 800 feet thick occurring on the southern cliff between 3,100 feet and 3,900 feet elevations. The basal member is 200 feet of rhyolitic tuff and agglomerate (both accidental) which is overlain by obsidian, immediately below the 3,303 feet trigonometrical site. Above this rise spectacular columnar rhyolite cliffs for 600 feet, near the top of which Stephenson (1956) reports some local thin flows of basalt; the succession is capped by basalt of the uppermost basalt sequence (see later).

Similarly on Mount Glennie, tuffs and agglomerates, with very occasional accessory fragments, are overlain by a thick sequence of columnar rhyolite which is capped by basalt. A trigonometrical station (3,169 feet) is situated about 300 feet above the base of the sequence.

Glennie's Chair, a marked prolongation from the slopes of the mountain, is a rhyolite plug intruding Beechmont Basalt equivalent; this plug is undoubtedly a point of origin of the acid lavas and pyroclastics of the Mount Lindesay Rhyolite sequence.

The writer has no hesitation in correlating the Binna Burra and the Mount Lindesay
GEOLOGICAL MAP OF THE MT WARNING VOLCANIC SHIELD
Rocks of the Mount Warning Volcanic Shield

Rhyolites on the basis of similarities in their lithologies, sequences and stratigraphic position indicate an average of just under one hundred feet for each flow. (In the Binna Burra area at least twenty such outpourings, which would exceed 1,600 feet. Mount Witheren (1,857 feet) is as follows:

- Albert Basalt: 800 ft.
- Hobwee Basalt: 1,960 ft.
- Chinghee Conglomerate: 200 ft.
- Nimbin Rhyolite: 800 ft.
- Mount Glennie: 1,400 ft. but it persists south-west to Nimbin, vicinity of Mount Neville at an elevation of 300 feet in the Tweed Range appears to have little, if any, representation in the Nightcap area. Richards counted more than with the Hillview Rhyolite.

Considering this and also the similarity of stratigraphic columns from Binna Burra and Mount Lindesay and the absence of any contiguous formation analogous to the Nimbin Rhyolite in the Nightcap area compares favourably with and is probably the equivalent of the Binna Burra and Mount Lindesay Rhyolites and the Lismore Basalt below the Nimbin Rhyolite. The Albert Basalt correlates the Nimbin Rhyolite with the Binna Burra Rhyolite: 900 ft. thick in its type area.

On Section C-D across the erosion caldera of the relationship between the 1,600 feet of the Nimbin Rocks. Lillian Rock, three miles north-west of Nimbin is also a rhyolitic, elongate, plug-like intrusive but there is no evidence that it extruded any lava.

Due to the steep scarps developed on the face of the erosion caldera, Richards counted some 400 feet and the base of the sequence falls where it forms residual cappings on several unnamed hills at the head of Wilson's Creek and the Canungra Range. The sequence is essentially lava; the tuffs and obsidian members occur as local intercalations up to 150 feet thick. The units are essentially members of the Nimbin Rhyolite "Boomerang Creek Obsidian" and "Minyon Falls Rhyolite" by Crook and McGarity (1956) and the rain forest soil capping Mount Glennie is almost certainly derived from basalt of the same sequence.

The Hobwee Basalt coincides with Richards' indication that the Canungra outcrop is a remnant of a local flow probably containing the Cretaceous remnants of the local forest. Several columnar residuals similar to "The Steamers" are in the Minyon Falls-Peach Mountain vicinity of Mount Neville at an elevation of 1,400 feet, but it persists south-west to Nimbin, where it forms residual cappings on several remnants of a local forest. Such plugs are Doughboy Mountain and Little Beechmont Basalt: 900 ft.

Lillian Rock, three miles north-west of Nimbin is a rhyolitic, elongate, plug-like intrusive but there is no evidence that it extruded any lava. Considering this and also the similarity of the stratigraphic position of the formation and the Mount Warning Volcanic Shield, an average of just under one hundred feet for each flow. (In the Binna Burra area at least twenty such outpourings, which would exceed 1,600 feet. Mount Witheren (1,857 feet) is as follows:

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Rhyolites on the basis of similarities in their lithologies, sequences and stratigraphic position in the shield succession. A comparison of stratigraphic columns from Binna Burra and Mount Glennie is as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Elevation</th>
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<tbody>
<tr>
<td>Binna Burra</td>
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<tr>
<td>Hobwee Basalt</td>
<td>1,960 ft</td>
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<tr>
<td>Binna Burra Rhyolite</td>
<td>800 ft</td>
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<tr>
<td>Beechmont Basalt</td>
<td>900 ft</td>
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<tr>
<td>Chinghee Conglomerate and Hillview Rhyolite</td>
<td>100 ft</td>
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<tr>
<td>Albert Basalt</td>
<td>400 ft</td>
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<tr>
<td>Mount Glennie</td>
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<tr>
<td>Basalt to top</td>
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<tr>
<td>Mount Lindesay Rhyolite</td>
<td>800 ft</td>
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<tr>
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</tr>
<tr>
<td>Albert Basalt</td>
<td>800 ft</td>
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</table>

Canungra Area

Rhyolite occurs as a capping on Mount Misery, on the Canungra Range, at an elevation exceeding 1,600 feet. Mount Withen (1,857 feet) to the south shows no evidence of rhyolite, indicating that the Canungra outcrop is a remnant of a local flow probably contemporaneous with the Binna Burra Rhyolite.

The Nimbin Rhyolite (McElroy, 1959)

This formation includes up to 1,300 feet of rhyolite tuffs and lavas with some obsidian that occur between basalts in the Nightcap Range. The sequence is essentially lava; the tuffs and obsidian members occur as local intercalations up to 150 feet thick. The units given the local names “Dorroughby Tuff”, “Boomerang Creek Obsidian” and “Minyon Falls Rhyolite” by Crook and McGarity (1956) are essentially members of the Nimbin Rhyolite.

The maximum thickness of 1,300 feet is attained in the Minyon Falls-Peach Mountain area on the southern side of the range. On the northern side, 1,000 feet of tuff and rhyolite underlie Jerusalem Mountain between the 1,400 and 2,400-foot contours. The tuff, there, forms columnar residuals similar to “The Steamers” on the Main Range, Queensland.

This sequence forms prominent cliffs to the west of Mullumbimby and at the head of Doon Doon Creek. Further west, it lenses out in the vicinity of Mount Neville at an elevation of 1,400 feet, but it persists south-west to Nimbin, where it forms residual cappings on several small plateaux. The thickness in that area is some 400 feet and the base of the sequence falls to 800 feet elevation.

The presence of several rhyolite plugs within the outcrop area of the sequence indicates a local origin for the Nimbin Rhyolite. Such plugs are Doughboy Mountain and Little Doughboy in the Jerusalem Mountain area, an unnamed hill at the head of Wilson’s Creek and Nimbin Rocks. Lillian Rock, three miles north-west of Nimbin is also a rhyolitic, elongate, plug-like intrusive but there is no evidence that it extruded any lava.

On Section C-D across the erosion caldera there can be seen the dip to the south of the Nimbin Rhyolite. This dip measured on the base of the formation is from 1,400 feet at Jerusalem Mountain to 600 feet at Minyon, a fall of 800 feet in seven miles.

Considering this and also the similarity of lithology between the formation and the Mount Lindesay and Binna Burra Rhyolites and the absence of any contiguous formation analogous to the Chinghee Conglomerate, the writer correlates the Nimbin Rhyolite with the Binna Burra and Mount Lindesay Rhyolites rather than with the Hillview Rhyolite.

Such a correlation necessitates consideration of the relationship between the 1,600 feet of basalt and sediments that occur below the Binna Burra Rhyolite and the 600 feet of similar strata below the Nimbin Rhyolite. The Albert Basalt in thinning from 800 feet in its type area to 300 feet in the Tweed Range appears to have little, if any, representation in the Nightcap Range. Thus the 600 feet of Lismore Basalt in the Nightcap area compares favourably with and is probably the equivalent of the Beechmont Basalt, 900 feet thick in its type area.

The Hobwee Basalt

This new formational name is used for 1,960 feet of basalt that overlies the Binna Burra Rhyolite. It typically occurs in the Parish of Roberts, which embraces the Lamington National Park, where its greatest thickness is attained on the state boundary at Mt. Hobwee, this point being the highest on the shield.

Due to the steep scarps developed on the sequence, excellent exposures can be seen of the successive flows of lava, especially on the face of the erosion caldera. Richards counted at least twenty such outpourings, which would indicate an average of just under one hundred feet for each flow. (In the Binna Burra area the Hobwee Basalt coincides with Richards’ Upper Division of basic rocks.)

On Mount Lindesay the Hobwee Basalt forms a thin capping (100 feet according to Stephenson, 1956) and the rain forest soil capping Mount Glennie is almost certainly derived from basalt of the same sequence.
Tertiary Earth Movements

It would be expected that the initial outpourings of basalt from the Mount Warning centre would have tended to fill the low areas in the basement and that subsequent flows would have built up a flat cone, individual flows showing very low dips away from the centre. However, the converse is seen in the western area of the shield where in the Tweed (e.g., Bar Mountain) and McPherson Ranges (e.g., the Richmond Gap area) the basalts dip eastward at angles up to two degrees (locally). Two alternative explanations can be proposed for this phenomenon:

(i) that the basaltic lavas west of Tyalgum and also the interbedded lacustrine deposits had a western source and were deposited on an easterly sloping surface, or

(ii) that all the basalts issued from the Mount Warning centre and have undergone subsequent folding.

The absence of any large basic eruptive centres to the west supports the second explanation. Furthermore, an examination of cross sections A–B, C–D and E–F shows the prevalence over the whole shield area of a south-easterly dip of strata, suggesting differential earth movement.

Of considerable interest is the relatively uniform band (about 200 feet) of lacustrine deposits comprising the Hillview Rhyolite and the Chinghee Conglomerate. Uniquely, it occupies an elevated sloping aspect (2,000 feet above sea level at Mount Lindesay falling to 800 feet in the Tweed Range) on the flanks of a volcanic shield. This horizon, which outcrops over an area of 500 square miles and shows complete conformability with the shield basalts, offers the most conclusive evidence of post-shield tectonism. The problem arises

(I) whether these sediments were deposited in their present aspect and have suffered no subsequent movement, or

(II) whether they were deposited in a low-lying position and were uplifted together with the other shield components.

The presence of boulders of metamorphic rocks (of Brisbane Schist lithology) together with granophyre boulders (apparently from the western source, Mt. Barney) in the Chinghee Conglomerate and the accessory tuffs of the Hillview Rhyolite is also problematical since

(a) there is no western source area of Palaeozoic metamorphics within 100 miles and

(b) the Chinghee Conglomerate rises westward to a height of 1,000 feet above the present (and hence the probable Tertiary) surface of local Palaeozoic rocks.

From (a) it appears that the metamorphic boulders had an eastern origin in the Palaeozoic mass of the Southport-Murwillumbah area. On this basis it would have to be assumed that the Chinghee Conglomerate-Hillview Rhyolite band was deposited on a horizontal surface under lacustrine conditions with contribution from both east and west.

Following (b) the Palaeozoic mass would have had to project to about 2,000 feet elevation during the Tertiary were it to supply material to the Chinghee Conglomerate at its present Mount Lindesay level, i.e., 2,000 feet. However, there is no evidence to assume that the Tertiary surface of the metamorphics rose to heights so exceeding their existing maximal points, i.e., 1,400 feet; it would be more reasonable to assume that the Tertiary sediments were deposited at low altitude and were subsequently uplifted to their present position. This conclusion would satisfy arguments (ii) and (II) above.

Due to the existence of the lacustrine sediments so close (16 miles) to the coastline, the writer considers it most probable that they were deposited at an elevation not much above the prevailing Tertiary sea level. Such an accumulation of rudaceous strata in a large, low lying, near coastal lacustrine depression, associated with basaltic lava flows, would
present a strikingly similar environment and succession to that shown by Tertiary deposits in the Brisbane and Bundaberg areas (see Age and Correlation of Shield Components). Thus, considering this and the above evidence, it appears that considerable post-shield uplift of the order of 2,000 feet has occurred in the Mount Lindesay area and possibly over 1,000 feet in the Lamington Plateau area.

It would be impossible to make any assessment of actual uplift in any particular area, but it may strengthen the case for relative uplift to quote the variations in the bases of the upper rhyolite sequences

- Mt. Lindesay Rhyolite: 3,100 ft.
- Binna Burra Rhyolite: 2,000 ft.
- Nimbin Rhyolite (north): 1,400 ft.
- Nimbin Rhyolite (south): 600 ft.

Of course the significance of these elevations depends largely upon the correlation of the three sequences. Nevertheless, the figures present attractive data, however superficial, for the proposal of late Tertiary differential folding of the shield.

Age and Correlation of Shield Components

The presence of dicotyledonous leaf impressions in the Numinbah Valley Formation indicates that the whole shield is post-Middle Cretaceous, most probably Tertiary in age.

Bryan and Jones (1946) placed the Lamington "Series" in the Pliocene, maintaining that the sequence was in age post-laterite, to which phenomenon they assigned a Miocene age. However, the presence of large areas of red-earth residual soils (Bryan, 1939) on the plateaux of Beechmont, Springbrook and Tamborine and of laterite on the latter leaves little doubt that the basalts of the shield have been subjected to intense lateritization. However, the age of this process is much in doubt and cannot really be confined to a more specific age assignment than Miocene to Pliocene. The writer therefore wishes to attack the problem along entirely different lines.

In the Brisbane area, where the writer has recently studied interbedded Tertiary lavas and sediments, the sequence argillaceous sediments-basalt-rudaceous sediments in ascending order, is pronounced over an area extending from Petrie to Ipswich and covering four separate Tertiary basins. Thus, in the Lamington Group when the writer was confronted with the same sequence of strikingly similar lithological components, the possibility of some form of correlation could not be overlooked.

The Numinbah Valley Formation has a lithology and contains a tridif venated dicotyledonous leaf flora similar to that of the Darra Formation in the Brisbane area and the Redbank Plains Formation of that type area. The maximum thickness of the basalt overlying the Redbank Plains Formation is 1,000 feet (writer's calculation) at Redbank Plains, while that of the Albert Basalt is 800 feet. At Redbank Plains the basalt is overlain by trachyte and fifty feet of boulder conglomerates, while in the Lamington sequence the Albert Basalt is succeeded by rhyolite and up to one hundred feet of boulder conglomerates, namely the Chinghee Conglomerate. The Beechmont Basalt, the upper rhyolite sequence and the Hobwee Basalt do not appear to have any equivalent in south-east Queensland except possibly in the Main Range (see section E-F).

According to Hills (1934) the fish *Phareodus queenslandicus* which is found in the Redbank Plains Formation and the Archerfield basalt (Cribb, McTaggart and Staines, 1960) at Brisbane, indicates an Eocene, probably Oligocene, age for those strata. The present writer therefore suggests an Eocene-Oligocene age for the Numinbah Valley Formation and the Albert Basalt.

Since the remainder of the sequence is 2,800 feet thick and is composed of one major and several minor sedimentary intervals, two thick basalt sequences of possibly thirty separate flows and two rhyolite episodes, it is possible that deposition of the shield volcanics lasted till late in the Tertiary and that the upper part, at least, of the Hobwee Basalt is Pliocene in age. Indeed, much of it seems to be post-lateritic, a feature which may be significant.

The age of the alkaline and granophyre plugs to the west cannot be any more accurately dated than Cretaceous-Eocene, i.e. post-Walloon Coal Measures-pre-Albert Basalt. Since there are plugs and flows of andesite, rhyolite and trachyte of Late Jurassic (post-Walloon Coal Measures)-Cretaceous age in the Maryborough Basin, 250 miles to the north, it cannot be discounted that the intrusives of the Woodenbong area may be Cretaceous in age.

Stevens (verb. com. 1960) has recently investigated the Main Range area between Mount Superbus and Cunningham's Gap, where he has noted two trachyte lava and pyroclastic bands. The cross section E-F from Mount Glennie to Wilson's Peak on the Main Range
encourages a correlation between the trachyte bands on Wilson's Peak and Mount Clunie and the Mount Lindesay Rhyolite. It is therefore not impossible that a more definite relationship may be established upon completion of mapping of the Main Range.

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