A RE-EVALUATION OF ‘PETROGLYPHS’ ON BLUE TIER, NORTHEAST TASMANIA

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Abstract

In 1957 several eminent scientists (‘the 1957 Blue Tier Expedition’) investigated unusual rock markings reported to be Aboriginal petroglyphs on Blue Tier in northeast Tasmania and concluded that some markings were the result of dissolution of granite by roots, some were made by the subaerial action of plants abrading granite, and others were made by miners and prospectors. However a recent publication has restated claims of an Aboriginal origin for the ‘petroglyphs’. As a result the markings were re-examined so that their genesis could be conclusively decided. The markings on Blue Tier are classified into eight types: (1) Rills; (2) Long Linear Grooves; (3) Circular Holes; (4) Inscriptions; (5) Oval Depressions; (6) Regularly Spaced Circular Depressions; (7) Short Linear Grooves; and (8) Small Circular Depressions. We conclude that Types 1, 2, 5, 7 and 8 markings are natural; Type 3 markings were drilled by prospectors or geologists; Type 4 markings were incised by miners or visitors; and Type 6 markings, which form a distinctive feature just below the crest of Australia Hill, were made by tin prospectors employed by the Mt Lyell Railway and Mining Company Limited. Therefore all markings on Blue Tier have been either produced by natural means (chiefly chemical weathering) or by geologists, prospectors and recent visitors. There is no evidence for the presence of Aboriginal petroglyphs on Blue Tier.

Introduction

The Blue Tier plateau is situated in northeast Tasmania (Figure 1), approximately 20km northwest of the coastal town of St Helens. Unusual markings on Blue Tier have been remarked on and described by scientists and bushwalkers since McIntosh-Reid and Henderson (1928:35) first described ‘ramifying grooves’ 0.25 to 4 inches (65–100mm) deep on ‘the surface of the great flat slabs of fine to medium grained granite west of the Australia Mine’. They considered that the grooves marked the positions of the roots and boles of trees, and noted that the grooves were lined with a thin film of white quartz which they attributed to the precipitation of silica from aqueous solution by the action of plant organic matter or, in part, by evaporation. The bushwalker Sharland (1957:41) was the first to suggest that these and other markings had an Aboriginal origin. Describing a long row of ‘imitation hoof marks’ approximately 300mm apart on the exposed granite boulders on the crest of Australia Hill, he concluded they were ‘symbols of an extinct race’; the grooves he likened to birds’ feet.

Sharland (1957) was apparently unaware of the results of the 1957 Blue Tier Expedition, which included staff of the Queen Victoria Museum (Launceston), the Bureau of Mineral Resources (Melbourne), the Australian Museum (Sydney), and the Soils Division of CSIRO (Williams 2008). In response to Sharland (1957), Ellis (1958:40) remarked that ‘examination of some freshly excavated ‘footprints’ led us to the unanimous conclusion that they were produced by a pointed metal tool such as a pick or hand-drill’ and reported that the ‘footprints’ were associated with old prospecting trenches. Luckman (1957) concurred that the ‘footprints’ were prospecting marks made by miners and reported that conversations with a local resident (Mick White) had established that the Mt Lyell Mining and Railway Company (the Mt Lyell Co) had made trench excavations at this site in 1906–1907. Ellis (1958) reserved judgement on the origin of the grooves, as did McCarthy (1957). Luckman (1957) looked for ‘chips’ and artefacts which might have indicated pre-European activity, but without success. He also reported that three members of the expedition found that the grooves were confined to the weathered surface layer of the granite (about 13mm thick) and concluded that some were formed by the abrasive action of stems and branches blowing in the wind and others were formed by subsurface chemical processes associated with roots.

Williams (2008) mentioned that the 1957 expedition set out in the expectation of finding petroglyphs on Blue Tier, but that the evidence they found did not support the initial expectation: ‘as far as I remember all were convinced that the special grooves were root solution marks and not man-made’ and consequently ‘it all fell flat’ and no official report was written (Williams 2008:1–2). Photographs taken by E. Williams during the expedition and...
sighted by the authors attest to the devastating effects of the 1901 fire and the previous presence of large trees on the bouldery ridges and peaks. In summary Williams (2008:3) concluded: ‘these pits were man-made, but for exploration purposes’.

Groves (1965) summarised the results of previous geological surveys but made no mention of the markings. Jackman (1997:161), in his comprehensive study of historical mining on the Blue Tier, noted that prospectors had taken chip samples from boulders on Australia Hill where these interrupted sampling trenches (costeans):

between 1905 and 1907 gangs commissioned by the Mt Lyell Mining and Railway Co. and supervised by Luke Williams cut a series of 50 costeans, totalling 2.2km, across the 2km length of soft dyke formation. The majority of the trenches are still plainly evident, running east-west across the sparsely vegetated terrain extending from Sun Creek to the summit of Australia Hill … Where the trench line crosses outcropping granite circular chip samples every 30cm have been substituted for the continuous sample.

The circular chip samples were taken using a primitive handheld portable hammer drill called a jumper (Moore 1912). The jumper is essentially a set of stone mason’s chisels mounted on a circular iron bar. It is hammered into rock and rotated between hammer blows; the method was used during quarrying of granite in Scotland (Burgoyne 1849; Kraut 1853). On Blue Tier the circular chip samples taken by this method were collected and analysed for their tin content and the locations of all samples and the chemical composition of bulked samples were recorded by the Mt Lyell Co and endorsed with the supervisor’s (Luke Williams’s) signature (Clark 1935).

Sims (1977:437) in his comprehensive review of ancient Aboriginal petroglyph sites in Tasmania, dismissed the reported finding of Aboriginal petroglyphs on Blue Tier: ‘of the twelve confirmed petroglyph sites, ten are located on the coastline and of these eight are on the west coast, and two are inland sites at low altitudes’. Sims’ conclusions regarding the west coast sites are corroborated by other studies (Cosgrove 1983; Gunn 1981), but there is doubt about the anthropogenic origin of markings at Mersey Bluff, Devonport (Murray 1980; Scott 1931).

Recently Bednarik et al. (2007) resurrected the idea that the regularly spaced circular markings on the Blue Tier, originally identified as ‘footprints’ by Sharland (1957) and named ‘cupules’ by Bednarik et al. (2007), were Aboriginal petroglyphs, and located similar markings on a flat turf-covered rock (their site BT2) and much smaller markings (20–40mm diameter) on boulders at the western end of the ridge forming Australia Hill (their site BT3). While acknowledging that many grooves resembled petroglyphs, Bednarik et al. (2007) concluded that most grooves on Blue Tier were formed by the action of tree roots, and like Luckman (1957) noted that the grooves are sometimes undercut (which implies the working of a natural process, i.e. the action of a growing root). However Bednarik et al. (2007) also considered some grooves to be of human origin, but they did not specify how they distinguished anthropogenic and natural grooves. On the basis of seven ‘micro-wane’ widths measured on one quartz grain at site BT2, and a dating curve derived from a schist outcrop at Grosio in the Italian Alps, Bednarik et al. (2007) wrote that the petroglyph in question was formed 1687+188/-281 BP (the validity of this age is discussed below). In their conclusion Bednarik et al. (2007) suggested that the supposed petroglyphs had ceremonial, metaphysical or cosmological significance.

As a consequence of Bednarik et al.’s (2007) study, there has been an initiative to set aside an area of Blue ‘Tier as a ‘sacred site’, and to redirect a public walking track that presently follows the crest of Australia Hill alongside the row of ‘footprints’ (P. Bird, Forestry Tasmania, pers. comm., 2008). In view of these developments, we have reviewed the evidence presented regarding the origin of the markings on Blue Tier, examined the historical records and conducted a rigorous field examination of as many previously mentioned sites on Blue Tier as we were able to relocate. As the climate, geology and vegetation of Blue Tier are an essential part of this re-evaluation, these natural characteristics are also reviewed.

Natural Characteristics
The Blue Tier (Figure 1) is an elevated granite plateau at 700–770m asl with low ridges extending to the north and south. Occasional monadnocks stand up to 100m above the surrounding country. The plateau is dissected by the headwaters of several major rivers (Jackman 1997).

The climate of the Blue Tier is mild and even, although it is more exposed to cold winds than the surrounding lower countryside. In winter and occasionally in summer, the plateau can be shrouded in cloud for extended periods. The nearest permanent weather station is at St Helens on the east coast, at 5m asl. Mean annual precipitation on the plateau is in the range 1000–1200mm, with historical data indicating annual maxima of c.2000mm; snow may settle but falls are generally light and melt quickly. Mean annual temperatures range from around 3°C (minimum) to 15°C (maximum) (Bureau of Meteorology 2009; McIntosh-Reid and Henderson 1928).

The Blue Tier has one of the last significant stands of callidendrous cool temperate rainforest in northeast Tasmania and is considered an important flora refuge (DEWHA 2007). Rainforest dominated by Nothofagus cunninghamii (myrtle) occurs on the plateau and in sheltered gullies. Eucalyptus regnans and E. obliqua tall eucalypt forest surrounds the plateau at lower altitudes, and drier sclerophyll forest occurs in the foothills below 300m (PLUC 1996). All but the extreme mountain tops and steepest escarpments are likely to have had forest cover: photographs taken in the 1920s and in 1957 show extensive areas with logs lying on the ground and tall dead stumps. Today shrubby understorey and moss is regaining a hold on the bouldery slopes of Australia Hill but such vegetation cover probably occurred over most of the bouldery crests in the past, being favoured by the moist conditions, frequent mist cover and the shade provided by large trees.

The plateau has a range of other vegetation types, including tussock grassland and grassy shrubland dominated by Poa labillardieri, Leptospermum spp. and Tasmannia lanceolata (mountain pepper) (Kirkpatrick and Duncan 1987), with the distribution and character of each reflecting a history of major disturbance since mining commenced in the 1870s. A bushfire in 1901, combined with years of ground sluicing and selective
clearing, destroyed much of the myrtle rainforest on the plateau. By 1903 over 1200 ha was sown to grass for cattle grazing – a practice that continued until the late 1960s – with ‘lawn’ sites later maintained by marsupial grazing (Jackman 1997).

The geology of the area consists of Upper Devonian to Lower Carboniferous granite (Blue Tier Batholith) with minor pockets of Quaternary river alluvium and dolerite dykes, Tertiary basalts and Tertiary clays and silts (McIntosh-Reid and Henderson 1928). Groves (1965) distinguished a finer-grained tin granite from a coarser-grained porphyritic granite.

Soils on the plateau have not been described but at highest altitudes are likely to be similar to Jessop soils (Semiaquic Podsolos) (Grant et al. 1995), which are the soils formed on undulating to rolling high altitude (>660m) granite plateaus in northeast Tasmania. Chemical analyses of a Jessop profile at 830m asl on the Rattler Range (McIntosh and Laffan 1999) show these soils to be extremely to strongly acid (pH 4.3–5.2) (Blakemore et al. 1977) and topsoils are peaty with carbon contents of 9–25%.

Alluvial and hard rock mining over a 100-year period has eroded most of the original Quaternary deposits on the plateau leaving a shallow nutrient-deficient residue of poorly drained hummocky gravels; a severe fire in 1901 is likely to have further encouraged soil erosion on the exposed ridges as well as on the lower lying plateau (Jackman 1997).

The Blue Tier is chiefly known for its rich tin mining history, dating from 1874. By 1878 the township of Blue Tier upper junction (Poimen) had three hotels, shops, stores and a small cluster of cottages and the reported combined population of upper and lower townships (Poimen and Lottah) was 1000 (Groves 1965; McIntosh-Reid and Henderson 1928). Although the main period of tin production in the Blue Tier was between 1875 and 1914, mining and prospecting have continued intermittently until recently. The area is littered with the physical remains of the mining era, ranging from large open cut faces to mining machinery, and even remains of prospectors’ picks (Jackman 1997).

Methods
We reviewed the literature relating to the Blue Tier markings, including past vegetation, geology, records of Aboriginal artefacts or occupation and mining history. We visited the Blue Tier and mapped, measured, recorded, photographed and counted regularly spaced circular depressions that had previously been found to occur in rows, and photographed and measured other markings. On the basis of these studies we classified the observed markings into eight types and deduced their mode of formation. In order to clarify the findings of earlier surveys we interviewed a member of the 1957 Blue Tier Expedition (Williams 2008).

Fieldwork was undertaken along the Australia Hill ridge (c.770m asl) in the Blue Tier Forest Reserve. Most observations were made in the vicinity of a walking track which traverses the ridge in an east-west direction (Figure 1) for approximately 1km from the Summit Mine in the east to the Compere Mine turnoff at the west end of Australia Hill. A preliminary survey (McIntosh et al. 2008) established the range of features visible in the general area and the field observations in this earlier report have been incorporated into the study reported here.

A detailed study of the main area of occurrence of regularly spaced circular depressions was conducted to confirm previous observations that the markings were in line with an exploration trench (Jackman 1997; McIntosh et al. 2008), and to record the location and dimensions of each depression. This site was referred to as site BT1 by Bednarik et al. (2007) and parallels the east-west walking track near the crest of Australia Hill (Figure 1) for part of its length. Measurements were also taken of the overall distances between the trenched sections and the granite rocks marked with circular depressions. Along Trench 3 each rock with circular depressions was photographed. We recorded the location of each depression using a combination of GPS instrument (Garmin eTrex) readings and a tape measure and at the same time plotted the location of intervening or intersecting trenches dug by the Mt Lyell Co (Williams 1907). Where depressions were covered with a thin (<100mm) soil layer we removed the soil layer, recorded the locations and dimensions of depressions, and replaced the soil layer.

We conducted a general inspection of the area surrounding trench No. 3 and the walking track, in order to identify Bednarik et al.’s (2007) sites BT2 and BT3 and to find further evidence relating to the origin of the claimed petroglyphs.

We sampled topsoils (0–100mm depth) from three locations along Australia Hill and two locations on Mt Michael (Figure 1). After air drying and sieving to obtain the <2mm fraction, soil pH in water (1:5 soil/water ratio) was measured by the method of Rayment and Higgison (1992).

Results and Discussion
Mean pH for the five topsoil samples was 4.8 (range 4.5-5.0), i.e. all samples are strongly acid (Blakemore et al. 1977) and within the pH range previously reported for Jessop soils (McIntosh and Laffan 1999).

We recorded eight types of markings on Australia Hill and Mt Michael:

1. Rills >300mm long and c.100mm wide (Figure 2A).
2. Long Linear Grooves >200mm (Figure 2B).
3. Circular Holes 40mm diameter (Figure 2C).
4. Inscriptions (Figure 2D).
5. Oval Depressions >100mm diameter on horizontal surfaces (Figure 2E).
6. Regularly Spaced Circular Depressions 100–120mm wide and c.10mm deep (Figure 2F).
7. Short Linear Grooves often 50–200mm long and <10mm deep (Figure 2G).
8. Small Circular Depressions 20–40mm diameter (Figure 2H).

Rills (Type 1)
These rills, visible on summit boulders (Figure 2A), are technically classified as karren. Although most often found in limestone, karren are also a common dissolutional landform in rocks which are homogenous and fine-grained (Ford and Williams 2007:322). They are formed by water flowing over the surface rocks, dissolving minerals as it does so. The rills are undoubtedly natural in origin.

Long Linear Grooves (Type 2)
These linear grooves are either planar (Figure 2B) or wavy (not illustrated) and extend throughout outcrops. They follow zones of weakness in the granite such as cooling cracks or flows of
Figure 2A Rills on a summit boulder on Australia Hill (Type 1 marking). This rilling is a result of run-off and demonstrates how prone the granite is to chemical and physical weathering.

Figure 2B Natural joints and zones of weakness in granite (Type 2 markings), forming long linear grooves >200mm long. Tape is 300mm long.

Figure 2C Circular holes on Australia Hill, 40mm diameter (Type 3 marking). Tape is 100mm long.

Figure 2D Recent inscriptions on Mt Michael (Type 4 marking). Scale is 300mm long.
Figure 2E. Oval depressions in horizontal granite exposures (Type 5 markings). These are likely to have formed by natural solution of the granite by acidic soil solutions in subsoils before the soils were eroded as a result of mining activity. Tape is 300mm long.

Figure 2F. Regularly spaced circular depressions 100–120mm diameter (Type 6 markings) are in line with sampling trenches (costeans) dug by Mt Lyell Co prospectors under the direction of Luke Williams.

Figure 2G. Short linear grooves (Type 7 markings) on Australia Hill. Tape is 200mm long. Note how these grooves are on horizontal surfaces and associated with soil remnants (upper part of photograph). They are also associated with logs of large trees.

Figure 2H. Small circular depressions (Type 8 markings). These apparently random depressions are 20–40mm diameter and up to 10mm deep. They occur on the sides as well as on the tops of boulders of fine-grained granite and are not associated with soil or water pools. They are deduced to have formed by weathering of granite penetrated by the root systems of lichens.
different mineralogy or particle size. These natural zones of weakness are common in igneous rocks.

**Circular Holes (Type 3)**

These holes c.40mm in diameter (Figure 2C) are found apparently randomly along the crest of Australia Hill (Figure 1) and may be the sampling holes drilled by Groves (1965) for his investigation into the composition and geometry of the granite.

**Inscriptions (Type 4)**

Inscriptions (Figure 2D) occur on one rock outcrop on Mt Michael (Figure 1). One inscription contains the date 1961. If the 1961 date is correct it seems most likely that all were inscribed by visitors after mining ceased near Mt Michael, but cutting of some inscriptions by miners cannot be ruled out.

**Oval Depressions (Type 5)**

Several of these occur on the summit boulders of Australia Hill and Mt Michael (Figure 1). Bednarik *et al.* (2007:Figures 5–6) considered these to be petroglyphs. Some are almost perfectly circular and others are oval or irregular. They vary in size from about 100mm to over a metre across and their geometry and depth varies greatly (Figure 2E). Some are filled with sandy peat and support moss or sedge vegetation, others are water filled. It is highly probable that before European mining and the extensive vegetation clearance and fires which followed, nearly all these depressions and their associated boulders would have had a vegetation or moss cover. The technical name for the depressions is gnammas or weathering pits (Dominguez-Villar *et al.* 2008). They are common in granite and their mode of formation by the action of water solutions varying in pH from 4.0 to 9.6 has been described by Dominguez-Villar *et al.* (2008): factors such as large pH oscillations, intermittent basic pH values, biological acids and alkali cations in solution were all noted as increasing silicate solubility, thus favouring granite dissolution. Dominguez-Villar *et al.* (2008) did not study soil-filled depressions, but the processes acting in these are likely to be similar, except that within soil-filled depressions the variation of solution chemistry is likely to be less than in water-filled depressions because of the buffering effect of soil organic matter. Further evidence against anthropogenic origins is: (1) the occurrence of oval depressions on flat surfaces with remnant soil and logs of large trees nearby, showing a previous association of the features with forest cover; (2) the likelihood that soil would need to have been removed to make the depressions; and (3) the complete absence of associated fragments of imported hard stone that might have been used to manufacture the depressions. In addition, it is noted that although Bednarik *et al.* (2007) asserted that these features, large and small, were produced by hammering, they provided no evidence to support this assertion.

**Regularly Spaced Circular Depressions (Type 6)**

A total of 102 regularly spaced circular depressions (Figure 2F) were noted, with eight new depressions being uncovered in the survey. All are aligned with Mt Lyell Co Trench 3 (Figure 3) which traverses the south side of Australia Hill, near its crest (Williams 1907). As noted by previous observers, the circular markings occur where granite outcrops or boulders have interrupted sampling trenches. The circular markings on the horizontal plane are spaced at approximately 300mm intervals between centres and the markings themselves are on average 112mm wide and 10mm deep. The markings are found not only on the flat tops of boulders but also on their sides. Some of the circular markings show clear evidence of cutting using a jumper and have raised centres where the uncut rock has resisted removal (Figure 4). Others show signs of being chipped with steel hand-chisels (Figure 5).

Bednarik *et al.* (2007:168) dismissed the idea that Type 6 markings were natural features or mining marks and concluded that at their site BT1 ‘the linear arrangement of cupules appears to be a distinctive feature of Tasmanian rock art’. Using the micro-wane technique they determined ‘a minimum age for the BT1 petroglyphs of about 1000 years’ (Bednarik *et al.* 2007:167). These authors seem to have been unaware of the study by Jackman (1997) who described the east-west sampling trenches (costeans) dug on Australia Hill and who also noted that where sampling trenches were impeded by rocks, the rocks themselves were sampled (Jackman 1997:68, 161). Bednarik *et al.* (2007) were apparently also unaware of the maps produced by the Mt Lyell Co showing the location of the trenches, and the fact that the circular markings at their site BT1 are exactly in line with the Mt Lyell Co’s Trench 3, as confirmed by our detailed field studies described above (Figure 3). Bednarik *et al.* (2007) also appear to have been unaware of the prospectors’ sampling technique of using a cylindrical 4-inch (100mm) diameter ‘jumper’ to collect assay samples (Moore 1912), the cylindrical traces still evident in the perimeters of some circular markings (Figure 4), and the evidence of chisels used to extract some sample cores (Figure 5). Thus there is overwhelming field and historical documentary evidence demonstrating that the regularly spaced circular depressions on Australia Hill (sites BT1 and BT2) were made by tin mining prospectors.

**Short Linear Grooves (Type 7)**

These are most abundant in the finer-grained granitic rocks, for example at the western end of Australia Hill (Figure 2G). They are mostly on flat slabs of rocks or their edges, and often associated with soil remnants in grooves or in joints between granite slabs or boulders or associated with remains of trees. Several instances of linear marks disappearing into soil were noted (Figure 6). The short linear grooves may be branched. They are much less abundant, or entirely absent, on large boulders at the tops of hills and on the edges of escarpments, except where soil-filled cracks are present.

The short linear grooves were considered by Luckman (1957) and other members of the Blue Tier Expedition (Williams 2008) to be formed by the subaerial or root action of plants. There is multiple evidence for this conclusion: (1) the occurrence of these root traces in deep crevices where people could not use tools; (2) the experimental evidence of Luckman (1957) who showed that the soft granite is easily eroded by a persistent rubbing action; (3) the overhanging lip on some grooves, which is most unlikely to have resulted from the action of abrasive stone tools, but is readily explained by the rubbing action of a partly enclosed and growing root within a groove; (4) the predominance of the grooves on flat surfaces with remnant soil and logs of large trees nearby, showing a previous association of forest with the...
grooves; (5) the necessity to remove thick soil layers in order to make the grooves, if they were made at any time in the Holocene before mining activity and vegetation burning caused forest removal and soil erosion; (6) the complete absence on Blue Tier of ‘rock chips’ derived from imported hard stone that might have been used to manufacture markings (Luckman 1957) and our own observations; (7) the absence of grooves from rocks forming escarpments, which arguably have not been soil covered (on account of their steep smooth faces) although they may have had a cover of mosses and lichens.

The vulnerability of the granite to rapid weathering and erosion is explained by mineralogical modification of feldspars under acid conditions; Moore (1912) noted that as kaolinisation of the feldspars in the Blue Tier granite proceeds, the matrix disintegrates. Luckman (1957) reported that much of the now-exposed area had been previously covered by beech (Nothofagus cunninghamii) forest with fern undergrowth. Under this vegetation type, soils developed in granite are strongly to extremely acid (Grant et al. 1995:155) and the soil pH results obtained in this study confirm the presence of strongly acid soils. Under such conditions rapid weathering of the more vulnerable minerals of the granite (e.g. feldspars) will have occurred, leading to disintegration of the granitic matrix.

The branched nature of some grooves (CLM category of Bednarik et al. 2007) (see Figure 2G for examples) is not proof of human origin, as roots are branched. The conchoidal fractures in quartz mentioned by Bednarik et al. (2007) within grooves at their site BT2 are evidence of abrasion but do not require human
1. The 'micro-wane' dating method is based on the assumption that the roundness of an abraded mineral grain increases in proportion to its age. However, in any collection of abraded quartz grains, the angle of the broken faces will vary from acute to >90°. In measuring the broadness of the fractured quartz, and using these measurements as an indication of age since abrasion, Bednarik (1992) does not allow for the range of initial angularity in the abraded quartz grain population.

2. Bednarik (1992) dismisses the simple theory of wanes (Černohouz and Solč 1966) and substitutes his own theory (Bednarik 1992), which is crucial to his argument that wane width (A), irrespective of actual retreat (dissolution) of the mineral considered, is determined by the ratio of two angles: α, the angle between two surfaces of a mineral grain and β, which was not defined but generally described (Bednarik 1992:282) as 'the angle expressing the rate of wane development relative to surface retreat'. If equal dissolution over all the mineral surface is assumed, α can be directly measured, but β must be estimated using a parameter x (distance of apical retreat) which is also not known. Thus Bednarik's (1992) equation 4, on which his calculations depend, cannot be resolved because it contains two variables neither of which can be measured.

3. The only way in which equation 4 can be put to use is to assume that the angle β is a constant proportion of α (Bednarik 1992:Table 1). However, no evidence is given to validate this assumption. Bednarik et al. (2007) appear to recognise the above problem, because they dispense with trying to predict β, and instead measure only A (wane width). However, wane width A is directly proportional to the apparent distance of apical retreat h (one can be calculated from the other provided the angle α is measured), and measurement of h alone, as promoted by Černohouz and Solč (1966) was discredited as a dating method by Bednarik (1992). It follows that measurement of A alone must also be suspect as a dating method.

4. Nevertheless, it is possible that measurement of A alone, as promoted by Bednarik (1992), might be useful if it could be shown empirically that values of A are proportional to petroglyph age. Bednarik (2001) apparently recognised this possibility and looked for sites for which he could construct a calibration curve for values of A against known petroglyph age. However, independent geological ages of petroglyphs are difficult to find, and the best obtainable time control was obtained for a schist rock with petroglyphs in the Grosio valley, northern Italy, which was estimated to have been uncovered by glacial retreat c.12,000 BP (Bednarik 2001), although no references were given to support this age. This age, if correct, is a maximum age for the petroglyphs (Bednarik 2001 stated it was a minimum). In theory the petroglyphs could have been carved at any time between 12,000 BP and the present, although in practice stylistic analysis indicated a minimum age of about 3000 years. Despite this great range of possible ages for the petroglyphs Bednarik (2001), without explanation, opted for the oldest possible age (12,000 BP) for constructing his calibration curve, while admitting that it was tentative (it is based on only one value). Bednarik (2001) also assumed a straight line relationship between values of A and age.

5. Without giving the details of how the climate at Grosio, northern Italy differed from that at Blue Tier, and ignoring the geological difference between the sites (despite the importance placed by Bednarik 1992:288 on climate and geology as factors affecting the practical application of his method) Bednarik et al. (2007) applied the Grosio calibration curve to measurements at Blue Tier and estimated grooves on Blue Tier to have been cut 1687+188/−281 BP, which is stating results to a high level of significance given the tentative nature (Bednarik 2001:112) of the Grosio curve, and the fact that ages of both 3000 BP and 12,000 BP are, on present evidence, equally valid for the oldest ages obtained at Grosio.

Figure 6 Short linear grooves (Type 7 markings) descending into soil (arrow). The longest groove (top left) is about 150mm.
independent dating specialists. The argument that the short linear grooves are petroglyphs cut about 1600 BP is discounted.

**Small Diameter Circular Depressions (Type 8)**

Bednarik *et al.* (2007:Figures 7-8) noted these depressions (‘small cupules’) at their site BT3, which is at the western end of Australia Hill close to where the east-west walking track turns to the north (Figure 1). They are mostly 20–40 mm in diameter and about 10 mm deep (Figure 2H) and occur randomly on the sides and tops of boulders, but are infrequent on low-lying slabs associated with soils. Under certain lighting conditions they may appear to occur in rows (Bednarik *et al.* 2007:Figure 8) but we relocated this site and found that the small circular depressions were randomly distributed.

Some small circular depressions on subhorizontal surfaces may be incipient gnammas but as they also occur on the sides of boulders an explanation not involving long-term ponding of water must be sought. Crustose, fruticose and foliose lichens are present over all boulders on Blue Tier (see Figure 2H for an example) and the fungal hyphae by which these plants attach themselves to rocks and withdraw nutrients are known to penetrate up to 10 mm into rocks (Simmons 2005). It appears likely that these small structures are the product of slow dissolution of the softer minerals of the granite: after weathering of the softer minerals like feldspar, the harder elements like quartz would be loosened from the granite matrix (Moore 1912), and a small depression would result. This process was probably faster in the moist understorey of the forest before it was burnt by fires.

Like Bednarik *et al.* (2007), we noted that these small circular depressions are found only on the fine-grained granites at the western end on Australia Hill, which are softer and ‘tend to be weathered more deeply’ (Bednarik *et al.* 2007:165). The tendency for the fine-grained granite to weather more easily is likely to explain why fungal action has had a more marked effect on these rocks than on the predominant coarser-grained granites elsewhere.

**Conclusions**

We have classified markings in granite on Blue Tier into eight types. We have examined each type and conclude that Type 1 markings are caused by dissolution of granite during surface flow of water over rocks; Type 2 markings are formed along natural zones of weakness in granite; Type 3 markings are sampling holes made by geologists; Type 4 markings were made by recent visitors and/or miners; Type 5 markings were made by the well-documented weathering and erosion of granite by ponded water or acid soils; Type 6 markings were produced by miners and prospectors acting for the Mt Lyell Co in 1906–7 using a primitive hand-held hammer drill; Type 7 markings were produced by acid dissolution of granite associated with the presence of tree roots when the granitic rocks were previously soil covered; and Type 8 markings were produced by the action of clusters of fungal hyphae or small roots.

As concluded by members of the 1957 Blue Tier Expedition, there is no evidence that any marks on Blue Tier are ancient Aboriginal petroglyphs. The archaeological importance of the area is that it contains widespread evidence of the early mining history and prospecting methods of the early twentieth century. The area is important to protect not only for its features of natural geological origin but for its industrial archaeological record.

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