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Geological setting of Jurassic plant fossils near Lune River

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Mineral Resources Tasmania

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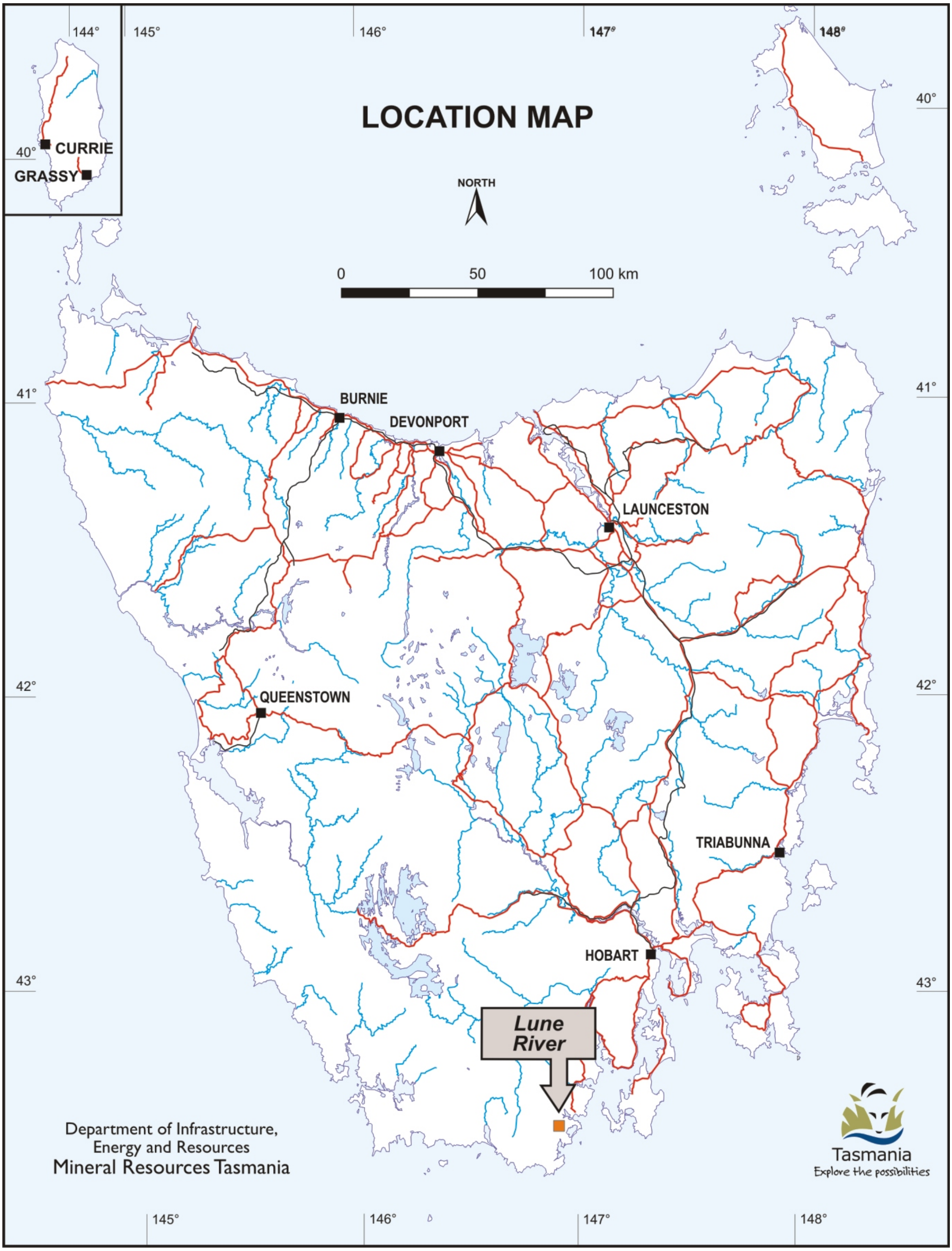

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Abstract

In order to clarify the geological setting of the well-known Jurassic flora of the Lune River area, geological mapping and an analysis of coal exploration drill-hole logs were undertaken. The flora is preserved *in situ* in two known places, in sandstone and mudstone immediately beneath basaltic andesite lava that has previously been shown to be co-magmatic with the widespread Jurassic dolerite. Volcanolithic sandstone hosting the fossils at one of these localities was recently dated at 182 ± 4 Ma (U-Pb on zircon; Bromfield *et al*., 2007). The Jurassic rocks are regionally underlain by Upper Triassic (Carnian) sandstone, mudstone and coal, and a significant (c. 40 m.y.) stratigraphic break between the Triassic and Jurassic successions is probably located at the erosional base of 1.5 m of conglomerate, 23 m below the andesite in drill hole CA106. This horizon (or one close to it) is associated with a low-angle unconformity between Triassic and Jurassic successions, corresponding to a 3° southwest dip of the Triassic, relative to the Jurassic stratigraphy.

The Jurassic succession, dominated by basaltic andesite, is poorly exposed but may be 250 m thick in the west of the mapped area. Within the basaltic andesite there is at least one impersistent, non-outcropping sedimentary interbed which has shed a surface lag of silicified wood, and another interbed of altered, highly vesicular lava, probably of intermediate to felsic composition.

A prominent ridge in the south of the mapped area, shown on older maps as dolerite, is composed of a poorly-sorted boulder deposit dominated by dolerite, with minor Parmeener Supergroup clasts. A nearby drill hole contains dolerite boulder beds of early Eocene age. Alternatively, the boulder deposit on the ridge could be Pleistocene till.

Introduction

For at least 50 years, silicified plant fossils have been known from an area approximately four kilometres south of Lune River in southern Tasmania. Notable amongst these fossils are tree-fern trunks with internal structure preserved in spectacular detail — a feature that has attracted the attention of collectors, lapidarists and palaeobotanists. The silicified ferns are typically found as fragments in shallow subsurface gravels that also include pieces of silicified conifer wood, agate and rare mudstone with leaf impressions (White, 1991). From this fragmentary but well-preserved flora, species belonging to the fern families Cyatheaceae, Osmundaceae, Guaireaceae, Matoniaceae and Dicksoniaceae have been described, as well as a seed-fern and a bennettitalean cycadophyte (Gould, 1972; Tidwell, 1987, 1991; Tidwell and Jones, 1987; Tidwell *et al*., 1987, 1989, 1991; Tidwell and Pigg, 1991; Tidwell and Skog, 1992; White, 1991). The fossil wood is thought to be araucarian (Bromfield *et al*., 2007). The flora was originally considered to be Tertiary by analogy with similarly preserved assemblages elsewhere in Tasmania (e.g. Gould, 1972), but by 1987 the taxonomic affinities of the flora were recognised as being considerably older — 'mid-Mesozoic' (Tidwell, 1987; Tidwell *et al*., 1987).

At about the same time, the 'basalt' which crops out just upslope and to the west of the fossil localities was shown to be co-magmatic with the widespread Jurassic dolerite, and chemically quite distinct from Tasmanian Tertiary lavas (Hergt *et al*., 1989). With 55% SiO_2, this rock is a basaltic andesite under the current IUGS classification scheme (Le Maitre, 2002; Bromfield *et al*., 2007). Reconnaissance regional mapping by Sharples (1994) showed the Jurassic extrusive rocks to be widespread within the bounds of a narrow meridional graben extending from near Catamaran in the south to Strathblane Plain in the north. Associated with the basaltic andesite are Triassic non-marine sandstone-dominated sedimentary sequences, including coal measures, and Jurassic dolerite.

Outcrop of sedimentary rocks containing the Jurassic flora preserved *in situ* was not found until 2003, when Nigel Ellis and Christine Klimek uncovered an outcrop of mudstone and sandstone at shallow subsurface depth with boles of silicified trees and tree-ferns, some in growth position. This site was excavated and systematically studied as a B.Sc. Honours project by Kate Bromfield in 2004, assisted by Forestry Tasmania and MRT (Bromfield, 2004). A volcaniclastic sandstone here yielded zircons dated at 182 ± 4 Ma, considered to be coeval with the deposition of the sediments and fossils (Bromfield *et al*., 2007). This date is Toarcian or late Early Jurassic. By comparison, many dates have been obtained from the Tasmanian Jurassic dolerite (recently reviewed by McDougall, 2008). Four isotopic systems have been used, and the results have been mostly rather imprecise. The best estimate of the age of the dolerite is considered to be a U-Pb zircon determination of 185.6 ± 1.5 Ma from the Red Hill granophyre (Williams and Hergt, 2000; McDougall, 2008). Given that the two uncertainties overlap, it can only be concluded that this date is not significantly different from the zircons in the sandstone dated by Bromfield *et al.* (2007).

Large fragments of silicified trees were found at a second locality, some two kilometres south of the first, in about 2004/2005. Holes dug by collectors at this locality encountered mudstone with leaf impressions some two metres below ground surface, in which silicified plant fossils were reported to be in growth position (P. Harris, pers. comm.). Two large silicified trunk segments were collected from this locality for the Tasmanian Museum and Art Gallery in November 2006, with the assistance of Forestry Tasmania and the co-operation of Mineral Resources Tasmania.

Despite the long history of collection and palaeobotanical investigation of the Jurassic flora, and the fact that these are the only known Jurassic sedimentary and extrusive rocks in Tasmania, no detailed geological mapping has been previously carried out, and the stratigraphy of the Jurassic succession, in particular its relationship with the regionally

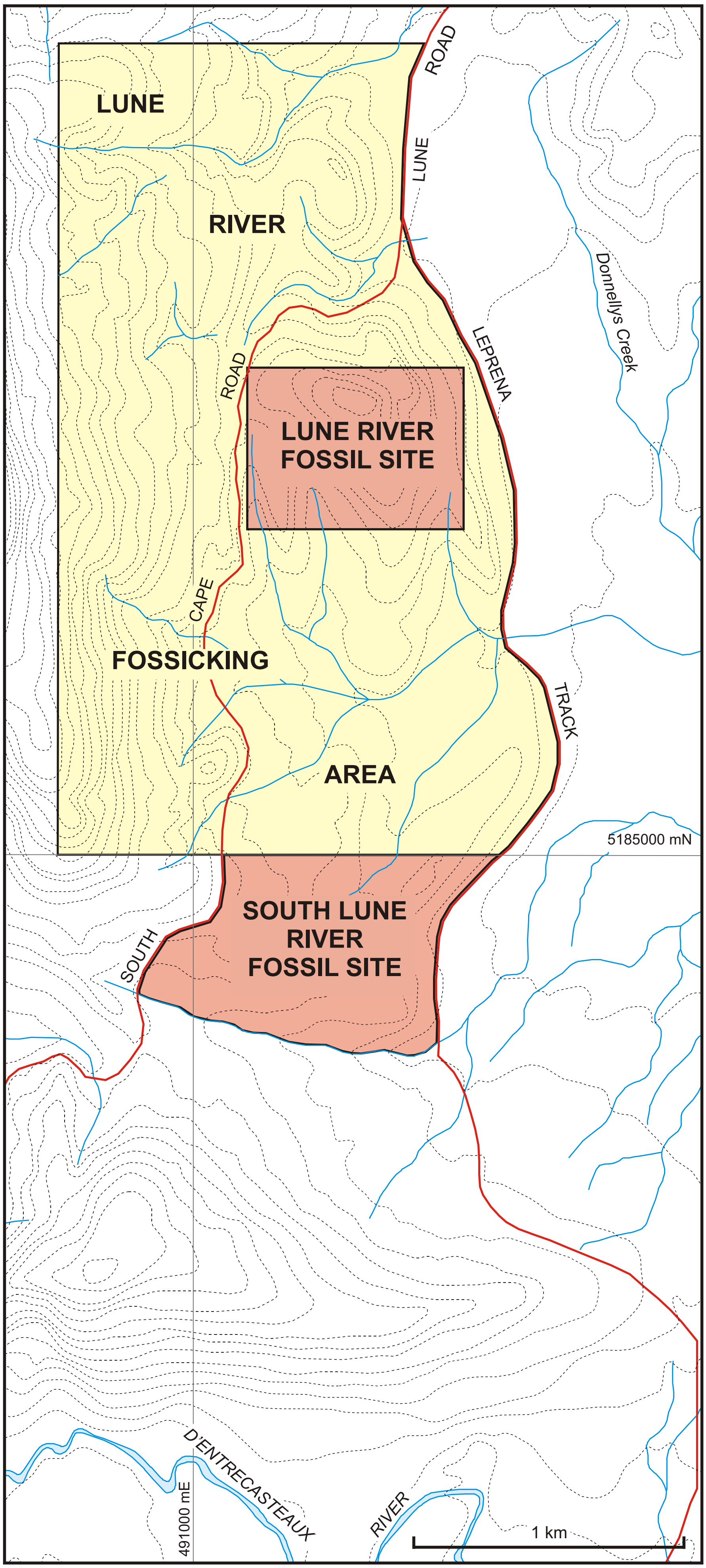

Figure 1

Locations of Lune River Fossicking Area, Lune River Fossil Site and South Lune River Fossil Site.

underlying Late Triassic coal measures, has remained unclear. The aim of the present work was to geologically map the Lune River fossicking area and environs to better understand the geological setting of the Jurassic flora. Records of coal exploration drill holes in the area were examined, providing valuable information. It is concluded that the Jurassic flora is hosted by a c. 20 m thick unit of sandstone, mudstone and basal conglomerate, which overlies the Upper Triassic coal measures with a low-angle unconformity. The Jurassic sediments are conformably overlain by thick (250 m) basaltic andesite, locally intruded by dolerite. The andesite contains at least one plant-bearing sedimentary interbed and an interbed of vesicular, intermediate to felsic, altered lava.

Land tenure

About five square kilometres of the area south of Lune River has been declared a Fossicking Area under the *Mineral Resources Development Act 1995* (MRDA), allowing the collection of rocks, fossils and gemstones without a prospecting permit subject to certain conditions (see Bacon and Bottrill, 2001). In order to protect the heritage and scientific values of the two fossil localities mentioned above, they have been declared Fossil Sites under the MRDA (fig. 1). Within the Fossil Sites, no fossil material may be collected without the permission of the Director, Mineral Resources Tasmania. The two Fossil Sites and the Fossicking Area are all in State Forest, managed by Forestry Tasmania.

Data sources

The area was mapped using a GPS receiver over four days in 2006/2007, concentrating mainly on the area between Leprena Track and South Cape Road. Thick regrowth west of South Cape Road allowed only limited traverses. The geological map (fig. 2) was compiled with reference to the earlier regional map of Sharples (1994).

Coal exploration drilling provided important supplementary information. Thirteen short holes were drilled by Australian Paper Manufacturers Ltd (APM) in the northeast of the area in 1976. More usefully for this investigation, nine coal exploration holes up to 321 m deep were drilled in the mapped area by Marathon Petroleum Australia Ltd (MPA) in 1982–1983. Abbreviated lithological logs of the MPA holes are shown in Figure 2. Most of these holes were cored, but unfortunately nearly all the drill core has been discarded. Detailed lithological and geophysical (gamma ray, density, resistivity) logs are presented in the open file company reports held by MRT (Perkins, 1982*a*, 1982*b*, 1983; Perkins and Dunn, 1984).

These reports show two different locations for drill hole CA101. The position shown in the more recent reports (Perkins, 1983; Perkins and Dunn, 1984) is accepted here.

Stratigraphy

Triassic quartz sandstone (Rq)

A Triassic succession dominated by fluvial quartz sandstone, with little or no coal, is found conformably underlying the coal measures in drill holes, but no outcrop at the surface is known in the mapped area. Drill hole CA116, in the northeast corner of the mapped area, encountered Rq in the shallow subsurface and this unit is reached at progressively greater depths in drill holes to the southwest, because of the regional southwest dip (see later section).

Drill-hole logs indicate a minimum thickness of 230 m for unit Rq. The lithological logs of Perkins (1982*a*, 1983) record greatly predominant (>90%) pale grey, fine to medium-grained sandstone, with minor dark grey mudstone and siltstone. The sandstone is recorded as quartzose, with a variable component (a few per cent to over 20%) of feldspar and lithic grains. Coal is very rare, and only occurs as very thin seams or wispy fragments. Forsyth (1989, p. 326) correlated this unit with his Middle Triassic Unit 3 of the Upper Parmeener Supergroup. It may also be in part equivalent to Unit 2 (Lower Triassic).

Upper Triassic coal measures (Rvc)

There is an upward conformable transition from unit Rq into coal measures, of sandstone, siltstone, carbonaceous mudstone and coal. This takes place at about 168 m depth in hole CA110. This hole was collared only about 10 m stratigraphically below the base of the Jurassic sediments, so the unit was originally about 180 m thick here before erosion to the present land level. From the lithologic log descriptions, the fine-grained lithologies (siltstone and mudstone) are much more prevalent in Rvc than in the underlying Rq, comprising c. 30–50 % of the succession. The sandstone is variable in composition, much of it being quartz rich (>90% quartz), while lithic sandstone is also recorded. Seven 'coaly intervals', named from top down A to G, distributed over a total thickness of about 140 m, were defined in the course of the MPA drilling program and correlated between drill holes (Perkins, 1982*b*; Perkins and Dunn, 1984). A bed of air-fall tuff, 0.17 m thick, was recorded at 7.5 m depth in hole CA102. Because of the gently angular unconformity at the base of the Jurassic, the coal measures thicken markedly southwards (see later section). A thickness of about 100 m is inferred in the vicinity of CA102 in the north of the area, while a minimum of 320 m is present at CA109, just south of the D'Entrecasteaux River (fig. 2).

There is poor outcrop of Rvc in several places in the mapped area. Weathered coal and lithic sandstone are seen in road cuttings on the spur road near the D'Entrecasteaux River and in the creek just north of hole CA102. On the basis of sparse float, poor outcrop in cuttings on South Cape Road, and soil characteristics, fine-grained quartzose sandstone appears to predominate in the area west of the central fault, south of hole CA117.

Forsyth (1989, p. 326) obtained a Late Triassic (Carnian) palynoflora from carbonaceous mudstone at 71 m depth in hole CA111, about three kilometres southwest of the mapped area. This depth was correlated with the 'A' interval by Perkins (1982*b*). The coal measures are similar to Upper Triassic coal measures in other parts of Tasmania with which they are correlated (Unit 4 of Forsyth, 1989), although the presence of quartz-rich sandstone is unusual, as elsewhere Unit 4 is predominantly lithic (largely volcaniclastic) sandstone.

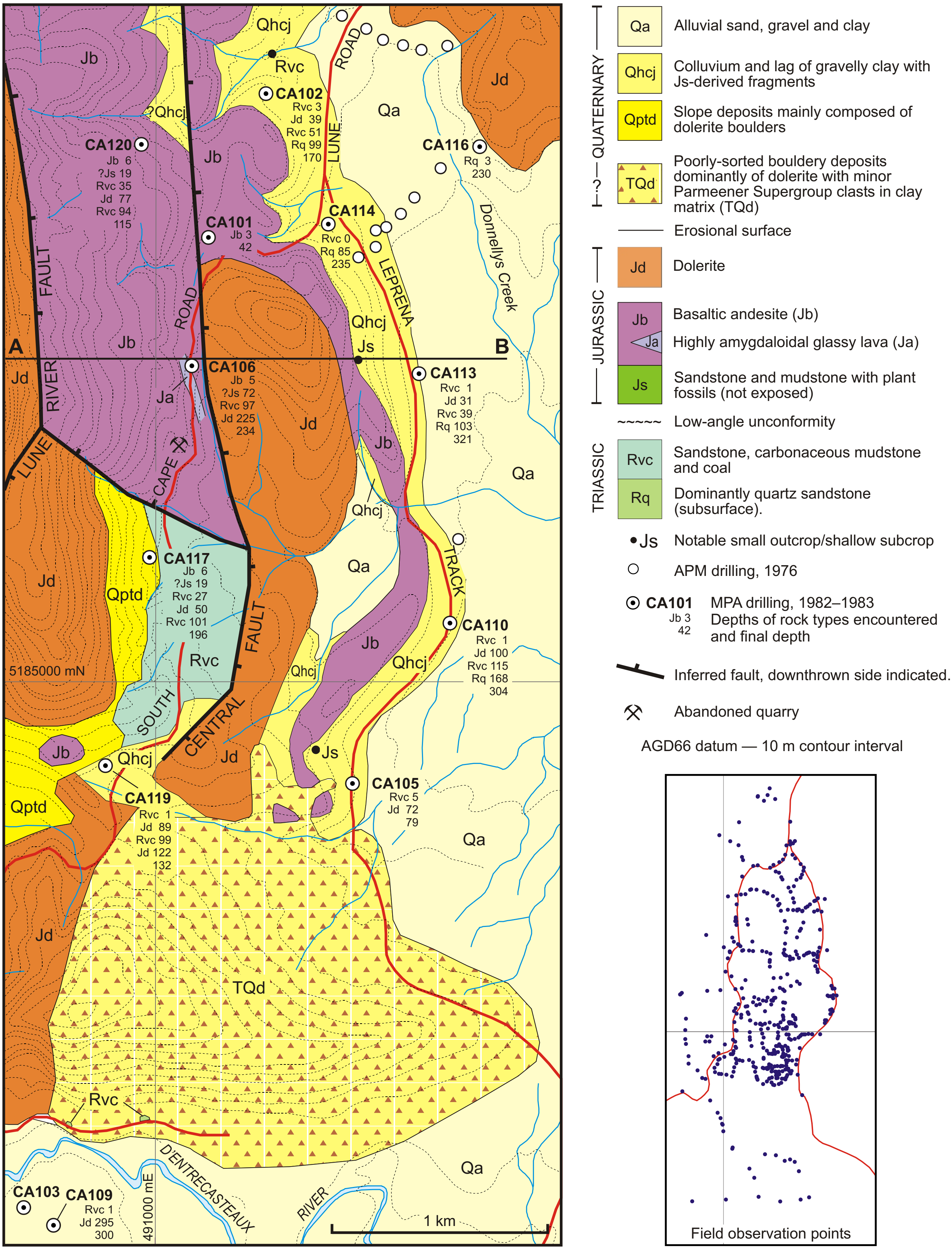

Figure 2

Geological map of Lune River Fossicking Area and environs, and locations of drill holes.
A–B: line of cross section (fig. 4)

Jurassic conglomerate, sandstone and mudstone (Js)

The Jurassic flora is found as fragmentary silicified wood and tree fern, and leaf impressions in mudstone fragments, within the surficial slope deposits mantling the east-facing slope along the Leprena Track and northwards (fig. 2). The mudstone with leaf impressions is pale brown to very pale grey and tends not to be particularly carbonaceous, unlike that of the coal measures (Tidwell *et al*., 1987; White, 1991). Known outcrop of this sequence has been documented only at the now-reburied site investigated by Bromfield *et al*. (2007). This site exposed, immediately underlying the basaltic andesite, about 1.5 m of weathered, quartz-rich volcanilithic sandstone, with minor interbedded mudstone, siltstone and tuff (Bromfield, 2004; Bromfield *et al*., 2007). Leaf impressions and silicified trunks (some in growth position) in this outcrop belong to the same araucarian-pteridophyte assemblage as that long known from the fragmentary transported material downslope to the east. Detrital zircons were extracted from the sandstone and dated by Bromfield *et al*. (2007), and the youngest and numerically predominant zircon population (182 ± 4 Ma: Toarcian, late Early Jurassic: ICS timescale) was considered to reflect the age of deposition of the sediment.

Another site with large silicified logs was recently found some two kilometres south of the Bromfield site, also just east of andesite and presumably closely underlying it. Here the plant material includes large (up to 250 kg) segments of prone trunks up to 60 cm in diameter, within a modern regolith of clay and gravelly clay. The larger logs are probably close to their original position. Bedrock of grey mudstone with plant impressions, with smaller silicified trunks in growth position, is reported to lie about two metres below ground surface (P. Harris, pers. comm.), and fragments of pale grey mudstone may now be found at the surface, excavated from collectors' pits and around nearby small dams dug by Forestry Tasmania. The fossils from this site have not yet been identified and tree-ferns have not yet been found here, but it seems highly likely that this site is at least broadly correlative with the Bromfield site.

Three drill holes (CA106, CA117 and CA120) are thought to have intercepted this sequence, having been collared in Jurassic basalt and drilled through into coal measures. Unfortunately only CA106 was cored (the others were percussion drilled and only chips would have been available to the logger) and neither core nor chips from the Jurassic sediments have been kept. From the lithologic log of CA106 (Perkins, 1982*a*), the 'A' coaly interval of the Upper Triassic coal measures is overlain by an interval (97–131 m depth) that is probably a continuation of the coal measures. This is dominantly dark grey carbonaceous mudstone and minor lithic sandstone and siltstone, with coal present as minor thin bands and fragments. At 97.0 m there is an abrupt erosional contact overlain by grey conglomerate of well-rounded pebbles in a poorly-sorted sandy matrix with a calcareous cement. The conglomerate (with minor grey sandstone) is 1.5 m thick, and is overlain by a generally fining-upward sequence of well-sorted, medium-grained grey sandstone passing up into fine-grained grey sandstone with an argillaceous matrix, then grey to greenish-grey mudstone with minor coal wisps in places. Grey to greenish-grey mudstone and siltstone with minor fine-grained sandstone characterise the 90.6 to 73.4 m interval, at which latter depth the basaltic andesite enters (fig. 3).

There is a significant difference in age between the 'A' coaly interval (Carnian, 228–217 Ma: IUGS timescale) and the dated sediments just under the andesite (182 ± 4 Ma), and a stratigraphic break or hiatus is expected in the ~60 m of section separating equivalents of these two horizons in CA106. It is probable that the conglomerate unit at 95.5–97.0 m marks this break, and that the conglomerate is the basal unit of the Jurassic. Regional analysis of the drill hole logs shows that this horizon appears to coincide with an angular discordance (see below). The Jurassic sediments (97.0–73.4 m) have a slightly subdued gamma ray response relative to the coal measures.

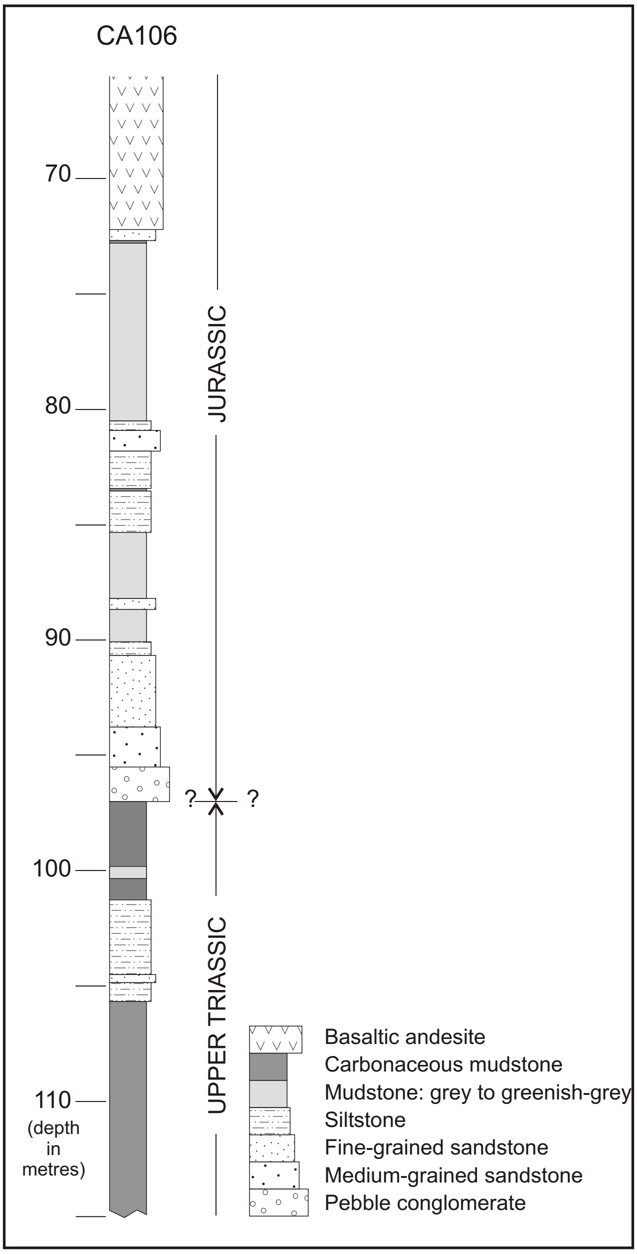

Figure 3

Stratigraphy of the inferred Jurassic sedimentary section in hole CA106, adapted from the lithologic log of Perkins (1982a).

In hole CA117 (hammer drilled) the andesite is recorded as being underlain by 31 m of dominantly quartzose sandstone (Perkins, 1982*b*) and the Jurassic section cannot be distinguished from the coal measures on available information. In CA120 (also hammer drilled) the interval between 35 m and 19 m (base of andesite) may be tentatively assigned to the Jurassic. Fine to medium-grained sandstone (31–35 m) overlies carbonaceous mudstone and is overlain by interbedded very fine-grained sandstone, siltstone and grey mudstone (Perkins, 1982*b*). The gamma-ray response of the 19–35 m interval is distinctly more subdued than the underlying coal measure sediments.

A float of well-rounded pebbles in a position consistent with having been weathered from a conglomerate equivalent to that intercepted in hole CA106 occurs along the spur road just north of hole CA102. These pebbles are composed of a strongly lithified, poorly sorted, pale grey-brown sandstone. A thin section shows the sandstone to be an immature felsic volcaniclastic rock, with clasts up to 3 mm of felsic tuffaceous and volcanic rock types in an abundant, well-cemented matrix of devitrified glassy fragments, many with cuspate outlines characteristic of shards. If, as seems likely, these pebbles characterise the basal Jurassic conglomerate, they may be derived from the lithologically similar Triassic felsic volcaniclastic rocks of the underlying succession. The coal measure sediments were probably poorly consolidated when erosion took place during the Early Jurassic, leaving the well-lithified pyroclastic lithologies to accumulate as a pebbly lag on the unconformity.

Jurassic basaltic andesite (Jb)

This is a dark grey, fine-grained rock to which the term 'basalt' has generally been applied in the past. Chemical analysis shows the rock to be significantly more siliceous (c. 55% SiO_2) than typical Tasmanian Tertiary basalts (~45% SiO_2: Hergt *et al*., 1989; Bromfield *et al*., 2007) and the rock is correctly termed 'basaltic andesite' under the current IUGS classification (Le Maitre, 2002; Bromfield *et al*., 2007).

In outcrop, the andesite has randomly orientated curviplanar joints and sparse amygdales, features which readily distinguish it from fine-grained dolerite. The amygdales are generally round, a few millimetres in diameter, and filled with white chalcedony. Larger, irregular agate-filled amygdales are locally present and have weathered out into the associated surficial gravels and soils.

The andesite is also petrographically distinct from fine-grained dolerite. The andesite contains phenocrysts (1 mm) and glomerocrysts (1–2 mm) of augite, pigeonite and plagioclase (labradorite) in a quench-textured groundmass of acicular skeletal plagioclase and augite and abundant dark brown glassy mesostasis. The fine-grained dolerite, by contrast, is a more or less equigranular intergrowth of augite and plagioclase (0.5–1 mm), with relatively minor mesostasis.

Drill hole CA106, located west of an inferred east-side down fault, intersected 68 m of andesite before reaching the sub-andesite sediments. Assuming no undetected faulting west of CA106, a total thickness of about 250 m of dominantly andesite may be present near the Lune River Fault (fig. 4).

Jurassic sedimentary layer within basaltic andesite sequence

Common silicified wood fragments are found in soils to the west of the andesite strike ridge that parallels Leprena Track, for example around 491 500 mE, 5 185 000 mN, and 492 000 mE, 5 186 000 mN; fig. 2). Given the regional gentle westerly dip, this woody debris is probably derived from a relatively thin Jurassic sedimentary unit not exposed at surface that overlies the lowest 50 m or so of basaltic andesite. This unit appears to wedge out to the north, possibly due to transgression by the fine-grained dolerite sill that overlies it to the west.

A similar plant-bearing sedimentary interbed may be present on the eastern side of Coal Hill, where a very large silicified log was found at a position stratigraphically overlying basaltic andesite (Sharples, 1994).

Jurassic amygdular lava (Ja)

Weathered outcrops in cuttings on South Cape Road (around 491 100 mE, 5 186 400 mN) are of an unusual, probable extrusive rock containing irregular rafts of mudstone and a rounded siliceous pebble. A thin section of the weathered rock shows a highly amygdular glassy lava, mainly composed of amygdules up to 3 mm across, filled with clear quartz and zeolite (Plate 1). The amygdules are contained in a groundmass of brown glass with almost-irresolvable microlites and rare microphenocrysts of euhedral tabular plagioclase. Southwards, this unit, possibly no more than a few metres thick, appears to be overlain by basaltic andesite, although the contact is not exposed. It is inferred to be underlain by the 68 m of basaltic andesite intercepted by nearby drill hole CA106. Despite its close association with basaltic andesite, the rock's petrographic aspect suggests a distinctly more felsic composition.

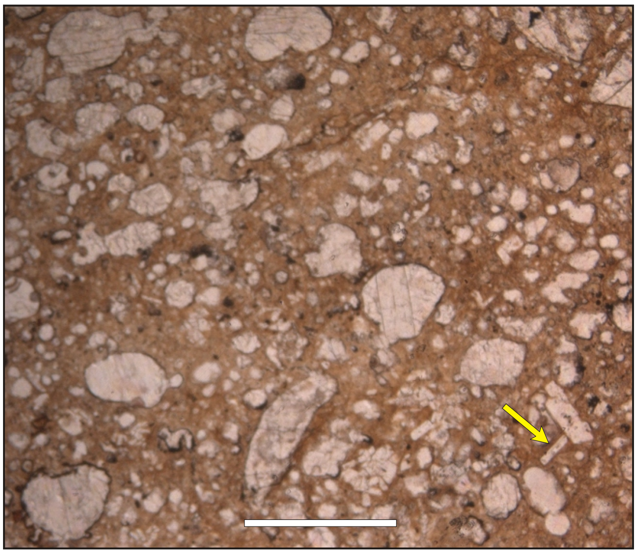

Plate 1

Photomicrograph of amygdular glassy lava exposed in a road cut on South Cape Road. Scale bar = 1 mm. Amygdules are filled with zeolite and quartz. Arrowed (lower right) is a euhedral feldspar microphenocryst.

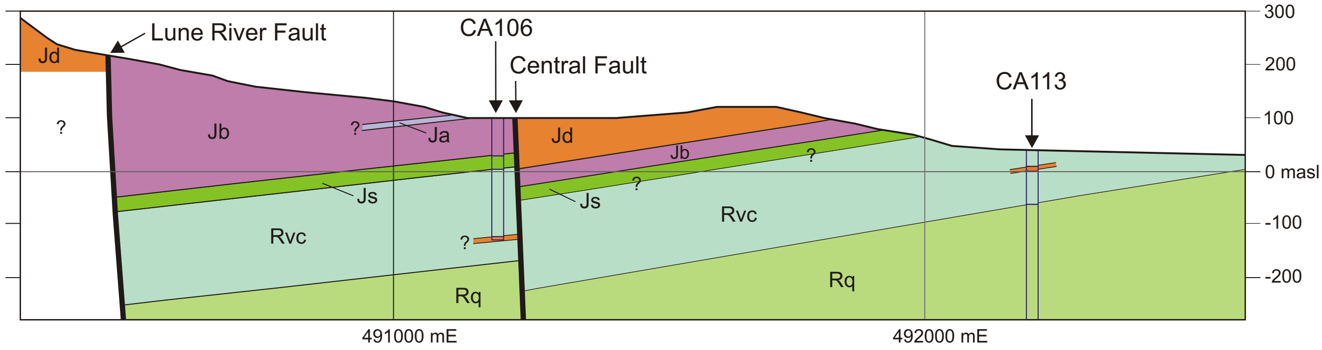

Figure 4

Cross section along section line A–B (see Figure 1 for location of line)

Jurassic dolerite (Jd)

Dolerite in the central part of the mapped area, bounded by a fault to the west, is very fine to medium-grained, with variably developed subvertical or steeply-dipping platy jointing, of variable trend, which causes the rock to break up into platy fragments. Thin (1–2 mm) chalcedony veins are locally present in the south of this area. This dolerite body is interpreted as a sill that has intruded at a level 40–50 m above the base of the basaltic andesite (fig. 4).

Poorly-sorted dolerite boulder deposits (TQd)

Part of the east–west ridge in the south of the area has recently been clear-felled. Ground traverses and road cuttings show that a boulder deposit dominated by dolerite, with minor fine-grained quartzarenite, in a matrix of stiff grey clay with sparse rounded to angular pebbles and cobbles of quartzarenite, mudstone, hornfels and micaceous siltstone occurs in this area. Dolerite boulders are up to three metres in size and weathered rinds preserved *in situ* are up to several centimetres thick. The dolerite boulders vary in grain size (fine to coarse) from boulder to boulder. The sedimentary clasts are a representative population of Parmeener Supergroup lithologies. The western end of this ridge is Jurassic dolerite bedrock, exposed in the road metal quarry on South Cape Road just west of the mapped area. The boundary between bedrock and the boulder deposit is poorly constrained, but no outcrop is seen on the eastern part of the ridge. This ridge is shown on previous geological maps as all dolerite, although some geophysical interpretations show sediments here because of the lack of aeromagnetic response (e.g. Perkins, 1982*b*).

The age of this deposit is uncertain. Drill hole CA107, two kilometres south of the mapped area, retrieved 57 m of discontinuous dolerite core intercalated with breccia, clay, sandstone and mudstone, probably from a similar boulder deposit. An early Eocene palynoflora was recovered from this hole (S. M. Forsyth, pers. comm.). The deposit intercepted by hole CA107 is evidently the erosional remnant of a Tertiary graben fill. The deposit on the ridge in the south of the mapped area may be of a similar age or alternatively may be Pleistocene till. The sharp-crested morphology of the ridge is suggestive of a lateral moraine. If a glacial deposit, its elevation (c. 100 m above sea level) would be unusually low in the Tasmanian context, but it is noteworthy that the Southern Ranges constitute a high snowfence only ten kilometres west of the mapped area.

Colluvium with Js-derived fragments (Qhcj)

A thick (1–2 m or more) mantle of gravelly clay comprises some of the slope deposits in the area, and unit Qhcj was mapped on the basis of the presence of silicified wood fragments. Also present are fragments of andesite, chalcedony, agate, mudstone and rare silicified fern. This material is derived, in part, from the plant-bearing Jurassic sedimentary rocks and indicates local or up-slope subcrop of that unit.

Structure

Regional structure

The mapped area lies at the western side of a graben whose bounding fault (the Lune River Fault) has an east-down throw of several hundred metres (Sharples, 1994). A smaller, east-side-down, N–S fault was mapped passing just east of drill hole CA106; east of this fault (hereafter called the Central Fault), a dolerite sill intrudes the older Jurassic sequence about 40 m above the base of the andesite (fig. 4). Two fault blocks divided by another newly mapped NW-trending cross-fault (fig. 2) occur west of the Central Fault. The northern block appears to contain thick Jurassic andesite without the dolerite sill (fig. 4). The southern block exposes coal measures and Jurassic andesite (seen in hole CA117 and in outcrop just west of CA119) overlain by a thick dolerite sill.

The few outcrops of sedimentary rocks seen in the course of the mapping were too massive or highly weathered for the attitude of bedding to be determined. Mapped boundaries east of the Central Fault indicate a gentle (c. 10°) dip to the W-SW, with a swing to a more W-NW direction in the south (seen in the trend of the ridge of Jb just west of CA110 and CA105). Dips from outcrop in the vicinity of the Ida Bay coal mine were reported to be 20–25° southwest (Bunny, 1976), but could not be confirmed by the current study. Dips of between 10° and 20° were recorded in the APM drill holes (fig. 2; Bunny, 1976) but no dips were recorded in the logs of the MPA drill holes. The elevations of the correlated coaly intervals decrease progressively southward along the CA102–CA114–CA113–CA110–CA105 line of drill holes (fig. 5). For example the 'D'seam is

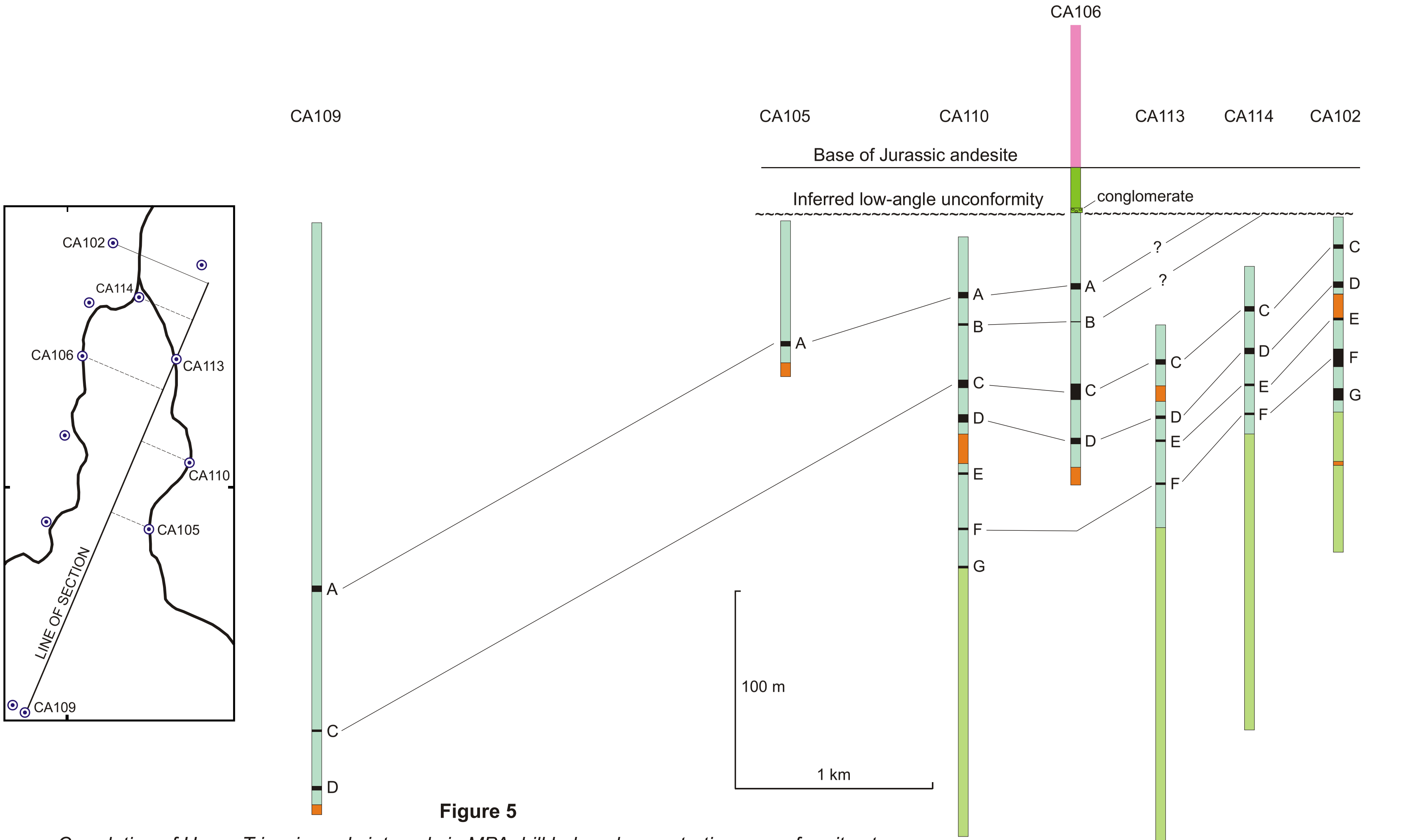

Figure 5

Correlation of Upper Triassic coaly intervals in MPA drill holes, demonstrating unconformity at or near the base of the Jurassic section. For stratigraphic legend see Figure 2.
Datum for drill holes CA105, CA110, CA106, CA113, CA114, and CA102 is the base of the Jurassic andesite; for all except CA106 this is projected from nearby outcrop (assuming 12° W–SW dip for CA102, CA113, and CA114, and 10° W dip for CA110 and CA105). Correlation of the coaly intervals (A–G) follows Perkins (1982b) and Perkins and Dunn (1984) except for CA105 (see text; fig. 6).

44 m above sea level in CA102 and 61 m below sea level in CA110, indicating a southerly component of dip of the coal measures of about 2°, but the true dip direction is poorly constrained from the drill hole data. Gravity modelling suggested a regional dip of about 4° west in the area between Donnellys Creek and the Lune River Fault (Leaman, *in* Perkins and Dunn, 1984). The evidence considered together suggests a dip of approximately 10° to 12° W or SW, east of the Central Fault, and possibly less to the west of the Central Fault (fig. 4).

Inferred unconformity at base of Jurassic

The seven 'coaly intervals' (A–G) in the MPA drill holes were correlated by Perkins (1982*b*) and Perkins and Dunn (1984) using lithostratigraphy and geophysical logs. With the exception of hole CA105 (which only intercepted one seam and was not wireline logged) the correlations of Perkins (1982*b*) and Perkins and Dunn (1984) appear to be internally consistent and are accepted here (fig. 5). The seam in hole CA105 was correlated by them with the 'D' seam, but correlation with the 'A' interval is better supported by the evidence. The thickness and internal stratigraphy of the seam in hole CA105 matches well with the 'A' interval in CA110 and CA106, as shown by lithostratigraphy, gamma ray and density logs (fig. 6). Perkins (1982*b*) and Perkins and Dunn (1984) relied partly on the position of minor dolerite sills in correlating the coaly intervals, and may have been led astray by dolerite in the holes in question.

The ~40 m.y. stratigraphic break between the Late Triassic coal measures and the Jurassic sediments is expressed as a gently angular, erosional unconformity. This is evident in Figure 5 where six drill holes are drawn with the base of the andesite as datum. In one of these holes (CA106) the base of the andesite was intercepted; the other five were collared below the base of the andesite and this horizon is projected from nearby outcrop. Northward overstep of the Triassic is shown by truncated coal measure sections in the north, for example in hole CA102 where 'A' and 'B' intervals are missing. The most southerly drill hole shown (CA109) has the greatest thickness of coal measures preserved above the 'A' interval.

Holes CA106 and CA110 have approximately equal thicknesses of coal measures preserved beneath the inferred unconformity and therefore lie roughly along the strike of the pre-Jurassic dip, assuming a planar unconformity and no movement on the Central Fault prior to the Jurassic. The coal measures have a dip of approximately 3° to the southwest, relative to the base of the andesite. The inferred, gently angular unconformity is probably located at the base of the conglomerate bed in CA106 (fig. 3, 5).

Conclusions

Geological mapping and an analysis of coal exploration drilling records show that the taxonomically and palaeoenvironmentally significant Jurassic flora of the Lune River area is hosted by an approximately 20 m thick succession of sandstone, mudstone and basal conglomerate that unconformably overlies Upper Triassic (Carnian) coal measures. The unconformity corresponds to a 3° regional southwesterly dip of the Triassic succession, relative to the Jurassic. The Jurassic sedimentary succession was recently dated by Bromfield *et al*. (2007) at 182 ± 4 Ma (Toarcian). The Jurassic sediments are conformably overlain by Jurassic basaltic andesite, which may be up to 250 m thick and whose stratigraphic top is unknown. The surface distribution of fossil wood, both here and at Coal Hill, suggests at least one fossiliferous sedimentary interbed within the andesite, indicating an hiatus between andesite flows sufficiently long for colonisation by trees. An interbed of highly amygdaloidal, probably felsic lava is also present within the andesite. The andesite is locally intruded by fine-grained dolerite. The regional dip of 10–15° W or SW is probably associated with Tertiary faulting that produced the narrow meridional graben in which the Jurassic sediments and extrusive rocks are now preserved.

Jurassic fossils may be present elsewhere within the graben, just beneath Jurassic basaltic andesite or in interbeds within it. The similar-aged Kirkpatrick Basalt of the Transantarctic Mountains is associated with well-preserved terrestrial invertebrates and fossil logs (Babcock *et al*., 2006). The major constraint to investigation of the Jurassic flora in southern Tasmania is the thick present-day vegetation and poor outcrop. Locally, forestry activities (clearfelling) provide a brief window of opportunity for investigation before regrowth renders access difficult once again.

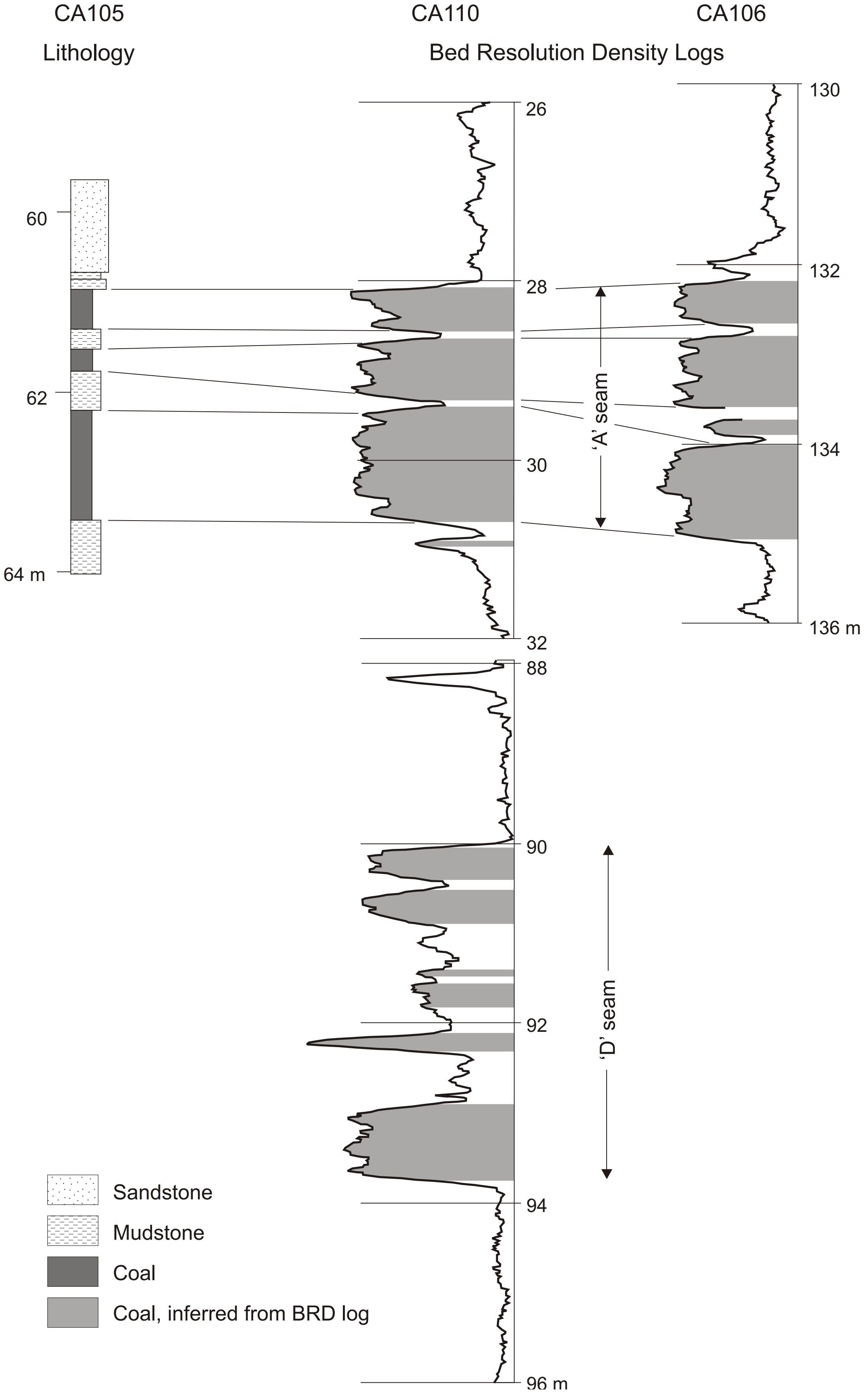

Figure 6

Proposed correlation of the 'A' seam using drill core lithological log from hole CA105 and Bed Resolution Density Logs from holes CA110 and CA106. Perkins (1982b) and Perkins and Dunn (1984) correlated the seam at 60.9–63.4 m in hole CA105 with the 'D' seam in hole CA110, but correlation with the 'A' seam is better supported by log comparisons.

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