# CHARLES DARWIN'S FIELD NOTES ON THE GEOLOGY OF HOBART TOWN — A MODERN APPRAISAL

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(with six text-figures and three plates)

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A transcription of unpublished field notes made by Charles Darwin details the observations and initial deductions he made on the geology of Hobart, Tasmania, and comments thereon place his work in a modern context. The field notes enable the routes of his excursions while in Hobart Town to be inferred in considerable detail and confirm earlier ideas about the site from which important fossils were collected. They also allow some appreciation of Darwin's style of geological study.

Darwin's field notes reveal that he thought of the possibility of the influence of earthquakes on Tertiary beds at Sandy Bay. Several of his ideas on the geology, shown by these notes, some of them also in his publications (e.g. the origin of a Tertiary freshwater limestone, and relative movement of the land and sea in the area), remain topics for further study.

His work in the Hobart area and his understanding of the geology of Van Diemen's Land were enhanced by contact with George Frankland, Surveyor-General, who had a long-term and systematic interest in the topic.

The notes formed the basis of a geological "Memo on Hobart Town" and, later, two publications, each work having a different purpose and emphasis. His work near Hobart did not produce enough information for the construction of a stratigraphic framework ("imperfect sketches of the Geology"). The imperfections, with other considerations, may have influenced him not to publish the memo which rendered subsequent publications less clear and less useful than had the memo been published. Darwin recognised the influence of glaciation on the Permian sedimentary rocks in the area but did not publish his observations and interpretation.

**Key Words: Charles Darwin, Hobart, Tasmania, geology, Frankland, Permian glaciation, Tertiary limestone, sea-level changes.**

## INTRODUCTION

Within three years of the return of HMS *Beagle* to England in 1836, Charles Darwin published a journal of his part in the voyage, a *Journal and Remarks* (Darwin 1839a – as Fitzroy 1839, Vol. III) and shortly thereafter separately as *Journal of Researches* ... (Darwin 1839b, 1845 and subsequently; the cover and spine bearing the words "*A naturalist's voyage round the World*", the title page, the words "*Journal of Researches etc.* ..."). This volume gave only a general account; the specialist aspects of Darwin's activities, e.g. geological and zoological, were published separately (for details see Nicholas & Nicholas 1989). The main vehicle of publication of his Australian geological observations and deductions was his *Geological Observations on the Volcanic Islands* (1844). The *Journal* ... and *Geological Observations* ... went through many editions and were subject to minor changes with time (Nicholas & Nicholas 1989: *X* and appendix 2).

Darwin visited Hobart Town early in February 1836, the town being one of the ports of call of HMS *Beagle* in its circumnavigation of the world under Captain FitzRoy. During an attempt 30 years ago to determine as accurately as possible the sites in the Hobart area from which Darwin had collected fossils, it was found that there existed in the University of Cambridge Library an unpublished "Memo on Hobart Town" by Darwin, which dealt largely with the geology of Hobart Town. This, made available by the Syndics of the University, revealed much more of Darwin's activities in and around Hobart than any published source and allowed the fossil sites to be identified, along with many of the places visited in his "pleasant little excursions" (Darwin 1839: 534) and, to some extent, when the excursions were made. The memo and a commentary thereon were published by Banks (1971). Subsequently, research by F. and J. Nicholas on Darwin's activities in Australia, enabled them to add a diary of Darwin's time in Hobart and to provide some details of his zoological observations (Nicholas & Nicholas 1989). They also made available to one of the authors (MRB) a microfilm of Darwin's field notes (DAR 40) and a transcription of them prepared by Mrs Jan Nicholas. This was subsequently refined somewhat by M.R. and D.M. Banks, particularly with respect to geological terms and phrases, so that most ambiguities are now removed.

With the field notes in hand, it became clear that some of the deductions made earlier about the routes were incorrect and that some parts of Darwin's routes had not been covered in the memo. Some interesting differences between his field notes and the memo will be considered later.

The aim of this paper is to publish, as far as possible, Darwin's field notes on the Hobart area, to interpret his observations in a modern context, to reconstruct more accurately than previously his "excursions" (figs 1–6), to consider the mode of Darwin's geological work in the area and to examine and possibly explain differences between his field notes , the memo, his *Journal of Researches* ... and his *Geological Observations on Volcanic Islands* ... with respect to the geology of Hobart Town. In attempting to achieve these aims, several problems raised by his observations were seen to be still unsolved, and attention is drawn to these.

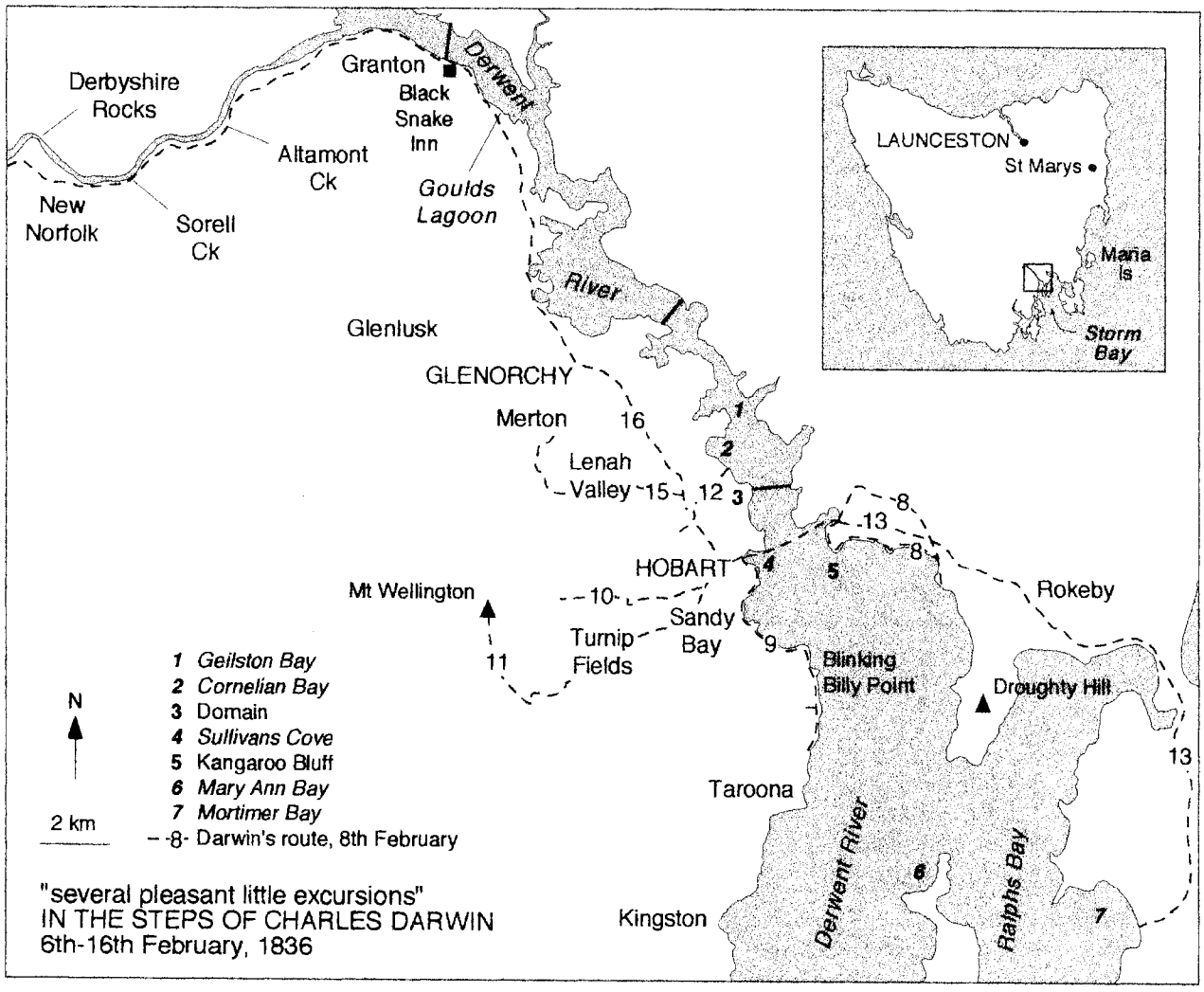


*FIG. 1 — A map of the Hobart region showing the areas visited by Darwin.*

## THE FIELD NOTES AND COMMENTARY THEREON

The field notes printed below are those transcribed from the Geological Field Notes in the Darwin Archive, Cambridge University Library, DAR 40 Hobart Geology (pl. 1), by J. Nicholas, with amendments by M.R. and D.M. Banks. The page numbers used here, e.g. *(1)* , are transcribed from a copy of the microfilm and may not be part of Darwin's original text. They are, however, retained and used for the convenience of the reader. Darwin's text is rendered in italic font, textual comments by the present authors thereon are given in plain text in square brackets. Particular points in Darwin's notes on which we provide a commentary, mostly geological, are indicated by use of the page number and a reference letter. Material from Darwin's field notes quoted in the body of our text is rendered in italics.

*(1*

*Feb 7th - In the town: Sandstones & Greenstones alternately appear, & perhaps in equal proportion — the Strata of Sandstone inclined, — In entrance of Harbour* 1A
*observed, a SW dip, not great.—Sandstone generally fine grained, particles of quartz with very little cement, — much fine grained laminated, & mottled pale red — alternate,* [*sandy* inserted above] *clay Shale — There are many layers of very thin black carbonaceous matter & some Carbonaceous Shale.—*
*Some Sandstone ferruginous*
*I am doubtful whether stratification generally = -tal; on account of current cleavage:* 1B
*Very general resemblance to Sydney — Here* 1C
*Trappean rocks far prevalent, — Basaltic Plateaus columnar — near mouth of Harbour. —* 1D
*Greenstone, generally well character[ised?] — coarse grained — even containing large Crysts of Hornblende — in Government domain —* 1E
*a* [*Granitic* deleted] *Syenitic Greenstone — Only found one plane of contact, when* [or *where*] *some sandy shale & ferruginous* [inserted] *sandstone were in close* 1F
*proximity to a decomposing Greenstone — The strata were highly inclined & dipped from the mass at* < [angle sign]

(See figure 2 for some details of localities near the Town.)

### Commentary

1A: The *entrance of Harbour* probably refers to the entrance to the Derwent River. Sedimentary rocks at and to the north of Cape Direction, at the mouth of the Derwent (fig.1), dip at a low angle to the southwest, and this situation could be seen from a vessel moving up Storm Bay and the river.

**1B**: = *-tal* is a short form of "horizontal". Darwin used the

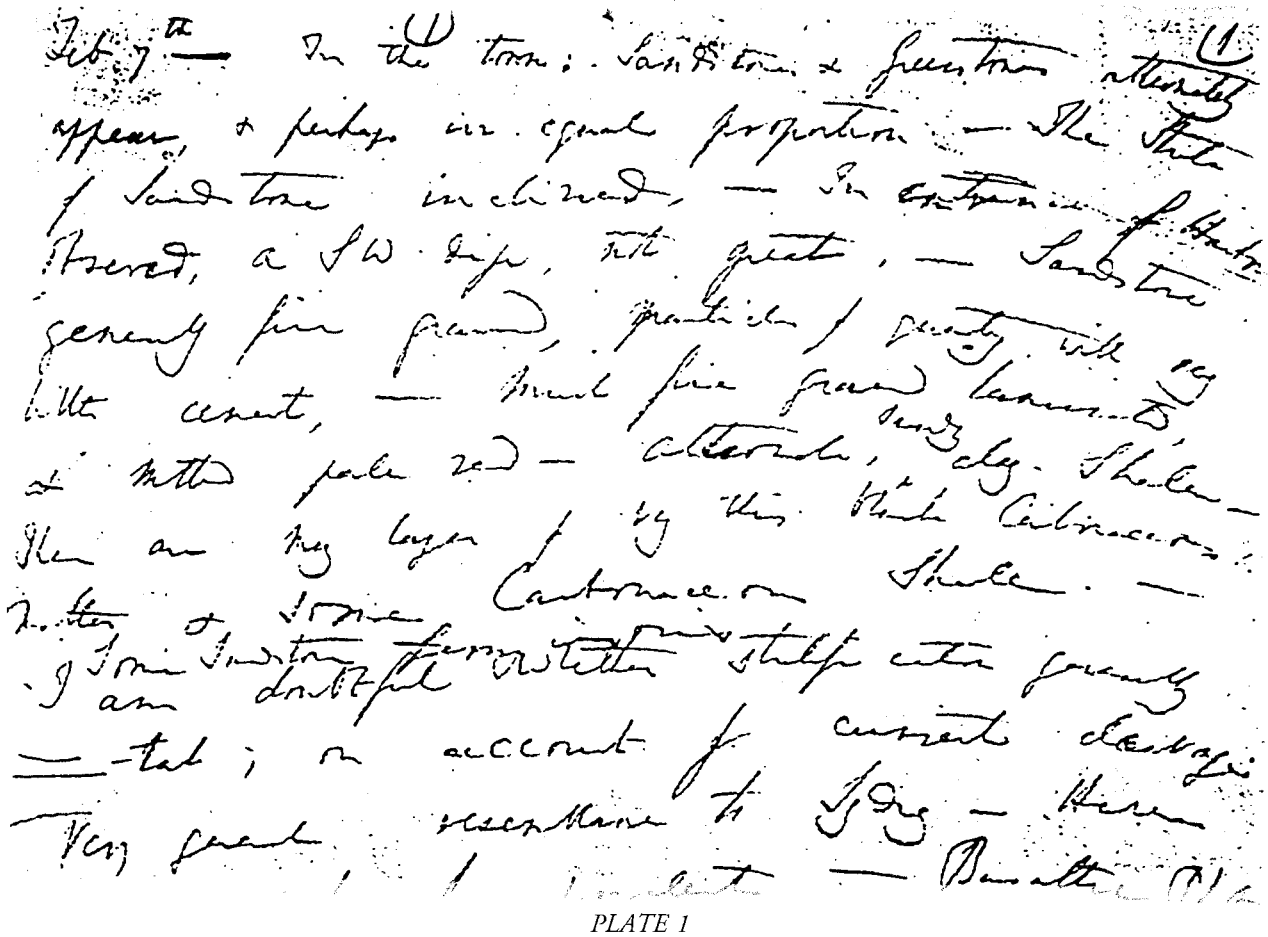

*PLATE 1*
*Part of the first page of Darwin's field notes at about 5/6 original size.*

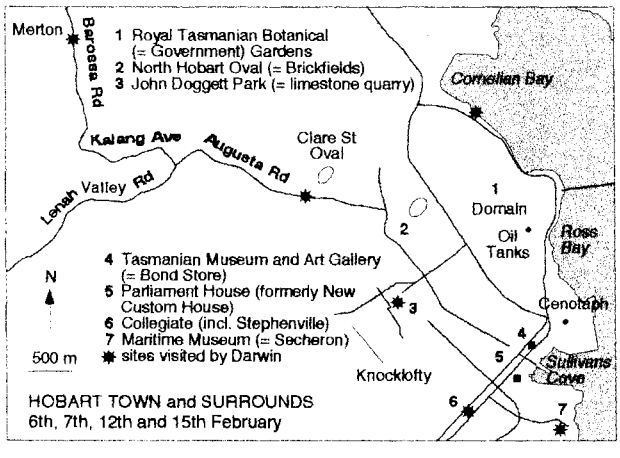


*FIG. 2 — A map of the Hobart and Glenorchy areas, showing the areas visited by Darwin on 7, 12 and 15 February 1836.*

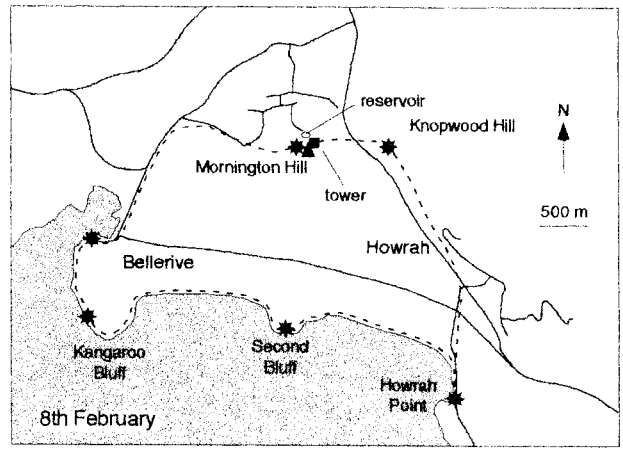


*FIG. 3 — A map of the eastern shore of the Derwent showing the areas visited by Darwin on 8 February 1836.*

term *current cleavage* in reference to what is now called cross-bedding.

**1C**: The sandstones Darwin saw in the neighbourhood of the town do indeed resemble the Hawkesbury Sandstone, so prominent around Sydney.

**1D**: Columnar jointing in the dolerite (*Basaltic Plateau*) is a prominent feature seen from a ship near the *mouth of Harbour* (i.e. Storm Bay): e.g. Tasman Island, Cape Pillar, Cape Raoul on the eastern shore and, on the western shore, Fluted Cape and Cape Queen Elizabeth. Darwin noted on p. 5 of his memo (Banks 1971: 7) that near Port Arthur he saw white horizontal strata faulted against greenstone (dolerite) and capped by greenstone. The site may have been close to Haines Bluff, at Cape Raoul, or in the small embayment west of Tunnel Bay.

**1E**: In these field notes and in his memo, Darwin referred consistently (except for a note on the back of p. 21 — Banks 1971: 13) and incorrectly, to the dark minerals (pyroxenes)

in the dolerite as *Hornblende*. The exception was a reference to hypersthene, an orthopyroxene; which does occur in the dolerite (Hergt & McDougall 1989: 378). Dolerite in the Domain approaches a granophyre in composition and texture and, in the state of knowledge at the time, could appropriately have been called *syenitic Greenstone*.

1F: This is the nonconformable contact of Tertiary claystone and ferruginous sandstone on the ancient landscape of weathered coarse-grained dolerite (*a decomposing Greenstone*) exposed on the shoreline for about 300 m southeast of Cornelian Bay Beach (fig. 2), the area referred to as "Pipeclay Bluff" by Johnston (1882). The Tertiary beds dip at up to more than 20° towards the river (Johnston 1882: fig. 4 [1]). Some beds of sandstone are cross-bedded. One lamina in a cross-bedded or slumped unit can be observed dipping at 58° towards the river.

*2)*
*of 68 or 70 — The Shale, judging from fragments*
*altered into a Porcelain rock & the Sandstone* 2A
*rendered much harder & compact. —*
*Thus origin of some of the Trappean rock*
*explained = Conical hills over whole country* 2B
*Fossil shells in district of Launceston.—* 2C
---
*Walking Coast to South on E side of ferry; Greenstones; then* 2D
*in close neighbourhood, a quite white — pottery-like*
*very fine grained Sandstone, — in parts rather more Sandy*
*in others frequently more Aluminous or porcelain like*
*((3447:48) Vide description*
*is crossed by many veins ferruginous, which project upwards* 2E
*passes into & overlies a blueish rock, possessing more*
*of the character of Clay Slate. — These two contain*
*few impressions of Terebratula & a very few rounded*
*pebbles of Quartz rock — Siliceous stones, like what will*
*be described & one volcanic looking pebble.—* 2F
*Strata dip at small* < [angle sign] *Easterly. — I believe*
*but am not sure, this is coeval with General* 2G
*Sandstone. — (N B observed flat at high*
*water line, I remember it is same at Chiloe & Port* 2H
*Famine)* [*New Zealand* inserted ].— *There appears to have*
*been a*
*general rise —Shells on sides in beds in very many*
*parts — get deep water in Coves; & similarity of productions* 2I

(See figure 3 for localities on the *#E side of the ferry.*)

## Commentary

**2A**: The shale and sandstone are hardened in some places by cementation by calcium carbonate or, in others, by silica derived from the decomposition of the dolerite.

**2B**: Darwin may have been told of the *conical hills* by Frankland; such hills (possibly assumed by Darwin to be volcanoes) are to be found particularly in the Midlands of Tasmania; some are capped by basalt, most by dolerite.

**2C**: The reference to the *Fossil shells in district of Launceston* must be based on information Darwin had received from George Frankland, the Surveyor-General of Van Diemen's Land (VDL) at the time of Darwin's visit (see below for more detail). This inference suggests that Darwin met Frankland within a day or so of the arrival of the *Beagle* as these comments precede his notes on his walk on the eastern shore on Monday, 8 February.

**2D**: In walking west along the foreshore from the ferry wharf, Darwin walked from dolerite over a contact onto the overlying Fern Tree Mudstone. The mudstone above the dolerite sheet has been contact metamorphosed. To the south, the broad shelves of the rock are blanched white by modern weathering processes, and some have a porcellanous appearance. Some beds are sandy. Local stratigraphic names (e.g. Fern Tree Mudstone) were not applied to rock units in the Hobart area until the 20th century. The relationships of local rock units named in this text are dealt with by Banks & Hale (1958) and Leaman (1976).

"*3447:48*" are specimen numbers.

**2E**: *ferruginous* joint fillings are common in the Fern Tree Mudstone along the foreshore, particularly close to Bellerive Bluff. Many resist erosion and form ridges. The *blueish* colour noted by Darwin is normal in the fresh mudstone.

**2F**: *volcanic looking pebble*, a dropstone in the Fern Tree Mudstone, may have been a Cambrian volcanic rock such as occurs now in western Tasmania, a Devonian volcanic rock originally from the St Marys area in northeastern Tasmania or a fine- to medium-grained intrusive rock such as occurs widely in northeastern and western Tasmania. Pebbles of other compositions (especially siliceous) are more common. The fossils (brachiopods) are rare and restricted to one or two beds only (the sites are shown by Leaman 1972).

Note that, on the following line, Darwin attributed an easterly dip to the mudstone. It has, in fact, a westerly dip of 1° to 3° overall.

**2G**: The Fern Tree Mudstone Darwin saw on the shore platform at Bellerive is Permian, the *General Sandstone* is Triassic, i.e. they are not, as he supposed, *coeval.* " Permian" and "Triassic" were not terms used by Darwin.

**2H**: Darwin correctly observed that there is a relatively flat zone at and just above high-water mark, a feature common in shore platforms developed in Permian sedimentary rocks in southeastern Tasmania. Port Famine is in Tierra del Fuego.

**2I**: Many of the embayments along the shores of the Derwent River are deep e.g. Sullivans Cove (see also comment 3A). It may be that, as Darwin walked around the shore near Kangaroo Bluff, he looked across the river, noted ships anchored in Sullivans Cove and realised that there was deep water close to the shore, not a feature of every port. It is likely that the *productions* referred to the marine flora and fauna.

*between here & Australia, & soundings in* *(3*
*channel as if Subsidence. —* 3A
*Water is said to be retiring. — Earthquakes?*
---
*Beyond these white beds we find ordinary*
*Sandstones with current cleavage & then* 3B
*again appears The greenstone —* 3C
---
*Ascending the hills, some hundred ft*
*behind the coast, we met with common*
*Greenstone but the commonest rock*
*is a Greenstone* [above this (*3453*)] *—Syenite — On the* 3D
*summit there were gently inclined Strata*
*of altered rocks —Siliceous white, &* 3E
*blue — Siliceo-porcelain rocks* 3F
*(3449: 3450)*
*& 3451 — Greenstone (?) poss. belonging to the*
*axis of the hill?* [last nine words encircled] 3G
*I must believe from these came the*
*pebbles in the lower beds; otherwise* 3H
*I should think the same only slightly*

Commentary

**3A**: The deep water noted earlier may indicate subsidence (presumably due to tectonic causes), as suggested by Darwin, or, at least in part (as later work has suggested), rise in sea level.

**3B**: The *Sandstones with current cleavage* outcrop in fine sections at Second Bluff.

**3C**: *The greenstone* outcrops on the shoreline at Howrah. At this point Darwin seems to have turned inland, possibly because of the state of the tide, possibly to ensure that he reached the ferry in time for a return trip. "Predicted" high tide was at about 12.30 p.m. The trip across in the morning was probably enjoyable, as the air temperature at 9 a.m. was about 13°C with a light, variable breeze (FitzRoy, *Narrative*, appendix to Volume II: 51–52). It should, perhaps, be noted that Darwin not only looked at the geology but also at animals and plants. He is known to have collected shoreline animals as well as rocks.

**3D**: Granophyre occurs on Knopwood Hill NNE of Howrah and could well have been called *Syenite* by Darwin. He probably traversed the western slope of the spur leading to Knopwood Hill.

**3E**: The *gently inclined strata* belong to the Fern Tree Mudstone and outcrop on Knopwood Hill.

**3F**: On the southwest flank of Knopwood Hill the grade of contact metamorphism of the Fern Tree Mudstone is relatively high; the rock looks porcellanous.

**3G**: Near the summit of Knopwood Hill, dolerite forms the axis of the hill and is thought to be part of a feeder. There are irregular plug-like outcrops of dolerite. The western spur of the Hill is capped by siltstone and the contact between dolerite and siltstone is now visible on the northern slope of the hill in the face of Mornington Quarry.

**3H**: It seems that the *volcanic looking pebbles* (see Comment 2F) looked like the dolerite on parts of Knopwood Hill which Darwin would have traversed on his way back to the ferry via Mornington Hill (see Comment 4A); this suggests that the pebbles seen by Darwin were intermediate or mafic plutonic rocks. The *greenstone* at the *axis of the hill* is Jurassic dolerite and could not have been the source of the pebbles in the Permian mudstone.

*4)*

*Metamorphised* [sic].— *On a neighbouring & higher hill, whole rock a dull red ordinary Sandstone — Do the hard rocks belong to a distinct formation?* 4A

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*Tuesday 10th* [*sic:* should be *9th*.] *Walked coast South of town. — Greenstones; generally globular concentric structure:* 4B *in close connection with inclined strata, (but not inclined by this rock) of Sandstone Conglomerate,* 4C *containing numerous pebbles of the underlying GreenStone; the White Chert with Organic impressions &c &c:* 4D [*Alternately* deleted] *covered with softish Sandstones; which however in parts, are firmer & whiter* 4E *& are quarried — associated with layers of slightly indurated Clayey beds & other ferruginous ones: — perhaps inclination from original* 4F *deposition: — Many of the white pebbles strictly resemble the* [*Porcelain* inserted ] *beds of yesterday: —* 4G *Still travelling onwards, preponderant quantity*

(See figure 4 for route *South of Town*.)

Commentary

**4A**: As Darwin walked from Knopwood Hill back towards the ferry he could well have seen red siltstone in the saddle between Knopwood Hill and Mornington Hill, on the higher slopes and top of which *dull red ... sandstone* is common. The colour is well displayed in a quarry now cut in these slopes. The observations, revealed in the field notes (i.e. on Second Bluff, Howrah, Knopwood Hill and Mornington Hill), make it clear that the route up Flagstaff Hill, as interpreted by Banks (1971: 10) from the memo, was incorrect.

**4B**: the *globular concentric structure* is onion-skin (spheroidal) weathering in the dolerite that outcrops along the shoreline around Battery Point.

**4C**: The rocks described here outcrop in low cliffs behind what is now Marieville Esplanade, but now are largely concealed by vegetation and buildings. Darwin correctly considered them not to have been tilted by the greenstone.

**4D**: *White Chert with Organic impressions* which *strictly resemble the ... beds of yesterday* (4G) may have been pieces of Fern Tree Mudstone with trace fossils (fossil burrows and faecal pellets), as seen by Darwin on the Bellerive foreshore, derived from outcrops, now eroded, from above the dolerite on Battery Point or from the upthrown block of the fault cutting the University site just above Churchill Avenue. Had Darwin seen fossil shells or fossil plants it is likely that he would have used those terms rather than the general term *organic impressions*. (See Comments 7 F, G, and H.)

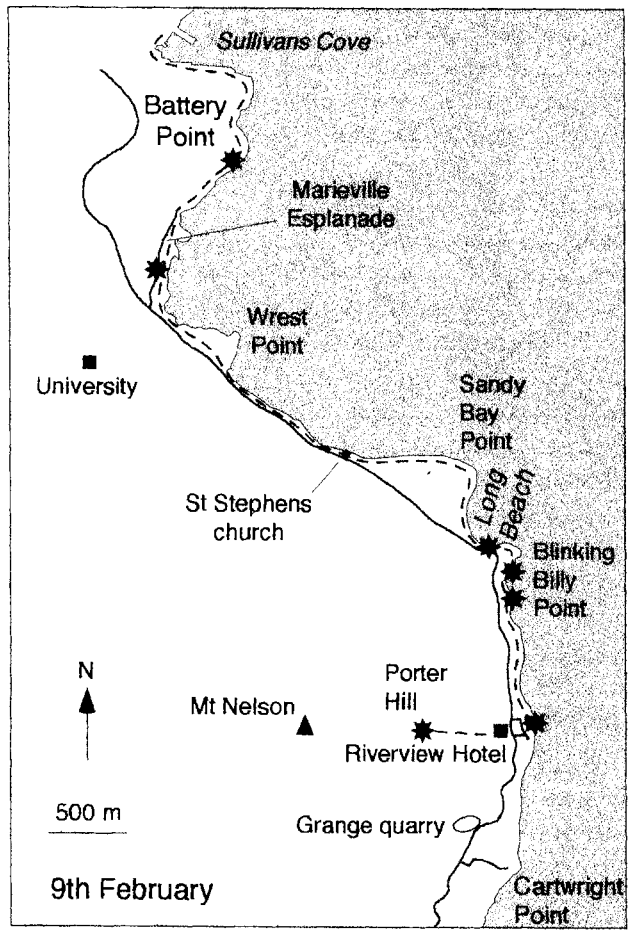



*FIG. 4 — A map of the western shore showing the areas visited by Darwin on 9 February 1836.*

4E: The *softish Sandstones ... quarried* are likely to have been Tertiary, though we know of no record of their having been quarried.
4F: The inclination of the clayey beds, as noted by Darwin, was shown by Johnston (1882) as due to faulting, the fault being close to the southwestern end of the cliffs behind Marieville Esplanade.
4G: Probably Fern Tree Mudstone (see Comment 4D) but may have been Tertiary.

*of Greenstone* [two words deleted] *generally, what I (5* 5A
*call Syenitic like 3453)* [*like 3453* encircled]. — *We then meet* 5B
*with some white softened, rather thinly stratified*
*mass of Aluminous Sandstone: (Somewhat*
*like those of Chiloe) which rested on a*
*Sandstone : & it contained some darkish* 5C
*impure clayey beds — on these rested*
*a stratum of compact (few minute* [underlined twice]
*vesicular cavities) 3467* [number encircled] *blackish Basalt,*
*containing*
*numerous atoms of red Olivine.—* 5D
*(NB in the white beds, there was one*
*stratum brecciated with pieces of same* 5E
*kind with itself: would not these cases*
*be produced by violent Earthquake beneath*
*the spot at time of deposition.)*
*This basalt had a greenish tinge*
*externally: it was separated from a*
*superior stratum of similar kind, by*

## Commentary

5A: The *greenstone* was probably seen at Wrest Point and along the shore south to Manning Avenue, where large blocks of dolerite outcrop on the shoreline. Darwin did not realise (probably could not have realised) that the blocks are not bedrock but large boulders derived from the dolerite on Mt Nelson by a rock slide or slides (Stevenson 1971: 115-117).
5B: It is surprising that Darwin made no clear mention of the sandstone (Triassic) in low cliffs along the shoreline at Red Chapel Ave, which dips north at about 30°.
5C: The *white, softened, thinly stratified ... aluminous sandstone* probably refers to Tertiary beds like those now exposed in the cuttings on the Channel Highway at Long Beach (Banks 1971: 6), but cuttings are unlikely to have been present early in 1836. Work on upgrading the pre-existing cart track to a road started in August 1835 (Lord 1998: 9). However, reference to the drawing of this exposure in Johnston (1882: fig.1) and consideration of the topography, suggests the possibility of outcrops in low cliffs behind the shore, which Darwin could have seen. The identity of the *Sandstone* on which this sequence is said to rest is not clear; it may have been (a) the Triassic sandstone in the cliffs under St Stephens Church, though this outcrop is distant from any present outcrop of the Tertiary rocks, (b) the Permian sandstone and mudstone exposed in the cutting beside Sandy Bay Road between Mt St Canice and Fisher Avenues. Johnston (1882) showed Tertiary beds resting against and on the rocks near Fisher Avenue. The contact was still visible 50 years ago.
5D: The *Basalt* (Tertiary) was described in detail by Spry (1955) and shown to be about 26 million years old by Sutherland & Wellman (1986: 84).
5E: *brecciated with pieces of the same.* Some of the beds in the outcrop contain angular blocks of white mudstones up to 20 mm long, some friable, some compact. Darwin suggested an origin involving disturbance of a slope underlain by mudstone by tremors associated with earthquakes. He did not remark on the boulder beds at the base of the Tertiary sequence here, as revealed by more recent road cuttings, the boulders being of Permian mudstone (Johnston 1882). Johnston regarded these beds as resulting from cliff collapse due to wave undercutting of cliffs of the Permian siltstone (his "Porter Hill Beds" which crop out just to the north). In 1947, Professor S.W. Carey explained such occurrences to Geology I students in Darwin's terms, but such an origin was not published until 1955 (Spry 1955).

***6)*** *(3469)*
*angular bed of Wacke or vesicular Clay* 6A
*or Tufa for it wore all these appearances*
*it contained balls and masses of true Basalt.*
*I found by tracing structure it is decomposed*
*scoria, clearly separating two streams : These*
*& the lower Sandstone beds all dipped S*
*at angle of about 30°. — following for a few*
*100 yards the Basaltic beach, came to*
*cliffs entirely composed of cemented fragments,* 6B
*very vesicular, & possess vesicular cavities*
*linear following sweeping lines, lined with*
*green matter (3468).— Amidst fragments* [word off page?]
*of red jaspery & Porcelain rock. — This flat* 6C
*point, now formed of such confused, vesicular*
*rocks probably old Crater, now no trace of*
*do — This is the first of the great* 6D
*Basaltic columnar streams which we saw*
*at the mouth.— Directly beyond this*
*point, & near, we again had, the Greenstone*

## Commentary

6A: *Wacke* was probably used by Darwin here in the sense of Lyell (1830) — i.e. "a rock nearly allied to basalt, of which it may be regarded as a soft and earthy variety"; *Tufa* was defined by Lyell as " a volcanic rock of earthy texture, seldom very compact, and composed of an agglutination of fragments of scoriae and loose matter ejected from a volcano". These definitions occur in the Glossary at the end of Volume 1 of Lyell's *Principles of Geology* (1830), which Darwin had on the *Beagle.*
6B: This description refers to breccias and scoria exposed in the cliffs at the southern end of the beach immediately south of Blinking Billy Point.
6C: The *red jaspery & Porcelain rock* probably refers to chalcedonic veins, noted by Spry (1955).
6D: The reasoning behind the statement *This ... at the mouth* (i.e. at the mouth of Storm Bay) is not clear, and the conclusion is incorrect — the crater and the lava associated with it are Tertiary, the *Basaltic columnar streams* are thick intrusive sheets of Jurassic dolerite. Darwin may have noted the similarity of the columns in the dolerite to the prismatic cooling columns in volcanic rocks well known to European observers at places such as Fingals Cave, Giants Causeway, Auvergne and on several Mediterranean islands, without appreciating the difference in scale (Leaman 1999). Lyell mentioned such columns under "Basalt" in his Glossary (1830) and figured them in a drawing of the Isle of Cyclops in Volume 3 (1833), which Darwin received while in South America.

*its appearance externally is quite like that of (7*
*Granite — indeed I believe it is such, but* 7A
*imperfect (V [Vide?] 3455) — Beyond this we* 7B
*have strata full of organic remains, which*
*will be described — Beyond this immediately*
*the Granite, which continues for some miles*
*along the Coast.— The organic beds appear* 7C
*here the lowest — The Volcano has burst* 7D
*through these. — It may be suspected this*
*Granite has been protruded subsequent to* 7D
*the Organic beds. = These latter consist of*
*gently inclined Strata of 3 varieties and their*
*intermediate variations — a white cherty rock*
*with grains of quartz.* 7E
*(3457) — a blue, slightly Calcareous, siliceous*
*Clay* [inserted above – *not laminated*] *Slate* [erasure]
*(3458) & a brown rather*
*softer do* [ditto?] *(3459)— These two latter in places*
*are softer and thinly laminated — all three*
*are composed of impressions of Betepora & other* 7F
*Coralline (Mem. Limestone of Argyl) & some few* 7G
*Terebratulae. I saw impressions of one Univalve & a large* 7H
*Bivalve —*

## Commentary

7A: The *granitic* appearance of the greenstone which is coarse-grained, is due to differential alteration of the minerals in the coarse-grained dolerite, as noted by Banks (1971: 10). In the memo, Darwin reported "mica" in the rock. He had noted, probably during shipboard examination of his specimen (3455), very shiny, dark crystal faces which he identified as mica, a common component of granite. The shiny faces probably belong to orthopyroxene showing schiller structure, a structure not recognised until 1885 (Judd 1885), which Darwin could not have detected with the equipment available to him in 1836.

7B: The fossiliferous beds (*strata full of organic remains*) outcrop over only 200 m of shore platform and fringing cliffs centred on a point 476N on the *TAROONA* 1: 25 000 Map Sheet. Fossils are abundant and beautifully preserved.

7C: The dolerite (*granite*) does not *continue for some miles along the coast.* It extends to Cartwright Creek, just over 0.8 km south of the outcrop of the fossiliferous beds. Darwin clearly did not walk as far as Cartwright Point, just beyond the creek mouth as, from there, he would have seen cliffs of bedded Tertiary sedimentary rocks and would hardly have failed to mention them. From the dolerite point immediately south of the fossiliferous beds, he may well have looked south along the coast or even walked as far south as the point immediately south of the mouth of Riverview Rivulet and then looked south. As far as he could have seen, the cliffs are dolerite. Just beyond this southerly point, there is a break in the shore platform which would have been well and truly awash at high tide and passable only with difficulty and discomfort. The tidal "predictions" provided by Dr Bill Mitchell, National Tidal Institute, Flinders University, Adelaide, indicate that the tide would have been high early in the afternoon (about 2 pm) and the meteorological record in the appendix to FitzRoy's *Narrative* ... (1839) shows a noon air temperature of 17°C and a fresh (i.e. >5 knot) southeasterly breeze (a sea breeze) blowing at noon, which would have made the passage more difficult and uncomfortable. It is possible that Darwin took advantage of the gap in the cliff-line provided by the mouth of Riverview Rivulet to leave the shoreline, whence he could have ascended the Rivulet to Porter Hill.

7D: Darwin expressed here the correct age relationship of the fossiliferous beds to the dolerite, i.e. the dolerite subsequent to the sedimentary rocks.

7E: The rocks present are calcareous mudstone with some beds of limestone, mudstone, some of which weathers brown, some white or almost so (the *white cherty rock*). The rocks are correlated with the Bundella Mudstone.

7F: *Betepora* should be *Retepora* (a bryozoan).

7G: The bracketed insertion seems to be a note that the fossils seen here reminded Darwin of the fossils in the Carboniferous limestones of Argyll, which he may have seen during excursions led by Professor Robert Jameson in connection with the Wernerian Society of Edinburgh (Desmond & Moore 1991: 42) or during his travels in Scotland after leaving Edinburgh in April 1827 (ibid.: 45). The Carboniferous limestones of Argyll occur near Machrihanish (Johnstone 1966: 70).

7H: *Terebratulae* was the term applied by Darwin to any of the several kinds of fossil brachiopods he saw near Hobart. Gasteropods (*Univalve*) and large *Bivalves*, of the genus *Eurydesma*, occur in the sedimentary rocks on the shoreline.

***8)***

*Some of the Corallines, pretty silicified,— a* [? @] 8A
*most few pebbles of quartz, blue siliceous Sandstone* 8B
*& a glassy micaceous Clay Slate. — This is* 8C
*evidently same as Beds of Yesterday; there*
*are Specimens from near Launceston identical* 8D
*(3470 3471). — The neighbouring mountain,* 8E
*is in its lower parts thus constituted;*
*these beds are covered to the thickness*
*of some hundred feet, with rather siliceous*
*reddish, yellow, or white Sandstone, with granules*
*of quartz (3466), — There however at summit*
[to the right of these lines a broad arrow >]
*a pass of dubious Greenstone (3456) & lower*
*down another of Basalt. —*
*Thus we see, Retepora strata, with their*
*Sandstone, have been preceded judging by pebbles by* 8F
*Siliceous Sandstones, (which rocks perhaps were*
*those I yesterday examined) — have been*
*probably upheaved by the Syenitic Greenstones, otherwise*
*in such close proximity, there would have been pebbles.* 8G
*These two distinct formations have been*

## Commentary

8A: *silicified* bryozoans have not subsequently been reported from this site and recent close examination failed to disclose any. Within, but close to the landward edge of the rock platform washed by waves, the bryozoans, particularly the fenestellids, stand out from the general level of the outcrop, many of them pale in colour, and might be thought to be silicified. The fenestellids were referred to as *Retepora* by Darwin. They react with dilute hydrochloric acid, indicating the presence of calcium carbonate.

8B: Dark grey sandstone crops out close to the fault at the southern end of the exposure but *blue siliceous Sandstone* is likely to refer to pebbles of this nature, now regarded as dropstones derived from earlier Palaeozoic or Precambrian outcrops in western Tasmania.

8C: The *glassy micaceous Clay Slate* was probably a dropstone of Precambrian schist or of micaceous phyllite of early Palaeozoic age.

**8D**: It seems likely that Darwin had seen specimens in Frankland's collection.
**8E**: *The neighbouring mountain* is Porter Hill. The *Sandstone, with granules* is Member A of the Malbina Formation which outcrops on Porter Hill and is intruded by dolerite near the top of the hill, the dolerite being fine-grained (*Basalt*) at the contact and somewhat coarser at the summit, beyond which is a low saddle separating Porter Hill from the main mass of Mt Nelson.

This section of the field notes shows that Darwin climbed Porter Hill, an activity not hinted at in the memo or in his published works. The section also places any location other than the shoreline below Porter Hill out of contention as the site from which Darwin collected the type specimen of *Stenopora tasmaniensis* Lonsdale (cf. Banks 1971: 9).
**8F**: *pebbles* — dropstones of older rocks, including those of earlier Palaeozoic siliceous sandstone.
**8G**: Darwin correctly pointed out that, had the greenstone been older than the sandstone, pebbles of greenstone might have been expected in the sandstone.

*succeeded by other Sandstones, Clays & Shales* (9
*which alternate with Lavas— & partly amongst*
*which most of the Freestone will be*
*classed [?] —Thus we have sandstone of*
*three distinct ages. — perhaps the most* 9A
*modern in mere fringes. —*

---

*A good deal of Resemblance with*
*New Zealand & with Australia.*

---

*as in the Sandstone Conglomerate (most modern) there*
[opposite broad arrow on p.8]
*was white freestone, perhaps some such occurs in*
*parts of this series, & the Sandstone in the*
*town must remain of doubtful age.*

---

*NB. this most modern Sandstone was crossed by* 9B
*ferruginous veins in nests, like older series*

---

*I found shells in such quantities 10–30 & 40*
*ft above high water all along fields* [?]; *I am* 9C
*tempted to believe upheaval. — Comminuted, difficult*
*to decide* [next five words inserted possibly in pencil]
*not having visited wild parts.*
*Agriculture. — Parts in heaps —*
*Yet very much spread* — [ symbol here like "Z" with vertical
middle limb] *on small*
*scale, few pebbles on upper surfaces. —*

## Commentary

**9A**: Darwin seems to have decided on the correct number of sandstones, i.e. three: one Permian (on Porter Hill), one Triassic (*in the town*), one Tertiary (*most modern*), but he was unable to assign the correct relative age to all outcrops of the older sandstones.
**9B**: *nests* — Darwin saw the *most modern sandstone* (*mere fringes*) at Cornelian Bay, Marieville Esplanade and Long Beach. In the gravels on the foreshore at Cornelian Bay, beneath cliffs of Tertiary sandstone, siltstone and claystone, ovoid bodies occur which have a structure like that of wasps' nests. in places the cavities in the *nests* can be seen to be partly filled with ferruginous clastic sediment. The cavities are delineated by "septa" of white and pink to reddish calcium carbonate. The bodies probably originated as septarian nodules in the Tertiary sediments. Darwin seems to have been likening the *nests* and possibly the network of ferruginous veins present in places, to the pattern of ferruginous veins seen in the Fern Tree Mudstone on 8 February.
**9C**: Darwin showed an inclination to accept the occurrence of shell beds 3–13 m above high water mark as due to uplift but was clearly uncertain. Beds within this range of heights extend considerable distances between Cornelian Bay and the Royal Tasmanian Botanical Gardens on the eastern slope of the "Government domain".

***10)***
*Strata with impressions, half-Slate, Chert Sandstone* 10A
*— Limestone.— capped by Sandstone, reddish*
[underlined beginning of word off page]
*did not see Stratification: — up to perhaps*
*12-1400 ft — rest Greenstone of one character*
*Crystals of Hornblende — columnar — large* 10B
*flat surface — grand extensive formation* 10C
*many* [*ditto* inserted] *mountains — enormous blocks, numer ...* 10D

(See map, figure 5.)

## Commentary

**10A**: This is a very brief description of the rocks seen during the ascent of Mt Wellington (fig. 5: Routes 10 and 11 February). In the discussion of the route in the paper on the memo (Banks 1971: Comment L, p. 7) mention was made of the possibility that he used the coach road, but this was not opened until 1869 (de Quincey 1987: 55). It is known from Darwin's diary that he climbed the southern side of the mountain. His most likely route would be to have followed the early part of the Bridle "Road" from Hobart Town to the Huon River, i.e. from Fitzroy Gardens or Stoney Steps along the valley of Wellington (now Sandy Bay) Rivulet to Halls Saddle close to the present junction of Chimney Pot Hill Road and the Huon Road. If he traversed the northern side of the valley, he would have travelled over the rock types noted (e.g. *strata with impressions, limestone* at Turnip Fields). Darwin's assistant, Syms Covington, described the route as "very intricate roads" (Covington 1831–36).

Darwin's description of this section is rather fuller (but more dispersed) in his memo.

We suspect that it was not a very good day to be climbing Mt Wellington. The 9 a.m. air temperature was already 19.5°C, there was a moderate (5 to 6 knot) NNW wind and the barometric pressure was 30.19 in. The day was *splendidly clear* (Darwin in his diary) — a typical early February day with an anticyclonic area over Tasmania, and probably with hot winds coming from the centre of Australia. Darwin also reported in his diary that it had taken $5^1/_2$ hours to reach the summit from the *Beagle*, which they did not reach on return until 8 pm *after a severe day's work.*
**10B**: It is clear from this comment that Darwin noted the columns in the *Greenstone*, so clear in the Organ Pipes, but did not comment on their being volcanic or otherwise.
**10C**: Darwin's comment on the *large flat surface* was expanded in the memo (Banks 1971:11).
**10D**: The *enormous blocks* are common and obvious in the scree (block fields) beneath the Organ Pipes and elsewhere on the Mountain; Darwin may well have climbed over the block fields during his ascent as they are less thickly vegetated than areas underlain by solid rock.

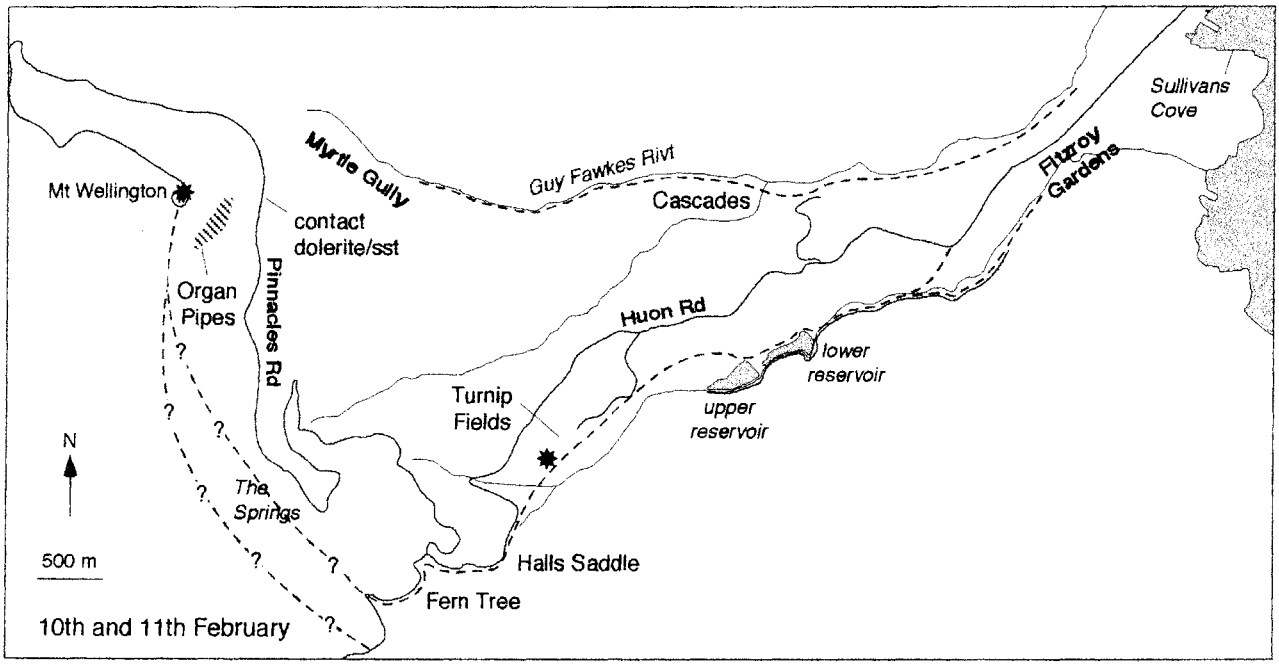



*FIG. 5 — A map of the Hobart–Mt Wellington area showing possible routes on 10 and 11 February 1836.*

***XII***

*Friday 12th — limestone quarry — Stratified dip about 50° — occasional pebbles of quartzose rock — cellular linear cavities — pale brown — pure Limestone — Layers of flint — very numerous impressions of* 11A
*leaves. Said to be different from present same — Whole hill covered by very curious formation, balls of Trappean rocks — decomposed, so as* 11B
*to resemble Wacke, Calcareous* [*Aluminous* inserted above]
*matter (like St Jago)* 11C
*few pebbles — broad fissure in underlying rock & [or is] filled up — Volcanic Eruption somewhere* 11D
*near. subsequent to upheaval but beneath Water — Very limited formation — sm. creek* [last two words encircled]

---

*Sandstone in Government domain, not Stratified* 11E
*very free — I certainly believe, the 3d formation.* 11F
*— Broken by Trap rocks: — There is a hard Siliceous Sandstone quarried high up, may belong* 11G
*to the older —*

---

*Shells in the Government domain. 60 or 80 ft generally* 11H
*round pebbles — much to be said on both sides 30 or 40 — wonderful numerous* [?] *— yet has not quite —Small Shells. — appearance of upraised beach —Certainly much shells brought by natives - pile stone hatchets — But these may have been upheaved: Bay formerly low land — Shells. beach — pebbles* [*of* deleted] *with Serpula* 11I

(See figure 2 and plate 2 for the limestone quarry.)

## Commentary

**11A**: The limestone quarry referred to here is the former quarry in West Hobart above Burnett Street (fig. 2) and within the block bounded by Arthur, Lochner, Hamilton and Brown Streets. It is referred to variously as " within the outskirts of Hobart Town" (M), "behind Hobart Town" (V), "Arthur Street quarry" (*Statistics of Van Diemen's Land*, 1842), "at Hobart Town" (Strzelecki 1845), "outskirts of Hobart Town" (Jukes 1847), "in the vicinity of Hobart" (M'Cormack, 1847), "in the suburbs of Hobart Town between Elizabeth Street and 'Knocklofty Range' " (Milligan 1849), "the neighbourhood of Burnet - street, Hobart" (Johnston 1882 and 1888) and "Shoebridge's Lime Kiln" by Ettingshausen 1883).

The quarry has been filled in and the site is now occupied by John Doggett Park. From the quarry came limestone deposited from a spring (Darwin 1844) and burnt in Shoobridge's Lime Kiln. A detailed consideration of this deposit may be found below (under "Challenges Disinterred").

**11B**: The *balls of Trappean rocks* are the fresh cores of weathered blocks of dolerite.

**11C**: For definition of wacke see Comment 6A.

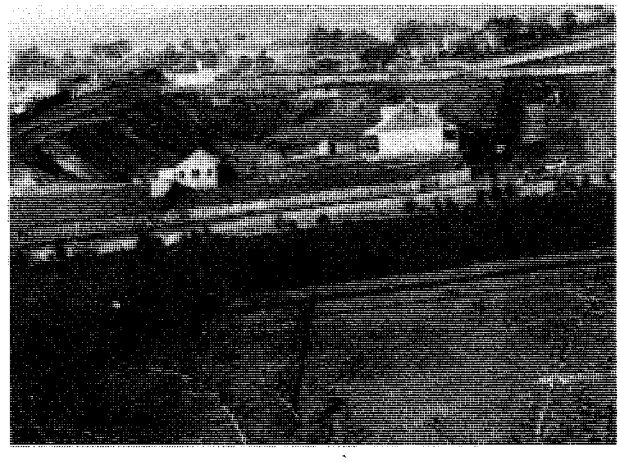


*PLATE 2*

*Photograph of the Burnett Street (Shoobridge's) Quarry looking south, taken by Charles A. Woolley in about 1861 (reproduced by courtesy of Mr Lewis Woolley). White areas within the quarry limits are probably travertine, the darker material, wacke. Note that the white mass near the northeastern corner of the quarry dips quite steeply in a southerly direction.*

**11D:** The suggestion of volcanic activity close to the quarry is discussed below ("Challenges Disinterred").
**11E:** This sandstone may be Tertiary sandstone cropping out along the shoreline below the Domain just south of Cornelian Bay.
**11F:** *free* refers to the property of many of the sandstones of splitting readily.
**11G:** The sandstone being quarried *higher up* could refer to quarries in Triassic sandstone, subsequently the site of Beaumaris Zoo and the Oil Tanks, or to the quarries in the grounds of what is now Government House. The sandstone also crops out near the Powder Jetty in Ross Bay (273.532 on the *HOBART* 1:25 000 Map Sheet).
**11H:** This report of shells at 60–80 ft (18–24 m) in the Government Domain is fascinating.and is considered more fully below (see "Challenges Disinterred").
**11I:** It is not known where Darwin saw the pebbles encrusted with the tubes made by the marine worm *Serpula* (the worm was probably a serpulid, but not *Serpula*) (fig. 6). The matter is more fully discussed below (see "Challenges Disinterred").

*Blue Limestone in old formation* ***X 12*** 12A
*12–15 ft above present high water — Before*
*However the low land had formed Harbor*
*considerable fetch — Yet* [ a symbol like a "Z" with a vertical middle limb] *& these facts inclined*
*me to believe, — trifling rise — Mr F. —* 12B
*oysters have all disappeared within 2 years*
*Mem. Ascidia in Chiloe only known* [?] *with*
*edible animals — Earthquakes*
---
*Centre of Island lofty Greenstone — divided by valley*
*of the Derwent — On North side grand formation* 12C
*of Limestone & some Conglomerate, &* [*hard* inserted]
*Clay Slate* [words or letters off page ]
*see fossils same formation — Limestones & Conglomerates*
*replacing beds Here.— Again on* [*North* inserted] *Coast. Basaltic*
*formation — Here the old formation probably extends*
*to Is* [*Santa?* deleted] *Maria — Coal probably 3d*
*formation — On the NE extensive Granite* 12D
*on the SW. Quartz formation — origin of pebbles in*
*old formation — Centre fossil wood in quartz*
*Agate pebbles — Salinas —* [*plains* deleted] *probably Some*
[*diluv* crossed out] 12E
*modern or Tertiary Series —*
---
*Monday 15th — I see the Greenstone of 1st day consists of*
*a dyke about 100 yards wide — the Strata on opposite* 12F
*side; almost a coal — (Mem: Sandstone & black*
*lines in Quarry) vertical and disturbed: — No doubt* [word or letter?]
*Arthurs Coal — Again along the road; greenstones*
*alternate with Sedimentary rocks — Mem: case on coast* 12G

## Commentary

**12A:** The *Blue Limestone* probably refers to the Permian limestones which were being worked near Hobart at the time of Darwin's visit. He saw one such limestone on 15 February.
**12B:** Darwin again suggested a *trifling rise* but doesn't seem to have been at all certain about it.
**12C:** Darwin's information almost certainly came from George Frankland.
**12D:** *Granite* had been reported in northeastern Tasmania by the French explorers under Baudin (Péron 1807), the *Quartz formation* in the southwest by Matthew Flinders (1801) but Darwin may have got this information from Frankland. (See also Comment 8B.)
**12E:** Salt had been reported in salt pans (*salinas*) in the Midlands of Tasmania by A.W.L. Humphrey as early as 1809 (*Historical Records of Australia* [H.R.A.] III (1): 431, 769-770). *diluv* - short for "diluvium", the origin of which was a topic of considerable debate in geological circles early in the 19th century.
**12F:** This locality could be the former quarry, now occupied by Clare St Oval, or a nearby cut or low embankment on what is now Augusta Road (fig. 2), more likely the latter. The reference to *the Greenstone of the 1st day* is puzzling unless Darwin had been as far as New Town on 6 or 7 February. We have no other evidence that he went as far as that.
**12G:** *Mem: case on coast* may well refer to the situation on the shoreline below the Government Domain south of the present site of the Tasman Bridge. Along this stretch of shore outcrops of sandstone and dolerite alternate. Darwin probably saw this stretch of coast on Sunday, 7 February. [See also note 11G.]

***(X13***
*in Government domain = limestone foot of M.* 13A
*Wellington opposite side of my ascent — mass of strata*
*occurring with organic strata* [*Blackish brown* inserted];
[*Blue* hatched out in pencil] *compact Crystalline;*
*occurs with slaty impure limestone— Organic remains chiefly*
*Terebratula* [inserted *impressions of a Pecten*] *& beds composed*
*of small oysters like at Isd*
*of Maria — Dendritic Manganese — Corallines chiefly* 13B
*occur in the Siliceous strata. — Stratification not* 13C
*quite regular — very rare pebble — uneven stratum*
*of white pulverulent Calcareous* [*Aluminous* deleted] *Substance,*
*used to burn with Limestone — singular aspect* 13D
---
*on road to New Norfolk — we met the very same —*
*stone — This formation much stratified — & strata not*
*very much tilted, only very little — Perhaps S.W. ? —*
[next five words bracketed but line of bracket is partially hatched out]
*(Whole town & valley of Derwent, newer formation). —*
*old sst, alternate with much Trappean rock — At* 13E
*New Norfolk, white rocks, similar to those of Kangaroo*
*point — Some more brittle. coarse & siliceous ( )*
*Some few pebbles, all siliceous & greater number*
*pure* [*White* underlined twice and inserted] *quartz: Higher*
*parts of hill had reddish*
*Sandstone:— General occurrence: —* 13F
---
*Very frequent beds of shells from 6 to 10 ft above the breaking* 13G
*of highest tides, on shores of Derwent, where now the water is*
*either fresh or at most brackish & no shells exist*
*I think an elevation would account for this change of*
*level & state of water — form of small, flat-bottomed* 13H
*creek line valleys:* [sketch here; see plate 3] *— banks of shingle*
[underlined twice] *interstratified*
*with such Shells. —*

## Commentary

**13A:** "=" probably the symbol used by Darwin to indicate horizontal beds. The *foot of M. Wellington* etc. refers to a former quarry beside Barossa Rd, Glenorchy.

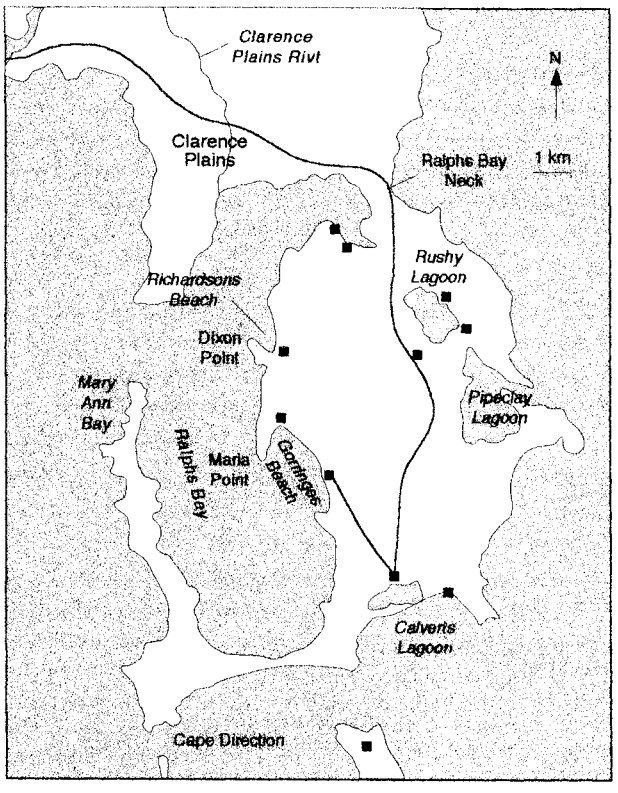
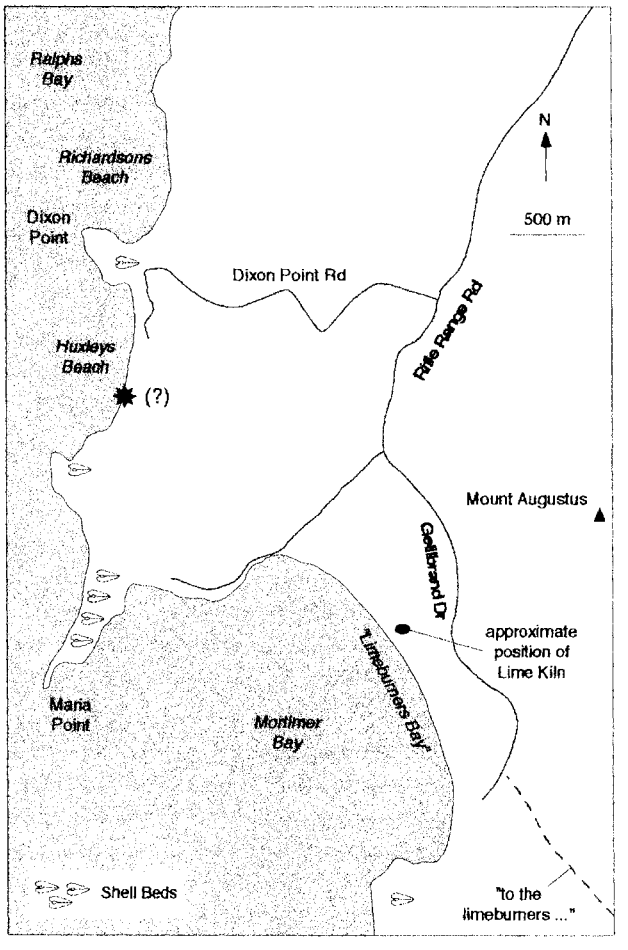



*FIG. 6 — (A) A tracing of part of Hebert's map (1830) showing the track to Calverts Lagoon and Gorringes Beach and buildings south of Ralphs Bay Neck. (B) Tracing of part of the* TAROONA *1:25 000 topographic sheet showing possible Darwin site, positions of elevated shell beds and track and name of bay from map " Monmouth Ph Ralphs Bay by Wm Dawson" (Monmouth 26, DELM).*



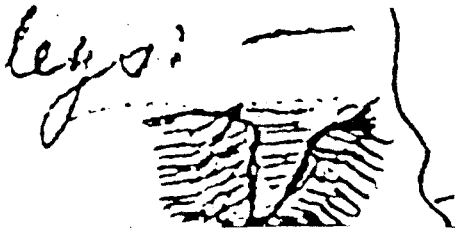



*PLATE 3*
*Copy of Darwin's sketch to illustrate the valleys seen beside the Derwent on the way to New Norfolk on 16 February 1836.*

13B: *Dendritic Manganese* i.e. dendrites. The *Corallines* (bryozoans) are more obvious in the siltstone (*Siliceous Strata*) than in the limestone.
13C: The bedding surfaces in the limestone outcrop seen by Darwin are slightly wavy.
13D: *Singular aspect* presumably refers to the association of limestone and calcareous travertine.

This comment introduces his observations during his coach trip on 16 February (fig. 1). Limestone and travertine similar to that at Barossa Rd occur beside the road to New Norfolk, close to Altamont Creek, where lime kilns formerly operated.
13E: The *old sst* (*sst* is abbreviation of sandstone) is probably the Triassic but could be, in part, the sandstone in the Malbina Formation. The *white rocks* noted on the next line refer to the Fern Tree Mudstone.
13F: *reddish Sandstone* is Triassic, as is rock of the same appearance on Mornington Hill (Comment 4A). Above Fern Tree Mudstone at Derwent Cliffs and Derbyshire Rocks close to the bank of the Derwent River just below New Norfolk, Triassic sandstone outcrops (Leaman 1972). Darwin could readily have seen this sandstone by looking north from New Norfolk but the colour is not obvious.
13G: The sentence beginning *Very frequent* ... refers to the area above Granton where the delta of the Derwent River occurs and water may be somewhat brackish. No beds of shells are now visible from the highway.

13H: Many such flat-bottomed valleys (pl. 3) occur upstream from Goulds Lagoon (fig. 1) at least as far as Sorell Creek, about four kilometres east of New Norfolk. The flat bottoms, the flood plains of the streams, are little above the level of the Derwent River and probably graded to it. Darwin, in his memo (footnote (b) on the back of p. 18), postulated that they had been the floors of little coves.

(Page crossed through and overwritten: *Hobart town* in thicker darker ink; it is the unnumbered verso of page X13 and was used as a cover for the other pages i.e. 1–X13; for convenience it is quoted below as "[14]". It is partly a diary of the last six days of Darwin's visit, partly a series of memos about social matters, and partly a geological memo.)

[14]
*Friday 12th — Called on Surveyor General Mr*
*Frankland. — Walked to Lime Kilns & Government* [14]A
*Garden =. Sandstone traversed Dined with*
*him in evening.* [14]B
*Saturday 13th — Crossed ferry — Rode to examine*
*beds of Shells — Very nice country. However* [ or *House*?] [14]C
*returned to. — Dined Attorney General*
*Very pleasant Musical perf*[ormance?]. *very comfortable*
[*house* off page?]
*large numerous rooms. beautifully furnished*
*Very pleasant guest* [?] *party —*
*Sunday 14th. Staied on board writing letters*
*Stopped for want of sun*
*Monday 15th — Mr Frankland came on board. Went*
*out riding with him — stormy day — dined in*
*evening most pleasant:=*
*Tuesday 16th — Went in coach to New Norfolk*
*banks of the Derwent — farms — very nice country:*
*mountainous — woody = Walked from town & fell asleep*
*beneath a tree. —*
*Wednesday — 17th Sailed — Mr Duff —*
.....
*on the whole like Hobart town better*
*Blacks removed* [?]. *— excellent police — probably less* [14]D
*crime than England. —* [ At bottom in deeper ink and finer script]
*N.B. Quartz = pebbles in F.W. Limestone* [above this
*& Siliceous Sandstone*]. [14]E

### Commentary

**[14]A**: *Lime Kilns*, i.e. Shoobridge's Lime Kilns above Burnett Street; the *Government Garden* later became the Royal Tasmanian Botanical Gardens.

**[14]B**: Triassic sandstones occupy much of the Central Hobart– North Hobart area and would have been exposed as low benches.

**[14]C**: Darwin and Franklin crossed the river to Bellerive but, beyond that the locality of the shell beds to which Darwin and Frankland rode is uncertain. The matter is more fully considered below ("Challenges Disinterred").

**[14]D**: A reference to the removal of the Aborigines to Flinders Island a few years earlier.

**[14]E**: reference to the presence of siliceous pebbles in the rocks at Shoobridge's Lime Quarry and in the Permian sandstone on Porter Hill (see p. ***XII*** and Comment 8F).

## INFORMATION NEWLY AVAILABLE

The field notes reveal more detail than later documents of Darwin's activities while in the Hobart area, with observations on, and deductions about, the geology not previously published. The new material on the route of his excursions will be dealt with first, followed by the new material on the Permian to Tertiary rocks in stratigraphic order, information on the structure, changes in sea-level and finally the marine fauna and flora.

## Excursions and Excursion Routes

As noted earlier, Darwin made several "pleasant little excursions" during his visit to Hobart Town. Possibly that to Mt Wellington was not quite as pleasant as some (Comment 10A) but, compared to his excursions in South America and over the Blue Mountains from Sydney, they were probably pleasant and little.

It can now be shown that on Monday, 8 February, Darwin took the ferry across the river, and then walked around the shoreline as far as Howrah, inland to Knopwood Hill and back to the ferry over Mornington Hill (Comments 2D to 4A), not, as thought earlier, up Flagstaff Hill. Syms Covington, who noted that he had accompanied Darwin over the river and to Mt Wellington at least (but probably on most of his excursions), recorded that "steam ferries cross the river almost every hour" and that the trip cost sixpence.

In his walk south along the western shore on the following day, Darwin climbed Porter Hill (Comments 7C, 8E).

## Rocks

### Permian

Darwin reported, probably incorrectly, that the corallines in the rocks on the shoreline at Porter Hill were silicified (Comment 8A). He noted dendrites in the limestone at Barossa Rd [Comment 13B), limestone on the road to New Norfolk (Comment 13D), the Malbina Formation on the slopes of Porter Hill (Comment 8E) and ferruginous veins in the Fern Tree Mudstone on the foreshore at Bellerive (field notes, p.2).

### Triassic

He recorded sandstone near New Norfolk like that at Mornington Hill (Comment 13E, 13F) and the free nature of some sandstone in or near the Government Domain (Comment 11F).

### Dolerite

The field notes extend knowledge of his observations on the greenstone (Comments 1D and 5A).

### Tertiary

Darwin must have looked quite closely at the Tertiary sedimentary rocks under the basalt at the southern end of Long Beach to have noticed the angular blocks of white mudstone in the bedded silts and clays (Comment 5E) and possibly at Cornelian Bay. The Tertiary limestone from above Burnett Street, West Hobart, first described by Darwin, is a puzzle taken up below ("Challenges Disinterred").

In the basaltic rocks in the crater at Sandy Bay, he noticed "jaspery and Porcelain rock" (Comment 6C).

### Post-Tertiary

In the field notes he used the term *Salinas* (Comment 12E), probably one he picked up in South America, in writing of the ponds with salt referred to in the memo on p.15.

## Stratigraphic Relationships

Comments 7D and 8G show that Darwin correctly inferred the age of the dolerite relative to the fossiliferous sedimentary rocks at Lower Sandy Bay and he noted that the Fern Tree Mudstone at New Norfolk lies under the red Triassic sandstones (Comment 13F), a relationship he also inferred at Bellerive and on the slopes of Mt Wellington. From his observations he concluded that there were three sandstone horizons in the area (Comment 9A) and that the latest, the

Tertiary, formed a fringe beside the Derwent River e.g. Cornelian Bay, Marieville Esplanade and at Long Beach, Sandy Bay, a distribution also noted and expanded by Johnston (1882). He was not always clear, however, as to which of the three horizons a particular outcrop belonged, a difficulty which has also confronted later geologists.

### Correlations

Darwin made some local correlations, some in agreement with later views, others not. He saw the similarity between the limestone at Barossa Road and that on the New Norfolk Road at Altamont (Comment 13D). He correctly related Permian and Triassic rocks at Bellerive with those close to New Norfolk (Comments 13E, 13F) but with some uncertain. He correlated, incorrectly, the Fern Tree Mudstone (Permian) at Bellerive with the sandstone (Triassic) of the city area (Comment 2G). Part of the problem may reflect variations in grainsize within the younger Permian siltstone sequences. Some beds are predominantly of mud-sized fragments, others of fine sand; most are very poorly sorted, producing the impression of a rock with sand-size grains. The siltstone sequence does include better sorted but pebbly sandstones. The Triassic succession contains well-sorted rocks, but some are fine-grained and may have characteristic cross bedding or fine bedding. Where exposure is restricted, some of the finer members may appear similar to some Permian siltstone — in colour as well as texture. Darwin was not correct in suggesting that the basalt at Sandy Bay (Tertiary) was of the same age as the dolerite (Jurassic) near the mouth of Storm Bay (Comment 6D). A careful analysis of his envisaged age relationships reveals that he had gained insufficient information in this area to allow the construction of a stratigraphic framework.

Darwin did, however, see the similarity of the rocks, particularly the Triassic rocks, near Hobart to those around Sydney (Comment 1C). He suggested a similarity between the fossils in the Permian rocks around Hobart with those of the Carboniferous limestones of Argyll (Comment 7G), which was plausible within the constraints of the knowledge at the time.

### Geological Structure

Darwin made few remarks about the geological structure (Comments 1A, 3E, and pp. *1*, *2*, *6*, *X13*) and had no clear picture of the general structure of the district which is scarcely surprising. Even now much remains to be done to understand the structure fully.

### Changes in the Relative Level of Land and Sea; Shell Beds

More information is now available about the places Darwin may have visited during his ride with George Frankland to see the shell beds at Ralphs Bay (see "Challenges Disinterred" below). The field notes reveal that Darwin saw beds of shells at higher levels than he reported in later works and provide more detail of the shingles with Serpula-encrusted boulders (Comments 9C, 11H, 11I, 13G).

While he was aware of the possibility of confusion of shell beds and native middens, and although he had criteria for distinguishing one from another, he did not always succeed in doing so.

The little flat-floored valleys were noted, such being a feature of several of the tributaries flowing into the western side of the Derwent River above Goulds Lagoon (Comment 13H).

Further, Darwin commented on the depth of water in the coves bordering the Derwent River and attributed this condition to subsidence (Comments 2I, 3A; see also "Challenges Disinterred" below).

### Marine Fauna and Flora

Darwin noted the similarity of the marine flora and fauna in the Derwent River to those near Sydney (Comment 2I).

## A GENERAL COMMENT AND DARWIN'S MODE OF FIELD OPERATION

These previously unpublished observations and deductions reinforce earlier suggestions (Banks 1971) as to the astuteness of Darwin's observations and of his geological deductions. They represent a very creditable total for nine days fieldwork.

It is appropriate at this stage to consider briefly what his field notes and memo reveal about Darwin's mode of operation as a geologist. At the strategic level of designing his field programme, Darwin noted the outcrops in cliffs and on the shoreline as the *Beagle* sailed up the Derwent, and he remarked on Mt Wellington. Soon after reaching Hobart, he seems to have made contact with the Surveyor-General George Frankland (see later). From Frankland he could well have learnt of interesting sites close to the town, e.g. the lime quarry. After that meeting he could have decided on the broad outline of his "excursions" — visits to the shoreline on eastern and western bank of the river, Mt Wellington and interesting places. So he went east and southeast, south, west and north. Noting the ebb and flow of the tides, he may even have decided on when he would visit the shoreline exposures.

When he reached the outcrops, he observed clearly and closely — Geikie (1909: 6) noted that he had "sharp enough eyes", an attribute well borne out in his work around Hobart Town. What he saw he interpreted in the light of his already very considerable experience (see the early chapters of Darwin by Desmond & Moore [1991] for details of his early life; the points judged relevant are summarised below).

His early education was first in classes taken by a Unitarian minister and then in the Anglican Shrewsbury School. In Edinburgh, a hot-bed of radicalism at the time, he joined the Wernerian Natural History Society and came into contact with Professor Robert Jameson, a "Neptunist", who attributed great importance, as did Werner, to a hypothetical global, encompassing ocean in the history of the earth and in the origin of rocks. Darwin had the opportunity to take practical classes in mineralogy while in Edinburgh and to make geological excursions. Later, at Cambridge University, one of the pillars of the Anglican establishment, he attended soirées for budding naturalists, events attended also by Adam Sedgwick, Professor of Geology, whose lectures Darwin attended. Sedgwick had very different views of the Earth from Jameson; he was a "Plutonist", a believer in the igneous, as opposed to aqeous origin of

granite, and a "Catastrophist" (a believer in the occurrence of major convulsions and catastrophes during the history of the Earth). In the summer of 1831, Darwin carried out geological mapping around his home in Shrewsbury and later joined Sedgwick in mapping in North Wales,where he was given the opportunity to map some areas on his own. Darwin was encouraged to read Charles Lyell's *Principles of Geology* after the publication of the first volume of that work in 1830. Lyell was also a "Plutonist" but, as a "Uniformitarian", he did not accept the views of the catastrophists but thought that present geological processes had operated in the past at about the same intensity as they do now. Thus, from his "mentors", Darwin was exposed to all the important shades of contemporary geological philosophy. And then he boarded the *Beagle*!

By the time he reached Hobart, he had experienced climatic zones from the tropical to the polar, been exposed to conditions from sea-level to the high mountains of the Andes and been able to observe the processes operating over that range. He had experienced tropical rain forest and a cool temperate desert. Geologically he had seen a variety of minerals, flat-lying rocks and strongly folded rocks, igneous rocks from granites to basalts, glaciers carving the land surface, ice bergs floating on the sea and volcanoes erupting; he had experienced an earthquake and seen the effects of a major one.Thus, he had fitted into his voyage a great wealth and range of experiences of geological phenomena.

In observing and thinking about geological features near Hobart, he observed clearly and closely, and then placed his observations in the context of his intellectual and earlier geological background. He was not observing "blindly" nor "thinking" in a vacuum or in a straitjacket of a particular philosophy. He came from a family of dissenters, had been educated in dissenting and establishment institutions, and had been exposed to the full gamut of geological philosophies. He interpreted what he saw with a well-filled but open mind. His explanations were, however, predominantly "uniformitarian".

## THE DIFFERENCES BETWEEN TEXTS

Darwin reported observations, deductions, impressions and ideas about his time in Hobart Town and surrounds in at least four forms — field notes (FN), a memo (M), a published *Journal* (1839a, b) (J) and a book, *Observations on Volcanic Islands* (1844) (V). As might be expected, the contents and structures of the four records differ in accord with the functions and circumstances of production of each.

### The Field Notes (FN)

The field notes are to a considerable extent a record of his observations almost as he made them in the field, his immediate thoughts and deductions and brief comments to act as memory joggers. The structure of the field notes is virtually, as might be expected, chronological, with references to other parts of Tasmania or the world made where appropriate. The notes include a sketch of a flat-floored valley. In terms of the local scene, the notes are the most informative.

It is clear that within a day or so of reaching Hobart Town, Darwin had met George Frankland and talked at length with him, with the result that he was able to make comments about the geology of parts of Van Diemen's Land (VDL) he did not see. In several places the notes reveal that he recognised similarities between what he was seeing in the field in VDL and what he had seen in Scotland before his voyage began (e.g. *Mem. limestone of Argyl*) or during the voyage with references to Port Famine, Chiloe, New Zealand, Sydney and others.

Darwin noted in the field notes [2F, 8B, 8C] that there are pebbles of several rock types in the fossiliferous (Permian) strata, pebbles now interpreted as ice-rafted dropstones. In one of his notebooks in Down House Museum, Downe, Kent, UK (Darwin's former home, where his instruments are also preserved) (RN: 21), Darwin wrote "There is a resemblance at Hobart Town between the older strata and the bottom of the sea near T. del Fuego". Banks (1971: 17) interpreted this comment to mean that Darwin attributed the pebbles he had noted in the Permian fossiliferous rock near Hobart to ice transport by analogy with those he had seen on the sea floor off southernmost South America (Darwin 1846). In none of Darwin's published statements was this resemblance mentioned. It has been suggested (Banks *et al.* 1987: 233) that Darwin was hesitant to propose at a time when there was a fierce debate about the past extent of Quaternary glaciers, that glaciers (spawning icebergs as they do now in Tierra del Fuego) were present late in the Palaeozoic. It was not until 1852 that Ramsay even hinted for the first time that there may have been ancient glaciations, and not until 1855 did he explicitly infer the existence of Late Palaeozoic glaciers. Darwin may well have thought that he did not have sufficient evidence to convince a sceptical audience. This situation can be contrasted with the almost immediate publication of his ideas on the origin of coral reefs with which he was comfortable and for which he had considerable evidence. The glaciation situation is more comparable with his hesitation in publishing his thoughts on evolution. There are still debates on ancient glaciation and on evolution.

In the field notes he recorded the observation that the mudstone on Knopwood Hill was altered (3E) but did not explicitly say that the *greenstone* had caused the alteration. He shortly thereafter (top of his p. 4) used the word "*Metamorphised*" but the text is not clear enough to decide what he thought might have been "*Metamorphised*". In the memo (p. 1) he noted the presence of *Porcelain rock and indurated sandstone, lying in the lines of junction, point out the effect of an igneous mass* (the *greenstone*, i.e. dolerite). He also inferred that coal (*Arthurs Coal*) had been disturbed close to the dyke.These observations on metamorphism were important in potentially demonstrating that the dolerite was intrusive into the Permian Fern Tree Mudstone on Knopwood Hill and into the Triassic coal measures near New Town, both sedimentary rocks being regarded as "Carboniferous" by Darwin. Darwin used the lack of pebbles of *greenstone* in the fossiliferous rocks and higher units on Porter Hill to suggest that the dolerite was younger than the sedimentary rocks (see comment 7D). These observations on the relative ages of the dolerite and sedimentary rocks were not published by Darwin. This omission was regrettable in the light of subsequent history — it was not until over 60 years later (Twelvetrees & Petterd 1900) that the vexed question of the relationship of the dolerite to the sedimentary rocks was satisfactorily resolved, largely using, *inter alia*, the criteria that Darwin had observed.

## The Memo (M)

The memo is clearly a later production than the field notes. It contains information on the mineralogy of the dolerite which would have required access to his microscope, such access being possible while the *Beagle* was still in Hobart Town. He incorporated in the memo observations on specimens which included those recorded in the field notes but others in addition. Some references, e.g. to Scott, MacCulloch and others, occur in the memo and may have been made after the *Beagle* left Hobart. It seems possible, even likely, that Darwin wrote most of the memo during the voyage from Hobart Town (sailed on 17 February) to King George Sound in Western Australia (reached 6 March). Armstrong (1985: 6) suggested such a possibility.

The function of the memo is not clear but it was certainly written with geologists in mind. It may have been a first attempt to get the field notes into the sort of order appropriate to a systematic account of the geology of the Hobart area, perhaps a preliminary to a later paper or chapter in a book. It is clearly only a first attempt and the structure is difficult to discern. A section on the geology of the town area is followed by an account of an excursion along the western shore of the Derwent River south of the Town. The *singular assemblage* of fossiliferous sedimentary rocks (i.e. the Permian) is next considered in its various occurrences including observations made on them on the eastern shore, followed by treatment of the *greenstone* (dolerite) which includes the comment that the rock strongly affects the magnetic needle on Mt Wellington, although no mention of this property appears in the field notes. Robert Brown had noted this phenomenon late in May, 1804 (Robert Brown's *Diary*, Botany Library, Museum of Natural History, London; see Leaman 1997) and Flinders (1814: clxxxviii) reported in a footnote that

> Upon the top of Mount Table, the compass has since been found to vary as much as 20°, from one part of the mountain to another.

The Flinders volume was on the *Beagle* (Burckhardt & Smith 1985, appendix to Volume 1: 569). Brief mention of the apparent surface seen from Mt Wellington then precedes sections on the geology of other parts of VDL, an extensive treatment of the limestone quarry in West Hobart, uplift of the land and finally a summary of the geological history of VDL and correlations with Argyll, NSW and New Zealand.

The reader is left with a confused idea on the geology for, as noted earlier, Darwin was, understandably, not entirely clear in his own mind on the order of geological events. He may have intended to write it up more systematically later but have realised that he had insufficient data with which to do this, particularly as there were many pressing and more important demands upon his time once he returned to England. Indeed, he wrote to W. Fox from Hobart Town on 15 February (Burckhardt & Smith 1985, Vol. 1: 491–492)

> I draw up very imperfect sketches of the Geology of all the places to which we pay flying visits, but they cannot be of much use. Leaving America, all connected and therefore interesting, series of observations have come to an end ...

As noted above, Darwin recorded similarities between what he saw in the vicinity of Hobart Town and what he had seen earlier in Scotland or during his voyage. He made no reference in the field notes to publications. In the memo, Darwin did, however, refer to a number of publications. These references include two which might be regarded as practical manuals, D'Aubisson (1819) and MacCulloch (1821), and others which were works about VDL, e.g. Bailly in Péron (1807), Flinders (1801, 1814), Lesson (in Duperrey 1830) and Scott (1824). It seems likely that Darwin brought the manuals, and perhaps other volumes (e.g. Péron, Flinders 1801 and Scott), on board with him and the others may have been on board as part of the extensive library known to have been on the *Beagle* (Armstrong 1985: 10, Burckhardt & Smith 1985: appendix 1, Desmond & Moore 1991: 107).

## The Journal (J)

The main points made by Darwin in the Van Diemen's Land section in his published *Journal* concerned social matters — the aborigines, the town, gardens, public order and commerce, with the flora including the tree ferns and gums, and the climate also receiving attention. Darwin (1839a: 535) wrote of emigration and in his diary (Keynes 1988: 409–410) occur the words " if I emigrate, choose this rather than Sydney". Later, on the same theme, he wrote to the botanist, Joseph Hooker on 1 March 1854 (Burckhardt & Smith 1985, Vol. 5: 180–181)

> ... it is a very *remarkable* and creditable fact to the Colony: I am always building veritable castles-in the air about emigrating, & Tasmania has been my head-quarters of late, so that I feel very proud of my adopted country.

This comment arose upon Darwin hearing from Hooker that the Executive Council of VDL had voted him (Hooker) £350 "in acknowledgement of my past and coming services to Tasmanian Botany" (Burckhardt & Smith 1985, Vol 5: 178).

He made some note of the limestone at West Hobart, *a solitary and superficial patch of yellowish limestone or travertine*, and passing mention of the highly fossiliferous nature of some of the strata and of the small rise in the land. This publication was an account for public information.

A new comparison emerges in the *Journal* between Bell Mountain in Chile and Mt Wellington (*Narrative* and subsequent editions). In referring to Bell Mountain, Darwin (1839a: 313) noted the large accumulations of loose boulders near the summit which he believed to be due to "frequent earthquakes". On the following page, he commented "Mt Wellington, near Hobart Town, ... summit similarly composed and similarly shattered ...". Six years later (J 1845: 259), in commenting on this matter he wrote "Mt Wellington, in Van Diemen's Land, where earthquakes do not occur ...". He did, however, further comment in respect of Mt Wellington "all the blocks appeared as if they had been hurled into their present position thousands of years ago". Geologist now tend to assign the accumulation of loose boulders on the slopes of Mt Wellington ("block fields") to periglacial activity and creep, but seismic activity may have been a factor in the

longer term. A few earthquakes have occurred along the Derwent south of Bridgewater in historic time and others are likely to have occurred in the area since the block fields began to form, presumably during the Pleistocene ice age.

### Geological Observations on Volcanic Islands (V)

The limestone (travertine) was the prime point of interest in the published account Darwin produced for geologists — *Geological Observations on the Volcanic Islands* ... (1844) — with the uplift of the land as his second main interest. In keeping with the title of the book, Darwin gave considerable detail about the volcanic crater at Sandy Bay. The Permian rocks also engaged his attention for their indeterminate character (mineralogy and unusual texture) and abundance of fossils. Triassic rocks, coal measures and dolerite, and the pre-Permian rocks found elsewhere in VDL were minor to passing themes. Very importantly, he included in the book descriptions made by British experts W. Lonsdale and G.B. Sowerby of some of the fossils he collected. The fossils allowed a statement on the age of the rocks to be offered, a statement which, although wrong on present information — if only just — was the best answer available at the time he wrote (i.e. Carboniferous; they are now known to be early Permian, but the Permian System had not been proposed at the time of the *Beagle* voyage). With the exception of the first few lines, which deal with the greenstone as the main component of the mountains, the account in *Geological Observations* ... moves from the oldest to the youngest rocks, picking out points of general geological interest and minimising local detail. About a quarter of the section on Van Diemens Land deals with "Elevation of the land".

## DARWIN'S INSTRUMENTS AND MEASUREMENTS

Darwin quoted the height of Mt Wellington as 3100 ft (944 m) in his memo (p.11) and noted that this figure was based on angular measurement from the *Beagle*. He also quoted (p. 11) the height of the top of the sandstone on the mountain as 1200 ft (366 m). Both figures were repeated in later publications.

The height now accepted for Mt Wellington is 1271 m, so that the height quoted by Darwin was much too low. This is surprising in view of the fact that some older maps, e.g. that of Hebert (1830), gave heights approaching 4000 ft — Hebert gave it as 3800 (i.e. 1158 m). It seems highly unlikely that the measurement of the angle of elevation from the *Beagle* to the top of the mountain was seriously in error, which implies that the assumed horizontal distance from the *Beagle* to the summit was far too low. Another possibility is that the original recording of the figures was incorrect and, once having been recorded, was simply repeated.

The height quoted for the top of the sandstone was also far too low. It should be about 920 m, i.e. about 560 m above that given by Darwin. If the assumption is made that the figure of 1200 ft was measured accurately by barometer, the position could have been at Halls Saddle, near the head of Wellington Rivulet, a locality quite likely to have been on Darwin's route as he climbed Mt Wellington on 11 February. Sandstone certainly crops out to almost that position. Beyond it is mudstone, which may not have outcropped on the tracks taken and, if Darwin followed tracks to the first or second spur beyond the present site of Fern Tree before beginning the ascent of the *damp southern side of the mountain,* he could well have seen nothing but dolerite talus and thick vegetation during most of the climb to the summit.

Darwin's instruments are preserved at Down House. Miss Strachey, Curator with Down House, informed us that Darwin had a barometer, labelled "Newman's Portable Iron Cistern, 122 Regent Street, London". He also had with him a combined compass and clinometer made to his own specifications by Cary, London. In V he quoted heights of several places stated as measured by barometer; he also quoted heights he stated as estimated, in some instances to the nearest foot, in others to the nearest ten or hundred or thousand feet. He quoted the heights of the Blue Mountains west of Sydney accurately. He may have constructed a simple staff for use with the clinometer in measuring heights but, as far as we know, made no mention of measurements made by such a device. It seems likely in the absence of mention of a level in his list of instruments, that the heights he quoted for shell beds around the Derwent were estimated heights.

When Darwin quoted directions, it was mostly in terms of the points of the compass e.g. NE by N, but, in a few instances, he quoted the actual direction e.g. E.57°N. In quoting angles of dip of geological features, he used descriptive terms, e.g. horizontal, gentle, high, etc., in some places; in others, a range of values, e.g. 30° to 40°, 30° to 36°; in a few cases both dip angle and direction, e.g. 12° to N, were quoted. His practices in these respects seem appropriate to the reconnaissance type of geology he was mostly doing.

## CHALLENGES DISINTERRED

### Introduction

In reading Darwin's field notes it became clear that while some of the problems recognised by Darwin or arising from his observations have now been solved (e.g. stratigraphy of the Permian and Triassic rocks, age and relationship of the dolerite to the sedimentary rocks), others remain unresolved even now, including the distribution of shell beds around Ralphs Bay, the origin of the limestone in the Burnett Street Quarry and its structure, the history of relative movements of land and sea along the Derwent River, and the causes, e.g. seismic activity or other process, of such movement. The challenges posed by such unresolved problems will now be addressed.

### The Ride to Ralphs Bay and the Early Burning of Limestone

It seems likely that Darwin expressed to George Frankland at an early stage in their association his interest in relative movements of land and sea and the significance of shell beds in casting light on such movements. Frankland was probably aware of the occurrence of shell beds near the shores of Ralphs Bay and the suggestion of a joint excursion would naturally arise.

It is not clearly stated in any of Darwin's texts where the "beds of Shells" (FN) were which they rode to examine. The site appears as "In Ralphs Bay ..." (M), and "on the shore of Ralph Bay ..." (V) and Frankland would have known that shells had been burnt for lime in the Ralphs Bay area for several decades.

A map by Hebert (1830, and fig. 6A herewith) shows a track from the ferry wharf at Bellerive, south through Clarence Plains, now Rokeby, to the neck at Ralphs Bay, beyond which it passed west of Rushy Lagoon, near the southeastern margin of which a building was shown, west of Pipeclay Lagoon, reaching just north of Calverts Lagoon, where it turned NNW to reach a building just behind the shoreline of what is now called Gorringes Beach. This map showed a building north of Maria Point and another just north of Dixon Point but none just south of Gorringes Beach. A map in the Archives of the Department of Environment and Land Management (DELM), "Monmouth 26" by Mr Dawson, a surveyor (1831–36) under George Frankland, shows Mortimer's property and, near the southeastern corner of that property, a track with the words " To the limeburners' point [or punt or ...]" in pencil, and, in the area just off the beach, "Limeburners Bay", an insertion of unknown date and authorship (Mr Bill Reid, DELM). On this map a structure is shown in the same position, just behind Gorringes Beach, as the building on Hebert's map, but in addition one is shown on the hill south of Gorringes Beach and also shown on Frankland's 1839 map. Frankland's map of Tasmania shows the bay as "Mortimers Bay", so it is likely that Dawson's map was produced before 1839. Mortimer owned the property behind Gorringes Beach at one stage, the house being on the hill to the south of the beach, just behind Gorringes Jetty, shown on a map, Monmouth 3 (28.5.1939), a little to the south of the end of Gorringes Beach. The structure behind the middle of Gorringes Beach may have been the limeburners' hut, but it is not labelled. Small creeks flow into Mortimers Bay close to the position of the "hut" and could have supplied the water needed to slake the quicklime obtained from burning the shells. The lime would need to have been slaked prior to transport by water, as quicklime reacts readily with water, with production of much heat.The lime-burners' hut was stated to be about 2 miles (3 km) from Mr McCauley's house and was reached by water from Hobart (Nicholls 1977: 137, 141, 154). The McCauleys lived at Waterloo Farm just southeast of Rushy Lagoon (probably the building shown on Hebert's map) about 3.5 km from Gorringes Beach (Hudspeth *et al.* 1994).

Shells were being burnt to produce lime near Sandford as early as 1806 (HRA, Series III, Vol. 1: 539). Shells are abundant at Gorringes Beach, and there are thick accumulations, some partly cemented, in the foredune and the next dune inland. In places there are signs that pits have been excavated in these dunes. Mrs Audrey Hudspeth (letter 4.12.1997) drew attention to an advertisement in the *Hobart Town Courier*; an advertisement over the name of H.W. Mortimer appeared on 29 June 1832, for "Oyster or Cockle Shell Lime", which, judging from the prices quoted, came from south of Hobart Town — at the kiln it was sixpence, at the wharf, one shilling, and at New Norfolk two shillings a bushel. Present outcrops of shell beds behind Gorringes Beach are only 1–2 m above high water mark.

Although shell beds are abundant on the Ralphs Bay side of the neck at Lauderdale, recent search has not yielded any evidence of shell beds a few metres above high-water mark; Mr Richard Lord, who spent holidays in the area as a boy, did not recall any being present fifty years or so ago. Higher level shell beds occur on the hill south of Gorringes Beach, on the ridge leading down to Maria Point and at Richardsons Beach (fig. 6).

On available information, it is likely that Darwin and Frankland rode to Mortimers Bay by the old road over Ralphs Bay neck and further south until they met the track to Gorringes Beach over Mt Augusta.They may well have returned to the neck by a coastal route including the property north of Maria Point and that north of Dixon Point.

## The "Burnett Street" Lime Quarry

The limestone above the top end of Burnett Street (fig. 2) was discovered by two convicts, McCoy and Boon in 1813 (HRA 111(2): 41); quarrying started soon afterwards. Darwin's comments were the first of a geological nature on it, there being comments by Strzelecki (1845), Jukes (1847), M'Cormack (1847), Milligan (1849) and Johnston (1882) later in the 19th century. Darwin recorded his initial observations in his field notes, and subsequently commented on it in the memo, his Journal and *Volcanic Islands* ... The geology and origin of this limestone formed one of the four main threads in his *Volcanic Islands* ... The occurrence is of some interest, first from being noted by Darwin, second because it contained fossils, probably figured by Strzelecki. However, the quarry has been filled in for many years and no satisfactory account of the stratigraphy and structure (nor any diagrams or photographs of it) have been published previously. It is a challenge.

The limestone was pale brown (FN) or pale yellow (M), porous, not very compact but hard (FN), contained cellular, linear cavities, pebbles of quartzose rock (FN and V) and quartz (M), and layers (FN) and nodules (M) of flint. Strzelecki (1845) noted four types of limestone, which differed in structure, texture and smell, some of them smelling argillaceous when moistened. The memo records a Darwin specimen number for flint from the quarry, the specimen presumably still being in the Sedgwick Museum in Cambridge, UK.

Leaves different from existing species were reported as impressions in the limestone by Darwin (FN), being particularly abundant in the lower layers (M). There were four or five kinds, including a trifid palmate frond (Darwin quoting Robert Brown in V). Strzelecki also reported Brown's findings and illustrated three of them (pl. V11, figs 5, 6 and 7), one showing the "aspect of a Proteaceous leaf" (1845: 254). Milligan (1849) also noted the leaves and suggested affinities with some modern Tasmanian species (e.g. the *Sassafras, Weinmannia, Banksia, Leptospermum* and *Phlebalium billardieri*, the trifid frond being perhaps a fern). Ettingshausen (1883) figured a fossil plant collected by Dr John Lhotsky from this quarry, "*Cinnamomum" woodwardi*, which is now in the Natural History Museum, London (OR 1301) (letters from Ms Tiffany Foster, Curator, Department of Palaeontology). Strzelecki (1845: 254) noted that specimens he illustrated came from the "yellowish compact limestone ... described by Mr Darwin" (his fig. 5 on pl. 7, OR 41176, ? *Phyllites*; his fig. 6,, OR 52610, labelled ?*Fagus*, and figure 7 based on V 19870, probably from the Stokes Collection).

Ettingshausen (1883) figured material from "Tertiary travertine, Hobart", which had been collected by Robert M'Cormack, surgeon with the Ross Expedition, and named *Salix cormickii* (V 13604), *Cinnamomum hobartianum* (V 13610) and *Echitonium obscurum* (V 13611). It is likely that these came from the quarry in Burnett Street as some of the specimens he collected were labelled specifically as from Geilston Bay or Lindisfarne, but these specimens were not.

Darwin reported land shells from the limestone (M, N) and two snails, which may have come from this quarry, were described by G.B. Sowerby and illustrated in Strzelecki (1845: 298, pl.XIX, figs 5, 6). Sowerby named them *Bulinus gunnii* and *Helix tasmaniensis*.. Some later geological visitors were unable to find the snails.

Darwin postulated an origin of the limestone beneath water in a small creek (FN), later (M) allowing the possibility of deposition in a lake. In *Volcanic Islands* ... he wrote of it as formed by a calcareous spring entering a small pool or narrow creek. A spring origin is indicated by the texture. Milligan (1849) postulated deposition in a "shallow sedgy valley, maintained chiefly by calcareous springs". The pebbles of quartzose rock and quartz could well have been derived from Triassic sandstone outcrops upstream from the spring, i.e. to the west.

The depth of the deposit was given as 9–12 m by Milligan (1849), but no internal stratigraphy or basement rock has been recorded. The limestone deposit was covered by *Wacke* (see Comment 11B, and pl. 2) as was the whole hill (FN). The wacke contained calcareo-aluminous matter and a few pebbles. It is assumed that the *calcareous (aluminous) matter* was a mixture of calcium carbonate which Darwin could have detected by its effloresence with dilute hydrochloric acid, and a clay mineral detected by its earthy smell after moistening, a feature noted by Strzelecki (1845). In fact, Milligan (1849) noted the presence of irregular beds, masses and nodules of clay and Fullers Earth (a form of the clay mineral, montmorillonite). Darwin (FN, M) noted that the *Wacke* occupied a fissure in the limestone and contained a rounded pebble (M, V). Milligan described the wacke as boulders of greenstone (dolerite) in clayey loam with encrusting and interstitial calcium carbonate and unusually shaped carbonate bodies which he interpreted as fossil fungi. The wacke rested on fossiliferous limestone, greenstone, sandstone, shale and claystone throughout the district and had a depth of 3–4.5 m. In 1853, Milligan (1854) reported lignitic wood near the base of a "diluvial boulder bed" about 7.5 m thick in a shaft at the head of Warwick Street, West Hobart, the bed resting on sandstone. This was presumably the wacke. The origin of the wacke did not receive specific attention. From his comments (V), it would seem that Darwin may have thought it to have been volcanic; Milligan (1849) saw it as "the result of the last great upheaving force" which raised the limestone to its present level.

Darwin recorded a dip of 45 to 50° for the limestone (FN,M; see pl. 2), the higher figure also reported by M'Cormack (1847), who stated that it was to the WSW. The limestone had been tilted and fissured after deposition (FN), with the wacke resting unconformably on it. The tilting was attributed by Darwin to a volcanic eruption which also covered it (V) and by Jukes (1847) to an adjacent trap intrusion. No evidence is now available of volcanic activity in the vicinity, a mafic dyke, cutting the Triassic rocks beside the nearby quarry at the head of Arthur Street, being dolerite, not a feeder to a Tertiary basaltic flow. An alternative explanation is that the wacke is a mass flow deposit shed from the upper slopes of an ancestral Knocklofty, which incorporated dolerite, sandstone and pebbles from the rocks over which it flowed and tilted, disrupted and covered the earlier, uncompacted spring deposit in its passage. Perhaps Milligan had the essence of the story as proposed above.

The carbonate in the spring deposit and in the overlying wacke, and the siliceous bodies in the spring deposit merit consideration. It is likely that both were deposited from groundwater which had acquired the calcium from the decomposition of minerals in the dolerite, and the silica from the same processes. Water falling on the ancestral Knocklofty would percolate through the dolerite, decomposing the feldspars and pyroxenes in it to yield calcium and other ions, and silicic acid in solution, and leaving residual clay minerals. Where such solutions came into contact with air and evaporated, calcium carbonate and silica would have been precipitated. Some other travertine deposits occur where dolerite has been intensely shattered or involved in mass flow deposits (e.g. Granton, Otago Bay).

The entire setting (Comment 11B) is consistent with this explanation i.e. a spring deposit later disrupted by a mass-flow down the slope of an ancestral Knocklofty.

## Relative Movements of Land and Sea

A recurrent theme in Darwin's writings on the voyage of the *Beagle* is the telative movement of the land and the sea, commonly the uplift of the land so clearly seen by Darwin in South America. Oldroyd (1996: 177) noted that Darwin had associated uplift in South America with volcanic activity. In his writing on this subject as he saw it in the Hobart area, Darwin noted evidence of both uplift and subsidence of the land. He tended to think in terms of upward or downward movement of the surface of the lithosphere and hardly considered the possibility of the movement of the surface of the hydrosphere. The concept of eustatic movements of sea level controlled by changes in glacial ice volume was first mentioned in about 1842 (Dott 1992: 6–7) but not taken seriously for another 20 years.

### Uplift

Taking first the evidence Darwin saw for uplift, he relied mainly on shell beds at various heights above sea level and to a lesser extent on shingle beds and on the geomorphology. He made it clear that elevated shell beds could be of one of three possible origins. In the first instance, they could be uplifted marine or littoral shell beds. Such an origin would be indicated by their occurrence in large numbers, in beds rather than in heaps (M), associated with rounded pebbles and interstratified with beds of shingle (M and V), and containing shells too small for eating. Prime evidence of a geological rather than a human origin for shell beds was his discovery of shells associated with pebbles encrusted with the tubes of marine (serpulid) worms.

Second, Darwin was aware that farmers might spread shells over their fields as fertiliser (FN: 9) but he did not see enough agricultural land to develop criteria for recognition of such an origin.

Third, Darwin also knew that the aborigines gathered shellfish for food and left the shells close to their campsites.

He expected such accumulations to be in heaps (FN, V) and associated with stone instruments e.g. hatchets (FN, M). The shells should be those of edible species and big enough to be worth gathering for food. The possibility of uplift of the land after accumulation of the heaps was noted (FN: **X11**). Uplift of an island after human occupation had been deduced by Darwin for the Island of San Lorenzo, off Callao, on the west coast of South America (J 1909: 375).

Darwin did not make clear how the heights of shell beds (etc.) were measured. Heights up to say 15 ft (4.5 m) are likely to have been estimated and to be reasonably accurate but higher figures must be regarded as approximate only.

Darwin wrote (FN: **2**) *There appears to have been a general rise — Shells on sides in beds in very many parts.* The occurrence of shell beds at 1.8–3 m above the breaking of highest tides and interstratification with beds of shingle were seen by Darwin on the way to New Norfolk (FN: **X13**), referred to in the memo (p.18) but played down in *Volcanic Islands* ..., in which Darwin noted the possibility that tides might have been higher in the past. He noted that, in the areas where he saw the shell beds, the water is now fresh or brackish. Also on the way to New Norfolk, he saw flat-bottomed valleys close to high-water level (FN: **X13**), explained later (M, footnote b on the back of p. 18) as "the floors of little coves". He had earlier (FN: **9**) reported shells at 3 m to 9 and 12 m *all along fields ... Comminuted* after having walked along the shoreline south of Bellerive and walked back from Porter Hill, probably along along the cart track through the farmlands of Sandy Bay on the western shore. He reported the shells as being *very much spread ... on a small scale, few pebbles on upper surface*, but expressed uncertainty as to their origin.

The report of a beach containing pebbles encrusted by serpulids, at 4–5 m above high-water mark (FN; M: 18; V: 141) is particularly interesting as such a beach has to record a stand of the sea, such encrustations normally being found in shallow water with a pebbly bottom. Regrettably, its locality has not been firmly established. It was "on the shore of Ralph Bay" (V:141) and was near a creek — the creek being *only separated from a larger expanse of water by a low strip of land* (M: 18). Darwin (*loc. cit.*) regarded it as an occurrence *of no value* in the context of evidence of uplift. Possibilities include (a) a low bank on the west side of Clarence Plains Rivulet, just upstream from the Droughty Point Road, (b) beside a small stream flowing into the Bay near the southern end of Huxleys Beach, (c) the rise at the south end of Gorringes Beach (fig. 6) and (d) near Calverts Lagoon. The first two are more probable, as there is deeper water immediately off-shore, a more likely environment for serpulids than Gorringes Beach, and Calverts Lagoon is not strictly on the shores of Ralphs Bay. Interbedded shingle and shell beds occur in an erosional cut at the back of Huxleys Beach, and dip south. Shingles and shells occur together on a vegetated bench at about 4.5 m above high-water mark just south of the small creek at Huxleys Beach.

Shells were reported at 60–80 ft (18–24 m) in the Government Domain (FN: **X11**) associated with round pebbles. A pebble horizon at about 18 m a.s.l. can be found south of Cornelian Bay and at Selfs Point to the north. If the shells were part of a shell bed deposited during a high sea-level, a bench due to marine erosion at this level might be expected. A bench occurs at just above 30 m a.s.l. at Government House and extends a little to the northwest to just above the entrance to the Royal Botanical Gardens. Another bench occurs at just above 20 m a.s.l. at the Cenotaph and at Selfs Point. It is interesting to note that Kerrison & Binns (1984: fig. 1) showed a shell midden at about 35 m a.s.l. topographically just above the Botanical Gardens, and another at about 25 m just inside the entrance to the Gardens. Darwin, apparently in some doubt as to the origin of the shell beds he saw, wrote (FN) *much to be said on both sides.* In a comment without further explanation, Darwin wrote *Water is said to be retiring — Earthquakes?* (FN: **3**).

In an uncheckable comment, Wintle (1864a) reported extensive deposits of comminuted shells, all of recent species, for miles along the banks of the Derwent River, some at elevations of up to 100 ft [30 m] a.s.l. and from 50–100 yards [45–90 m] from the water's edge. In a further report (Wintle 1864b) he noted a cliff section ("part of the river-bank at Sandy Bay") including two shell beds separated by "a stratum of large rounded pebbles of the adjacent felspathic trap and greenstone with ... sandstone", the lower shell bed on a thin stratum of marl on the "equivalent to the English New Red Sandstone". The exposure was probably at the southern end of Long Beach or it may have been near St Stephens Church.

Shell beds are now known to occur around Ralphs Bay close to modern sea-level at many places, up to about a metre above sea-level at Richardsons, Huxleys and Gorringes Beaches, up to about 18 m a.s.l. at Dixon Point, Maria Point and on the hill south of Gorringes Beach and at 29 m north of Maria Point. All of these localities are on the eastern shore of the Bay south of the Neck. At Mary Anne Bay on the western shore south of Gellibrand Point at the southern entrance to Ralphs Bay, a shell bed at 24 m a.s.l. has been dated at 125 000 years BP and shows uplift of the area since the Last Interglacial Stage of about 18 m relative to the rest of eastern Australia (Murray-Wallace & Goede 1991).

In *Volcanic Islands* ... Darwin settled for the view that there had been "a small elevation of the land".

### Subsidence

Darwin noted only two points indicating possible subsidence of the land. In FN: **2** and **3**, he reported *deep water in Coves ... & soundings in channel* as suggesting the possibility of subsidence.

### Earthquakes

In three places (FN: **3**, 5 and **XII**), Darwin invoked earthquakes to explain phenomena that he observed. In the oldest of these phenomena, the occurrence of fragments of white siltstone in the Tertiary beds at Long Beach, his explanation was probably correct. No published comment was made by geologists on the influence of seismic activity on Tertiary sedimentation in Tasmania until those of Carey (1947) and Hills & Carey (1947). Application of the concept to the sediments at Sandy Bay was not published until 1955 (Spry). Darwin also invoked, with some doubt, the effect of earthquakes to account for *water said to be retiring.*

An earth tremor had been reported in Tasmania in 1827 (*Hobart Town Gazette*, 30 June) but it is unlikely that Darwin knew of it.

## DARWIN AND FRANKLAND

The field notes reveal that Darwin gained considerable information about the general geology of VDL, acknowledged to have been from George Frankland, Surveyor-General. It included information on *Conical hills*, *Fossil shells* from the Launceston area, as well as geological observations on the centre of the island, the northwest, the northeast and the southwest. It seems from the field notes that it was ... *Mr. F*... (Frankland?) who was also able to tell him about the disappearance of oysters from the Derwent *within 2 years* (FN: X12), although in the *Geological Observations* ... (1844 edition: footnote to p. 141) the observation is attributed to "an intelligent farmer" and the date of disappearance given as 1834 (within two years of Darwin's visit).

Darwin may have walked about Hobart with Frankland on the 12th and certainly rode out with him on two occasions (the 13th and the 15th). From comments on Tasmanian geology (FN: 2) it is likely that Darwin had met him on or before the 7th. It is at least possible that Captain FitzRoy, as commander of an expedition with the prime function of measuring latitude and longitude, called upon or made contact with Frankland as Surveyor-General soon after the *Beagle* reached Sullivans Cove and may well have introduced Darwin to him. With Frankland, Darwin would have found a community of interests.

Frankland was born in Somerset, UK, in 1800, joined the army in 1819 and served in India (Eldershaw 1966: 410–411). He was appointed Surveyor-General in Poona in 1823 but later returned to England after taking leave in South Africa. Governor Arthur wrote to Earl Bathurst (Secretary of State) on 22 April 1826, asking for a mineralogist and civil engineer (HRA III, 5: 192). Unaware of this approach, Bathurst wrote to Arthur on 17 May 1826 (HRA,5: 233) instructing Arthur to appoint Frankland to "any of the appointments of a superior description to which he may be fitted as soon as possible". Three days later, Hay (Permanent Under-Secretary, Colonial Office) wrote to Arthur (*ibid.*: 234) appointing Frankland as Assistant Surveyor, pointing out that Frankland was an experienced surveyor as well as " being a person of Education and Science" and noting Bathurst's suggestion that Frankland might at the same time be employed in collecting "information in regard to Geology and Natural History".

Frankland arrived in VDL in July 1827 as Assistant Surveyor and was appointed Surveyor-General in March 1828. He participated in several major expeditions within the island and instructed his surveyors to take note of "every remarkable fact connected with the Natural History of the island". He also encouraged them to collect geological specimens and he maintained a museum which included geological specimens in the Surveyor-General's Office (Tasmanian State Archives, Outward Despatches 16: 270). Frankland was the Foundation Vice-President of the Van Diemen's Land Society, founded in 1830 for the "publication of local scientific information and foundation of a museum and botanic garden" (Robson 1983: 181). Darwin could have called upon Frankland's fund of knowledge so accumulated, and to a lesser extent upon reports of early expeditions such as those of D'Entrecasteaux and Flinders. From the Museum, Frankland gave Darwin fossil specimens (Banks 1971: 15), which included some that later received the attention of G.B. Sowerby in England (V, Appendix to Part 1 — Palaeozoic Shells from Van Diemen's Land) and became types of new species.

Darwin dined with Frankland twice, on the 12th and 15th, presumably at "Secheron", Battery Point, where Frankland lived with his wife and three children.

## SUMMARY

Darwin's field notes record more fully than any other known sources his geological observations and thoughts while in Hobart Town and bring to light "new" observations. In so doing, they confirm that the site of collection of fossil bryozoa on which the genus *Stenopora* is based was the shoreline below Porter Hill, Lower Sandy Bay. They allow the routes of his "*pleasant little excursions*" to be more accurately traced and highlight some areas of present ignorance or uncertainty, namely the origin of the deposit of spring limestone above Burnett Street, Hobart; the localities of possibly uplifted shell beds and shingle with serpulids; and, from them, the presence and amount of uplift along the shores of the Derwent River.

The field notes would not receive a prize for spelling or ease of reading but they are useful as records of observations and deductions in the field. Darwin himself used them subsequently as the basis of the appropriate sections of published works, and they have been used by independent observers 150 years later, to pinpoint the localities of many of his observations.The observations were acute and as good as could be made at the time.

There is no doubt that Darwin took full advantage of the opportunities offered by his visit. He explored the geology (and zoology) of Hobart and its surrounds, as well as the countryside to the southeast, the south, the west and the north. He consulted and worked with the local "expert", George Frankland. He was active — he took only one day, a stormy Sabbath, off from his duties as a naturalist to write letters home. His observations ranged over many areas — geological, geomorphological, botanical, zoological, anthropological and social. He applied his considerable geological and zoological learning and experience acquired in Britain prior to his embarkation on the *Beagle* and during the voyage itself. His background allowed him to think imaginatively about what he saw.

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