The Tertiary Volcanic Rocks of Lower Sandy Bay, Hobart

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(WITH 3 PLATES AND 6 TEXT FIGURES)

ABSTRACT

Alkali-basalt (nepheline basanite) and basic pyroclastics occur near Blinking Billy Point where they overly Tertiary lacustrine beds. The latter consist of a boulder bed, probably of landslide origin, and mudstones which contain poor plant fossils. There is a total thickness of at least 450′ of Tertiary rocks lying on a down-faulted block surrounded by Permian and Triassic sediments and Jurassic Dolerite. The Tertiary rocks were folded against the confining blocks by forces associated with the rise of magma during vulcanism.

INTRODUCTION

The area described here, and shown in fig. 1 is located at Blinking Billy Point (formerly One Tree Point), Sandy Bay, about three miles south of Hobart. The Tertiary rocks are limited to an area of about fifty acres and are only exposed to any extent in the cliffs or in excavations and road cuttings.

The sequence appears to be as follows:

Volcanic Rocks	Dolerite Boulder bed	5′ +
	Blinking Billy Point basanite	80′ (?)
	Tuff	1–5′
	Basanite	0–15′
	Interbedded basanites and pyroclastics	250′
Lacustrine Sediments	Mudstone with plant remains	20′
	Boulder Bed	60′ +

Previous Literature

Ease of access has led to the investigation of this area by a number of workers in the past. The discovery of "basaltic lava" and "brecciated scoria" on the "west side of Storm Bay" by Darwin (1844) was probably the first reference to this locality. Johnson (1881) was the first to give a detailed description of the lacustrine and volcanic rocks together with the fossils present. He briefly outlined the structure of the area and related the rocks to those at Cornelian Bay and Lindisfarne. A brief reference was made to marsupial bone fragments found apparently in a joint in the basanite. He regarded the boulder bed as the result of landslides from steep cliffs.

White and Macleod (1898) gave a description and chemical analysis of the Blinking Billy Point basanite. Petterd (1910) recorded melilite and hauyne in the same rock. Noetling (1913) gave further details of the area, particularly of the structure in the large cutting on Sandy Bay Road. He suggested that the boulder bed and " leaf bed " were shoreline sediments which had been deposited on a downfaulted block. He considered that the boulder bed was a Pleistocene till and that the vulcanism was consequently post-Pleistocene. Aurousseau (1926) presented a valuable and detailed description of the basanite together with a chemical analysis. He discredited the analysis of White and Macleod (1898) and showed that the determination of fayalite by White and Macleod (1898) and of melilite and hauyne by Petterd (1910) were incorrect. He classified the lava at Blinking Billy Point as a nepheline basanite and discussed the origin of the iddingsite. Edwards (1949) grouped the basanite with similar rocks from other Tasmanian localities in a regional petrological study. An account of the regional geology of the surrounding area by Carey and Banks has not yet been published.

TERTIARY ROCKS

Lacustrine Sediments

Probably the oldest representative of the Tertiary System in the area is the boulder bed which is exposed in the central and northern parts of the large road cutting at Blinking Billy Point. It consists of large angular fragments of Permian sediments set in a light coloured, fine grained matrix, and is very poorly sorted with no bedding visible. The large fragments are generally not more than a foot across although boulders up to four feet in diameter are found. Similar boulder beds have been found close to this fault system from Taroona to Claremont by S. Warren Carey (personal communication) who first realised their tectonic significance. A mechanical analysis shows that the sediment lacks sorting and is bimodal in character with the boulder and the silt-clay fractions predominating. Pebbles and sand are present but to a lesser extent. A detailed analysis is not given because of the difficulty in sampling a bed containing such large boulders. This rock is called a *boulder* bed rather than a *breccia* because the unsorted nature prevents any exact terminology. The clastic fragments present show a complete range of sizes from clay to boulders and there is less than 50 per cent in any one size class.

The fragments of greater than sand size are of Permian mudstone and are very angular with a moderate sphericity. The smaller fragments consist of quartz and Permian mudstone with a high degree of angularity and low sphericity. The angularity increases with the size of the particle. The shape of the fragments suggests that the smaller ones were formed by the smashing together of the larger fragments during transportation.

The texture is typical of till, landslide debris or mudflow material. The boulders show a random distribution in the lower parts of the bed but a tendency for them to be concentrated in layers becomes marked towards the top.

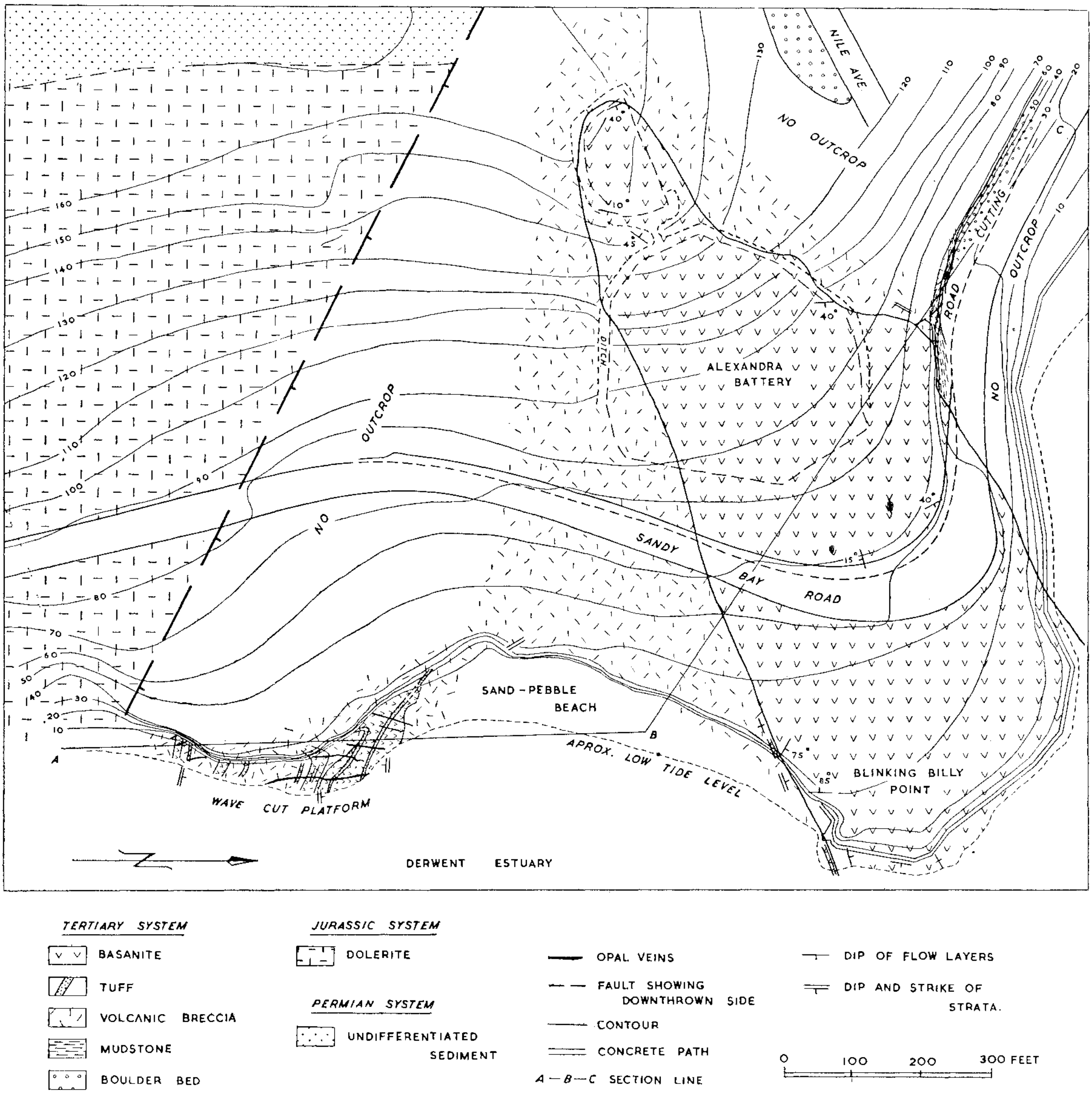

FIG. 1.—Map of the Blinking Billy Point area.

The base of this formation is not exposed due to subsequent road construction, but as Johnson (1851) stated that it then extended down to sea level, there would be a thickness of at least 60′ present.

The overlying bed is a white mudstone which differs from the boulder bed only in that it lacks large boulders, possesses well developed bedding and contains plant fossils. Boulders are distributed rather sporadically throughout, and many are concentrated in distinct layers. Some layers are rich in pebbles or in coarse sand. The upper part of the mudstone contains poorly preserved leaves, twigs and fruit as described by Johnson (1881).

A mechanical analysis shows that the mudstone is poorly sorted and closely resembles the matrix of the boulder bed. It is composed predominantly of clay but with about 10 per cent of sand and 40 per cent of silt. The fragments are angular with a moderate sphericity but show a somewhat higher degree of roundness and sphericity than the boulder bed matrix. This would be due to some attrition during transport by running water although the large proportion of small rock fragments and the lack of sorting indicates that the sediment is not a normal mudstone. It probably resulted from the rapid erosion of debris on the steep fault scarps, with only slight washing on the lake floor.

In the centre of the syncline in the main road cutting is a few feet of post-volcanic boulder bed which is composed chiefly of rounded dolerite boulders in a clay matrix. This is also well exposed along Nile Avenue.

Following the work of Carey (1946, 1954) it is believed that early in the Tertiary, major faulting took place along the present location of the Derwent which was then an irregular, complex graben. Lakes were formed on the downthrown blocks and considerable thicknessess of clays and sands accumulated. The boulder beds are located close to the fault scarp margin of the lake and are composed of debris shaken off the scarp during earthquakes caused by later movements along the faults. The massive beds towards the base of the main road cutting may partly consist of mudflow debris which flowed off the steep slopes after heavy rains following earthquakes and uplift. As the lower boulder bed is rich in Permian mudstone boulders while the upper boulder bed contains chiefly Jurassic dolerite boulders, it appears that erosion removed the mudstone which composed the scarp before the vulcanism to expose an underlying dolerite sill which was the source of the post-volcanic debris. The difference in angularity between the mudstone and the dolerite boulders is probably attributable to differing modes of weathering of these rocks rather than to differing processes of transportation or differing amounts of corrosion. The jointing in the mudstone caused it to form angular blocks while spheriodal weathering of the dolerite resulted in round boulders. This latter tendency would be accentuated if the climate was warmer and more humid as suggested by the flora present.

The white mudstone was deposited during the period of comparative quiescence which followed the faulting. Each layer of pebbles or boulders represents a sudden earthquake with uplift due to repeated movements along the faults indicating that normal deposition was periodically interrupted.

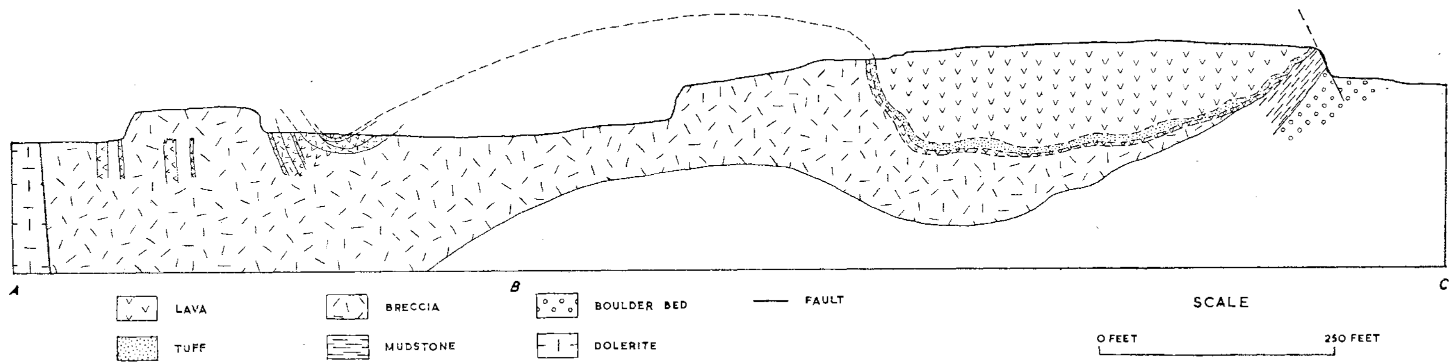

FIG. 2.—Section across fig. 1 from the main road cutting C, to the wave-cut platform A.

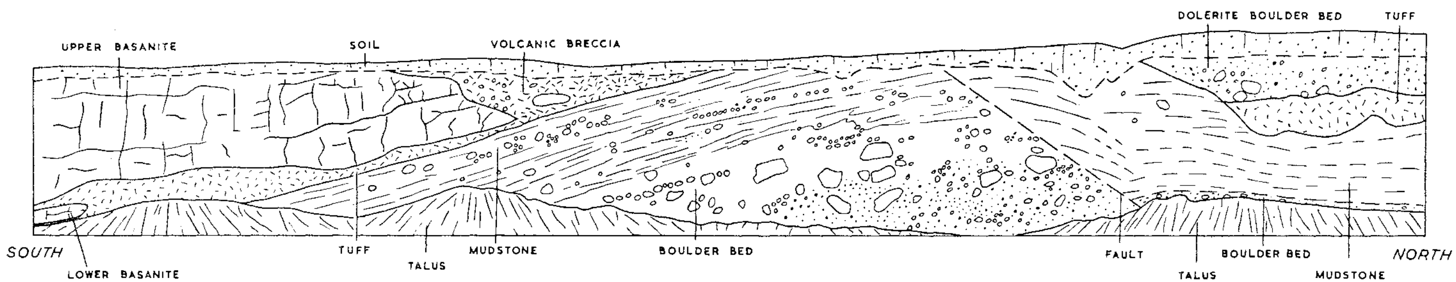

FIG. 3.—Section along portion of the Sandy Bay Road cutting.

Volcanic Rocks

The sequence from top to bottom is as follows:

Wave-cut Platform		*Main Road Cutting*	
basanite	10′ +	Blinking Billy Point basanite	80′ (?)
red tuff	3′ — 5′	tuff	1 — 4′
basanite	0 — 15′	basanite 2′ (perhaps thicker in part)	
breccia with thin lava flows	250′ (?)		

The oldest volcanic rocks in this area are exposed on the wave-cut platform on the small promontory just south of Blinking Billy Point. There is at least 250′ of interbedded lavas and pyroclastics which are quite strongly folded as shown in figs. 4, 5 and 6.

In the small bay in the centre of the area is a volcanic breccia which may be 60′ thick; this is the equivalent of the lower breccias and tuffs of the wave-cut platform.

Lavas

The lavas are dark grey, fine grained and speckled with flecks of red iddingsite, and show only a slight variation in composition between different specimens. The Blinking Billy Point basanite is generally massive except for a platy flow structure which is strongly developed in some parts (see plate 1 No. 1), while some of the thinner flows are quite scoriaceous and ropy. One thin flow, now vertical, on the southern end of the wave-cut platform shows a fine-grained base and scoriaceous top as shown in plate II, No. 1. The base of the Blinking Billy Point basanite and that of the probably equivalent lava above the red tuff on the wave-cut platform, are rich in small sedimentary xenoliths. These show only slight metamorphic effects, being baked and slightly silicified with chalcedony. A thin section shows that there is a distinct concentration of feldspar around some xenoliths.

The lavas grade from massive to blocky varieties and some pass abruptly into breccia along the strike. This is seen at the top of the main road cutting at its southern end in fig. 3.

Thin sections show the lavas to be very fine grained, holocrystalline and porphyritic. They consist of euhedral to subhedral phenocrysts of iddingsite (after olivine) in a fine groundmass composed of pyroyene, nepheline, feldspar, iron ore and apatite. Secondary opal and chalcedony fill tiny amygdales.

The iddingsite averages 0·2 mm. diameter but may be as much as 1 mm. across and is usually deep red with a peripheral zone which is darker in colour and rich in iron ore inclusions, see plate 3, No. 1. It is weakly pleochroic, biaxial negative with an optic axial angle about 45°, and has straight extinction on the single, well-developed cleavage. Many cyrstals contain inclusions of apatite, while others are surrounded by a growth of pyroxene. The iddingsite has replaced olivine due to a late magmatic (?) reaction involving addition of water and silica.

The pyroxene occurs as abundant, tiny prisms which are usually only ·02 mm. across but which are up to ·2 mm. in some specimens. It is faintly pleochroic from light yellowish green to light green. Some crystals are twinned and others show hourglass structure. The flow structure of the basanites is shown by parallelism of these prisms.

Apatite is a fairly abundant accessory and it shows unusual properties. It occurs as pale purplish grey prisms which are faintly pleochroic with a very low birefringence. The well formed crystals are usually about ·04 mm. diameter and up to ·3 mm. long and thus occur as distinct phenocrysts. It contains many tiny inclusions in the order of ·0005 mm. across, which are ilmenite or possibly rutile. These occur as needles parallel to the C axis or as plates oriental parallel to the hexagonal prism face of the apatite.

TABLE I

Nepheline basanite, Blinking Billy Point

		Norm	
SiO_2	45·59		
Al_2O_3	12·48	or.	18·62
Fe_2O_3	9·93	ab.	21·48
FeO	2·84	an.	0·83
MgO	4·71	ne.	12·50
CaO	8·26	hl.	0·23
Na_2O	5·51	th.	0·10
K_2O	3·16	di.	22·68
H_2O	1·73	ol.	1·68
H_2O—	1·64	mt.	3·71
CO_2	Nil	il.	3·93
TiO_2	2·10	hm.	7·36
P_2O_5	1·65	ap.	3·86
MnO	0·16	H_2O	3·37
Cl	0·16		
SO_3	0·09		100·35
	100·06		

Analysis by Aurousseau (1926).

The dark minerals are set in a clear, colourless, almost isotropic material of low refractive index, which the analysis (table 1) by Aurousseau (1926) indicates to be a mixture of nepheline, orthoclase and plagioclase. The quotation of this analysis by Edwards (1948) is incorrect in the amount of SiO_2, has H_2O+ and H_2O— transposed, and omits SO_3. Nepheline is recognizable as tiny hexagonal prisms showing zonal structure but the feldspars are rarely distinguishable. There may be more nepheline than the 12·5 per cent indicated in the norm in Table I, because free silica (of secondary origin) is present in the rock and some of the 40·93 per cent of normative feldspar may actually be present as nepheline, feldspar, and chalcedony or opal. Despite Aurousseau's (1933) doubt of the validity of Petterd's (1910) hauyne, there is a small amount of a mineral present which might actually be hauyne, thus explaining the ·09 per cent of SO_3 in the chemical analysis. Gypsum, sulphur, mirabilite and thenardite were reported by Aurousseau (1933) although these were not observed by the author.

There is usually about 5 per cent of free silica present as concentric layers of opal and chalcedony in tiny amygdales and these are probably the " sulphate vesicles " referred to by Aurousseau (1933). The silica is a post-magmatic introduction to a rock which clearly shows its undersaturated character by the presence of olivine and nepheline. The magma originally contained nearer 40 per cent silica rather than the 45·59 per cent shown in the analysis.

The most common composition is about 45 per cent of felsic minerals with 35 per cent augite, 7 per cent red iddingsite, 7 per cent iron ore, 4 per cent opal and chalcedony, and 2 per cent apatite as shown in specimens 6079, 6080, 6084, 6087, 6088, 6089, 6098 in the collection of the Department of Geology, University of Tasmania. Some rocks however differ from this general description give above in containing much more pyroxene (up to 55 per cent) and less feldspar and feldspathoid (about 25 per cent). These also contain iddingsite which is yellow. Specimens numbered 6078, 6090, 6091, 6092 belong to this group.

The basanite (6079*b*) above the red tuff on the wave-cut platform is very rich in augite and differs highly from the other lavas in containing pyroxene phenocrysts, together with clots of feldspathoid. One other lava here (6079*a*) is quite rich in green opal.

The common rock is an undersaturated, alkaline, olivine basalt and thus is classed as a basanite, and because of the abundance of nepheline, it would best be called a nepheline-basanite.

Breccia

The coarse pyroclastics are massive, unsorted breccias consisting of angular blocks of very scoriaceous lava. They possess no bedding and often very little matrix (see plate 2, No. 2). The fragments are usually about 6″ across but some large, well formed bombs are almost a yard long. Following the terminology of Wentworth and Williams (1932), the fragments appear to be all *essential* and *accessory* ejecta without any *accidental* material.

At the north end of the little cliff above the wave-cut platform a coarse breccia grades upwards into fine breccia which passes into a well-bedded, reddish lapilli-tuff containing bands of finer tuff. This transition also takes place laterally, a few yards further south along the cliff face.

Tuffs.

The fine grained pyroclastics are much less abundant than the breccias but are well shown in the following places:—

(*a*) Immediately below the Blinking Billy Point basanite in the road cutting is about 18″ of dark-brown, vitric tuff (6082). It is composed chiefly of small angular fragments of scoriaceous, brown glass. The tachylyte contains a little fresh olivine (?), iddingsite and much iron ore while the amygdales are usually filled with chalcedony.

(*b*) In the north-eastern end of the ditch around the old Alexandra Battery is a lithic-crystal tuff (6081). It is composed of angular fragments which are usually about 1 mm. in diameter but which range up to 5 mm. The fine grained basalt fragments present have been altered to a mixture of chlorite and brownish clay. Present abundantly are fresh augite crystals showing strong polysynthetic and herringbone twins (see plate III, No. 4). There are a few fragments of fresh basic plagioclase and a quartz-albite particle.

(*c*) On the northern end of the wave-cut platform is a bed of reddish tuff about 3′ thick. It is quite well bedded and thus differs from the other tuffs which are quite massive.

(*d*) At the southern end of the wave-cut platform is a coarse tuff with a distinctive red and white colour (6083). It consists of irregularly shaped fragments of amygdaloidal glass which is cemented by much calcite. A little clastic pyroxene is present, together with reddish brown opal. The amygdales of the lava fragments are filled chiefly with chalcedony. This tuff occurs immediately next to an opal vein which is very rich in calcite and thus the carbonate cement of the tuff can be attributed to a late hydrothermal introduction (see plate III, No. 3).

(*e*) At the western and upper extremity of the Blinking Billy Point basanite, in the ditch around the Alexandra Battery, there is a thin layer of tuff which lies below the basanite but above a massive volcanic breccia. It shows well developed prismatic jointing with tiny hexagonal columns only about 1 cm. across.

Hydrothermal Activity

Not only has there been considerable introduction of opal and chalcedony to the lavas as amygdale fillings but also those minerals, together with calcite, form distinct masses among the volcanic rocks of the wave-cut platform. A number of parallel, dyke-like veins up to 2½′ wide run approximately north-south as shown in fig. 5. These are composite veins composed of opal, chalcedony and quartz with variable amounts of calcite and are reddish, orange and white in colour with a crude brecciated and banded structure. These sections show that there was an introduction of red, almost opaque, opal first, and that this was followed and partially replaced by calcite giving a brecciated appearance to some specimens (6076). Later colourless, isotropic opal formed encrusting layers on the earlier minerals and this was covered by layers of birefringent, fibrous chalcedony and finally quartz giving a banded, crustified mass (6077) (see plate III, No. 2).

There is a line of outcrops of calcite-impregnated breccia running parallel to the opal veins on the wave-cut platform. A thin section (6093) shows that the scoriaceous basalt fragments are glassy with a little iron ore, pyroxene, apatite and iddingsite present as shown in plate III, No. 2. The amygdales are partly or wholly filled with carbonate with later opal and chalcedony which were deposited on the carbonate. Banded opal and chalcedony fill some amygdales.

There has been an introduction, chiefly of silica, filling some joints, and of calcite impregnating the porous breccia. Silica also entered the basanites and their xenoliths although to a lesser degree. It is presumed that these minerals were deposited from hydrothermal solutions during the late or decadent phases of volcanism. The opal and chalcedony in the lavas may have been deposited from late magmatic fluids derived from the magma of the flow although the magma is so basic that it is unlikely that it could yield a siliceous residue. Probably all the silica and carbonate was deposited from fluids passing upwards from a deeper magma body to feed hot springs or geysers. The mineral sequence of calcite, opal, chalcedony and quartz appears to be typical of this area while silicification is found widely associated with Tertiary basalts throughout Tasmania.

Structure

The structure of the faulted Permian, Triassic and Jurassic rocks which surround the Tertiary complex is very difficult to determine because of the paucity of outcrop and the close settlement, consequently only a generalized interpretation is shown in fig. 6 which is based on Banks' unpublished work. The area has been broken up by Tertiary faults and the Tertiary rocks occupy a downfaulted block.

Figure 3 shows a section along part of the main road cutting on Sandy Bay Road. The boulder bed is overlain by mudstone, tuff and basanite. These generally strike at approximately 230°* and dip at 45° to the south west but towards the northern end of the cutting the beds form a broad anticline plunging shallowly to the west. The beds are disturbed in the central part of the cutting where a small syncline and a faulted anticline are visible. Six feet of tuff occurs in the centre of the syncline where it is overlain by several feet of dolerite-boulder bed. There has been a downthrow of approximately 18′ on the northern side of the normal fault which strikes at 135° and dips at 60° to the north-east. A number of tiny horizontal faults occur between the anticline and the syncline, and these show overthrusting of up to six inches from the north. A number of small faults with throws of an inch or so occur in the plant-bearing mudstones, sandstones and boulder beds in an excavation on the corner of Wayne Street and Sandy Bay Road, where they strike at 210° and dip at 45° to the east.

The Blinking Billy Point basanite has the form of a shallow assymetrical syncline which plunges at 10° into the Derwent, and this was first recognized by Carey (personal communication). The northern limb dips at 45° in the prominent exposure in the main road cutting but flattens a few feet to the south where the underlying tuff thickens rapidly and part of a thin lower flow appears, as shown in fig. 3. The flat dip is seen just above sea level on this limb of the fold, where the lower flow is at least 12′ thick and there is a breccia between the two lavas. The thin lower lava is also visible on the southern limb of the fold where it is separated from the main basanite by a foot or so of breccia. The flow structures within the basanite show strong irregularities as shown in fig. 1, thus indicating undulations within the main fold. These undulations are probably of primary origin due to lava flowing over an irregular layer of tuff.

The volcanic rocks exposed on the wave-cut platform of the small headland just south of Blinking Billy Point, show quite strong folding. The interbedded lavas, tuffs and breccias show dips up to 90° (see plate I, No. 2).

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* All bearings are taken from true north.

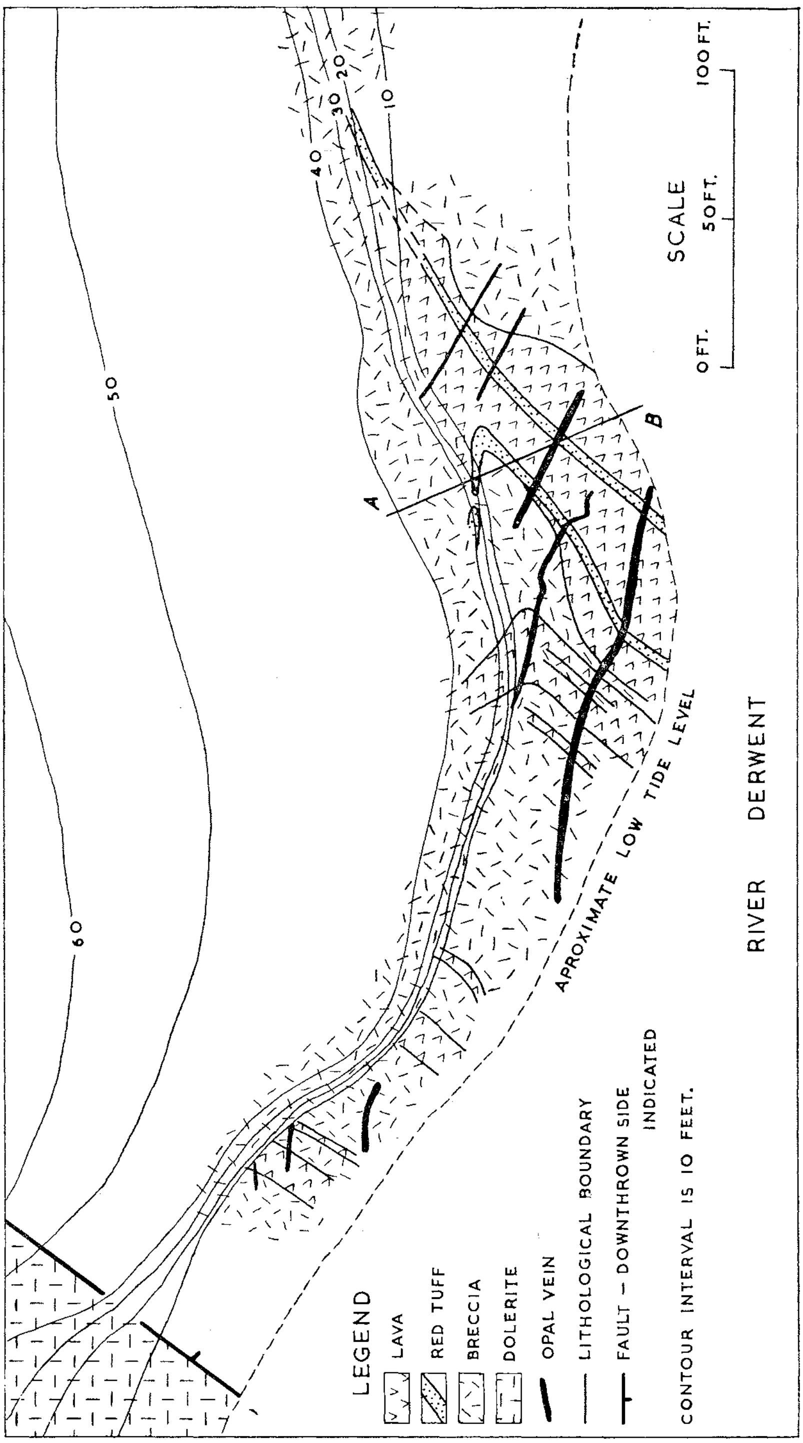

FIG. 4.—Detailed sketch of the wave-cut platform.

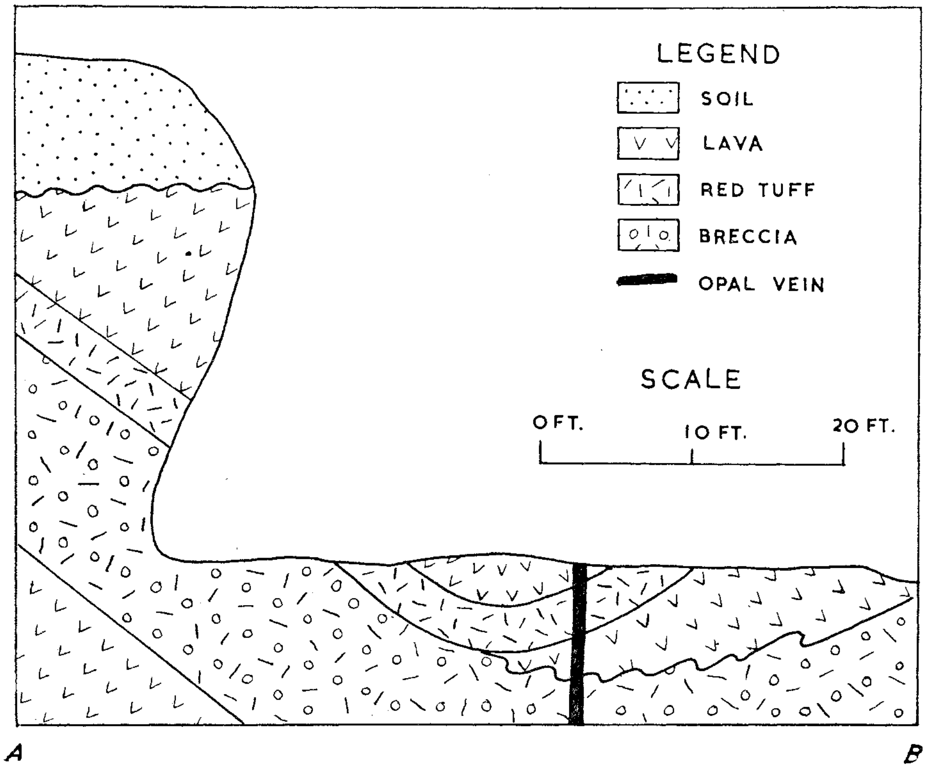

FIG. 5.—Section across the wave-cut platform.

A simple syncline is outlined by the red tuff on the northern end of the platform and this is illustrated in fig. 5. Immediately below the tuff on the north-eastern side of this fold is a scoriaceous lava, whereas on the south-western side there is about 15′ of coarse breccia between the lava and the tuff. It is a characteristic feature that all the volcanic rocks show quite rapid variations in thickness.

The structure of the rocks on the central and southern parts of the platform is difficult to determine. There is a change from the northerly dip of the southern flank of the syncline to a southerly dip and this is followed by vertical dipping beds containing one lava showing a distinct north-facing as shown in plate II, No. 1.

When one looks at the face of the cliff above the platform for confirmation of the folding, it is seen to consist of a uniform, unsorted mass of breccia lacking either bedding or interbedded lava flows. The general relations suggest that the breccia lies unconformably on the eroded surface of the lower folded lavas and pyroclastics. Towards the southern end of the wave-cut platform, the breccia in the cliff face passes directly down into the breccia shown in fig. 2, thus showing that there is probably no unconformity. The cliff breccia dips vertically and the thin lava flows do not appear in the cliff because of very rapid thinning out. Thus the southerly dipping beds in the central part of the platform are overturned.

Structural interpretation in such folded volcanic complexes is difficult for the following reasons:—

(*a*) The pyroclasts usually lack bedding thus preventing determinations of attitude.

(*b*) Initial dips of lavas and tuffs may be quite high near centres of erution.

(*c*) There are abrupt changes of thickness and facies (breccia to tuff, lava to breccia or tuff).

(*d*) It is not possible to distinguish between similar looking breccias or lavas which have different positions in the sequence.

The structure between the syncline of Blinking Billy Point and the folded rocks to the south is obscure because of insufficient outcrop. The red tuff, together with the overlying and underlying lava flows pass very abruptly into a massive breccia which dips to the west, in the centre of the little bay. The breccia dips more and more steeply towards the basanite to the north until it is nearly vertical at the contact. Thus there is an assymetrical anticline in this bay. Although it cannot be proved, it is likely that the Blinking Billy Point basanite is equivalent to the lava above the red tuff which in turn is equivalent to the tuff immediately below the basanite in the main road cutting. Thus the thin lava just below the Blinking Billy Point basanite would then be equivalent to the discontinuous lava below the red tuff on the wave-cut platform.

Figures 1 and 6 show that the general structure within the area occupied by Tertiary rocks consists of a series of anticlines and anticlines whose axial directions converge and which are generally assymetrical with the southern limb of the synclines steeper than the northern.

Tertiary sediments and volcanic rocks in Tasmania are usually quite flat-lying, and where appreciable dips are found they are usually due to initial dip or to drag against faults. The rocks in this area differ in showing quite strong folding although they lie upon unfolded Mesozoic and Palaeozoic rocks. Carey (1954) has shown that vulcanism was associated with a period of epeirogeny and crustal tension. In Tasmania, Tertiary folding is restricted to pyroclastics and lavas in the dissected areas in and around composite volcanoes, e.g., that described by Brill and Hale (1954) on north-western Tasman Peninsula. Two possible mechanisms which might produce these structures are briefly outlined but as it is considered that a number of these volcanic centres will need to be studied before the details are clear, details will be left for a future paper.

The folding may be related to local compression associated with the rise of magma and volcanic eruption. The thin, unconsolidated sediments and still hot lavas would be folded in a *dècollement* manner with the basal lacustrine clays acting as a lubricant as the beds slid over the rigid basement of Mesozoic and Permian rocks and were pushed against the enclosing fault blocks. The association of folding with volcanic rocks and the relation between the fold axes and marginal faults, implies the vulcanism produced the energy for folding and the fault blocks controlled the structure pattern.

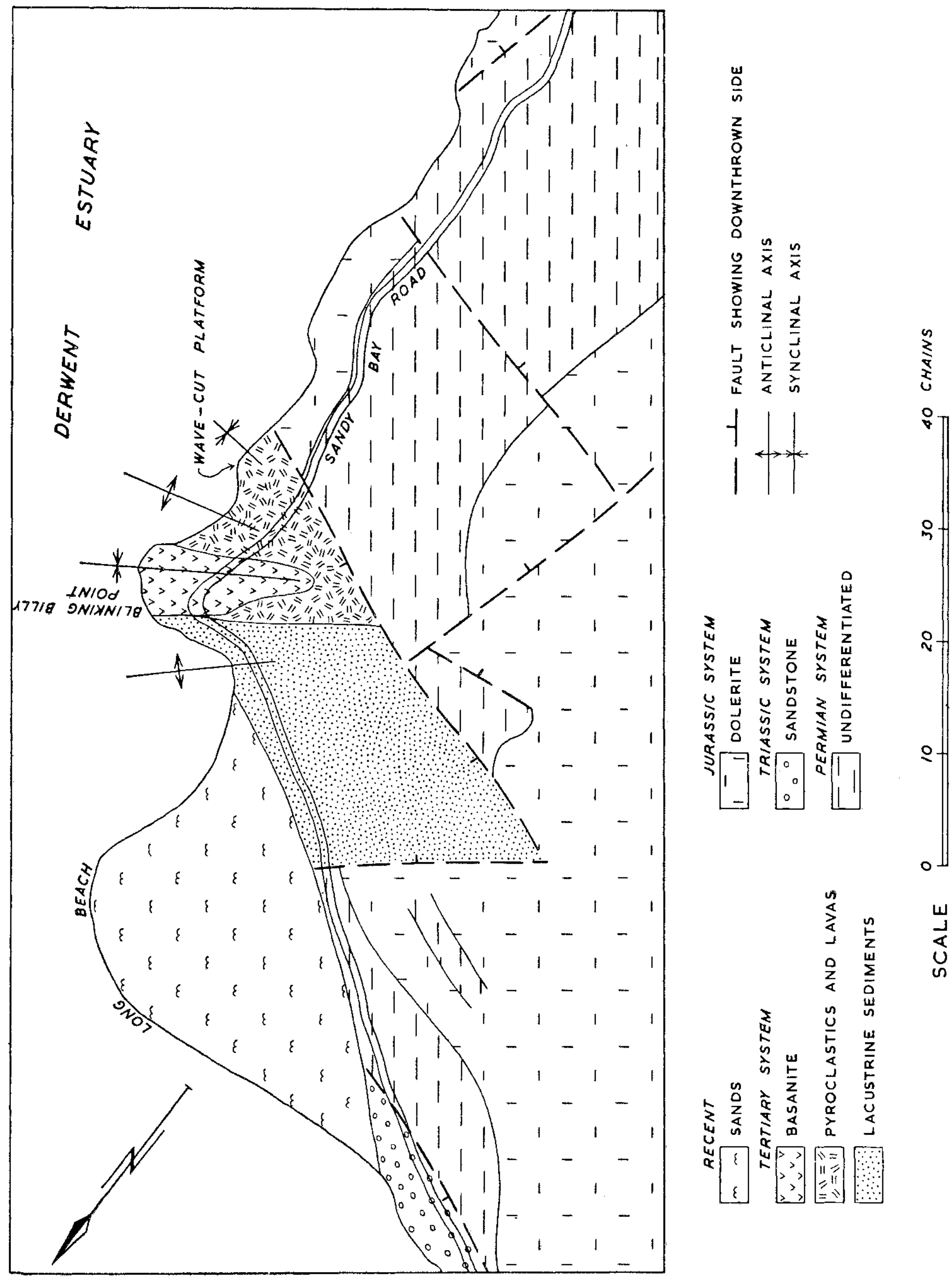

FIG. 6.—General structural environment of the volcanic rocks, chiefly after Banks.

It is possible that the folds were caused by a combination of the drag of the lavas passing over wet unconsolidated clays, together with gravity slumping down a slope. The cold lavas would be too brittle to fold without a considerable confining pressure, and as there is no evidence that the volcanics were covered by a large thickness of later materials then they must have folded when in a hot, plastic condition. This feature, combined with the assymetry of the folds suggest that the Blinking Billy Point basanite may have first flowed down a slope composed of lacustrine sediments and some volcanic rocks. When the lava was partly solidified, it slid down and crumpled the underlying material and was itself folded. The volcanic material as thicker towards the southern part of the area and the assymetry of the folds is in harmony with slumping towards the north.

Age of the Vulcanism

Johnson (1881) considered that the plant fossils indicated an Eocene age for the lacustrine beds while Noetling (1913) considered that they could be as young as Pleistocene. Lewis (1946) and Edwards (1949) considered that there were two separate periods of vulcanicity in Tasmania during the Tertiary and that these corresponded to the Older and Younger Basalts of Victoria. Lewis (1946) regarded the Blinking Billy Point rocks to be equivalent to the Younger Basalts.

Unfortunately the plant fossils are poorly preserved and in any case are not sufficiently diagnostic to give an age of better than Oligocene to Pliocene. Recent work throughout Tasmania, chiefly by Carey (personal communication), has not supported earlier ideas of more than one period of vulcanism in Tasmania during the Tertiary.

There is not sufficient data available to determine the age of the basalts although the following is known:—

(*a*) The basalts appear to be later than the Tertiary faulting.

(*b*) Basalt has been glaciated during the Pleistocene near the Great Lake.

(*c*) Basalt lies above Tertiary lacustrine beds which are approximately Miocene in age, in many places in Tasmania.

(*d*) Basalt lies on the eroded surface of Tertiary marine beds at Table Cape and Marrawah and these have been dated as Miocene (Gill and Banks, in press).

(*e*) The basalts show very deep dissection in many places throughout Tasmania and a study of the volcanic rocks of Sandy Bay illustrates this. Erosion has penetrated through the overlying basalt sheets to reveal the deep cores of the central volcanoes. The original volcanic cones have been either completely obliterated or persist as solid cores as at Table Cape. At Sandy Bay (also Tasman Peninsular, Cambridge and elsewhere) folded lavas have been truncated. As the degree of dissection resembles that of the Older Basalts of Victoria (Oligocene), rather than that of the Newer basalts (Pliocene), a tentative age of Miocene is advanced for the Tasmanian basalts. This is supported by the fact that Edwards (1949) showed that the Tasmanian basalts show petrological affinities with both the pre-Miocene and post-Miocene volcanic rocks of Victoria.

SUMMARY AND CONCLUSIONS

During the early Tertiary epeirogeny, the Derwent Valley was initiated as a graben bounded by a complex system of intersecting faults. Lakes formed on the downthrown blocks and a hundred feet or so of sediments were deposited at Sandy Bay. Further tension resulted in repeated movements along some faults and the rise of magma along major fractures. The initial vulcanism was of Icelandic type with numbers of central volcanoes situated along faults, and explosive eruption caused the deposition of lithic, vitric and crystal tuffs with basaltic breccias and thin lava flows. There were a number of large cones situated within the present Derwent estuary but these have been entirely removed by erosion. A cone existed a short distance south-east of Blinking Billy Point, just seawards of the wave-cut platform.

There has been continued erosion since this time and this has destroyed the cones which were located along the main valley line, and the remains were covered by water following the drowning of the estuary since the Pleistocene.

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The author wishes to acknowledge the assistance of Professor S. Warren Carey whose interest in the area caused the work to be undertaken. Discussion of the problem with him has meant that many of his ideas have been incorporated in this work and although some have been acknowledged in the text, there are others which have become modified and have lost their original identity.

Thanks must go to M. R. Banks for allowing the incorporation of fig. 3 which is based on his unpublished map of the area. A. T. Wells and K. Nicholls assisted in the field mapping.

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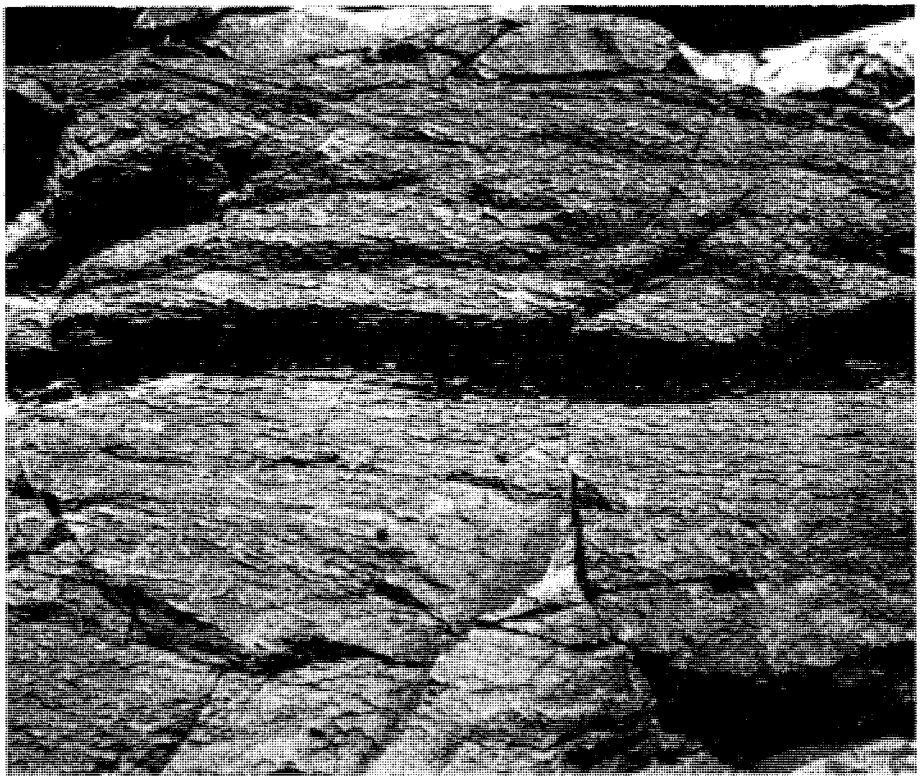
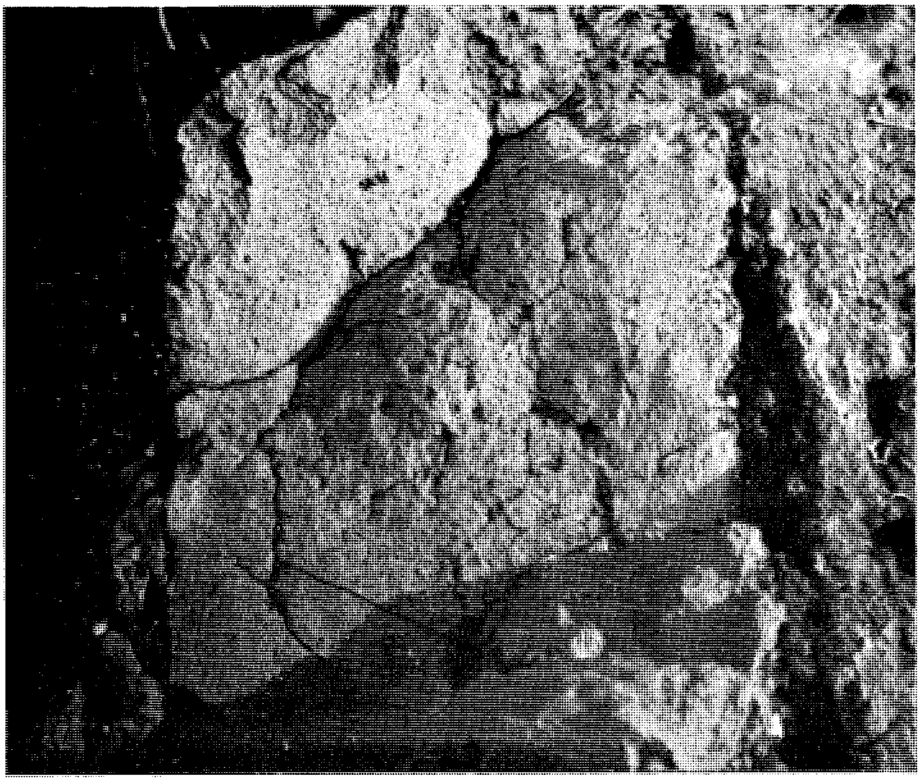
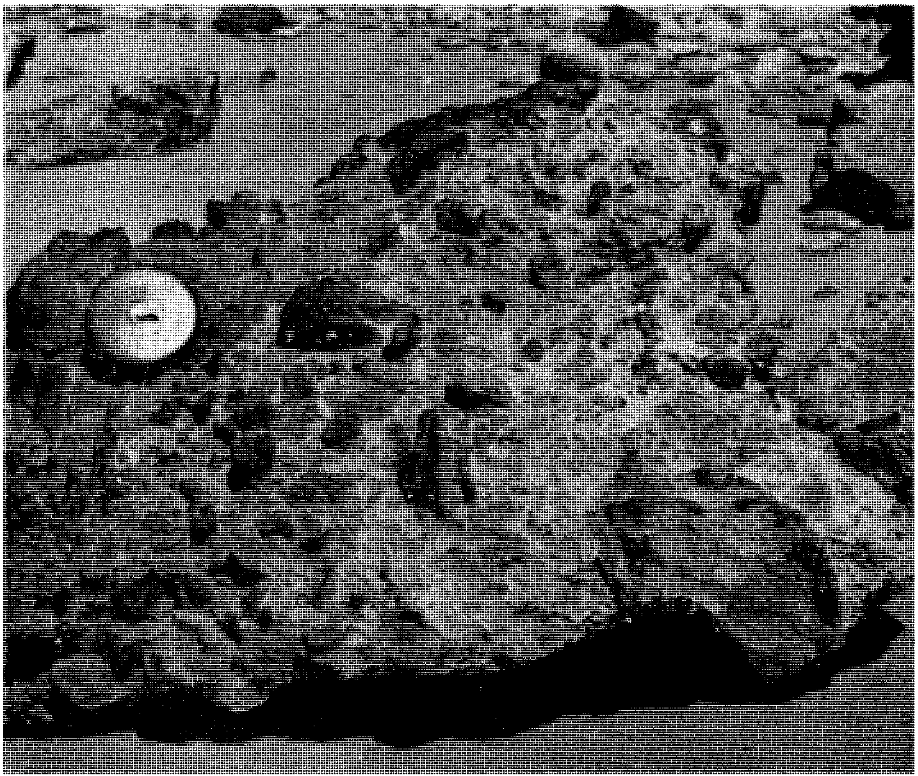


No. 1.—Flow layering revealed as platy jointing in the basanite of Blinking Billy Point. Photograph covers an area approximately five feet long.

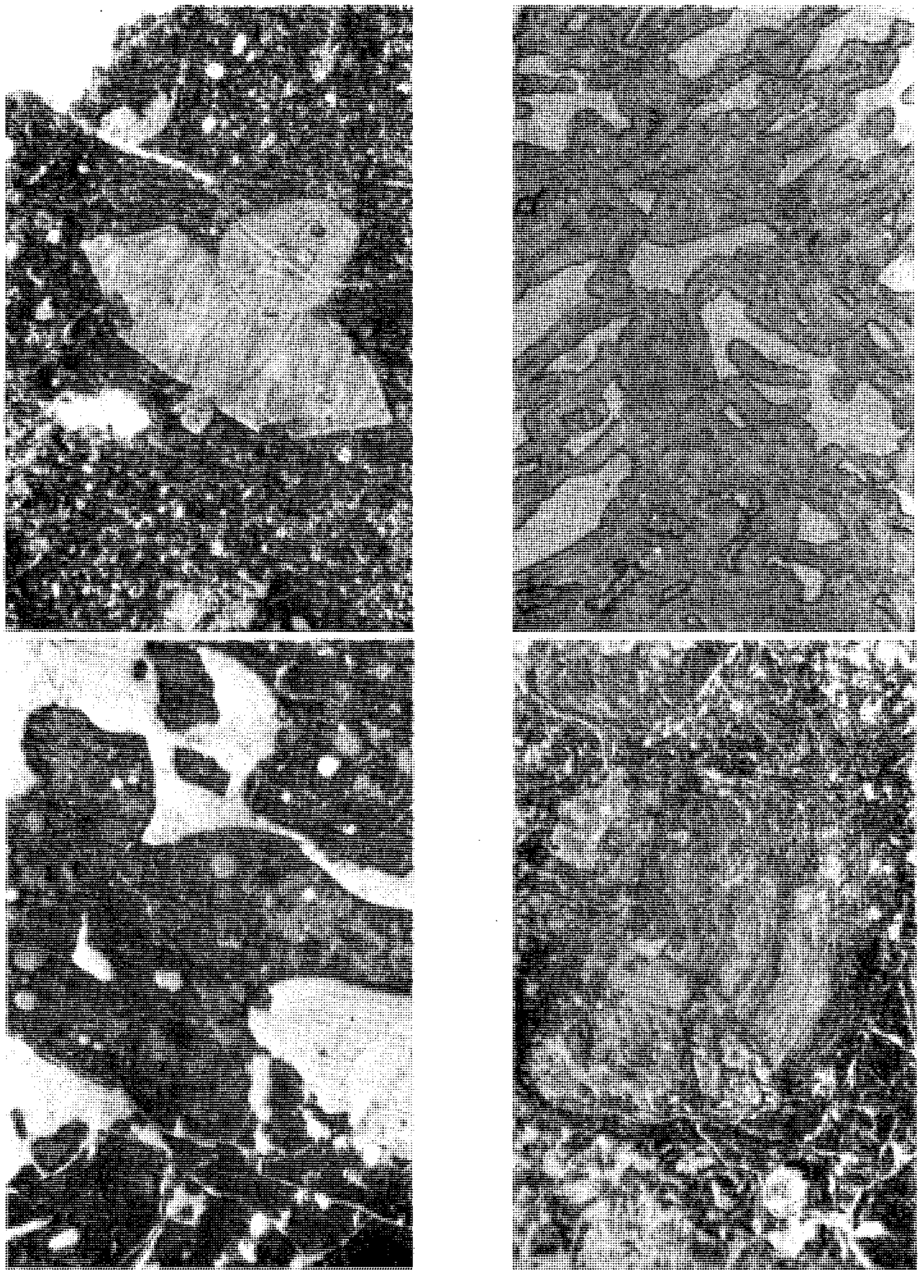
No. 2.—View of portion of wave-cut platform from top of cliff showing near-vertical lava flows passing out under the water. Section shown is approximately thirty feet long.



No. 1.—Vertical lava flow 18 inches thick showing fine grained base on left and scoriaceous "flow top" on right. Southern end of wave-cut platform.



No. 2.—Coarse volcanic breccia from cliff above wave-cut platform.



No. 1.—Photomicrographs of basanite showing iddingsite pseudomorphs after olivine. Ordinary light, magnification 70X. Slide 6078.

No. 2.—Photomicrograph of opal vein showing opal (darker) with crustification structure and chalcedony (lighter) in spaces. Ordinary light, magnification 40X. Slide 6077.

No. 3.—Photomicrograph of volcanic breccia showing dark-coloured glass fragments containing silica-filled amygdales, cemented by colourless calcite. Ordinary light, magnification 40X. Slide 6083.

No. 4.—Photomicrograph of pyroxene fragments in tuff. Crystal shows herringbone twinning. Ordinary light, magnification 40X. Slide 6081.