

10. GEOLOGY OF THE CAPE PORTLAND AREA with special reference to the MESOZOIC (?) APPINITIC ROCKS

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ABSTRACT

Jurassic dolerite, which forms the bedrock throughout the Cape Portland area is relieved by Tertiary basalt flows and appinitic rocks of intermediate age. The appinitic rocks form a porphyrite complex, lamprophyric dykes and andesitic lavas. The Tertiary lavas are tholeiitic and alkali olivine basalts. A geological map is presented and petrological descriptions and chemical analyses are quoted.

INTRODUCTION

General

Cape Portland forms the W tip of the NE promontory of the Tasmanian mainland. The country between the W seaboard and the Little Mussel Roe River has been mapped from the N coast to 40°46'S, constituting some 20 sq miles (fig. 30). Swan Island was also mapped (fig. 11). Lying 8 miles E of Cape Portland and 2 miles from the Tasmanian coast the island is elongated E-W, some 2 miles long and $\frac{1}{2}$ mile wide.

This report describes the results of individual and joint mapping undertaken on a number of visits from 1966 to 1968 and microscopic examination of the igneous rocks by F. L. Sutherland. The chemical analyses of selected rocks quoted in the text were carried out in the Mines Department laboratories, Launceston.

The terrain of Cape Portland is low rounded hills of dolerite interspersed with poorly drained sandy flats. Where hill ridges reach the coast they form low serrated rocky headlands with wide intertidal platforms. Between the headlands broad sweeping sandy beaches are backed by dunes frequently trapping seasonal lagoons on the landward side. Remnants of basalt flows occur as low plateaux inland and on the N coast as an intertidal pavement. Exposed to prevailing westerly winds of Bass Strait, extensive sand-dune systems have developed particularly along the W shoreline and much of the hinterland carries a blanket of blown sand. Minor creeks and drainage ditches discharge into dune-barred lagoons. The major creek of the area, the Little Mussel Roe River flows into an extensive shallow estuarine lake, from which water escapes to the sea through a narrow gap maintained in the sandbar, in the lee of a rocky headland. Swan Island consists of a low platform of dolerite inundated with dune sand.

Cape Portland is privately owned and has been developed as a ranching property with sheep and cattle. The homestead is reached by good unsealed road 15 miles N from Gladstone and except for the dunelands most parts are accessible from a sparse network of farmtracks. Soils derived from dolerite, and more particularly basalt, with the addition of some blown sand produce a satisfactory

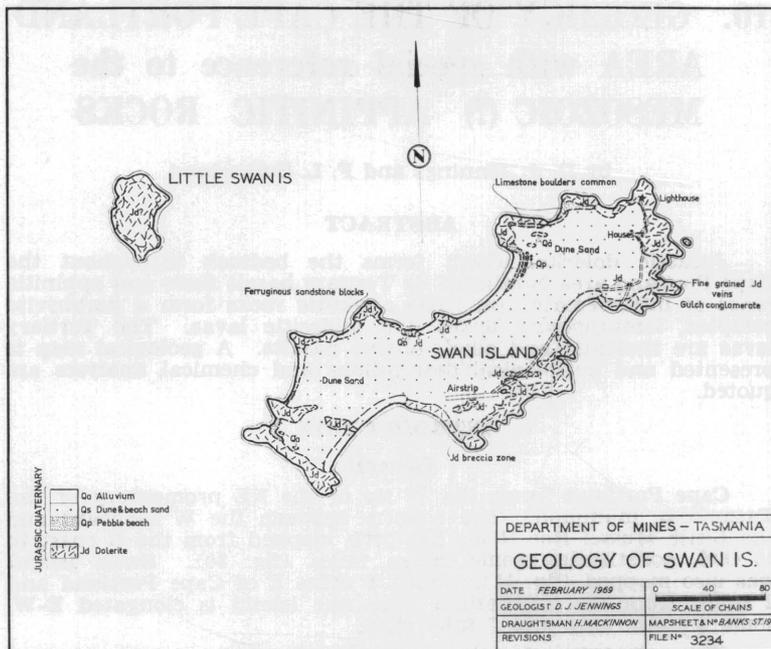


FIGURE 11.

loam which, with adequate rainfall, supports excellent pasture. However, much of the area carries an excessive mantle of blown sand and in poorly drained areas about sea level saltmarsh conditions prevail. Beyond the pastureland vegetation is limited to Marram grass on the dunes, low heathland scrub on the sandy soils, and clumps of *Banksia*, *Casuarina* and *Tea Tree* in sheltered positions and in the vicinity of lagoons. Swan Island is retained as a Commonwealth Lighthouse Reserve, and a few sheep are run on patches of rough pasture.

The climate is mild and the rainfall low (between 20 and 30 inches per annum) but the dominating feature of the weather is the persistent strong westerly wind to which Cape Portland and Swan Island are particularly subject because of their prominent position.

Geological information for Cape Portland was plotted directly onto a mosaic of aerial photographs enlarged to a scale of 10 chains to 1 inch, subsequently reduced by pantograph and redrawn on a base map on a scale of 20 chains to 1 inch adapted from the Survey Department sheet for the Land District of Dorset. No similar base map of Swan Island is available.

5 cm

Previous Geological Work

Reference to the Cape Portland area in previous geological literature is sparse. Gould (1872) refers to arfvedsonite from Swan Island, but current work revealed nothing of the mineral. Twelve-trees (1916) mentioned dolerite at Cape Portland and the presence of scoriaceous basalt was recognised by Chesnut (1966).

Acknowledgements

Appreciation is registered for assistance and co-operation by the residents of areas visited, and members of the Mines Department, Hobart and Launceston; the Geology Department, University of Tasmania; and the Tasmanian Museum, including Mr. M. Bower for production of thin-sections.

GEOLOGICAL SUCCESSION

General

Igneous rocks form the hard rock succession and consist of dolerite, appinites and basalts.

Dolerite is invaded by appinitic rocks which form dykes, flows and an intrusive complex. Petrological similarities between the appinites suggest relation in origin and time. The flows rest on a mature dissected terrain indicating a lengthy period of erosion between formation of the dolerites and the appinites. The latter rocks are themselves severely eroded so that the complex now occupies a shallow depression between dolerite hills.

Erosion of basalt flows has left remnants dispersed on the plains, invariably at slightly higher levels than the nearest appinite outcrops, indicating that basalts overlie appinites.

The dolerite correlates with the Middle Jurassic dolerites and the basalts with the Cainozoic basalts of Tasmania (Spry, 1962). The appinitic suite is established as Mesozoic (probably Upper Jurassic-Lower Cretaceous) in age on the following grounds.

- (1) Appinites intrude and disconformably overlie Middle Jurassic dolerite.
- (2) Topographic relationships indicate that appinites are disconformably overlain by Tertiary basalts.
- (3) Sediments of Lower Cretaceous age in southern Victoria contain fragments of andesitic rocks from an unknown source (Singleton 1965); these andesites closely resemble the appinitic rocks of Cape Portland.
- (4) Petrologically the appinites show affinities to the intermediate intrusive rocks of Middle Cretaceous age at Port Cygnet, S Tasmania. The Port Cygnet rocks could differentiate from similar parent magma to that forming the Cape Portland suite.
- (5) A biotite lamprophyre dyke on King Island has been dated at 137 million years (Jurassic-Cretaceous; McDougall and Leggo, 1965) and may be related to similar lamprophyres of the appinitic suite at Cape Portland.

The superficial deposits of the region are composed of littoral, aeolian, alluvial, talus and derived soil material of Quaternary age. A sub-basalt sandstone, probably Tertiary in age, outcrops W of the homestead and float fragments of lagoonal limestone of Lower Miocene age occur locally $1\frac{1}{2}$ miles N of the homestead. A silicified quartz-sandstone breccia of indeterminate age forms an elongate exposure isolated from surrounding dolerite outcrops on the eastern shore of the Cape Portland promontory (locality 37, fig. 30).

Jurassic Dolerite

Dolerite forms the bedrock throughout the area extending to Swan Island and the headland 2 miles to the E of Little Mussel Roe Bay. These exposures constitute the most northerly extent of the dolerite in Tasmania.

The major rocky headlands of Swan Island and Cape Portland consist of dolerite, where boldly jointed outcrops are severely dissected by marine erosion producing serrated outlines and excellent exposure on rugged intertidal platforms, backed by low bluffs. Small offshore islands of irregular outline and spikey profile have not been visited but are probably dolerite as is the low tabular outcrop of Little Swan Island. Inland, on Cape Portland, low rounded hills and ridges mantled with sand, rise sporadically from the sand and boulder-strewn plains. The hills attain heights of some 200 feet in the NE and NW, and rise to over 400 feet S of the area. These occasionally show massive exposure, but commonly an abundance of tumbled joint-blocks and small angular dolerite fragments provide evidence of outcrop.

Systems of major joints are well-displayed, trending near-vertically NNW-SSE and E-W, and from sub-horizontal to 30° S. Small exposures show parallel platy fractures and elsewhere sheaf-like jointing has developed, as is common in the central parts of dolerite sheets (Hill, 1965). Polygonal jointing is only well defined on the coastal outcrops in the SW, with massive polygons 8 to 12 feet in diameter displayed on the major headland and columns $1\frac{1}{2}$ to 2 feet in diameter developed on the smaller headland in the extreme SW. Polygonal sections of large joint columns form a conspicuous feature of the shore platform of Little Swan Island when viewed from the air.

Movements within the dolerite have produced crush zones and tracts of breccia, frequently 1 to 3 feet wide and rarely attaining widths of 12 feet. These are commonly disposed sub-parallel in groups but no consistent regional trend was observed. Breccia zones were only recognised in good coastal exposures, and are numerous N and NW of the homestead, but are feebly developed to the NE and on Swan Island.

The dolerite, usually medium-grained, varies to coarse-grained on the major W headland and the extreme NW promontory, where irregular shallow-dipping lensoid pegmatitic patches are exposed on the foreshore. Impersistent thin dykes of fine-grained dolerite cut the rock on the N and NW headland of Cape Portland and the E end of Swan Island. They are inconspicuous, rare and trend N-S.

Devonian granite outcrops 4 miles SE of the homestead and Palaeozoic Mathinna Beds, locally capped by dolerite, are exposed 7 miles to the S. Dolerites from peripheral exposures to S and E are types common in the basal zones of differentiated sheets in

Tasmania, whilst the dolerite in the NW has features typical of the central and upper parts (McDougall, in Spry 1962), inferring a substantial depth of dolerite beneath Cape Portland. Petrological variation confirms the apparent drop in the base of the dolerite towards the NW.

Mesozoic (?) Appinites

The main exposures of appinitic rocks are in areas of poor relief in the paddocks $\frac{1}{4}$ mile SW and $1\frac{1}{2}$ miles NW of the homestead. Dykes and lava flows are only conspicuous on the dolerite headlands around the coast. The general nature of the rocks and their relative disposition suggests that they form a small intrusive porphyrite complex, an associated lamprophyric dyke swarm and andesitic lava flows.

Porphyrite complex

In the main exposures (fig. 12) the rocks are well-jointed and readily weathered and have suffered selective erosion. They now occur in alluvial flats, as low hummocks and on the surrounding shallow slopes. Bedrock exposure is sparse. Outcrop is frequently inferred from slight variations in terrain and a copious litter of joint blocks and float fragments, but precise delineation of rock boundaries is impossible. Talus from neighbouring dolerite hills, soil creep from basalt flows and blown sand combine to obscure detail.

Lamprophyre dykes

The dykes vary in shape, size and rock type but are grouped to form a sector of a single radial dyke swarm of common origin (fig. 13). The dykes are often preferentially eroded and occupy troughs in the dolerite bedrock, now partly filled with recent beach pebbles.

Dyke shapes are most commonly parallel-sided, but some are irregular, and attain widths of 25 feet, rarely pinching and swelling and locally tapering to nothing. Isolated dykes extend over lengths of 350 feet; elsewhere short dykes of some 10 feet occupy neighbouring joint planes and form *en echelon* groups. Adequate evidence of dilational intrusion is provided. Frequently dolerite joint-blocks have been laterally displaced and parallel-sided dykes show regular progressive side-stepping to give an aggregate trend divergent from regional joint directions. Occasionally dykes terminate abruptly and resume several feet away on the same or parallel cross-cutting joint planes. Major joint directions are frequently shared by dykes and dolerite host rock, but joints are often closer spaced in the dykes.

Dyke margins are well-defined, usually straight but occasionally gently sinuous, and typically display a narrow chilled patina, only rarely exceeding 1 inch in thickness. A fine-grained to glassy texture is observed in small intrusive patches localised at the intersection of major joint planes in the neighbourhood of dykes and in minor branches of dykes consisting of intrusional tongues occupying joint fractures. Occasionally narrow sinuous and tapering tracts of dolerite breccia are cemented with chilled black dyke material. Weathering affects dykes differently, but usually dolerite bedrock remains upstanding. The chilled patina is often selectively eroded and occasionally zones parallel to the margins show contrasting resistance to weathering.

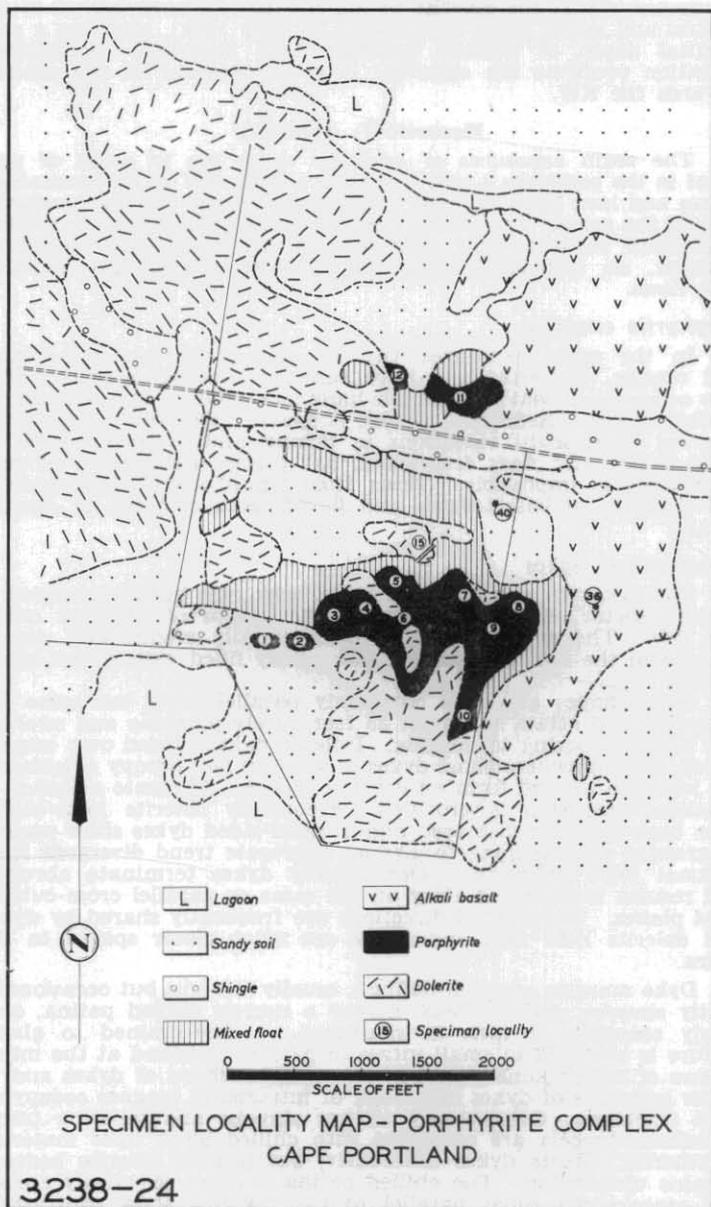


FIGURE 12.

5 cm

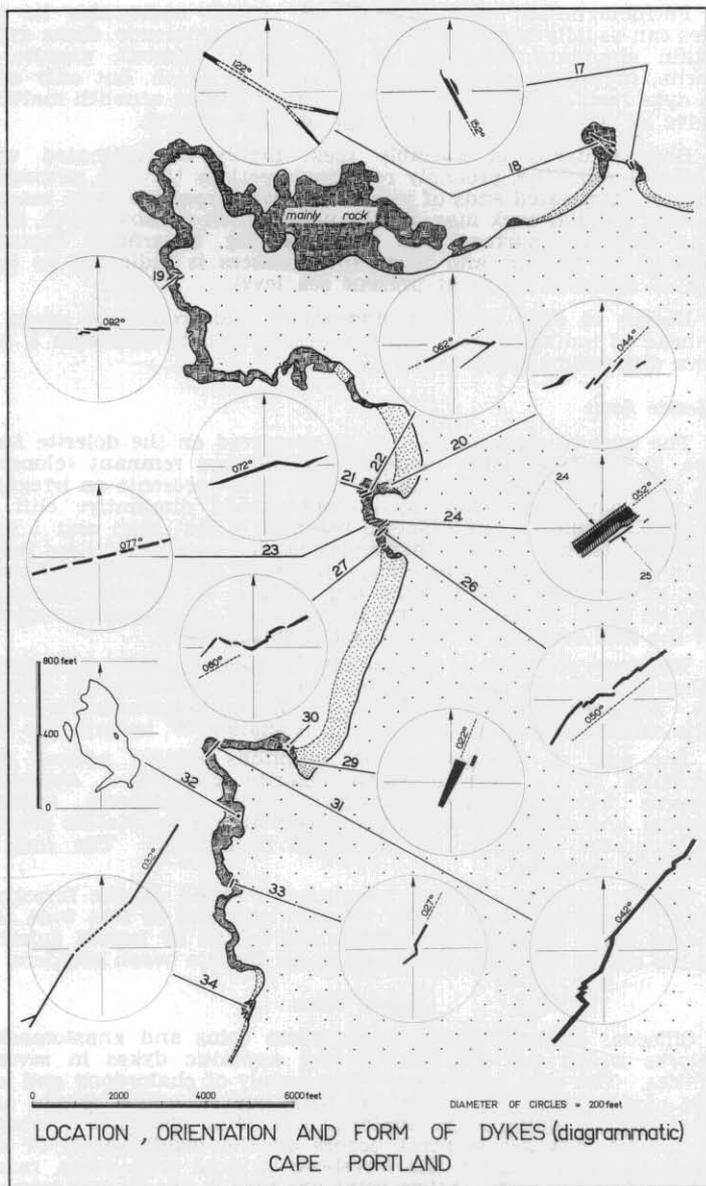


FIGURE 13.

5 cm

Ferromagnesian phenocrysts and crystal aggregates in the dykes can usually be recognised as biotite or hornblende. Some dykes contain abundant xenoliths of hornfelsed sediment, granite or dolerite, indicating rock types intersected at depth, but only once was dyke rock of contrasting type observed among xenolith material to give an indication of relative age of emplacement.

Breccia dykes of variable rock, highly contaminated with accidental xenoliths, probably represent sections through advancing fronts or attenuated ends of injections, away from the main magma channel. Similar rock may also be produced at shallow depth, from dykes breaking surface and incorporating superficial deposits. Proximity of present and past land surfaces is indicated by lava flows of appinitic rocks at present sea level.

Details of dyke outcrops, dimensions and trends are given at the head of individual petrographic descriptions in Appendix 1, and shown diagrammatically in fig. 13.

Andesite flows

The base of an andesite flow is preserved on the dolerite foreshore, 2½ miles W of the homestead. The flow remnant (elongate N-S, some 200 yards long and 100 yards wide) presents an irregular scalloped boundary, often as a well-defined diminutive cliff of polygonal columnar joint blocks, reaching 4 feet high and 1 foot diameter*. Honeycomb weathering is common on exposed joint faces. Locally, marine erosion has etched the basal contact forming small caves, an archway, and dividing the outcrop. A dolerite hummock forms an inlier 30 feet long and 20 feet wide. Topography suggests that the flow remnant does not exceed 20 feet thick.

The gross structure is tiers of short regular columns, with major cooling joint-planes perpendicular to an uneven, undulating dolerite floor. Around the N margin the layers dip gently towards the centre of the outcrop, but in general the dip is shallow W, towards the sea.

The sole of the flow shows a pitchy chilled patina, and apparently flowed over a clean dolerite platform. Abundant prismatic ferromagnesian phenocrysts and aggregates, cognate xenoliths, and accidental xenoliths of vein quartz, pegmatitic granite and indurated sediment are displayed in outcrop. The rock is moderately vesicular.

Similar rock, but lacking xenoliths, is found on the foreshore ¾ mile N, exposed over an area 150 feet long and 50 feet wide and trending 062°. The outcrop, surrounded inland by jagged dolerite, suggests a flow, but is largely obscured by dolerite beach boulders.

Silica Veins

Siliceous material forms impersistent veins and anastomosing networks which cut the dolerite and appinitic dykes in several localities. The vein material consists mainly of chalcidony and low grade agate, sometimes associated with quartz, minor calcite and pyrite. In the dolerite the material fills joint planes and breccia zones. The best development occurs on the headlands N of the homestead, where locally the foreshore is laced with veins, rarely reaching 6 inches wide. Silica veins are rare in the S, and towards Little Mussel Roe Bay.

* See frontispiece.

Agate and carbonate segregations several inches long occur in the appinitic dyke at locality 19, and a narrow vein runs between dyke and host dolerite. Elsewhere (loc. 18, 20, 22, 26, 27) bold joints which cut both dolerite and appinite dykes (particularly those joints along which dykes have side-stepped) are occupied by agate veins occasionally with subordinate carbonate. Where dykes taper to nothing the joint extension beyond the limit of the dyke sometimes carries silica.

The invading siliceous fluids that produced these veins are probably late-stage phases associated with intrusion of the appinitic rocks, some of which contain silica and carbonate amygdales. No silica veins were observed in Tertiary basalt.

The Tasmanian Aborigine sometimes used these siliceous materials in the manufacture of flaked stone implements, found in the vicinity of midden deposits in the area.

Tertiary Basalts

Basalt outcrops are concentrated in a N-S topographic depression $\frac{3}{4}$ mile wide extending from S of the homestead to the N coast. The depression is devoid of dolerite hills (though occasional dolerite outcrops form part of the floor), and may indicate the site of a Tertiary valley, possibly dictated by a N-S fault line. Within the low-lying tract remnants of basalt flows form minor elevated plateaux, eroded into irregular shapes with margins obscured by ubiquitous blown sand. At least two lava types are present, a tholeiitic basalt and an alkali basalt.

Tholeiitic basalt

This basalt occupies the central part of the depression as patches of blue-grey float boulders along the line of the road N and S from the homestead. More vesicular tholeiitic basalt outcrops on the N coast, and further W is preserved mainly as intertidal pavements in a shallow N-S depression confined by low dolerite ridges.

The coastal outcrops are characterised by variable vesicularity, large scale polygonal columnar jointing up to 8 feet in diameter and patchy honeycomb weathering. The basal layer is scoriaceous with denser chilled material forming occasional sub-horizontal lenses and vertical N-S dykes up to $1\frac{1}{2}$ feet wide with sinuous margins. The main part of the basalt grades from a uniform blue-grey finely-vesicular rock to a darker basalt with denser matrix and numerous large vesicles, sometimes containing chalcedony and botryoidal linings of carbonate mainly altered to iron-oxide. The darker basalt is enclosed in the lighter type as vertical to sub-vertical tubes and cylinders up to 1 foot long and 2-4 inches in diameter, and extensive sub-horizontal undulating zones and anastomosing networks 2 inches to 3 feet in depth.

The base of the tholeiitic basalt attains its highest level just N of the homestead, which suggests that it erupted in this vicinity and flowed N down a valley before spreading out below present sea-level.

Numerous boulders of similar basalt (commonly 1 foot in diameter (are washed-up on the N coast of Swan Island and are probably derived from submarine outcrops.

Alkali basalt

This basalt is best exposed on the knoll at the homestead from which lobes extend eastwards, and northwards along both E and W margins of the 'valley' but fail to reach the coastline. Outcrop is poor and boundaries are delineated from float boulders and minor topographic features. The basalt is generally a dark dense rock which contains sporadic amygdalae.

Outcrops of the alkali basalt reach their greatest elevation near the homestead, and their pattern suggests a source in this area. The relationship of the alkali basalt to the tholeiitic basalt is nowhere clearly demonstrated but near the homestead its base outcrops above exposures of tholeiitic basalt, and to the N float boulders of alkali basalt locally overlie inferred tholeiitic basalt outcrops. This suggests that the alkali basalt was erupted later and its distribution resulted from lava utilising drainage channels developed lateral to the tholeiitic basalt flow. A small occurrence of Lower Miocene limestone float on a site at the base of the basalt $1\frac{1}{2}$ miles N of the homestead provides a tentative Miocene/post-Miocene age (Appendix 2) for the basalt.

Small alkali basalt boulders are rare on the beaches of Swan Island, except in the extreme SW where locally they are common.

Tertiary Sediments

Sandstone

Excavation of water holes in the sector to the W of the homestead (locality 38) produces massive flags of clean siliceous quartz sandstone with subordinate grit and conglomerate which occur naturally only as sporadic float. The disposition of the sandstone indicates that it overlies appinites, and underlies the alkali basalt flow. Its age relative to the tholeiitic basalt is uncertain; however, ill-defined sandstone outcrops at higher levels than the chilled tholeiitic basalt outcrop to the S of the homestead, suggest that the sediment may be intercalated with the flows. Bedding in rare chloritic sandstone rubble from the water hole 300 yards W of the homestead (locality 39) is highly contorted and may indicate soft sediment deformation during basalt extrusion.

Limestone

Rounded, sculptured fragments of limestone several inches long are scattered in a small alluvial flat S of the track $1\frac{1}{2}$ miles N of the homestead (locality 40). The locality of the float, below the local apparent base-level of the alkali basalt flow, suggests deposition in a pre-basalt depression confined by ridges of dolerite and appinite. Investigation of the micro-fauna indicates a probable Lower Miocene age for the limestone (Appendix 2).

Irregular sculptured discoidal fragments of compact bryozoal limestone, occasionally attaining 1 foot in length form a significant component of the boulder beaches on the N coast of Swan Island. The source locality is presumably submarine. Micro-faunal investigation again indicates a probable Lower Miocene age (Appendix 2).

Quaternary Deposits

Prevailing westerly winds of Bass Strait have developed an extensive dune system along the W seaboard and maintained a veneer of blown sand inland on Cape Portland. Consequently all Quaternary deposits carry a variable and usually high sand content.

Areas of mixed float boulders

Boundaries of rock outcrops are often difficult to define from float evidence due to scree, soil creep, and redistribution of float boulders in the interests of agriculture. However, areas carrying a significant proportion of appinitic boulders in a mixed float have been indicated on the map to show possible extension of the appinite outcrop.

Gravel and shingle

These deposits are widely scattered and occur at heights between sea level and 75 feet. Locally they show minor cementation. The most conspicuous shingle bank, or fossil storm beach, carries the E-W track north of the main appinite exposures and extends to their W. The bank height remains constant at about 30 feet.

A succession of minor shingle ridges at a lower level is exposed parallel to the present coastline on headlands on the N coast and across corridors between longitudinal dunes of the W coastal system, well inland and above high tide level.

Sand

Blown sand is the main constituent of the soil cover of the Cape Portland area, and locally has been modified by incorporation in basalt and dolerite soils to produce a rich loam, and elsewhere washed into alluvial flats or seasonal lagoons. To the E of the road, S of the homestead, a low ridge is capped by ferricrete, probably indicating a past water-table level. Several blocks of iron-cemented sand presumably from a local source, occur on a NW beach of Swan Island.

Longitudinal dunes, both mobile and stable are common in the N and W producing a chaotic relief in which an E-W pattern is locally pronounced, and dune peaks commonly attain 75 feet. Several 'blow-outs' currently menace farmland. Hummocky features inland often represent stabilised dunes.

The topography of Swan Island is a tract of stabilised E-W longitudinal dunes relieved by sporadic marginal dolerite outcrops with associated patches of loamy soil and rare gulch conglomerite.

PETROLOGY

Dolerite

The dolerite is medium to coarse grained bluish-grey rock, consisting of plagioclase, pyroxenes and a silicic mesostasis, with subophitic to ophitic and intersertal textures. The normal dolerite of the area contains plagioclase, zoned from calcic labradorite ($\approx Ab_{30}$) gradational to, or mantled with, calcic andesine ($\approx Ab_{90}$), intergrown with augite (commonly mantled with more ferroan augite) and pigeonite, in an abundant mesostasis (T.S. 580, 699, 769, 774; 67-90B, 67-95C*). The pale mauve to brown mesostasis contains spherulitic and radiating acicular quartz, patches of opal, long slender crystallites of augite and andesine-oligoclase, curved crystallites and spherulitic intergrowths of potash feldspar, apatite prisms, indeterminate chloritic material, and crystals and globules of iron ore.

* T.S. numbers refer to thin sections catalogued and held in the Tasmanian Museum; the other numbers refer to thin sections catalogued and held in the Mines Department.

Mesostasis is most abundant in the pegmatitic varieties in which crystals attain 10 mm in length (67-94A-B). In alteration zones the pyroxenes of the dolerite are replaced by hornblende (67-90A).

The preceding rocks are typical of the upper levels of differentiated dolerite bodies in Tasmania (Spry, 1962).

Dolerite containing orthopyroxene mantled with clino-pyroxene, and relatively small amounts of mesostasis, forms the headland 2 miles E of Little Mussel Roe Bay (67-96) and caps Mathinna Beds, 9 miles S of the homestead (T.S. 581). These are more typical of the lower differentiation zones of dolerite bodies.

Fine-grained, late-stage dykes in the dolerite at Cape Portland (T.S. 632, 632a) and E Swan Island (T.S. 771) are composed of dense, dark to light coloured, sugary-textured, feldspathic micro-dolerite. They contain laths and tablets of zoned andesine-oligoclase (mainly to 1 mm, rarely to 2.5 mm long), slender clino-pyroxene crystals (sometimes partly altered to carbonate and chlorite), interstitial quartz and potash feldspar, and irregular patches of silicic mesostasis.

Appinites

The appinites form a small porphyrite complex, lamprophyre dykes and andesite lavas. The rocks show strongly porphyritic textures, with different assemblages of phenocrysts of plagioclase, hornblende, augite and biotite, with microphenocrysts of irregular to euhedral iron ore, prismatic apatite, and rarely sphene. The groundmass is typically cryptocrystalline to fine-grained and feldspathic, containing andesine-oligoclase and/or potash feldspar, associated with granular iron ore and apatite needles. Quartz, carbonate, biotite, augite and chlorite may be present.

Classification

These rocks represent a near-saturated to saturated intermediate suite, moderately rich in alkalis (Table 2). Hornblende is conspicuous in the majority of the rocks, designating them as appinites. Many rocks in the complex, dykes and lavas are petrologically similar in type, but different names are given according to their occurrence. The most common rock types carry plagioclase as the main feldspar. In the complex these are named porphyrites (phenocrystal plagioclase) and appinites (groundmass plagioclase only). In the dykes these are named plagioclase-spessartites (phenocrystal plagioclase, with hornblende and/or augite), spessartites (groundmass plagioclase only, with hornblende and/or augite) and kersantites (groundmass plagioclase only, with biotite). The lavas are andesites (groundmass plagioclase only). The rocks range from sodic types, with minor or no potash feldspar ($\text{Na} > \text{K}$; Tables 1 & 2) to potassic types, with biotite or significant amounts of potash feldspar in the groundmass ($\text{K} > \text{Na}$; Tables 1 & 2). Rare rocks amongst the dykes lack plagioclase, and are named vogesites (potash feldspar groundmass, with augite). The rocks are further subdivided according to the main phenocryst minerals present (Table 1).

As these rocks form a new suite for Tasmania, detailed petrographic descriptions are given (Appendix 1); approximate contents of individual phenocryst minerals are indicated by the terms rare (<2%), sporadic (2-5%), common (5-10%) and abundant (>10%).

TABLE I
SUMMARY OF PETROLOGY OF THE APPINITIC SUITE

<i>Rock Type</i>	<i>Analysis No.</i>	<i>Locality No.</i>	<i>Major Phenocrysts†</i>	<i>Minor Phenocrysts†</i>	<i>Main Groundmass†</i>	<i>Xenoliths</i>	<i>Na:K</i>
PORPHYRITE COMPLEX							
Biotite-hornblende-porphyrite ..	1	1	Pl, A, B	I, Ap	Pl, Pf, Q, C	AX	K > Na
Hornblende-porphyrite	3	2	{	Pl, H	I, Ap, B	Pl, Pf	K ≈ Na
—Augite-hornblende-appinite ..				H, A	I, Ap	Pl, Pf	CX	K ≈ Na
Biotite-augite-porphyrite	4	3	Pl, A	I, Ap	Pl, A, B	AX*CX*	Na > K
Altered porphyrite .. .. .	..	4, 5, 7	Pl, H, A ± B	I, Ap ± Sp	Pl, Q	..	Na > < K
Augite-hornblende-porphyrite ..	2	6, 9	H, A, Pl	I, Ap, B	Pl, Pf	..	K > Na
Sphene-augite-hornblende-porphyrite	5	8, 10	Pl, H, A, Sp	I, Ap	Pl, Pf	CX, AX	Na > < K
Porphyrite breccia .. .. .	..	11	H, A, Pl, B	I, Ap	..	AX*	Na > K?
Biotite-augite-hornblende-porphyrite	..	11, 12	Pl, H, A, B	I, Ap, Sp	Pl, Pf	CX, AX	Na > K?
Quartz-hornblende-porphyrite ..	..	13	Pl, H	I, Ap, B	Pl, Q, C	..	Na > K?
Biotite-augite-hornblende-appinite	..	14	H, A, B	I, Ap	Pl	AX	Na > K?

<i>Rock Type</i>	<i>Analysis No.</i>	<i>Locality No.</i>	<i>Major Phenocrysts†</i>	<i>Minor Phenocrysts†</i>	<i>Main Groundmass†</i>	<i>Xenoliths</i>	<i>Na:K</i>	
LAMPROPHYRE DYKES								
Biotite-kersantite	8	22	B	I, Ap	Pl, Pf, B	..	K > Na	
Augite-biotite-kersantite	6	19	B, A	I, Ap	Pl, Pf, B, C	..	K > Na	
Biotite-augite-vogesite .. .. .	..	33	A, B	I, Ap	Pf, A	..	K > Na
Hornblende-spessartite	9	20, 34	H	I, Ap ± A, Pl, B	Pl, ± Pf, A	..	K > < Na	
Augite-hornblende-spessartite .. .. .	..	26, 31	H, A	I, Ap ± Pl	Pl ± Pf, Cl, B	± AX, CX	K > < Na
Augite-biotite-hornblende spessartite .. .. .	..	21	H, B, A	I, Ap	Pl, Pf	AX	K > Na
Hornblende-plagioclase-spessartite .. .. .	..	16, 27, 28	Pl, H	I, Ap, ± B, A	± Pl, Pf, B, Q	± AX*	K > < Na
Hornblende-plagioclase-spessartite breccia .. .. .	..	23	Pl, H	I, Ap, B	Pl, Pf	AX*CX	K > Na
Biotite-augite-hornblende-plagioclase-spessartite	7	24	{	Pl, H, A, B	I, Ap	Pl	CX*	Na > K
—Hornblende-plagioclase-spessartite			Pl, H	I, Ap, A, B, Sp	Pl, Pf, Q	..	K > Na
Altered-augite-hornblende-plagioclase-spessartite .. .. .	..	15, 17, 18	Pl, H, A	I, Ap, B, ± Sp	Pl, Pf, C, Q	± CX, AX	K > < Na
Lamprophyre breccia .. .. .	..	25	..	..	..	AX*	K > Na?

<i>Rock Type</i>	<i>Analysis No.</i>	<i>Locality No.</i>	<i>Major Phenocrysts†</i>	<i>Minor Phenocrysts†</i>	<i>Main Groundmass</i>	<i>Xenoliths</i>	<i>Na:K</i>
ANDESITE LAVAS							
Augite-hornblende-andesite ..	10	32	H, A	I, Ap	Pl, A	CX*AX*	Na > K
Augite-hornblende-trachyandesite ..	..	30	H, A	I, Ap, ± Pl	Pl, Pf, A	AX	K > Na?
COGNATE XENOLITHS (described)							
Biotite-augite-diorite .. ..	..	15, 24	..	..	..	..	..
Augite-hornblende-diorite	11	8, 10, 24, 32	..	..	..	..	K = Na
Hornblendite .. .. .	..	3	..	..	..	..	..
H = Hornblende	A = Augite		B = Biotite		Pl = Plagioclase		
Pf = Potash feldspar	I = Iron Minerals		Ap = Apatite		Sp = Sphene		
Q = Quartz	C = Carbonate		Cl = Chlorite		CX = Cognate Xenoliths		
AX = Accidental Xenoliths and Xenocrysts							

†Phenocrysts and groundmass minerals are listed in approximate order of abundance.

*Abundant xenoliths and xenocrysts present.

Mineral characteristics

Plagioclase phenocrysts (1.2 cm max. size) are zoned outwards from calcic cores to sodic margins, with a compositional range from about Ab_{35} to Ab_{75} . Cores commonly show fine oscillatory zoning and some patchy mosaic zoning, and are rimmed with gradationally zoned andesine-oligoclase. Partial or selective corrosion and sericitisation is common in crystal interiors. Inclusions of iron ore, apatite, biotite, hornblende and augite may be present. There is albite, Carlsbad, pericline and rare Baveno twinning.

Hornblende is commonly twinned on 100, and shows normal, reverse and simple oscillatory colour zoning (α yellow, β brown or green, γ brown or green; $\gamma \geq \beta > \alpha$, $\gamma:Z \approx 12-30^\circ$). Variations in the pleochroic scheme and longitudinal extinction angles are detailed in the petrographic descriptions (Appendix 1). No overall relationship between colour, absorption, and extinction angle is apparent, although deeper colours in zoned crystals generally show smaller extinction angles.

Augite is colourless to faintly coloured and pleochroic (α pale yellow, β pale bluish green, γ pale green; $\beta > \gamma > \alpha$; $\gamma:Z$ $44-50^\circ$). Normal zoning occurs with increase in extinction angle outwards from deeper coloured cores to paler rims, but complex zoning and hour-glass structure are common. There is twinning on 100.

Biotite shows variation in pleochroic scheme (α grey or yellow, $\beta = \gamma$ orange, brown or black), as detailed in the petrographic descriptions (Appendix 1) and crystals are sometimes bent.

The ferromagnesian phenocrysts form euhedral to corroded crystals (2 cm max. size) and in some rocks are strongly altered to talc, carbonate and/or chlorite, sometimes with the development of secondary iron ore. Hornblende and augite commonly form glomeroporphyritic groups; they invariably include iron ore and apatite, and occasionally biotite and plagioclase. Occasionally augite shows partial alteration to hornblende.

Opaque minerals in the rocks (preliminary identifications by Dr. D. I. Groves, Tasmanian Mines Department) include iron oxides and sulphide minerals. Magnetite is the dominant primary oxide whilst ilmenite and rutile were not positively identified, and if present are rare. Magnetite occurs as small grains in the groundmass or discrete larger cubic, skeletal or embayed crystals or phenocrysts (1 mm max). It is locally altered to maghemite, seldom hematite, which generally forms an outer rim with lobate contacts between minerals. Magnetite contains small inclusions of chalcopyrite and pyrite, and is rarely rimmed or veined by these sulphides, which also occur as discrete grains in the groundmass of most rocks. They also form rims around silicate crystals, and rarely invade along cleavages. Pyrite, which sometimes occurs as cubic crystals 0.8 mm across, is the dominant sulphide mineral in some rocks, but in others almost equal amounts of chalcopyrite are present. Other sulphides include sphalerite (with exsolution bodies of chalcopyrite) and more rarely pyrrhotite.

Cognate dioritic and hornblendic aggregates, rich in ferromagnesian minerals are found in a number of the rocks, and typical examples are described with the host rocks in the petrographic descriptions (Appendix 1). Accidental fragments of quartz, feldspar, meta-sediments, granite, lamprophyre and dolerite country rocks also occur, and in some cases form the major part of the rock.

Discussion

Petrological observations helpful in elucidating the magmatic and crystallization history of the appinites are:—

1. augite-hornblende-kersantite is found as fragments in a brecciated hornblende-plagioclase-spessartite dyke (locality 25);
2. a thick hornblende-plagioclase-spessartite dyke, shows potassic margins, passing inwards to more sodic rock rich in cognate dioritic aggregates (locality 24);
3. marginal rocks of the complex include potassic, biotite-rich rocks, grading inwards to more sodic rocks in the main part of the complex;
4. a number of rocks contain both augite and hornblende phenocrysts;
5. cognate dioritic aggregates include types with augite and no hornblende, types with augite altering to hornblende, and types with hornblende and no augite.

Pending future more detailed discussion current work suggests:—

1. emplacement of a magma chamber, with a front rich in volatiles and potassium, from which biotite-bearing, potassic dykes and marginal phases of the complex crystallised;
2. crystallisation of plagioclase, biotite, augite (in volatile-poor zones) and hornblende (in volatile-rich zones) within the main body of magma, accompanied by movement of volatiles and differential settling, late-stage enrichment and tapping of crystal fractions;
3. crystallisation of a dioritic phase in part of the magma chamber, later fragmented and involved in movements of magma.

The structure and distribution of the appinites suggests an eroded sub-volcanic chamber (porphyrite complex) within which the outcrop of coarse biotite-augite-porphyrite (locality 3) may represent a volcanic pipe, and from which dykes intruded the country rocks, locally erupting as lava.

Basalts

Tholeiitic olivine-basalt (Analysis 13, locality 35)

This is a light- to mid-grey, fine- to medium-grained rock grading from dense, non-vesicular to strongly vesicular and amygdaloidal types.

The fine-grained varieties (T.S. 627, 671, 702, 778) carry sporadic phenocrysts of olivine (7%; 2.5 mm max. size) completely pseudomorphed by serpentine, nontronite and rarely carbonate. Some pseudomorphs still retain original euhedral to strongly corroded outlines, but others are completely obliterated by alteration. The groundmass is mainly inter-granular to sub-ophitic augite and zoned labradorite. Iron ore (4-7%) forms subhedral to irregular grains and laths (2 mm max.). The mesostasis (5-12%) is a pale mauve to brown microlitic glass or serpentine, or more rarely zeolite resembling chabazite. These basalts resemble the Jordon type of McDougall (1959).

Similar basalt (T.S. 775) S of the Cape Portland homestead, differs in containing mostly fresh olivine and a mesostasis of black, opaque glass. This resembles the Bridgewater-Pontville types of McDougall (1959), but whether the rock represents a thin, more quickly chilled tongue of the main flow, or whether it is a small separate flow is uncertain.

The more vesicular varieties (T.S. 163, 164, 67-91A-D, 67-92, 67-88A, 67-93) grade into coarse sub-ophitic to ophitic basalt, lacking olivine pseudomorphs and containing a sporadic to abundant microlitic mesostasis. Plagioclase (3 mm max.) shows albite, Carlsbad and pericline twinning and zoning outwards ($\approx Ab_{85}$ to Ab_{100}). The clinopyroxene forms colourless to faint brown crystals (5 mm max.), which show normal zoning with twinning on 100 and is mainly augite with minor pigeonite. Crystallites in the mesostasis display a brownish or greenish tinge suggesting a more ferroan pyroxene. Iron ore commonly forms laths (4 mm max.). Interstitial and vesicular fillings include chalcedony, opal, clay, and hematitic iron ore with relic carbonate cores, which apparently represent late-stage oxidation of ferroan carbonate. These rocks resemble the Midlands type of McDougall (1959).

A chemical analysis of a dense fine-grained variety from the foreshore E of Cape Portland (locality 35), indicates an over-saturated basalt, with relatively low soda and potash, typical of the tholeiitic suite (analysis 13, Table 2).

Alkali olivine-basalt (Analysis 12, locality 36)

This is a dense, dark bluish-grey rock, speckled with numerous olivine phenocrysts in a fine-grained groundmass of augite and plagioclase with an alkaline mesostasis (T.S. 161, 168, 671, 705, 773).

Euhedral to strongly corroded olivine (12-20%; 4.5 mm max.) is altered along cracks to serpentine or 'bowlingite' and includes iron ore. Sporadic augite phenocrysts (5 mm max.) tend to form glomeroporphyritic groups. Colourless augite grades to titanite on crystal margins, pleochroic from pale fawn to mauve. Larger crystals may show corroded, riddled interiors, and rarely a core of interlocking plates, or small aligned inclusions of apatite. The augite commonly shows normal zoning (more rarely complex zoning or hour-glass structure) and multiple twinning on 100.

The groundmass consists of intergranular augite-titanite, laths of labradorite zoned to andesine (0.8 mm max.) and numerous iron ore grains in a pale yellow, poorly crystallised zeolitic and feldspathoidal (?) base (5-10%). The rock contains scattered zeolitic amygdals, rare augite aggregates and partially fused siliceous and feldspathic inclusions sometimes with reaction coronas.

Petrologically the basalt resembles the Branxholm type, common in N Tasmania (Edwards, 1950) and a chemical analysis (analysis 12, locality 36) shows it is an under-saturated basalt rich in alkalis.

Chemical Analyses

General

Microscopic examination confirms variations observed in the field among rocks of the appinitic suite. To clarify the relationships between mineral assemblages and bulk rock composition, samples were chemically analysed. The results (analyses 1 to 11, Table 2) illustrate the variation and compositional range, aid precise classification of the rock types and suggest possible genetical relationships.

Chemical analyses of both types of basalt are presented for comparison and contrast (analyses 12 and 13).

Varying amounts of carbonate in the rocks, revealed by chemical analysis, complicate comparisons. The occurrence of the carbonate as interstitial and patchy alteration material suggests late stage introduction. It is significant that rocks with the highest carbonate content generally carry biotite; have high K:Na ratios; are likely hosts for volatile constituents and liable to late-stage deuteric alteration.

In acid leaching of these rocks not only carbonate but also original minerals and derived products are removed. However, those rocks with higher carbonate content are generally more amenable to acid leaching. The analyses show no increase in one or more metal ions in relation to increase in CO_2 . A possible approach is to assume that attack was by H_2CO_3 , to which all minerals have succumbed to some degree, deriving a mixture of carbonates and other secondary products appropriate to the original mineral composition. Superficially this involves derivation of chloritic material from ferromagnesian, and sericitic material from feldspars, reactions observed in thin section. In each case silica is released, some or all of which may be transported from the rock by the agency that introduces the carbonate. To utilise the analyses of carbonate-rich rocks for normative calculations various adjustments have been devised. In each it is assumed that no metal ions were introduced with the carbonate and none removed. A comparison of the proportions of metal ions present in altered and unaltered rocks suggests that this is realistic.

Norms

In calculating 'norms' four alternative adjustments are considered.

1. Employ full chemical analytical data and accept a variable, and sometimes total utilisation of CaO by CO_2 with resultant imbalance throughout the remaining minerals of the norm, including the introduction of corundum as a norm mineral (Table 2).
2. Assume that CO_2 was introduced to the rock as H_2CO_3 and that SiO_2 and Al_2O_3 shown by analysis is either in primary minerals or was released from them and remained within the rock. In this case CO_2 values are ignored in the calculation of the norm, but no compensation is introduced. The relative proportion of metal oxides to silica is thus exaggerated in the analyses, resulting in reduction or elimination of normative silica with possible introduction of olivine (Table 3).
3. Assume the most probable secondary minerals are formed on alteration of primary minerals by carbonate-rich fluid. Assess silica released by this process and assume its total loss from the rock. Compensate by recalculating the original silica value from the amount of carbonate present. Employ the revised silica figure in the norm calculation whilst omitting the CO_2 figure. Replacement of CO_2 in the analyses by twice the molecular equivalent of silica suggested by this procedure results in over compensation, producing excessive silica enrichment.

TABLE 2
 CHEMICAL ANALYSES

	Complex				Dykes					Flow	Cognate Xenolith	Basalt Flows	
	An. 1 (Loc. 1)	An. 2 (Loc. 9)	An. 3 (Loc. 2)	An. 4 (Loc. 3)	An. 5 (Loc. 8)	An. 6 (Loc. 19)	An. 7 (Loc. 24)	An. 8 (Loc. 22)	An. 9 (Loc. 20)	An. 10 (Loc. 32)	An. 11 (Loc. 24)	An. 12 (Loc. 36)	An. 13 (Loc. 35)
SiO ₂	51.3	51.9	53.2	53.6	56.5	46.5	48.7	50.5	56.9	53.4	45.0	44.5	52.2
Al ₂ O ₃	15.1	15.5	15.1	15.5	16.2	14.4	15.1	13.8	16.5	15.5	10.8	13.2	12.6
Fe ₂ O ₃	3.2	2.8	3.3	3.3	2.6	4.0	3.6	3.1	2.2	4.2	3.6	1.8	2.0
FeO	6.6	7.0	6.5	6.1	5.5	6.7	7.5	5.1	6.0	5.3	8.3	11.1	10.8
MnO	0.15	0.18	0.19	0.17	0.18	0.17	0.15	0.14	0.15	0.16	0.19	0.18	0.15
TiO ₂	0.83	1.1	1.1	1.0	0.66	1.3	1.2	1.2	0.74	1.2	1.9	2.3	1.7
CaO	6.9	7.1	7.7	8.1	6.2	7.6	9.7	7.8	5.9	7.9	13.3	9.3	8.8
MgO	4.3	4.1	4.0	3.4	3.0	3.7	5.0	3.7	2.0	3.6	8.9	9.6	7.2
Na ₂ O	2.4	3.2	2.9	3.2	3.5	2.8	2.9	2.6	3.3	3.3	1.8	3.7	2.5
K ₂ O	3.7	3.6	2.8	2.7	3.1	3.7	2.4	3.9	3.5	2.7	1.8	1.5	0.39
	6.1	6.8	5.7	5.9	6.6	6.5	5.3	6.5	6.8	6.0	3.6	5.2	2.89
P ₂ O ₅	0.4	0.74	0.70	0.59	0.37	0.88	0.78	0.68	0.34	0.65	0.53	0.70	0.19
CO ₂	3.0	0.08	0.79	0.47	0.33	6.0	0.89	4.4	0.12	0.16	1.9	0.09	0.13
-H ₂ O	0.8	0.31	0.95	0.37	0.57	1.6	0.88	1.5	0.82	1.2	0.94	1.0	1.0
+H ₂ O	1.7	1.7	1.1	1.1	1.4	0.36	1.3	1.2	1.6	0.80	1.1	1.2	0.25
SO ₃	0.16	0.97	0.15	..	0.04	0.05	..	0.21	0.10	0.11	0.25	..	..
Cl .. ..	..	+	..	..	..	..	..	+	0.15	..	0.06	..	..
F .. ..	..	..	..	..	..	..	..	..	..	..	..	..	..
TOTAL	100.54	100.28	100.48	99.60	100.15	99.76	100.10	99.83	100.32	100.18	100.37	100.17	99.91
K ₂ O : Na ₂ O ..	1.54	1.13	0.97	0.84	0.89	1.32	0.83	1.50	1.06	0.82	1.00	0.41	0.16

ANALYSES: J. FURST

NORMATIVE COMPOSITIONS

	Complex					Dykes				Flow	Cognate Xenolith	Basalt Flows	
	An. 1 (Loc. 1)	An. 2 (Loc. 9)	An. 3 (Loc. 2)	An. 4 (Loc. 3)	An. 5 (Loc. 8)	An. 6 (Loc. 19)	An. 7 (Loc. 24)	An. 8 (Loc. 22)	An. 9 (Loc. 20)	An. 10 (Loc. 32)	An. 11 (Loc. 24)	An. 12 (Loc. 36)	An. 13 (Loc. 35)
q	7.54	..	5.70	4.82	6.70	7.29	..	9.91	8.91	4.92	..	..	4.57
or	21.87	21.28	16.55	15.96	18.32	21.87	14.18	23.05	20.68	15.96	10.64	8.87	2.31
ab	20.31	27.08	24.54	27.08	29.62	23.69	24.54	22.00	25.71	27.92	14.34	13.13	21.16
an	12.65	17.30	19.92	19.96	19.34	..	21.10	6.44	21.05	19.51	16.55	14.98	22.01
ne	..	..	..	..	..	..	..	..	..	..	..	9.85	..
co	2.51	..	..	..	..	5.79	..	2.94	..	..	..	..	..
di	..	10.34	7.15	11.03	5.72	..	13.35	..	4.41	11.68	27.37	21.22	16.13
(en)	..	(2.81)	(1.99)	(2.95)	(1.44)	..	(3.78)	..	(0.84)	(3.77)	(9.30)	(6.30)	(4.25)
(fs)	..	(2.27)	(1.52)	(2.48)	(1.38)	..	(2.76)	..	(1.38)	(1.89)	(3.89)	(4.06)	(3.71)
(wt)	..	(5.26)	(3.64)	(5.60)	(2.89)	..	(6.81)	..	(2.19)	(6.02)	(14.18)	(10.86)	(8.18)
hy	18.97	11.31	14.08	10.18	11.80	16.34	9.12	14.13	10.94	7.80	4.88	..	25.63
(et)	(10.71)	(6.25)	(7.97)	(5.52)	(6.03)	(9.21)	(5.27)	(9.21)	(4.14)	(5.20)	(3.44)	..	(13.68)
(ft)	(8.23)	(5.04)	(6.01)	(4.64)	(5.75)	(7.10)	(3.83)	(4.90)	(6.77)	(2.60)	(1.43)	..	(11.90)
ol	..	1.52	..	..	..	..	4.30	..	..	..	9.66	21.12	..
(fo)	..	(0.80)	..	..	..	..	(2.38)	..	..	..	(6.61)	(12.34)	..
(fa)	..	(0.72)	..	..	..	..	(1.92)	..	..	..	(3.05)	(8.78)	..
mt	4.64	4.06	4.79	4.79	3.77	4.18	5.22	4.50	3.19	6.09	5.22	2.61	2.90
il	1.58	2.09	2.09	1.9	1.25	2.47	2.28	2.28	1.41	2.28	3.61	4.37	3.23
ap	0.95	1.75	1.66	1.40	0.88	2.08	1.85	1.61	0.81	1.54	1.26	1.66	0.45
py	0.11	0.73	0.11	..	0.04	0.04	..	0.15	0.08	0.08	0.19	..	..
ca	6.82	0.18	1.80	1.07	0.75	13.03	2.02	10.01	0.27	0.36	4.32	0.21	0.30
Others	2.60	2.59	2.14	1.47	1.99	2.71	2.18	2.83	2.73	2.07	2.29	2.2	1.25
TOTAL	100.55	100.23	100.53	99.66	100.18	99.49	100.14	99.85	100.19	100.21	100.33	100.22	99.94

Complex

- An. 1. Biotite-hornblende-porphyrite
- An. 2. Augite-hornblende-porphyrite
- An. 3. Hornblende-porphyrite
- An. 4. Biotite-augite-porphyrite
- An. 5. Sphene-augite-hornblende-porphyrite

Dykes

- An. 6. Augite-biotite-kersantite
- An. 7. Biotite-augite-hornblende-plagioclase-spessartite
- An. 8. Biotite-kersantite
- An. 9. Hornblende-spessartite

COMPUTED: UNIVERSITY OF TASMANIA

Flow

- An. 10. Augite-hornblende-andesite
- Cognate Xenolith
- An. 11. Augite-hornblende-diorite
- Basalt Flows
- An. 12. Alkali olivine-basalt
- An. 13. Tholeiitic olivine-basalt

TABLE 3
COMPARATIVE NORMATIVE COMPOSITIONS OF ROCK WITH ADJUSTMENTS FOR
CARBONATE CONTENT

		1	1a	1b	2	2a	2b	6	6a	6b	8	8a	8b	10	10a	10b	11	11a	11b
q	.. ..	8	2	6	-	-	-	7	-	5	10	2	8	5	5	5	-	-	-
or	.. ..	22	22	22	21	21	21	22	22	22	23	23	23	16	16	16	11	11	11
ab	.. ..	20	20	20	27	27	27	24	23	24	22	22	22	28	28	28	14	9	14
an	.. ..	13	20	20	17	17	17	-	16	16	6	14	14	20	20	20	17	17	17
ne	.. ..	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	3	-
co	.. ..	3	-	-	-	-	-	6	-	-	3	-	-	-	-	-	-	-	-
di	.. ..	-	10	10	10	11	11	-	13	13	-	16	16	12	13	13	27	37	37
hy	.. ..	19	14	14	11	11	11	16	-	10	14	6	6	8	7	7	5	-	1
ol	.. ..	-	-	-	2	2	2	-	7	-	-	-	-	-	-	-	10	10	9
mt	.. ..	5	5	5	4	4	4	4	6	6	4	4	4	6	6	6	5	5	5
il	.. ..	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4
ap	.. ..	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
py	.. ..	+	+	+	1	1	1	+	+	+	+	+	+	+	+	+	+	+	+
ca	.. ..	7	..	..	+	..	..	13	..	..	10	..	..	+	..	..	4	..	..

1. Biotite-hornblende-porphyrite (complex)
2. Augite-hornblende-porphyrite (complex)
6. Augite-biotite-kersantite (dyke)

8. Biotite-kersantite (dyke)
10. Augite-hornblende-andesite (flow)
11. Augite-hornblende-diorite (cognate-xenolith)

Analysis numbers—norms derived from total chemical analyses.

suffix a—norms from analyses with CO₂ omitted,

suffix b—norms from analyses with CO₂ replaced by SiO₂.

4. Assume an arbitrary correction factor, eliminating CO_2 from the analysis for the norm and increasing the silica values to figures comparable with those of unaltered rocks. This is effected by replacement of CO_2 by the molecular equivalent of silica and assumes that approximately half of the silica released by reaction remains among alteration products in the rock and appears in the analyses.

Table 3 has been compiled to demonstrate the effect of deriving norms using adjustment (1), (2) and (4) above, mainly for rocks rich in CO_2 but including analyses 2 and 10 for comparison. In analysis 6 the total demand for CaO by CO_2 and P_2O_5 (to form calcite and apatite respectively) exceeds the total CaO available from the analysis, requiring the formation of a small amount of FeCO_3 to absorb excess CO_2 . Mineral percentages are quoted in whole numbers, and apparently adjustment (4) produces the most realistic result.

The danger inherent in any revision of analytical results is that real but inconspicuous variations in compositional trend may be disguised or eliminated together with irregularities.

DISCUSSION

The most significant feature of the geology of the Cape Portland area revealed by the current work, is the presence of appinitic rocks of probable Jurassic-Cretaceous age. Their known occurrence in SE Australia was previously confined to detritus in Cretaceous sediments in S Victoria, and probably as a dyke on King Island. The possible extension of appinitic rocks to the N may influence future interpretation of the submarine geology of Bass Strait.

Knowledge of the late-Jurassic to pre-Tertiary history of Tasmania is sparse, but the Cape Portland appinites, like the Middle Cretaceous intrusions at Port Cygnet (Leaman and Naqvi, 1967) may provide information of the tectonic and magnetic environment of the period. The vague N-S alignment of porphyrite outcrops suggests a N-S lineament. A pronounced topographic break to the S, aligned with a N-S pre-basalt Tertiary valley crossing the Cape Portland area, including the probable site of the basalt eruptive centre, infers faulting and volcanism along this line. Although exposure is incomplete, the lamprophyre dykes associated with the porphyrite complex show approximate radial distribution with dominant NE-SW trends, an unusual post-Permian tectonic pattern for Tasmania.

Future work on the Cape Portland appinites will include the mapping of off-shore islands, and detailed studies of their mineralogy, petrological relationships and affinities to the Port Cygnet intrusions and others of similar age in SE Australia. Precise age determinations by isotopic methods, with palaeomagnetic studies and geophysical investigations would provide results of comparative interest.

The geomorphology and Quaternary deposits of the Cape Portland area provide information of past eustatic changes in Bass Strait and a detailed study may serve to link the histories of the Tasmanian mainland and the Furneaux Islands.

Appendix I

PETROGRAPHIC DESCRIPTIONS OF THE APPINITIC SUITE

Rocks of the Porphyrite Complex

Biotite-hornblende-porphyrite

(Loc. 1; T.S. 637, 637a, 793; Analysis 1)

Outcrop of this rock is indicated by a small patch of boulders on the W margin of the main complex. It is a medium-grey rock with common phenocrysts of biotite and hornblende in a porphyritic feldspathic groundmass.

Corroded biotite (1.5 cm max.; α pale greyish yellow; $\beta=\gamma$ pale to dark brown) shows patchy and marginal zoning, with deepening of colour and increase in extinction angle towards the rims. Hornblende (2.5 cm max.; α pale yellow, β olive-brown, γ olive-green, $\beta>\gamma>\alpha$, $\gamma:Z\approx 19^\circ$) is commonly altered and carbonated, with development of secondary iron ore.

Sporadic to common plagioclase phenocrysts (usually 0.3 to 2.5 mm, rarely to 4 mm) are zoned from sodic labradorite to andesine, largely sericitised and overgrown with zoned andesine. Some smaller crystals show hollow interiors.

The groundmass consists of zoned andesine laths (to 0.5 mm) apatite prisms (to 0.5 mm); iron ore (4-5%), potash feldspar, quartz and carbonate. The rock includes sporadic, aligned, elongate carbonate amygdalae (to 2.5 cm long), occasional fragments of cherty sediment with fused margins spotted with quartz, and scattered quartz crystals and aggregates. Some of the latter show interlocking grains, undulose extinction and biaxial figures with low 2V, and probably represent digested quartzitic xenoliths.

Hornblende-porphyrite and augite-hornblende-appinite

(Loc. 2; T.S. 623, 623a, 792; Analysis 3)

An outcrop of this rock forms a small hummock on the W margin of the main complex, E of the biotite-hornblende-porphyrite. It is a medium-grey rock containing common to abundant phenocrysts of hornblende and plagioclase in a feldspathic groundmass and includes patches of a dense darker appinitic phase.

Corroded hornblende crystals (to 7 mm; α pale yellow, β olive-brown to olive-green, γ olive-brown to olive-green, $\gamma>\beta>>\alpha$, $\gamma:Z\approx 18^\circ$) show narrow alteration rims of iron ore. Some crystals are altered with development of secondary iron ore, others occasionally show hollow interiors. Rare biotite (3 mm max.) is generally severely corroded, with development of secondary iron ore.

Plagioclase phenocrysts (to 2.5 mm) include apatite and iron ore and are zoned from sodic labradorite to calcic andesine cores, with overgrowths zoned from calcic to sodic andesine. The phenocrysts grade to small tablets of zoned andesine-oligoclase, in a cloudy base of potash feldspar, with apatite, iron ore and minor quartz. There are small scattered carbonate amygdalae and rare siliceous fragments.

The dark appinitic phase generally lacks plagioclase phenocrysts but carries common to abundant phenocrysts of hornblende and augite in a fine felted groundmass of andesine-oligoclase, sparse biotite, iron ore granules and potash feldspar.

Hornblende (to 1 cm; α pale yellow, β olive-brown to olive-green, γ olive-green, $\gamma > \beta > \alpha$) is zoned, from deeper coloured cores to browner margins with increase in extinction angle from $\approx 16^\circ$ to 21° . The augite (1 mm max.) occasionally shows partial alteration to hornblende. Small hornblende-rich aggregates are rarely present.

Biotite-augite-porphyrite

(Loc. 3; T.S. 626, 626a; Analysis 4)

This rock forms a small hillock on the W side of the main complex, E of the hornblende-porphyrite. In appearance it is a medium-grey rock with sporadic phenocrysts of augite and labradorite-andesine (mainly to 2 mm, rarely to 1.2 cm) showing corroded and sericitised cores. The porphyritic texture is not marked and phenocrysts merge into the intergranular to sub-ophitic groundmass of stout laths of zoned andesine (1 mm max.), corroded augite (10%; 1.5 mm max.), biotite (5%; α pale yellow, $\beta = \gamma$ reddish-brown; mainly to 0.5 mm, rarely to 1 mm), iron ore (7%; 0.7 mm max.), apatite and minor interstitial potash feldspar and quartz. Sporadic patches of carbonate (to 5 mm across) contain euhedral quartz (to 1 mm) and relic plagioclase. Rare corroded phenocrysts of hornblende are rimmed by coronas of biotite, apatite and iron ore. A few augite crystals are altered or corroded and overgrown with a corona of hornblende and/or biotite.

The rock contains xenoliths of altered Jurassic dolerite (exceeding 5 cm), siliceous fragments (to 2 cm) and cognate aggregates (to 10 cm) rich in ferromagnesian minerals.

A section of a cognate aggregate (T.S. 626b) shows a hornblende containing 80-85% hornblende (α light yellow, β olive-brown, γ olive-green, $\gamma > \beta > \alpha$, $\gamma:Z \approx 18^\circ$), as interlocking crystals (2-5 mm) with limited marginal alteration to biotite and bluish-green soda(?) amphibole. The hornblende is intergrown with and poikilitically encloses euhedral to irregular masses of iron ore (7-10%; to 2 mm), stout apatite prisms (5%) and biotite (3-5%; α light grey to pale orange-yellow, $\beta = \gamma$ purplish-brown to chestnut-brown: 1.2 mm max.), with some interstitial altered plagioclase and carbonate (3-5%).

Augite-hornblende-porphyrite

(Loc. 6 and 9; T.S. 633a, 633b, 706; Analysis 2)

Patches of boulders of this rock indicate narrow outcrops near the centre and E margin of the main complex. A light greenish-grey rock, it contains common to abundant corroded phenocrysts of hornblende and augite (2 cm max.) and rare to sporadic plagioclase phenocrysts in a cryptocrystalline groundmass.

Phenocrysts of augite and hornblende (α pale yellow, β olive-brown, γ olive-green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 20-22^\circ$) are more or less altered. Some augite shows marginal alteration to hornblende and rare small biotite flakes are aligned along hornblende margins and scattered in the groundmass. The plagioclase phenocrysts (1.5 mm max.) show sericitised cores with rims of zoned andesine.

The groundmass is a felted to microgranular base of andesine-oligoclase microlites (to 0.5 mm), cloudy potash feldspar and minor quartz, with iron ore (to 2 mm) and apatite (to 0.7 mm). The iron ore includes crystals and aggregates of pyrite.

Sphene-augite-hornblende-porphyrite

(Loc. 8 and 10; T.S. 634, 707, 707a; Analysis 5)

This light-grey strongly-porphyrific rock occupies a tract along the E margin of the main complex. Abundant phenocrysts of plagioclase, common to abundant hornblende, and rare to sporadic augite and sphene are set in a feldspathic cryptocrystalline groundmass.

The plagioclase phenocrysts (0.3-7 mm) are zoned from sodic labradorite ($\approx Ab_{60}$) to acid oligoclase ($\approx Ab_{75}$). Some crystals show corroded sericitised cores, presumably of more calcic plagioclase and a few show strongly sericitised margins.

The hornblende (α brownish- to greenish-yellow, β brown to olive-green or greenish-black, γ olive brown to deep green, $\gamma \geq \beta > \alpha$, $\gamma:Z \approx 18-21^\circ$) ranges to 6 mm long. Brown hornblende tends to mantle greener hornblende which occasionally shows alteration. Augite phenocrysts range to 1.5 mm across. Sphene forms euhedral crystals (to 1.2 mm long, twinned on 100 and multiply twinned on 221) faintly pleochroic from colourless to pale clove-brown.

The groundmass is cloudy with a microgranular to felted texture and consists of plagioclase microlites (largely oligoclase), potash feldspar and quartz, interspersed with iron ore and apatite. Scattered patches of carbonate and rare siliceous fragments are present with sporadic mafic aggregates containing hornblende, augite or biotite. Diorite and altered Jurassic dolerite(?) xenoliths (to 10cm) are included.

A section of typical diorite xenolith shows hornblende (50-55%) and augite (10-15%) to 3.5 mm across, with plagioclase and potash feldspar. The hornblende (α brownish-yellow to yellow to greenish-yellow, β brown to olive-brown to olive-green, γ brown to deep green, $\gamma \geq \beta > \alpha$) includes apatite iron ore and rare biotite. Green colours predominate and brown cores possess greener outer zones, with $\gamma:Z \approx 16^\circ$ (core) to 18° (rim). The augite includes iron ore and apatite, shows corrosion riddling and is commonly more or less altered to hornblende. The remainder of the rock consists of calcic labradorite zoned to sodic andesine, with some interior alteration and corrosion, and rare biotite (to 1 mm; α yellow, $\beta = \gamma$ black) set in a base of cloudy, altered potash feldspar.

Altered porphyrite

(Loc. 4, 5 and 7; T.S. 617, 625, 629, 630)

A copious float of joint blocks almost exclusively of this rock type indicates that it forms the bulk of the main complex. This light greenish-grey rock contains abundant phenocrysts of plagioclase and altered ferromagnesian minerals to 6 mm long.

The plagioclase phenocrysts are zoned from calcic labradorite to acid andesine or basic oligoclase, with sericitisation of the more calcic cores. The ferromagnesian phenocrysts are generally completely altered, sometimes with development of much secondary iron ore. Relic structures suggest derivation from hornblende, augite and occasionally biotite. In some rocks rare to sporadic biotite appears as the only unaltered ferromagnesian phenocrysts.

The groundmass is mainly felted and in parts fluidal, with microlites of zoned oligoclase, patchy carbonate, minor potash feldspar and quartz, interspersed with iron ore, apatite and rare sphene.

Biotite-augite-hornblende-porphyrite

(Loc. 11 and 12; T.S. 698, 701)

This medium grey porphyritic rock forms two small outcrops to the N of main complex. A sample from the most westerly outcrop (T.S. 698) consists of abundant plagioclase, common to abundant hornblende, and sporadic augite and biotite in a cryptocrystalline feldspathic groundmass.

The plagioclase phenocrysts (usually to 1.5 mm, rarely to 4.5 mm) show partly altered cores zoned from sodic labradorite to sodic andesine, overgrown with narrow rims of zoned andesine-calcic oligoclase.

Hornblende phenocrysts (8 mm max.; α pale fawn to yellow, β brown to olive-brown, γ deep olive-green, $\gamma > \beta > \alpha$, $\gamma:Z \approx 12-15^\circ$) possess cores with more deeply coloured margins showing smaller extinction angles. Augite crystals (3 mm max.) are riddled with corrosion and show incipient alteration to hornblende. Flakes of biotite (α yellow, $\beta = \gamma$ brownish-black; commonly to 0.5 mm rarely over 5 mm) are severely altered with development of secondary iron ore and show reaction coronas of prismatic augite. Rare apatite and sphene (to 0.5 mm) are present and iron ore (to 0.7 mm) forms marginal intergrowths with hornblende and augite.

The cloudy groundmass is composed of sodic plagioclase micro-lites and minor potash feldspar. Rare dioritic aggregates of mafic minerals and siliceous fragments are included.

A sample from the E outcrop (T.S. 701) shows abundant hornblende and sporadic plagioclase phenocrysts with sporadic to common altered, carbonated, sericitized and talcose pseudomorphs apparently derived from hornblende, plagioclase, augite and biotite.

The hornblende (α yellow, β olive-brown to olive-green, γ bright olive-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 16-19^\circ$) is zoned, with deeper colours and decrease in extinction angle towards the margins, and a final reverse to paler rims and increase in extinction angles. Biotite (1.2 cm max.) occurs as flakes on hornblende margins and dispersed in the groundmass. A cloudy base of sodic plagioclase with minor potash feldspar and quartz, is interspersed with iron ore (to 1 mm), apatite (to 0.5 mm), irregular carbonate patches and sparse carbonate and quartz amygdals.

Scattered siliceous fragments are present, also cognate aggregates, mostly rich in ferromagnesian minerals, but grading to rare leucocratic feldspar-rich layered diorite.

Porphyrite breccia (Loc. 11; T.S. 700)

This breccia was found as loose blocks associated with porphyrite (loc. 11) and is a light greenish-grey rock with a fragmental texture. It contains sporadic sub-rounded to angular rock fragments (2.5 cm) among smaller pieces and crystals, in a fine microcrystalline dark dusty groundmass.

The rock fragments are mainly porphyrites of different types, but include rare pieces of cherty sediment. The porphyrites include types with plagioclase the dominant phenocryst and others rich in ferromagnesian phenocrysts, particularly hornblende. Alteration of original minerals hampers precise determination.

Corroded to euhedral hornblende (to 5 mm; α pale yellow, β olive-brown to olive-green, γ yellowish-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 21-25^\circ$) is prominently scattered through the groundmass, accompanied by quartz, alkali feldspar (microcline?), plagioclase, augite, iron ore and biotite. The rock possibly represents a marginal phase of the porphyrite complex contaminated with accidental and cognate fragments, similar to the lamphophyre breccias observed in some of the coastal dykes.

Quartz-hornblende-porphyrite (Loc. 13; T.S. 776)

Several exposures of this rock occur on low ridges forming outcrops south of the main porphyrite complex $\frac{1}{4}$ mile SW of Cape Portland homestead. It is a light bluish-grey rock containing abundant phenocrysts of hornblende and plagioclase, in a fine-grained quartz-rich feldspathic groundmass.

Hornblende (α yellow to brownish-yellow, β dark brown to olive-brown, γ olive-brown to dark olive-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 16-19^\circ$) ranges to 1 cm long. Plagioclase (6 mm max.) is zoned labradorite-andesine, with altered cores and thin rims of sodic andesine-oligoclase. Rare corroded biotite ranges to 1.2 cm across.

The cloudy groundmass consists of sodic plagioclase microlites, interspersed with iron ore, apatite (0.3 mm max.) and common irregular patches of quartz and carbonate. Some quartz invades phenocrysts. Occasional cognate dioritic aggregates rich in ferromagnesian minerals occur as well as rare accidental xenoliths of granite and pieces of quartz.

Biotite-augite-hornblende-appinite (Loc. 14; T.S. 767)

An accumulation of float boulders of this appinite indicates an outcrop $\frac{1}{2}$ mile W of Cape Portland homestead. This dense, dark purplish-grey rock contains abundant phenocrysts of hornblende (α pale fawn, β olive-brown, γ yellowish olive-green, $\gamma \approx \beta > \alpha$, $\gamma:Z \approx 16^\circ$) augite (usually to 3 mm, occasionally to 1 cm) and rare to sporadic biotite (1.5 cm max.).

The groundmass is a fine microlitic felt of sodic plagioclase in a dark brown, cloudy base, which in places becomes slightly coarser and fluidal. It contains sporadic iron ore and apatite (0.5 mm max.) some irregular patches of quartz, quartz fragments and partly digested quartzose and cherty xenoliths up to 3 mm across.

Lamphophyre Dyke Rocks

Biotite-kersantite (Loc. 22; T.S. 639, 639a; Analysis 8)

This rock occurs as a well exposed dyke with a subsidiary sub-parallel branch, on the small headland 2 miles NW of the homestead. The main dyke is some 3 feet wide, 100 feet long and of general trend 062° .

This is a light- to medium-grey rock containing sporadic to abundant biotite phenocrysts in a fine-grained feldspathic amygdaloidal groundmass.

Corroded biotite (8 mm max.; α pale greyish-yellow, $\beta = \gamma$ dark brown) includes iron ore and apatite. Large crystals show zoning with deeper coloured margins.

The sub-fluidal groundmass consists of andesine laths (0.2 mm max.), potash feldspar, iron ore (to 0.7 mm), apatite (to 0.4 mm) and scattered small biotite flakes. Sparse biotite aggregates (to 5 mm) are associated with carbonate, apatite, and minor chlorite. Numerous amygdales (to 1 cm) contain carbonate, chlorite and opal.

Augite-biotite-kersantite

(Loc. 19; T.S. 635, 635a, 635b, 790; Analysis 6)

The most northwesterly of the swarm, this dyke outcrops on the western seaboard of Cape Portland, $3\frac{1}{4}$ miles NW of the homestead. The dyke is disjointed to form two outcrops with average width some 2 feet and total length of 40 feet on a general trend of 092° .

This is a medium-grey rock containing rare to sporadic phenocrysts of augite and biotite in a fine-grained micaceous, feldspathic and carbonated groundmass.

Biotite (8 mm max.; α brownish-yellow, $\beta=\gamma$ olive-brown) and augite (2.5 mm max.) are set in a groundmass of zoned andesine laths (0.2 mm max.), biotite, potash feldspar, augite, iron ore (to 0.7 mm) and apatite (to 0.4 mm). Carbonate is present as amygdalae, irregular interstitial patches and replaces augite and biotite in the groundmass.

Biotite-augite-vogesite (Loc. 33; T.S. 654, 806)

A dyke of this composition occurs on the foreshore of the headland $2\frac{1}{2}$ miles W of the homestead. The dyke is of irregular form and inconsistent direction and varies in width from 2 to 4 feet tapering rapidly to nothing at the seaward end. The outcrop of some 60 feet in length has a general trend of 027° .

This olive-grey rock contains sporadic phenocrysts of biotite and augite in a fine-grained potassic groundmass.

Biotite (4 mm max.; α yellow, $\beta=\gamma$ chestnut-brown) and augite (usually to 2 mm, rarely to 3.5 mm) are present in a groundmass of numerous slender augite prisms (to 0.2 mm), iron ore (to 0.5 mm) and apatite (to 0.8 mm) in a base rich in potash feldspar. Rare carbonate amygdalae attain 3 mm across.

Hornblende-spessartite

(Loc. 34; T.S. 656a, 656b, 656c, 796)

This rock forms a narrow dyke crossing the diminutive headland $2\frac{1}{2}$ miles WSW of the homestead. N and S extremities are exposed on the shore indicating a width of about 1 foot over a total length of some 350 feet on a general trend of 032° .

This is an olive-grey rock containing rare to sporadic hornblende phenocrysts in a fine-grained fluidal feldspathic groundmass.

Hornblende (α yellow, β deep olive-green, γ bright olive-green, $\beta>\gamma>>\alpha$, $\gamma:Z=16^\circ$) ranges to 4 mm across. The groundmass consists of tablets and laths of zoned calcic to sodic andesine-oligoclase (0.3 mm max.) associated with iron ore (to 1 mm), apatite (to 0.8 mm), and augite prisms (to 0.5 mm), in a cloudy, partly glassy base with potash feldspar.

Hornblende-spessartite

(Loc. 20; T.S. 619, 619a, 652, 648, 648a, 655; Analysis 9)

Rocks of this composition form a cluster of four irregular small dykes disposed *en echelon* on the N foreshore of the headland 2 miles NW of the homestead. Their trend varies between 042° and 062° and the largest is 30 feet long and 3 feet wide at its maximum.

This is a dense dark- to medium-grey rock containing sporadic hornblende and rare augite and plagioclase phenocrysts in a cryptocrystalline to fine-grained feldspathic groundmass, with variable amounts of sodic plagioclase and potash feldspar.

Hornblende ranges to 2 cm long. In rock with a potash-rich groundmass it shows α yellow, β olive-brown to olive-green, γ olive-brown to olive-green, $\beta \gg \gamma > \alpha$, $\gamma:Z \approx 16-18^\circ$. Crystals are zoned from green interiors to browner margins. In rock with a soda-rich groundmass it shows α greenish-yellow, β dark olive-green, γ olive-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 12-16^\circ$. Rare colourless augite (0.8 mm max.) accompanies plagioclase (0.5 to 2 mm) zoned from calcic andesine ($\approx Ab_{55}$) to sodic andesine-oligoclase ($\approx Ab_{30}$) with incipient corrosion and alteration of cores. Minor constituents include iron ore (to 0.9 mm), apatite (to 1.5 mm) and rare biotite relics.

The groundmass grades from a felt of sodic plagioclase and augite crystallites, associated with varying amounts of potash feldspar, to a fluidal texture of laths of zoned andesine-oligoclase (to 0.3 mm) in a dark cloudy base of potash feldspar and minor carbonate. Rocks with the latter groundmass typically contain xenocrysts of quartz, cherty to quartzitic xenoliths (occasionally corroded and partly digested) and rare cognate hornblende aggregates to 2.5 cm across.

Augite-hornblende-spessartite (Loc. 26; T.S. 646. 646a)

This rock type forms a well-exposed dyke some 3 feet wide and 220 feet long, cutting the shore platform of the headland 2 miles NW of the homestead. Disjointed in two places, the dyke outcrop shows progressive dilational side-stepping and gives a general trend of 050° .

This medium-grey rock contains common to abundant augite and hornblende phenocrysts in a fine-grained feldspathic and amygdaloidal groundmass.

Crystals of augite and hornblende (α pale yellow, β olive-brown to deep olive-green, γ deep olive-green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 25^\circ$) range to 5 mm long. Rare altered plagioclase phenocrysts range to 1.8 mm across.

The groundmass consists of felted zoned andesine-oligoclase crystallites (to 0.2 mm), iron ore (to 0.9 mm) and apatite (to 0.3 mm), associated with small flakes of biotite and chlorite and minor potash feldspar. Numerous amygdales containing carbonate and subordinate chlorite, attain diameters of 7 mm.

Augite-hornblende-spessartite (Loc. 31; T.S. 647)

A dyke of this composition, some 5 feet wide is exposed over a length of 370 feet with a trend of 042° . It cuts the NW promontory of the headland $2\frac{1}{2}$ miles W of the homestead.

This is a dark- to medium-grey rock containing sporadic phenocrysts of augite and hornblende in a fine-grained feldspathic groundmass.

Hornblende (α yellow, β dark olive-green, γ bright olive-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 25-27^\circ$) and augite range to 5 mm long. Iron ore (to 0.7 mm) and apatite (to 0.3 mm) are present.

The groundmass is a microlitic felt of sodic plagioclase and augite (to 0.1 mm), passing into a coarse fluidal groundmass of plagioclase laths (to 0.7 mm) zoned from calcic to sodic andesine-oligoclase, with minor potash feldspar and small, sparse patches of carbonate.

Biotite-augite-hornblende-spessartite

(Loc. 21; T.S. 645. 645a)

This rock type constitutes a dyke which is exposed on the fore-shore of the headland 2 miles NW of the homestead and veers about a general trend of 072°. The outcrop tapers from 5 feet to nothing and is partly obscured by beach boulders over a total length of 40 feet.

This medium-grey rock contains abundant hornblende, common biotite, and sporadic augite phenocrysts in a fine-grained feldspathic and amygdaloidal groundmass.

Hornblende (α yellow, β brown to olive-green, γ olive-brown to olive-green, $\beta > \gamma > \alpha$, $\gamma:Z \approx 22^\circ$), biotite (α greyish-yellow, $\beta = \gamma$ greenish-brown) and augite range to 1.5 cm across.

The sub-fluidal groundmass consists of plagioclase laths (to 0.2 mm) zoned from calcic andesine ($\approx Ab_{50}$) to sodic andesine-oligoclase, iron ore (to 0.7 mm), apatite (to 0.6 mm) and minor potash feldspar. Elongate carbonate amygdales attain 7 mm in length and rare quartz fragments are included.

Hornblende-plagioclase-spessartite ? (Loc. 28; T.S. 703)

An ill-defined exposure and sparse float boulders provide evidence of outcrop of this rock on the E flank of the hill forming the headland 2 miles NW of the homestead. It may be porphyrite.

This medium-grey rock contains abundant plagioclase and common to abundant hornblende in a cryocrystalline potash-rich feldspathic groundmass.

Plagioclase (zoned from sodic labradorite to sodic andesine, commonly with selective interior alteration and corrosion) and hornblende (α yellow to greenish-yellow, β dark olive-brown to olive-green, γ deep to bright green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 17-20^\circ$) range to 4.5 mm across. Rare biotite flakes (α amber, $\beta = \gamma$ black) are commonly partly or completely resorbed and altered to iron ore.

The groundmass contains iron ore (to 0.3 mm) and rare small apatite prisms, in an irregular mosaic of cloudy potash feldspar grains about 0.1 mm across.

Hornblende-plagioclase-spessartite ? (Loc. 28; T.S. 704)

This rock was collected from the same outcrop as the last.

It is a weathered purplish-grey rock containing sporadic to common plagioclase and hornblende phenocrysts in a fine-grained sub-fluidal micaceous, quartz-feldspathic groundmass.

Plagioclase (mainly zoned andesine, and commonly completely altered) and hornblende (α yellow, β deep olive-brown, γ deep olive-brown to olive-green; zoned from green interiors to brown rims, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 18^\circ$) range to 3 mm long.

The groundmass consists of small laths of zoned sodic andesine-oligoclase, and biotite flakes (to 0.1 mm), associated with minor potash feldspar and irregular patches of quartz, possibly of secondary origin.

Hornblende-plagioclase-spessartite (Loc. 16; T.S. 631, 631a)

Angular joint blocks of this spessartite were excavated from a waterhole $1\frac{3}{4}$ miles NW of the homestead in such abundance that local outcrop is suspected, although no exposures are seen.

This is a dark- to medium-grey rock containing abundant plagioclase and hornblende phenocrysts in a dark glassy to cryptocrystalline, patchy feldspathic groundmass.

Plagioclase (2.5 mm max.) is zoned from sodic labradorite ($\approx Ab_{10}$) to sodic andesine ($\approx Ab_{60}$), with interiors riddled by corrosion.

Hornblende (5 mm max.; α pale yellow, β olive-brown to olive-green, γ pale to bright olive-green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 20^\circ$ (darker colours) to 25° (paler colours)) is zoned from green interiors to browner rims.

There are rare altered and carbonated crystals (augite?) to 5 mm, and very rare biotite (to 1.5 mm).

The groundmass is a sub-fluidal microlitic felt of sodic plagioclase, with potash feldspar and quartz. In the groundmass are common quartz xenocrysts (to 1 mm), partly digested and carbonated cherty to quartzitic xenoliths (over 5 mm), fragments of altered dolerite and feldspar (to 2 mm) and scattered carbonate amygdales (to 3 mm).

Hornblende-plagioclase-spessartite (Loc. 27; T.S. 642, 642a)

An irregular-shaped dyke with outcrop side-stepped along joint planes, and locally tortuous and tapering in form, is exposed on the foreshore of the headland 2 miles NW of the homestead. The dyke, of maximum width 4 feet, can be traced over a length of 120 feet on a general trend between 060° and 080° .

The dyke rock is medium-grey in colour and contains abundant plagioclase and common hornblende phenocrysts in a dark cloudy, fine-grained feldspathic groundmass.

Plagioclase (to 2.5 mm) is zoned from sodic labradorite ($\approx Ab_{15}$) to sodic andesine ($\approx Ab_{65}$) with some interior alteration and corrosion. Hornblende (α yellow, β brown to olive-brown, γ olive-brown to olive-green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 16-17^\circ$) ranges to 5 mm long.

The groundmass is a fluidal felt of sodic plagioclase needles (andesine-oligoclase), with minor potash feldspar, and is scattered with iron ore (to 0.5 mm) and apatite (to 0.3 mm). Amygdales with carbonate and minor quartz are locally common.

Hornblende-plagioclase-spessartite breccia

(Loc. 23; T.S. 651)

A dyke breccia of this composition outcrops on the headland 2 miles NW of the homestead trending 077° .

The breccia is mottled yellowish-grey in colour and composed dominantly of fragments of hornblende-plagioclase-spessartite rock, ranging from less than 1 mm to over 12 cm, with scattered meta-sedimentary fragments up to 2 cm, in a dark fine-grained groundmass forming less than 5-10% of the whole. Towards the dyke margins and along its eastern extension inland the rock grades into dark mottled lamprophyre-breccia contaminated with abundant fragments of quartz, meta-sediment and dolerite country-rock.

The hornblende-plagioclase-spessartite of the breccia is a purplish-grey rock that weathers to a cream colour, and contains abundant plagioclase and common hornblende phenocrysts in a cloudy, cryptocrystalline feldspathic groundmass.

Plagioclase (0.2 to 2.5 mm) is zoned from sodic labradorite to sodic andesine, commonly with alteration of crystal cores.

Hornblende (5 mm max.; α yellow, β deep green to olive-green, γ olive-green to pale green, $\beta \simeq \gamma \gg \alpha$, $\gamma:Z \simeq 17-23^\circ$) shows deeper coloured cores with paler overgrowths. Rare biotite flakes range to 5 mm across.

The groundmass is a sub-fluidal felt of sodic plagioclase micro-lites, associated with potash feldspar, scattered iron ore (to 0.5 mm) and apatite (to 0.3 mm). Included are rare quartz xenoliths, cherty to quartzitic xenoliths, and rare cognate hornblendic aggregates.

Hornblende-plagioclase-spessartite and biotite-augite-hornblende-plagioclase-spessartite

(Loc. 24; T.S. 650, 624; Analysis 7)

A broad zoned dyke of these compositions which cuts the headland 2 miles NW of the homestead is preferentially eroded producing a deep indentation in the shoreline with a shallow trough in the coastal platform, exposing dyke-rock sporadically in the floor. The trough trends 052° and measures 24 feet wide.

The marginal phase of this dyke is a lighter coloured hornblende-plagioclase-spessartite, up to 5 feet wide, weathering to a creamy orange-buff colour, and passing centrally into a darker biotite-augite-hornblende-plagioclase-spessartite, containing numerous cognate ferromagnesian-rich dioritic aggregates.

The fresh hornblende-plagioclase-spessartite is a light-grey rock with abundant plagioclase and sporadic to common hornblende phenocrysts in a cryptocrystalline to fine-grained feldspathic groundmass.

The plagioclase (to 4 mm) is zoned from sodic labradorite to sodic andesine, with occasional altered cores.

Hornblende (8 mm max.; α yellow to brownish-yellow, β dark olive-brown to olive-green, γ bright to pale green, $\beta > \gamma \gg \alpha$, $\gamma:Z \simeq 17-25^\circ$) shows zoning from deep brown interiors to pale green rims.

Sparse iron ore, apatite (to 0.4 mm), rare biotite, sphene, and augite (to 0.3 mm) are scattered through the felted groundmass of sodic plagioclase crystallites, associated with potash feldspar and spotted with quartz.

The biotite-augite-hornblende-plagioclase-spessartite includes numerous cognate dioritic and hornblende aggregates (to 75 cm) in a medium-grey host rock containing abundant plagioclase and hornblende and rare to sporadic biotite and augite phenocrysts, among smaller crystals of these minerals interspersed in a cryptocrystalline feldspathic groundmass.

Plagioclase (to 4 mm) is zoned from sodic labradorite ($\simeq Ab_{10}$) to calcic oligoclase ($\simeq Ab_{70}$), with an outer rim of sodic andesine-calcic oligoclase and selective or complete alteration of crystal interiors.

Hornblende (2.5 cm max.; α yellow, β brown to olive-green, γ pale green to dark olive-green, $\gamma \simeq \beta \gg \alpha$) shows zoning from dark brown cores ($\gamma:Z \simeq 15^\circ$) to pale green rims ($\gamma:Z \simeq 17-23^\circ$ decreasing outwards).

Augite phenocrysts exceed 1 mm and larger crystals show colourless cores with faintly pleochroic margins. Scattered biotite (α pale orange-yellow, $\beta = \gamma$ dark purplish-brown) rarely exceeds 0.7 mm, but crystals to 2.5 cm are present.

The groundmass consists of small tablets of zoned andesine-oligoclase, some with hollow cores, iron ore (to 0.7 mm), apatite (to 0.4 mm), minor potash feldspar and sparse patches of carbonate.

The cognate aggregates in the rock range from biotite-augite-diorites through augite-hornblende-diorites to hornblende-diorites and hornblendites. Two sectioned examples are described below:

- (i) **biotite-augite-diorite** (Loc. 24; T.S. 624), is a medium grained rock containing plagioclase (55-60%), augite (20%), biotite (15%) and iron ore (5%).

Labradorite (zoned from Ab_{40} - Ab_{50} : 4 mm max.) grades into smaller laths of zoned andesine ($\simeq Ab_{60}$) and is intergrown with sub-ophitic to intergranular corroded augite (to 2.5 mm), biotite (to 2 mm; α yellow, $\beta = \gamma$ dark reddish-brown), iron ore (to 0.7 mm), and apatite (to 0.4 mm). A cloudy mesostasis forms less than 5% of the rock and contains potash feldspar and carbonate. There are rare groups of late-stage hornblende (1.2 mm max.; α yellow, β dark olive-green, γ dark olive-green, $\gamma \simeq \beta \gg \alpha$, $\gamma:Z \simeq 18^\circ$).

- (ii) **augite-hornblende-diorite** (Loc. 24; T.S. 624a, 624b, 624c; Analysis 11) contains hornblende forming half the rock, mainly as large crystals (exceeding 1 cm), plagioclase enclosing or sub-ophitically intergrown with plagioclase (30-35%), augite (15-20%), iron ore and apatite. Hornblende (α yellow, β dark brown to olive-green, γ olive-brown to olive-green, $\beta \gg \gamma \gg \alpha$, $\gamma:Z \simeq 16-30^\circ$) displays green colours in small crystals and zoning outwards from brown to green colours in large crystals, with decrease in extinction angle.

Plagioclase (mainly to 1 mm, rarely to 3 mm) is strongly zoned gradationally from calcic labradorite ($\simeq Ab_{30}$) to sodic andesine ($\simeq Ab_{70}$).

Many crystals show distinct overgrowths of more sodic plagioclase, and oscillatory zoning is generally absent. Augite (mainly below 1 mm, rarely to 4 mm), iron ore (to 1 mm) and apatite (to 0.5 mm) are present. Strongly altered interstitial potash feldspar (to 1 mm) is associated with carbonate and minor quartz.

Lamprophyre-breccia (Loc. 25; T.S. 622, 644, 649, 649a)

Heterogeneous material of this type forms several sinuous tapering minor dykes, only a few inches wide and more or less chilled, in adjacent joint fractures and along the margins of the major dyke previously described (loc. 24).

These are dark-grey mottled rocks containing numerous angular to sub-rounded fragments of quartz, meta-sediments, lamprophyres

and dolerite country-rock, in various proportions and sizes (sometimes exceeding 5 cm across) set in a dark contaminated base forming some 15% of the rock.

The meta-sedimentary fragments consist of silty, cherty and quartzitic rocks, and the lamprophyric fragments include hornblende-plagioclase-spessartite (similar to that in the adjacent dyke to the north (loc. 24)), and augite-hornblende-spessartite, with a biotitic feldspathic groundmass, similar to that in the nearest dyke to the south (loc. 26).

There are numerous xenocrysts of angular quartz (to 1 mm max.), hornblende, biotite, iron ore, and altered augite scattered through the cryptocrystalline groundmass of the rock.

Altered hornblende-plagioclase-spessartite

(Loc. 15; T.S. 640, 640a)

A drainage ditch dug in the paddock occupied by the main appinitic centre, 1½ miles NW of the homestead, affords poor exposure of a dyke trending NE-SW in dolerite bedrock.

This is a greenish-grey rock containing abundant hornblende and common plagioclase phenocrysts in a fine-grained feldspathic, carbonated groundmass.

Hornblende (8 mm max.) is often completely altered, with the development of talc, carbonate, chlorite and secondary iron ore. Some pseudomorphs may represent altered augite.

The plagioclase (zoned labradorite-andesine, to 4.5 mm max.) is largely altered to sericite and subordinate carbonate. Iron ore and apatite range to 0.5 mm and rare biotite to 1.8 cm across.

The micro-granular to felted groundmass consists of zoned andesine-oligoclase crystallites, potash feldspar and irregular patches and amygdales of carbonate and quartz. Cognate xenoliths are present and include diorite composed of zoned labradorite-andesine and biotite (to 2.5 mm; α pale cream, $\beta=\gamma$ orange-brown to chestnut-brown, partly altered to greenish chlorite), associated with intergranular patches of chlorite and carbonate (altered augite?) and interstitial carbonate.

Altered augite-hornblende-plagioclase-spessartite

(Loc. 17 and 18; T.S. 621, 621a, 621b, 643, 643a, 67-89 A-B)

Dykes are not common on the N shore but are located on the headland 3 miles NNW of the homestead. A bifurcating dyke of maximum width 6 feet cuts the N promontory and reappears on the foreshore much further E, giving an overall length of ¼ mile on a general trend of 130°.

This is a speckled green rock containing abundant plagioclase, hornblende and augite in a cryptocrystalline to fine-grained quartz-feldspathic groundmass.

Plagioclase (to 2.5 mm max.) is zoned from calcic labradorite (\approx Ab₃₅) to sodic andesine (\approx Ab₆₀). Many crystals show selective interior corrosion and form interpenetrant groups.

Hornblende (α pale yellow to yellow, β pale to medium olive-brown, γ pale to medium olive-green, $\gamma>\beta>>\alpha$, $\gamma:Z\approx 15-19^\circ$, decreasing from core to rim) and augite range to 5 mm across. Ferromagnesian phenocrysts are often altered and replaced in part

with carbonate and quartz; the augite proving particularly susceptible. Biotite (to 0.2 mm; α yellow, $\beta=\gamma$ chestnut-brown), iron ore (to 0.8 mm), apatite (to 0.5 mm) and sphene (to 0.3 mm) are scattered in the rock.

The groundmass grades from a glassy felt to a fine-grained matrix of zoned andesine-oligoclase microlites (to 0.1 mm) with potash feldspar, quartz and carbonate. Scattered amygdales and veins are filled with carbonate and minor quartz.

A specimen from a chilled intrusive tongue extending from the dyke (loc. 17, T.S. 653) contains fragments of altered and carbonated dolerite, pieces of lamprophyre with a strongly fluidal groundmass of plagioclase microlites, and rare pieces of silty cherty and quartzitic meta-sediment. There are numerous quartz xenocrysts (to 1.5 mm), with largely or partly carbonated xenocrysts of hornblende, augite and plagioclase, in a patchy dark cryptocrystalline matrix.

The Andesite Lavas

Augite-hornblende-andesite

(Loc. 32; T.S. 628, 628a, 794, 67-95 A-B; Analysis 10)

This rock forms the flow outcropping on the shore 3 miles S of Cape Portland, and is a medium-grey vesicular to amygdaloidal rock containing common to abundant augite and hornblende phenocrysts in a sub-fluidal, fine-grained groundmass of feldspar and augite.

Zoned hornblende (1 cm max.; α yellow to yellow-brown, β brown to olive-brown to olive-green, γ olive-green to deep olive-green, $\gamma>\beta>>\alpha$, $\gamma:Z\approx 12^\circ$ (paler colours) to 16° (deeper colours)), shows irregular resorbed margins and coronas of granular iron ore.

Augite (2.5 mm max.) displays colourless margins grading to pale faintly pleochroic cores. Some crystals show incipient alteration to hornblende. Iron ore and apatite range to 0.9 mm long.

The groundmass consists of zoned andesine-oligoclase crystallites ($\approx Ab_{60}-Ab_{75}$) and augite prisms (to 0.2 mm), associated with minor potash feldspar and quartz. Irregular vesicles and amygdales (to 3 cm) usually contain carbonates and subordinate red scolecite. Accidental xenoliths (to 13 cm max) are scattered through the rock and may be partly digested. They include common pegmatitic granite, vein quartz and rare indurated sandstone.

Cognate dioritic and hornblendic aggregates (to 3 cm across) are present and a thin section (67-95A) shows glomerophyritic hornblende (65-70%) and augite (10%) intergrown with, and enclosed by plagioclase (20-25%). Hornblende attains 3 mm long with α yellow, β olive-brown to olive-green, γ olive-green to green, $\beta\approx\gamma>>\alpha$, $\gamma:Z\approx 18^\circ$ (darker cores) to 22° (lighter rims). The crystals are marginally altered with development of secondary iron ore, becoming completely altered towards the borders of the aggregate. Augite (2.5 mm max.) sometimes shows partial alteration to hornblende. Also present is rare biotite (to 1 mm; α pale yellow, $\beta=\gamma$ light brown) and apatite (to 0.5 mm). Plagioclase is strongly zoned gradationally from labradorite to andesine with overgrowths of sodic andesine. Some cores show slight alteration and corrosion, more marked towards the borders of the aggregate.

Augite-hornblende-trachyandesite (Loc. 30; T.S. 636, 636a)

This rock forms a flow-like outcrop mainly obscured by beach pebbles on the shore, 2½ miles S of Cape Portland. It is a weathered, grey, minutely vesicular rock, containing common to abundant hornblende and augite phenocrysts in a sub-fluidal feldspar-augite groundmass.

Hornblende (to 1.2 cm max.; α yellow to yellow-brown, β olive-brown to olive-green, γ olive-green to deep olive-green, $\beta \approx \gamma > \alpha$, $\gamma:Z \approx 12-16^\circ$), shows resorbed margins with slight development of iron ore coronas. Large hornblende crystals show pale cores with deeply coloured borders overgrown with pale coloured rims.

Rare phenocrysts of zoned andesine (to 1.2 mm) with corroded and altered cores, accompany augite (to 2.5 mm), apatite (to 0.5 mm) and iron ore (to 0.5 mm).

The groundmass consists of zoned andesine-oligoclase crystallites and augite prisms (to 0.2 mm), with potash feldspar, and minor chlorite. Rare quartz xenocrysts show fused reaction rims.

Appendix 2

MICROPALAEONTOLOGICAL REPORT ON TERTIARY ROCKS FROM NORTH-EAST TASMANIA

By Patrick G. Quilty

(A) Cape Portland (Loc. 40)

The single sample from Cape Portland consists of a partly decalcified, iron-stained, grey, siltstone or fine sandstone without apparent bedding. The specimen is now deposited in the palaeontological collection of the Geology Department, University of Tasmania (No. 84553).

The rock is strongly indurated and only partly disintegrated under petrol impregnation followed by boiling in Na_2CO_3 solution.

The specimen has thus been studied mainly in thin section and only in part by particulate examination.

In thin section, the dominant fossils are ostracod carapaces (unidentifiable), which outnumber any foraminifera present by several hundred times. The only foraminifera present in thin section are very rare planktonic species (unidentifiable) and an elphidiid.

Partial disintegration yielded about 90 specimens, most of which are very poorly preserved. No ostracods survived the rigorous procedure of disintegration so that all specimens examined but one are foraminifera.

Species recovered include:

(1) Foraminifera

Quinqueloculina cf. *cuvieriana*

Elphidium sp. 1

E. cf. *macellum*

Elphidiononion cf. *poeyanum*

(74 specimens)

Globigerina sp. indet.

Discorbid sp. indet.

Cibicides perforatus
Planorbulina cf mediterraneensis
Ammonia beccarii
Calcarina mackayi

- (2) Charophyta
 ?*Chara* sp. indet.

Age

The species identified are not very diagnostic index fossils but *Calcarina mackayi* restricts the age to Carter's (1958) Faunal Units 5 or 6 of the Upper Oligocene or Lower Miocene. This age is in keeping with the hypothesis of a marine transgression in Bass Strait at this time.

Environment of formation

Several aspects of the fauna and flora can be used to infer the depositional environment.

The very high ostracod/foraminifera ratio suggests deposition in a small, coastal lagoon. Charophytes are brackish or fresh water plants and a lagoonal environment would explain the single charophyte present. *Elphidium poeyanum* is a brackish water to marine foraminifer. The fact that the latter species makes up more than 80% of the fauna attests to a shallow water origin.

(B) Swan Island

Several specimens of indurated limestone were submitted from this island. The specimens are all water-worn boulders picked up on the beach so little use can be made of any ecological inferences. The rocks are so indurated that no mechanical means were used to disintegrate the specimens and the only examination made was in thin section.

All the rocks are basically bryozoal calcarenites and most of those submitted consist only of bryozoal fragments and cement. One contains nodosariid foraminifera and *Carpenteria rotaliformis* and another contains abundant *Lithothamnion*, a calcareous alga implying deposition in warm, shallow water. The age of these rocks can only be placed, on faunal grounds, in Carter's Faunal Units 4-11 (Middle Oligocene to Upper Miocene or Lower Pliocene). However, most other Tertiary rocks in the area are Lower Miocene or Upper Oligocene and the Swan Island fragments also probably belong there.

Patrick G. Quilty, B.Sc. (Hons.), Ph.D.,
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GEOLOGY — CAPE PORTLAND AREA

GEOLOGY BY D. J. JENNINGS AND F. L. SUTHERLAND

20 10 0 20 40 60 80 CHAINS

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Cape Portland



LEGEND

- | | |
|---|--|
| QUATERNARY | <ul style="list-style-type: none"> Alluvium Dune and beach sand Ferricrete Sandy soil Basalt/Dolerite loam Shingle and gravel Mixed float boulders including appinites |
| TERTIARY | <ul style="list-style-type: none"> Sandstone |
| IGNEOUS ROCKS | <ul style="list-style-type: none"> Alkali Basalt Tholeiitic Basalt Andesite Lamprophyre Porphyrite Appinites |
| MESOZOIC (?)
(JURASSIC-CRETACEOUS) | <ul style="list-style-type: none"> Dolerite |
| JURASSIC | <ul style="list-style-type: none"> Dolerite |
| | Road or track |
| | Fenceline |
| | Drainage |
| | Contour |
| | Waterhole |
| | Geological boundary |
| | Locality number |
| | Inland dune |
| | Seasonal and permanent lagoon |
| | Miocene limestone float |
| | Building |

FIGURE 30 TR13.45.80

Cartography by P.B. Nankivell