THE GEOLOGY OF THE SOUTH ARM-SANDFORD AREA, TASMANIA

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(With 4 text figures.)

ABSTRACT

Permian mudstones, sandstones and limestones are intruded by Jurassic dolerite in the form of gently transgressive sheets, sills and dykes. The sub-horizontal intrusions are restricted to the Grange Mudstone and show a pronounced development of coarse-grained dolerite near the top of the sill. Two Tertiary volcanic centres, one a breccia-filled vent, are situated near Tertiary faults, and folded ?Lower Tertiary limonitic sandstones and clays are recorded. Tertiary tensional faulting has tilted the strata to the west and caused the repetition of one stratigraphic horizon, the Malbina Siltstone and Sandstone. Necks, spits and coastal dunes are related to older, higher sea levels.

INTRODUCTION

The area mapped consists of squares 5271, 5270, 5371 and 5370, the South Arm, Howrah, Ralphs Bay Canal and Clifton Beach squares which form the south-east part of the Hobart Sheet. Access to the area is readily available from the main South Arm road which is sealed as far as the Clifton Beach turnoff. The lower areas are used for orcharding or sheep grazing while the uncleared higher areas support an open sclerophyll eucalypt forest with a low scrub and bracken understory. The rainfall is a little lower than that of the Hobart area, 18-20 inches per annum.

Exposure is poor, except along the coastline where excellent sections are available. Mapping was carried out by walking boundaries, where this was practical, and pinpointing the outcrop on aerial photographs. The base map was constructed with the aid of a slotted template layout based on a limited amount of trigonometrical control. The compilation should not be regarded as entirely accurate in the Clifton Beach square as trigonometrical control was not available. The geological boundaries were transferred from the aerial photographs to the base map with a rectiplanigraph. Grid references are given as 6 figure coördinates referred to the State grid system. The map is included herewith as figure 1.

Specimens collected during field mapping are housed in the Geology Department, University of Tasmania, and the specimen numbers referred to in this paper are those of the catalogued specimens of the collection.

PREVIOUS LITERATURE

Johnston (1888) referred to fossiliferous rocks near Pipe Clay Lagoon but the first regional survey of the area was that made by Nye (1924). Lewis (1946) mapped the area in more detail; unfortunately, the distribution of rock types on the map accompanying his text does not concur with his recorded field observations. Hosking and Hueber (1954) referred briefly to the Grange Mudstone at May Point, an occurrence which had been previously described by Jukes (1847) and Stephens (1900).

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PHYSIOGRAPHY

The physiography is controlled by tilted fault blocks formed early in the Tertiary which strike approximately north and dip to the west at angles of up to 15°. The faults bounding these blocks provide planes of weakness along which later erosion has been directed.

Topographic relief is low with the exception of the range of hills above Rokeby, which rises to more than 800 feet. South of Ralphs Bay Canal, Mount Mather (581 feet) and Mount Augustus (535 feet) are more dissected remnants of this range. The tilted blocks of Permian sediments forming these mountains exhibit an almost cuesta-like structure, the westward slope approximating to a dip slope.

The present morphology of the area has been determined principally by the post-glacial drowning of the area and subsequent lowering of the sea level. Since the last glacial phase the coastline has been uplifted to the extent of 2 or 3 feet above the present H.W.M. and this former shoreline has been named the Milford level by Davies (1959). The peninsula is made up of several islands which are joined by deposits related to higher sea levels. The evolution of the Ralphs Bay neck has been described by

Davies (1959) and a similar mechanism of formation is proposed for the neck connecting the Sandford Peninsula to South Arm. Both erosional and depositional features are present; emerged shore platforms, abandoned cliffs, raised cobble, sand and shelly beaches, beach bordering dunes, stranded sea caves and cave deposits, spits and necks, all characteristic of a recently emerged coastline.

The Llanherne level (Davies, 1959) forms wavecut platforms and appears to be an erosional feature approximately 15 feet above H.W.M. It is possibly related to the last interglacial stage or a minor oscillation during the Würm glaciation. Earlier levels become progressively more dissected with elevation. Lewis (1946) recognised one level at 5-15 feet above sea level and another at between 50 and 60 feet. Other poorly developed levels are found at 100 and 180 feet with a better developed level at 250 feet. Submergence during interglacial stages has usually been brief. A deposit of marine sand at Mary Ann Bay contains a Pleistocene fauna 60 feet above the present high water mark.

Cliffs up to 150 feet in height and rising from a wavecut shore platform form most of the eastern seaboard. Wave action has been concentrated at right angles to the coast along minor faults and prominent joints, the closely spaced bedding planes and joints of the metamorphosed Grange Mudstone prevent extensive wave notching. The western sides of the peninsula have mature beaches in the protected bays and shore platforms developed on the Malbina Siltstone and Sandstone along exposed stretches.

Pipe Clay Lagoon at Cremorne is almost closed by a well developed, slightly arcuate sand-spit, post Milford in age, which has grown southwards from the Milford level shoreline. Tidal scour is responsible for the preservation of a narrow channel at the southern extremity. A shingle beach spit 4 feet in height is present on the eastern side of Gellibrand Point.

The coastal dunes are the result of a plentiful supply of sand from the beaches, the absence of obstacles in the sea (thus allowing the wind to blow more strongly than elsewhere) and the absence of vegetation in that part of the beach from which the sand is derived. The sand blown landwards from the frontal dune collects in dunes at right angles to the direction of the prevailing winds and thus a series of wavelike dunes is formed, separated by relatively flat-floored troughs. The parallel sets of coastal dunes produced in this manner are clearly demonstrated along Hope Beach, Clifton Beach, Opossum Bay and Half Moon Bay. Such dunes are characterised by an asymmetrical cross-section and cross bedding with a steep leeward slope which corresponds to the angle of rest of the sands. In the case of the dunes of Hope Beach, the leeward slopes of which are fixed by vegitation, the angle of rest is 40°. The angle of rest for dry unfixed sand of the same particle size as that in the ridges near Hope Beach is approximately 32°.

Most of the dunes which have migrated inland are now fossil dunes and contain an abundance of calcified roots and stems. These dunes are now perched and deprived of a supply of sand. The oldest dunes, i.e., those furthest inland and with the highest elevation, have almost lost their dune-like character and only in artificial exposures, such as present day sand pits, can cross bedding be recognised. Where the dunes have reached a degree of stability, a bed of podsolized sandstone (dark brown in colour) is commonly developed, and may be seen at the base of most sand excavations. The sand deposits are not worked below this resistant layer which assists materially in the stabilisation of the dunes.

Hope Beach and Clifton Beach slope towards the sea at angles of up to 10°, the steepness of the strand plain being due in part to the exposed nature of the beaches. Storm waves commonly produce " nips " in the poorly consolidated beach sands. Behind the necks a shallow lagoon is formed and commonly a salt marsh is found in this position, e.g. the marshes south of Ralphs Bay Canal.

Away from the sore platforms and cliffs, only the massive pebbly sandstones of the lower Malbina Siltstone and Sandstone outcrop at all strongly to form low cliffs. Sandstone beds in the Ferntree Formation outcrop as benches, and talus from these beds covers the shaly mudstone beds. In a similar manner, the upper mudstone member of the Malbina Siltstone and Sandstone is often covered with scree from the Risdon Sandstone. Inland the Grange Mudstone outcrops very poorly; one band more resistant than others is the zone of *Thamnopora* and *Cladochonus* 65 feet below the top of the formation. Fine cliff exposures of Grange Mudstone are found at Cape Deslacs, May Point and to the east of Single Hill.

Much of the area is covered by an extensive and often deep sandy soil and inland the dolerite is weathered deeply, especially on Droughty Point, where local run-off after heavy rain produces narrow steep-sided gullies. Terracettes due to minor soil slip on the steep sides of dolerite hills are common. More extensive landslips are found in the basalt soil near Cape Contrariety. The Clarence Rivulet is the only prominent drainage channel. Its course has been largely determined by the eastern edge of the Rokeby basalt, but the stream is now cut largely in its own gravels. During the summer the rivulet degenerates into a series of stagnant pools. The run-off in other parts of the area goes directly to the sea or into a chain of lagoons along the low-lying central portion of the Sandford Peninsula.

STRATIGRAPHY

Permian System

The Permian System in this area contains four formations, Grange Mudstone, Malbina Siltstone and Sandstone, Risdon Sandstone and Ferntree Mudstone. A complete section is not available and neither the base of the Grange Mudstone nor the top of the Ferntree Mudstone is exposed.

Grange Mudstone.

This formation consists of at least 150 feet of richly fossiliferous mudstone, siltstone, limestone and dolomite, with thin lenses of sandstone and granule conglomerate. It is the uppermost formation of the Cascades Group (Banks and Hale, 1957) in the Hobart area, and is overlain with a slight erosional break by the basal member of the Malbina Siltstone and Sandstone.

At the base of the measured section at Cape Deslacs (see Brill, 1956) is an impure dolomite, light green to grey in colour which contains thin bands of dark green diopside due to contact metamorphism. Twenty feet above sea-level granule conglomerates and pebbly siltstones predominate and a thin layer of recrystallised calcite sheets is commonly found along the bedding planes. The next 16 feet are composed of coarse-grained sandstones interbedded with impure limestones, dolomites and pebbly mudstones. Large spiriferids occur as rolled fragments, the rocks are poorly-sorted and contain pebbles up to two inches in diameter. Massive, fossiliferous limestones and dolomites with mudstone intercalcations occupy the succeeding 24 feet. Pebbles become increasingly common towards the top of the formation and the remaining 27 feet are composed of pebbly siltstones, granule conglomerates, calcerenites and subordinate impure limestones and dolomites. Graded bedding is a common feature and fewer fossils are found in this part of the section.

A thin section cut from an arenaceous limestone 68 feet above sea level at Cape Deslacs contains 35% of sand grade, subangular to rounded quartz particles of up to 4 mms. in diameter. The grains are separated by irregular patches of recrystallised calcite. A few fragments of prehnite are present, but most of the matrix is made up of very fine calcite, the individual grains being so small that the slide is opaque. Grains of zircon and small laths of andesine are also present.

North of Ralphs Bay Canal, on the western shore of Ralphs Bay, another section of the upper part of the Grange Mudstone is exposed. This has been measured in detail and may be correlated with the section at Cape Deslacs. The base of the section is covered by a shingle beach in which fragments of mudstone containing *Cladochonus* are present. The bottom 30 feet of the section is composed of alternating pebbly and rather fissile mudstones, with subordinate thin bands of bryozoal calcarenites and spiriferid calcirudites. This is overlain by 5 feet of slightly argillaceous limestone containing abundant *Strophalosia jukesi*, fenestellids and stenoporids. As at Cape Deslacs, the limestone underlies sparsely fossiliferous mudstone, with pebbles becoming increasingly common towards the base of the Malbina Siltstone and Sandstone, some beds having distinct graded bedding.

On the shoreline of Ralphs Bay beneath Mt. Mather a similar section is exposed and a zone of *Cladochonus* and *Thamnopora* is also present at the southern end of the hills behind Rokeby (317178), 65 feet below the Malbina Siltstone and Sandstone, where it is associated with *Schuchertella*. The *Cladochonus*-*Thamnopora* zone is 68 feet below the base of the Malbina Siltstone on Maria Island (pers. comm. M. R. Banks). Other fossils include *Polypora woodsi, Fenestella dispersa, Stenopora crinita, Strophalosia cf. clarkei* and *Strophalosia typica.*

At 341103, Grange Mudstone is well exposed in a P.W.D. quarry as a fossiliferous mottled limy mudstone with dolomitic bands. As in the case with every outcrop in this area the Grange Mudstone has been affected by the intrusion of Jurassic dolerite.

Metamorphism of the Grange Mudstone.

Where the Grange Mudstone is intruded by dolerite, the contact metamorphic effects are considerable. Silicification commonly extends for as much as 100 feet from the point of intrusion, and contact metamorphism is most pronounced in the calcareous beds. The rock immediately adjacent to the dolerite in the case of a sill, e.g. north of Cape Deslacs, is either fissile and heavily weathered or hardened and very closely jointed. Some specimens from the contact zone contain prisms of pale green wollastonite and coarsely recrystallised calcite. At May Point impure limestones are interbedded with mudstones and near the margin of the transgressive dolerite the argillaceous limestone is dark green in colour and recrystallised.

Thin section 1094, a dark green hornfels collected within one foot of the contact, contains 40% of recrystallised calcium carbonate, 10% of subangular quartz fragments, 20% of clay material and 30% of small green granules with high relief, which are probably diopside. The matrix is an intimate mixture of recrystallised calcite and clay flakes with a few well-rounded grains of zircon and needles of apatite. Lamellar calcite crystals form veins from 0.1 to 0.5 mms. in width. The rocks retain a clastic texture microscopically, although in the hand specimen they appear to be recrystallised.

Malbina Siltstone and Sandstone.

The Malbina Siltstone and Sandstone formation consists of at least 280 feet of coarse sandstone, granule conglomerate, pebbly mudstone and siltstone which is correlated with a type section measured by Messrs. M. R. Banks and D. E. Read (see Banks and Read this volume) during 1959 near Jarvis Creek in the Claremont square. The Malbina Siltstone and Sandstone underlies the Risdon Sandstone and overlies the Grange Mudstone and the formation replaces the undefined term " Woodbridge Glacial Formation ".

The basal member " A " overlies the Grange Mudstone with an erosional break or diastem owing to current scour. This is especially marked in the basal beds at Cape Deslacs and at 314174. Immediately above the base, member " A " contains 5-10 feet of poorly-sorted conglomerate and pebbly sandstone grading into a pebbly siltstone. Angular quartzite and granite boulders of up to 15 cms. in diameter are relatively common and the matrix is of fine sand to clay grade. The rock is thick-bedded, cream or grey in colour, tough and shows a rhythmic graded bedding which has been described by Brill (1956).

Rock fragments are composed almost entirely of quartzite and granite with subordinate angular fragments of slate, phyllite and quartz muscovite schist.

In thin section 1082, 80% of angular to subrounded quartz grains with a mean diameter of 0.45 mms. are present. Fresh plagioclase fragments are rare. The presence of a bent fragment of feldspar and quartz showing undulose extinction indicates a metamorphic source. The matrix (12%) is composed of silt grade quartz, chlorite, limonite and a small amount of micaceous clay grade material with zircon and rutile as accessory minerals. Rock fragments, mainly quartz mica schist and micaceous quartzite, constitute 5% of the rock. Small granules and powdery aggregates of limonite are concentrated around the edges of quartz grains. Where regrowth has occurred, the original outline is shown as a ring of inclusions of fine ilmenite. The texture is mosaic away from the larger patches of matrix.

Large poorly preserved casts and moulds of spiriferids are common, *Ingelarella* and " *Spirifer* " *avicula* have been identified. A peculiar feature of both this and the overlying member is that the spiriferids are aligned parallel to the bedding. Pebbles of the underlying Grange Mudstone are confined to the basal conglomerate.

At 348059 the basal member is exposed on top of a small hill. Here the rock is a poorly-sorted subgreywacke sandstone containing approximately 25% of highly angular quartzite fragments in a slightly calcareous matrix of sand to silt grade. Similar exposures are found on the shoreline beneath Mt. Mather and north of Ralphs Bay Canal.

Graded bedding, although imperfect, is present in this member and has been recognised in each of the above mentioned localities. A typical sedimentation unit consists of a poorly-sorted granule conglomerate at the base which grades upward within approximately 9 inches into a siltstone which contains less than 5% of angular quartz fragments. There are very few fenestellids in this member and it is rare to find complete shells of the brachiopods. These factors suggest that the depositional area was one of considerable turbulence.

The remainder of member " A " consists of approximately 55 feet of fossiliferous pebbly siltstone alternating with sandstone and subordinate bands of granule conglomerate. This member commences with a band of granule conglomerate three feet thick resting on an irregular bedding plane. *Ingelarella* and " *Spirifer* " *avicula* are common while *Schuchertella, Stenopora crinita, Peruvispira* and crinoid stems are present. Fenestellids and stenoporids as extended mats are almost entirely restricted to the siltstones and mudstones, although broken fragments are found in the coarser bands. Graded beds are present in this member and a small amount of load casting appears to have taken place at the base of some of the coarser beds.

Member " B " comprises approximately 125 feet of massive sandstone and siltstone, cream or white in colour and poorly fossiliferous, which contain fewer pebbles than the underlying member. This member forms most of the shoreline of the peninsula and commences with a pebbly sandstone 3 feet thick, which is overlain by massive sandstone beds with subordinate siltstone layers. The mean grain size decreases towards the top of the member where fissile and non-fissile siltstones alternate. Pebbles of quartzite, phyllite and granite as large as four inches in diameter are scattered through this member. The matrix is composed of clay minerals, chlorite and quartz, and is of clay grade. The sorting is poor and lenses of sandstone occur in many places.

The pebbles occur in irregular patches and may best be described as " erratics '. Evidence that the pebbles have in some cases been dropped into the mud on the sea floor is provided at 306155, where an elongate pebble with the long axis vertical has broken fine cross laminations and bent those at the base of the pebble. Similar rocks occur at many places on the peninsula, but correlation can be made only on lithological similarity unless the stratigraphic position can be ascertained.

At 313069 approximately 15 feet of pebbly sandstone overlie a pebbly mudstone and are overlain by two feet of very pebbly coarse mudstone containing large angular pebbles of quartzite and slate. This massive sandstone unit is recognised in several localities, but is very variable in character and in thickness. Such exposures are referred to as member " C ", but it is not clear that all such exposures can be correlated on the evidence available.

The top of the section consists of approximately 75 feet of poorly exposed fissile siltstone with subordinate sandstone and limestone bands. Poor exposures of this member are present near the top of Mt. Mather, and at 271185 sparsely fossiliferous mudstones are exposed which contain poorly preserved spiriferids and pelecypods. This exposure is probably close to the top of the formation. The *Terrakea* zone recorded in the Hobart area beneath the Risdon Sandstone is present at only one locality, 345002, where it is poorly exposed.

There are three horizons in this formation in which pebbly sandstone like the Risdon Sandstone outcrop. The first is approximately 10 feet above the base, the second approximately 60 feet above the base, and the third, approximately 185 feet above the base. The uppermost one is easily mistaken for the Risdon Sandstone if the outcrop is poor.

Erratics as much as four feet in width are exposed at 264165 on the Tranmere shore platform. This exposure is unusual in that sedimentary rocks are present as erratics in addition to the normal types from an igneous and metamorphic terrain. Angular fragments of mudstone, siltstone and sandstone comprise 40% of the surface area of a rock face about 3 feet square. The fragments have straight edges in many cases and appear to have undergone very little transport. In the same bed, there is a concentration of quartzite and granite boulders as much as 30 cms. in diameter, with a rounded schist fragment 25 cms. x 15 cms. and a boulder of grey granite 100 cms x 80 cms. The largest erratic is a subrounded boulder of quartz sandstone 120 cms. x 80 cms., which contains mica and a small amount of feldspar, is veined with quartz and shows faint cross-bedding.

At the western end of Hope Beach, 267006, a massive sandstone 16 feet 6 inches in thickness overlies fossiliferous mudstone and pebbly coarse mudstones of at least 50 feet in thickness which appear to be similar to the basal part of the Malbina Siltstone and Sandstone. Two bands, 3 feet 6 inches and 14 feet 9 inches beneath the base of the sandstone, are extremely fossiliferous and contain abundant poorly preserved impressions of a spinose productid.

The basal unit of the massive sandstone is 1 foot in thickness, is graded and has an irregular bottom contact with the underlying fossiliferous mudstone and contains more than 80% of angular pebbles of both quartzite and fenestellid mudstone as much as 15 cms. long. The matrix is of sand grade, the rock is poorly sorted and best described as a petromict paraconglomerate (Pettijohn, 1957). This unit is succeeded by a massive, poorly-sorted pebbly sandstone, which contains pebbly layers at intervals of approximately one foot and, at the base, large subangular pebbles of quartzite and granite. The massive sandstone is overlain by a pebbly siltstone containing abundant small calcareous tubes about 2 mms. in diameter. It is thought that this member is the basal part of member " C " and that this member varies considerably in both pebble content and thickness.

Irregular markings at least 35 cms. in length and 2 cms. in diameter occur on the undersurface of several beds of fine sandstone above the massive sandstone at 267006 and on at least one horizon below it. The best example is found on a block which has fallen from the cliffs, and on the bedding face more than two hundred separate markings, both straight and curved, are present. The most probable explanation is that worm trails left in a soft mud were later filled by fine sandstone. The markings are apparently continuous with the sandstone of the overlying bed and show no structures which allow identification of the parent organism.

A dark grey, coquinoid limestone is exposed approximately 160 feet above the base of the formation at 313193. Half the fossil fragments are of productid brachiopods while bryozoans, foraminifera, pelecypods and productid spines are present. The shell fragments are resorbed in some cases and are set in a matrix of recrystallised sparry calcite combined with smaller angular grains of silt to clay grade. Accessory minerals include plagioclase, ilmenite, muscovite and chlorite.

The Malbina Siltstone and Sandstone is a sequence of interbedded siltstone, pebbly siltstone, sandstone, granule conglomerate and rare limestone. Many of the sandstones are lithic greywackes (Pettijohn 1957), subgreywackes or protoquartzites as the labile fraction varies from less than 3% to as much as 30%. Rock fragments are more common than feldspars, but the presence of a few fresh feldspar phenoclasts suggests a degree of mineralogical immaturity. The finer-grained siltstones, often relatively well-laminated, contain less than 3% of phenoclasts which are rarely of greater than sand dimensions; quantitatively, these occupy over half the section and must be considered as the dominant rock type.

Almost all the large pebbles found in the Malbina Siltstone and Sandstone have come from a terrain of metamorphic and acid igneous rocks. The fragments have suffered little fluviatile transport and the relief of the source area must have been such that river transport was at a minimum.

The depositional area at this time was probably that of a shelf covered by silt. Currents appear to have had little effect and conditions were favourable for the growth of bryozoans. Deposition appears to have taken place below wave base, as the matrix of many of the rocks consists of material from both the silt and clay grades and is not well-sorted.

When sufficient gravel had accumulated close to the shoreline, where relatively robust spiriferids were common, a slight tectonic disturbance or even a climatic change would be sufficient to spread the gravels over the sea floor in the form of a " slurry " or tubidity current. Periodic disturbances of this nature would be competent to produce the graded bedding of member " A ". A small amount of post-depositional loadcasting took place before lithification.

A change in sedimentation conditions is shown by unit " B " and conditions were unfavourable for the development of marine life. The large erratics often seen in otherwise well-sorted siltstone are concentrated in patches and the most plausible explanation of this observation involves rafting, probably by ice. These deposits have none of the secondary characteristics of large scale turbidite sequence such as abundant slump structures.

The incidence of erratics decreases upwards; member " C " represents a temporary return to the deposition of a pebbly sandstone but silt deposition continued under conditions increasingly favourable to life towards the top of the sequence. At this stage the relief of the land surface had become lower and the supply of angular fragments had diminished, but periodic occurrences of Risdon-type sandstone through the Ferntree Mudstone suggest that stability was not completely attained.

Risdon Sandstone

The Risdon Sandstone outcrops strongly between the Malbina Siltstone and Sandstone, which underlies it, and the overlying Ferntree Mudstone. The formation is approximately 15 feet thick, and is best exposed as a bench at the summit of Mt. Mather, 317148, and at 313182.

The basal member is a conglomerate, approximately 1 foot thick and poorly exposed. This is overlain by a thick-bedded pebbly sandstone which is poorly-sorted and weathers to a dark brown to grey-black colour. The number of pebbles decreases towards the top of the bed and at the top, the formation is well-sorted sandstone. A thin-section (1056) from the centre of the formation contains 10% of angular quartz and quartzite pebbles with a small amount of twinned plagioclase and microcline. The matrix consists almost entirely of quartz and small rock fragments in the 0.5—1 mm. size grade. A few quartz fragments show undulose extinction. Some quartz grains show sutured boundaries, forming a patchy mosaic texture. The matrix is cemented by a small amount (1%) of ferruginous clay.

Sutured boundaries in a relatively clean sandstone are probably due to the absence of interstitial clay with its cushioning effect during diagenesis. There is no suggestion that thermal metamorphic recrystallisation has taken place.

Ferntree Mudstone

This formation is conformably underlain by the Risdon Sandstone and underlies the Triassic rocks. The only large outcrop of Ferntree Mudstone is at 313184 while Mt. Mather is capped by approximately 10 feet of mudstone overlying the Risdon Sandstone.

Lenses of poorly-sorted sandstone approximately five feet in thickness are present 20 feet and 100 feet above the base. Poorly-sorted siltstone bands contain up to 25% of angular quartz fragments of coarse-silt grade. The marix of the thin-bedded siltstone beds is made up of indeterminate rock fragments, cloudy feldspar and fine quartz particles of clay grade with small amounts of biotite and muscovite.

The sandstone bands are of fine to medium sand grade, poorly-sorted and pale cream in colour. Angular pebbles of quartzite and slate greater than 2 mms. diameter form 3-5% of these bands. The matrix is dominantly quartz with a small amount of feldspar and rock fragments, subangular in shape and of medium sand grade size. Only the lower 170 feet of this formation is exposed in the hills behind Rokeby, the section being terminated by a steep intrusive dolerite contact.

TRIASSIC SYSTEM

A quartzose sandstone outcrops on the north-east tip of Betsey Island which is correlated on lithological grounds with the Knocklofty Formation of the Hobart area. Approximately 60 feet of clean, well-sorted sandstone are exposed; the bottom 25 feet are bedded at intervals of between three inches and one foot, extensively cross-bedded, and contain a carbonaceous pebbly band nine inches in thickness. Thirty-five feet of friable thick-bedded sandstone occur above this unit, medium yellow orange in colour on the weathered surface.

A thin-section (1055) contains quartz fragments of high sphericity ranging in size from 0.6 mms. to 0.025 mms. with a mean diameter of 0.3 mms. and 1% of indeterminate, sericitised rock fragments. The rocks dip to the west at an angle of 30° and near a fault contact against the dolerite a considerable drag dip is visible.

At 322194 is a small outcrop of a well-sorted quartz sandstone under a thick cover of Recent sands. Triassic sandstones outcrop just to the north of the Ralphs Bay Canal square along the road to Seven Mile Beach, and the outcrop at 322194 is probably the southward continuation of this down-faulted wedge of Triassic rocks.

JURASSIC SYSTEM

Dolerite

In several places on the Sandford Peninsula the tops of dolerite sills or gently shelving sheets of presumed Jurassic age (Hills and Carey, 1949) are exposed. In almost all exposures the dolerite is intrustive into the Grange Mudstone within 100 feet of the base of the Malbina Siltstone and Sandstone. Typical examples are Cape Deslacs, Single Hill, Roches Beach and Cape Contrariety. The pegmatitic zone is particularly well exposed and pegmatitic veins are common in the upper zone.

In hand specimen the fresh dolerite is even-grained, blue-grey in colour and of medium grain size. At an intrusive contact the dolerite became dark-grey to black in colour and fine-grained. The pegmatitic veins exposed in cliff sections may either be concordant with the top of the sill, as thin transgressive " dykes ", or irregular schlieren of coarse-grained dolerite in relatively fine-grained material. The concordant veins are remarkably constant in thickness for several hundred yards with an average width of two feet, but thin rapidly at the extremities. The contact between the pegmatite veins and the normal dolerite is typically sharp at the base and a thin band of finer grain size and light colour may occur at the border of the vein.

The dolerite sills of this area differ from the sills hitherto described (Carey, S.W. (Edit.) Dolerite Symposium, July, 1958) in that the upper zone is less than 20 feet in thickness. A similar occurrence at 191017 (Kingborough Sheet) north of Piersons Point has been found by Mr. H. A. Bartlett.

The composition of the dolerite at a chilled margin is comparable to the Mount Wellington sill, containing 48% pyroxene, 45% plagioclase, 5% mesostasis and 2% iron ore. At the contact the texture is fine-grained, intergranular and porphyritic. Lathlike microphenocrysts of orthopyroxene, plagioclase and some clinopyroxene are common and slide 1000 contains a phenocryst of enstatite 0.7 mms. by 0.3 mms. in size. The groundmass is very fine-grained and consists of a small amount of quartz with small subhedral laths of twinned plagioclase, anhedral pyroxene and scattered granules of iron ore.

Away from the upper contact both the plagioclase and pyroxene increase rapidly in size and the texture becomes sub-ophitic. Some orthopyroxene remains but it is strongly corroded and is often rimmed by augite. In slide 1014 a phenocryst of secondary hypersthene is present. Pleichroic hornblende occurs as small prisms containing inclusions and often surrounds clinopyroxenes. Biotite and iron ore are scattered through the mesostasis and other accessory minerals include calcite, apatite, stilbite and prehnite.

The composition of the rocks in the pegmatitic zone is extremely variable and veins of pegmatitic material are found within 20 feet of the top of the sill north of Cape Deslacs. The pegmatitic zone proper extends well below this, as coarse-grained pegmatitic dolerite is exposed along the shoreline below Calvert's Hill.

In general, a high proportion of mesostasis is characteristic (13-37%), and in the slides counted the amount of plagioclase (34-51%) exceeds the amount of pyroxene (17-38%), while iron ore (0.6-5.6%) appears to be concentrated only in some specimens. The texture is hypautomorphic to automorphic granular with an intersertal groundmass. Laths of zoned plagioclase (Ab_{30}-Ab_{45}) of up to 5 mms. in length occur in a groundmass of low relief broken by rods, octahedra and anhedra of iron ore. Heavily chloritised primary orthopyroxene accounts for less than 2% of the pyroxene of slide 1003, 30 feet below the upper contact.

Both pigeonite and augite are present, uniaxial pigeonite is comparatively common and bladed pyroxenes as much as 11 cms. in length can be found at 386094. Some of the clinopyroxene is altered to pleochroic chlorite. The large automorphic plagioclase laths are of zoned labradorite but some of the smaller subhedral laths are more sodic in composition (Ab_{50}-Ab_{70}). The mesostasis in the pegmatitic rocks is dominantly of two types, types 2 and 3 of Spry (1958), and contains quartz, orthoclase and some subhedral plagioclase which has a refractive index indicative of albite. The most common type of mesostasis is a coarse-grained quartz-orthoclase graphic intergrowth.

On the road to Clifton Beach at 343102 a plug of dark-coloured, fine-grained dolerite outcrops. This rock contains approximately 8% of primary enstatite which is rimmed by simply-twinned clinopyroxenes Euhedral radiating laths of plagioclase (30%) are intergrown in an ophitic texture. The mesostasis consists of anhedral orthoclase with small needles of quartz and apatite and irregular fragments of iron ore which are closely associated with both the altered borders of the primary orthopyroxene and the mesostasis which accounts for 28% of the rock, an anomalously high value.

A slide (1024) cut from a loose block on top of Betsey Island shows the considerable increase in iron in the end products of the magma. The texture is intergranular and the rock contains plagioclase (50%), pyrozene (20%), mesostasis (20%) and iron ore (10%). The plagioclase is zoned from Ab_{40} to Ab_{70} and occurs as subhedral, interpenetrating laths up to 1.25 mms. in length. Pyroxenes, both pigeonite and augite, of prismatic habit average 10 mms. in length and are commonly altered to a red iron oxide along cleavage cracks and rimmed by small flakes of green hornblende. The pale brown colour of the unaltered augite suggests that it may be a ferroaugite. The mesostasis is predominantly anhedral quartz and orthoclase, containing many small skeletal crystals of iron ore. In a small patch on the slide the mesostasis is composed of chlorite and iron ore in equal proportions.

At the junctions of the pegmatitic lenses and the host rock a thin white line may indicate that the high concentration of water and potash in the residual has been responsible for deuteric alteration. No feeder dykes for the pegmatitic lenses were seen. The residual material forming the mesostasis is often well crystallised. The occurrence of pegmatitic segregation so close to the top of a sill suggests the magma was at least partly liquid and it seems likely that the magma was still in the form of a crystal " mush " in order to allow stratiform segregations to develop.

TERTIARY SYSTEM

It is probable that Tertiary sediments occupy much of the Sandford Peninsula, although they are now overlain by a cover of Quaternary sands.

Pipe Clay Lagoon Beds

On the southern shore of the entrance to Pipe Clay Lagoon, sandstones and clays are gently folded and interbedded with bands of limonite. The sandstone is friable and is light brown to chocolate brown in colour. Some cross-bedding is present. In section, the limonitic bands show a complexly crenulated structure. There is some resemblance to concretionary liesegang rings, but it seems more probable that intrastratal flowage and interal readjustmen along the clay layers has been responsible for the strucure. The crenulations become less pronounced close to the margin of the bed and the uniform thickness precludes large scale slumping.

TABLE 1.

Slide	1000	1001	1014	1002	1003	1004	1005	1006	1009	1012	1038	1015	1024	1007
Plagioclase	45.3%	35.0%	46.3%	31.5%	40.1%	47.5%	34.8%	47.0%	48.0%	50.2%	40.2%	50.9%	50.1%	30.2%
Pyroxene	48.4%	43.9%	40.6%	41.8%	37.9%	29.7%	23.2%	19.2%	36.1%	35.2%	17.0%	25.2%	21.6%	40.7%
Mesostasis	4.6%	19.8%	11.4%	26.3%	21.4%	26.3%	37.5%	32.6%	13.7%	14.1%	38.2%	21.8%	25.4%	28.1%
Iron Ore	1.7%	1.3%	1.7%	0.4%	0.6%	1.5%	3.5%	1.2%	2.2%	0.5%	5.6%	2.1%	2.9%	1.0%

Modal analysis of dolerite specimens.

The concretionary limonite probably originated as a lateritic coating, and this theory is supported by the presence of interbedded pure kaolin clay, a weathering product of potash feldspars. In the humid conditions necessary for lateritization, soda-lime feldspars and most silicates are completely hydrolysed. At the eastern end of the exposure the limonitic layers are almost vertical, but it is possible that the sandstones and clays retain a relatively shallow dip. No fossils have been found in these sediments, and the beds are overlain unconformably by flat-lying Quaternary sands.

A siliceous conglomerate with a chert matrix containing both angular and rounded pebbles of as much as 3 inches diameter occurs at 376084. The high degree of lithification suggests that the rocks are of Tertiary age and they appear to have been silicified, possibly by an overlying basalt flow which has since been eroded. Ironstone boulders found near the road to Seven Mile Beach, 322195, may also be of Tertiary age.

Cape Contrariety Volcanic Centre

In the cliffs of a small bay immediately to the north of Cape Contrariety, 355935, a breccia-filled volcanic vent is exposed (Fig. 2). The vent is approximately ¼ mile in width with almost vertical contacts against dolerite on each side. The rocks are folded considerably and dips measured on the base of the basalt vary from 32° to 80° to the west. At the south end of the bay a plug 40 feet in diameter intrudes the breccia and is veined with calcite and zeolites.

The volcanic breccia is composed mainly of coarse angular fragments of gabbroic dolerite as much as 30 feet in diameter, set in a tuffaceous matrix. The unbedded and poorly-sorted breccia contains patches of fine scoriaceous basalt with a small amount of carbonate ad opaline cement. Close to the walls, the fragments consist entirely of pegmatitic dolerite, but in the centre of the neck as much as 10% of the fragments is composed of baked Grange Mudstone. A few large volcanic bombs occur in the cliff face.

Overlying the breccia are thirty-two feet of lithic tuff which is deep red to brown in colour, and contains tachylytic fragments and small vesicular flows of basalt. A few fragments of mudstone and dolerite of as much as two inches diameter are present, but these are well rounded. The tuff is poorly-bedded, very scoriaceous and veined by calcite and silica. Amygdules are of calcite, zeolites and opaline quartz.

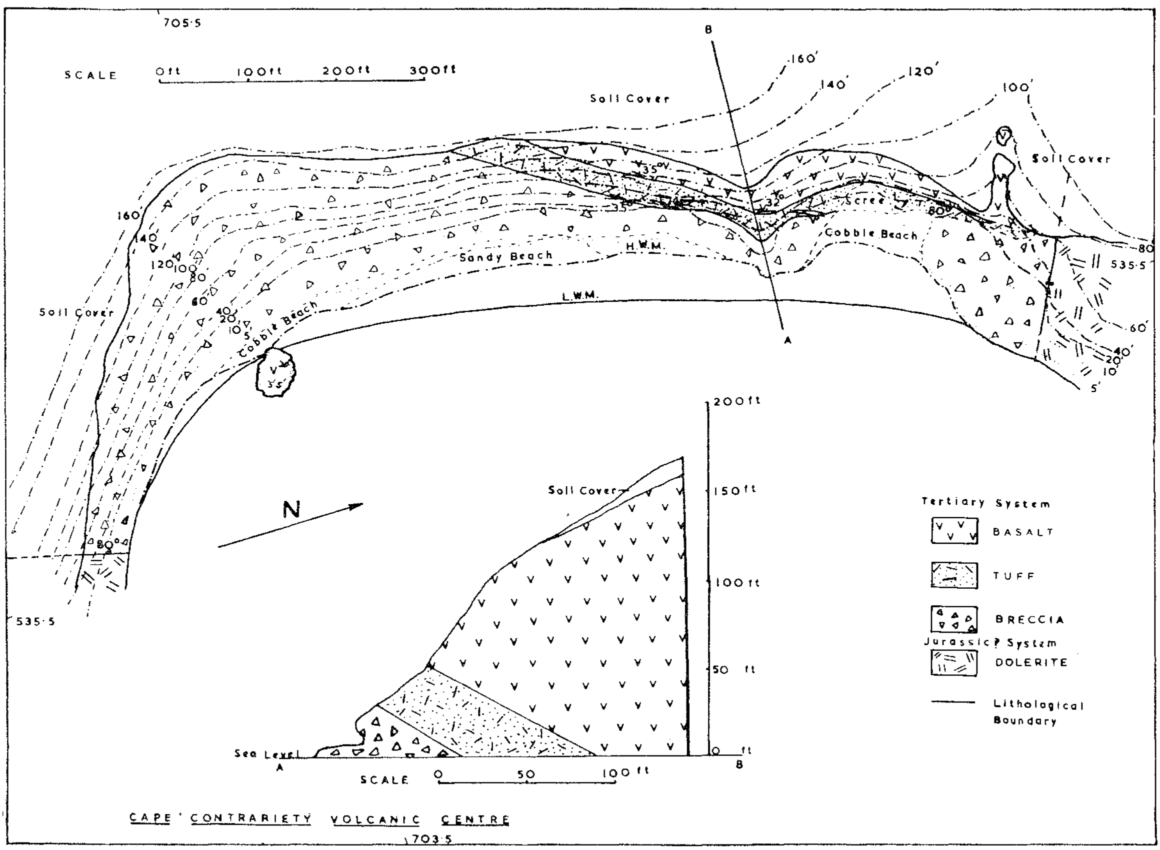

Figure 2.

The basalt fragments and small flows show well-formed olivine crystals. The top of the breccia is slightly baked by the overlying tuff and directly beneath the overlying basalt is a thin band of dark brown scoriaceous vitric tuff.

At least 100 feet of dark grey or reddish brown, fine-grained olivine basalt are exposed and as much as 150 feet may be present. Most of the basalt is massive, but the base is more vesicular and contains some sedimentary xenoliths. Basalt is exposed by minor landslips in the steep soil-covered slopes above the bay.

In hand specimen the rock is grey to brown in colour with yellow to red phenocrysts up to 8 mms. in diameter. The basalt is fine-grained, massive and vesicular to a small degree with amygdaloidal fillings of calcite, opaline quartz and zeolites. The olivine content of thin-sections (1032, 1033, 1039) ranges between 7 and 25% while the texture is markedly porphyritic with a very fine but almost entirely crystalline groundmass. Olivine is commonly altered to serpentine, which is found as a thin layer around the edges; a carbonate mineral and red iron oxides are other alteration products. Iron ore makes up about 10% of the rock and forms small rods, irregular fragments and euhedra in the groundmass.

Both pigeonite and augite occur as phenocrysts and the smaller microlites of pyroxene are of distinct relief and stained light green, they constitute approximately 30% of the rock. The phenocrysts of plagioclase are zoned from labradorite to andesine but the microlithic plagioclase shows very indefinite twinning and is probably albite or oligoclase. The large olivine phenocrysts have an intratelluric origin, as shown by their extensive late stage resorption and alteration.

The petrographic similarity of this basalt to the Rokeby basalt suggests that they are closely related.

The breccia-filled vent is probably due to an explosive phase of the Tertiary volcanism which has smashed the country rocks. Decrease of the gas pressure consequent upon magmatic withdrawal has allowed the angular blocks to fall back into the vent. At the same time as the explosive phase was in progress, some basalt entered the vent and formed a small amount of the matrix. The violently explosive phase was followed by the outpouring of interbedded lavas and tuffs and finally basalt. The folding is the result of subsidence into the vent rather than active control by the boundary faults and took place towards the end of the volcanic epoch.

Rokeby Basalt and Volcanic Centre

A dense, dark grey, fine-grained basalt outcrops strongly as benches at the top of Rokeby Hill, 276193. In the hand specimen (1030), the rock contains abundant olivine phenocrysts up to 2 mms. in diameter. Both massive and scoriaceous forms are present and the rocks sometimes have a ropy appearance.

On the east side of Rokeby Hill, a thickness of more than 200 feet of interbedded lavas and pyroclastics is exposed. The basalt is interbedded with volcanic breccia and subordinate tuff beds, the base of the basalt beds containing a few sedimentary xenoliths. The steep dip of these beds and the presence of a large number of interbedded flows and coarse pyroclastics suggest that a volcanic centre existed immediately to the east of this exposure and at approximately the position of the present town of Rokeby.

A structural break along the line of this valley is inferred from other evidence (see Structure). If the basalt on top of Droughty Hill has come from the same vent, it is likely that the top of the vent was at least 400 feet in height. The vent is now completely eroded and covered by Pleistocene and Recent alluvium.

In thin section (1027, 1030, 1031) the texture is porphyritic and the groundmass hyaloöphitic with a small proportion of intersertal mesostasis. The idiomorphic phenocrysts of olivine are almost entirely pseudomorphed in a crudely zoned manner by iddingsite. Olivine occurs as phenocrysts of up to 2 mms. in diameter and small granules constituting between 7 and 10% of the rock. Phenocrysts of augite (40%) and plagioclase laths (5%) of as much as 0.6 mm. in length are present. Iddingsite occurs as golden brown, slightly pleochroic lamellar pseudomorphs after olivine, the alteration following the cleavage cracks and the colour of the iddingsite becoming paler in distinct zones as the central core of unaltered olivine is approached.

Resorbed phenocrysts of altered olivine are surrounded by a layer of finely granular exsolved iron ore up to 0.06 mm. in diameter and it is likely that th outer zones of the olivine were originally richer in iron. The groundmass consists of microlithic laths of plagioclase (30%) with a mean length of 0.07 mm., short prismatic euhedral prisms of pyroxene (5%), small irregularly shaped granules of iron ore (approximately 5%) and small needles of apatite in a glassy isotropic material. The plagioclase laths are zoned and show a maximum extinction angle of 18° on albite twins, the extinction angle on the outside of the laths being as low as 8°. This suggests a composition of about Ab_{65}-Ab_{75} (andesine-oligoclase).

Some degree of preferred orientation is shown by the pyroxenes, which exhibit a faint blue pleochroism and moderate second order interference colours. The glassy fine groundmass (5%) is clear, has a refractive index less than balsam, and contains turbid hexagonal outlines with very low relief, possibly of nepheline. Apatite is present as small needles which contain inclusions, but forms less than 1% of the rock.

The basalt (1122, 1123) on top of the hills above Droughty Point is petrologically very similar to the Rokeby basalt. The fine groundmass is glassy and only rarely can microphenocrysts of plagioclase and pyroxene be identified. Phenocrysts of completely iddingsitised olivine make up 10% of the rock.

A norm of the Rokeby basalt shows that the magma was undersaturated and is typical of the olivine basalt magma type. However, the high albite ratio (Wagner, 1956—89.9) suggests that the rock is differentiated. Although undersaturated, it differs from the otherwise similar Blinking Billy Point basanite (Spry, 1955) in that it contains no normative nepheline.

Since 70-80% of the olivine in the Rokeby basalt has been altered to iddingsite, it is appreciably oxidised and the high state of oxidation is shown by the presence of haematite in the norm. The association of olivine phenocrysts in a groundmass of pyroxene, iron ore and a feldspar base is suggestive of a limburgite, a conclusion already drawn by Edwards (1950). A comparison may be made with the Hawaiian Alkaline Series of MacDonald (1949) and Wager (1956), in which basalts oligoclase are a middle stage differentiate.

TABLE II

	Rokeby basalt				*Blinking Billy Pt. Basanite*	*Limburgite, Woodend Victoria*
SiO_2	46.64		*Norm.*		45.59	45.10
Al_2O_3	13.22		or	7.78	12.48	12.86
Fe_2O_3	9.81		ab	34.58	9.93	5.66
FeO	4.16		an	3.50	2.84	7.10
MgO	7.01	di	wo	6.73	4.71	8.56
CaO	7.33	di	en	5.80	8.26	9.10
Na_2O	4.11	di	fs	..	5.51	3.99
K_2O	1.35	hy	en	13.90	3.16	1.02
H_2O	0.52	hy	fs	..	1.73	1.53
H_2O	2.14	ol	fo	5.74	1.64	1.10
CO_2	tr.	ol	fa	..	nil	tr.
TiO_2	2.50		mt	6.73	2.10	3.50
P_2O_5	1.00		hm	5.12	1.65	1.00
MnO	0.19		ilm	4.71	0.16	0.08
Cl	tr.		ap	2.35	0.16	tr.
SO_3	nil		H_2O	2.66	0.09	nil
ZrO	..			..	..	..
	99.98			99.60	100.06	100.60

Analyst:—
W. St. C. Manson (from Edwards, 1950)
Aurousseau, 1926 (from Spry, 1955)
W. St. C. Manson (from Edwards, 1950)

The iron ratio (Wager, 1956—25.5) is low, suggesting that differentiation has not reached an advanced stage, although post-fractional oxidation will reduce the ratio to some extent. Since an alkaline residual liquid is characteristic of silica-deficient alkalic rocks, the mineralogical composition of the base depends upon the amount of silica present. Thus the apparent difference between the Rokeby basalt and the Blinking Billy Point basanite may be due to a small difference in the amount of silica present in the end products of crystallisation.

Small patches of scoriaceous basalt which are similar to the Rokeby basalt occur at 323115, 335115, 322105 and 333106. They are probably eroded remnants of a nearby volcanic centre.

Pleistocene Series

Much of the area is covered by Pleistocene gravels, sands and clays, some of which are terrestrial and shoreline deposits, while others are marine deposits and represent transgressive phases. Recent sands often obscure these deposits and it is difficult to define a line of demarkation. In some cases rounded pebbles of basalt occur in the gravels.

The Rokeby Rivulet has cut into a poorly-bedded series of impure clays and gravels and approximately one mile to the east, at the head of Ralphs Bay, are small cliffs of poorly-bedded gravels and sands. Although these gravels and sands are poorly consolidated, they stand in vertical cliffs of approximately 20 feet, and dip to the east at approximately 3°. The bounders and pebbles, derived mainly from Permian sediments, are angular, of low to moderate sphericity and show little evidence of fluviatile transport. The lower part of this exposure is better sorted and throughout the matrix is of silt to sand grade. Lenses of sandstone of limited lateral extent are common.

Similar gravels are exposed in a stream channel crossed by the Roches Beach Road, and along the Rifle Range Road where a bore passes through 82 feet of gravels before reaching solid rock. Cliff sections on the South Arm Peninsula show a similar thickness of gravels, sands and clays, which Nye (1924) has correlated with the gravels of the Sandford Peninsula.

At several points around the shoreline, consolidated cross-bedded sandstones occur. These are best exposed at the southern extremity of Droughty Point 264135 where the sandstone is slightly iron-stained, well-sorted and shows festoon current bedding and scouring of the upper parts of each bed. The bottom of each bed is commonly marked by a layer of pebbles or small broken shells. These deposits represent old storm beaches and have an origin similar to those forming the beaches of the present day. Similar deposit are found below the Recent sand dunes of Opossum and Half Moon Bays.

Mary Ann Bay Sandstone.

The Mary Ann Bay Sandstone is defined as that formation of friable, fossiliferous marine sandstone, approximately 40 feet thick and probably Pleistocene in age, which is overlain by Recent sands and rests unconformably on an irregular erosion surface of dolerite. The type exposure is in the cliffs of 246093, Mary Ann Bay.

This is a poorly consolidated friable sandstone, perched 60 feet above sea-level containing a few large pectinacean shells and a gastropod fauna very

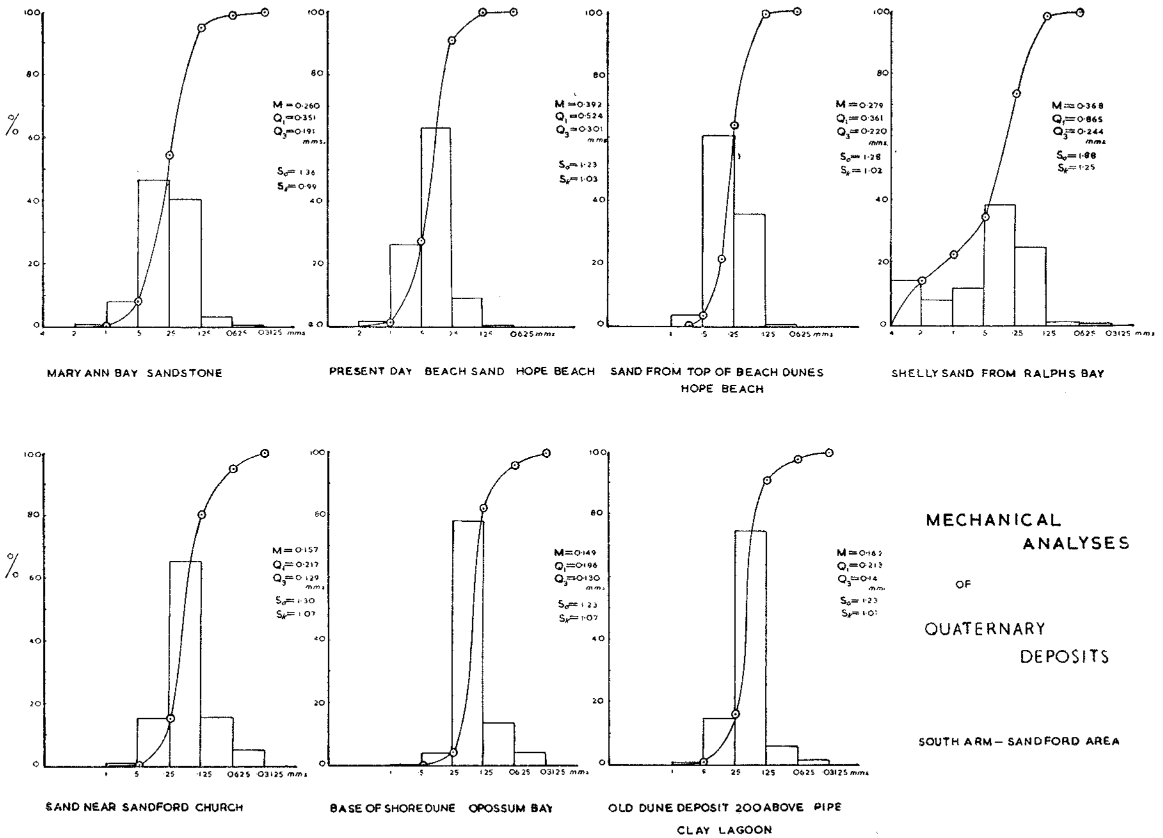

Figure 3.

similar to that found on the present shoreline, although no determination of genera could be made. A mechanical analysis show that it is well-sorted (So = 1.36) and that there is a slight predominance of a coarse admixture. Most of the sand grains fall in the size range 0.5-0.125 mms. and they are subangular to rounded. The fossil fragments are broken but not abraded to any extent and form most of the coarse admixture.

Recent Series.

Almost the entire area with the exception of Hayes Hills, the hills to the east of Rokeby and Single Hill, is covered by Quaternary alluvium. A deep sandy soil covers all that area which lies below an altitude of approximately 100 feet. Much of the sand, being swept inland by the prevailing winds, is derived from old and present day shorelines. Most of the dunes are now stabilised by vegetation, with the exception of those near the exposed ocean beaches on the south coast. Marsh deposits have formed on the protected side of narrow necks and the saline swampy areas support a samphire vegetation.

Present day beach sands (1113) contain as much as 25% of subrounded shell fragments up to 4 mms. in size. Quartz particles range from 0.20 mm. to 1.5 mms. in grain-size, a few are subangular but the majority are subrounded. Almost all shell material falls in the 2 mms.-0.5 mms. size range. Sand from the top of the beach dunes (1114) contains quartz grains (90%), shell materials (7%), small rock fragments (3%) and some heavy minerals. This sample shows a decrease of 0.12 mms. in medium grain-size compared with that at the sea shore, is slightly better sorted and almost all the quartz grains are subrounded at least, showing the effect of some wind transport. The quartz particles are of moderate to high sphericity and the heavy minerals include zircon and ilmenite with a few small grains of rutile, magnetite, ? zoisite and sphene. No micas were found in this sample, another factor which indicates aeolian transport.

The inland dunes, which have suffered extensive wind transport, are characterised by excellent sorting (So = 1.2-1.3), a slight predominance of the finer admixture (Sk = 1.7) and the modal class is 0.25-0.125 mms. These deposits consist almost entirely of quartz, subrounded to well-rounded in shape, and very few heavy minerals. Carbonaceous remains of roots are also present.

A distinct difference exists between the dune deposits on an exposed coast and those on the borders of sheltered bays and lagoons. Here the deposits are low shell ridges, the shells are often entire and the deposit is not as well sorted as a beach dune So = 1.88). A mechanical analysis of such a deposit at 309025 has a bimodal aspect (Fig. 3), with the secondary maximum consisting almost entirely of complete shells, including *Anapella cycladea, Cacozeliana cylindrica, Salinator fragilis, Mitraguraleus australis?* and a small high spired gastropod. Heavy minerals (magnetite and zircon) account for less than 0.05% of this deposit. The subrounded to rounded quartz grains have a mean diameter of 0.25 mms.

A small clay drill lent by courtesy of the H.E.C., enabled the following section to be obtained at 350114 on the Cremorne Road near Pipe Clay Lagoon.

Top.

3″	Black sandy soil
24″	Light brown sandy soil
15½″	Grey sand
3″	Alternation of grey and black sand ¼″ in thickness
7″	Grey sand with some clay matrix
6″	Sandy clay, slightly coarser at base
57″	Light grey-white pure clay—Tertiary.

STRUCTURAL GEOLOGY

Faulting

The area has been extensively disturbed by parallel sets of normal faults which strike to the north or west of north. These faults, which are thought to be of Lower Tertiary age (Hills and Carey, 1949), consistently downthrow to the east. Since the strata dip to the west at approximately 10-15°, the strike faulting cause the repetition of one stratigraphic horizon, the Malbina Siltstone and Sandstone, which outcrops over most of the area.

The fault with the greatest displacement is probably that which forms the western boundary of a downfaulted area of Triassic sandstone at 322196, part of which was named by Lewis (1946) the Acton Fault. It is possible that the throw is as much as 1000 feet and that this fault continues to the south-east, as a chain of Lagoons follows the extension of the Acton Fault in this direction. There is no evidence to suggest that the fault on the eastern boundary of the downfaulted wedge (Single Hut Fault, Lewis, 1946) continues southward to Ralphs Bay, as a Permian sequence of Grange Mudstone to Ferntree Mudstone at 315180 is complete.

The next major fault to the west is that which follows approximately the line of the road to Clifton Beach (Rushy Lagoon Fault). The Malbina Siltstone and Sandstone along the western side of Pipe Clay Lagoon is downthrown to the extent of 400 feet against the Grange Mudstone on the western side of the road. This fault is intersected by the Clifton Fault (Lewis, 1946) which has upthrown the southern block by approximately 450 feet. If it is assumed that the dolerite at 347050 is dipping shallowly under the Grange Mudstone the Cape Contrariety Horst has risen a further 300 feet. The westward continuation of the Clifton Fault has a throw of approximately 200 feet. To the west of the Cape Contrariety Horst, Malbina Siltstone and Sandstone is downthrown and exposed at sea level.

A fault with a throw of aproximately 150 feet is required between Mt. Augustus and the low range of hills to the east, as the base of the Malbina Siltstone and Sandstone has risen by that amount. A fault with a throw of 250 feet must be inferred between Collins Springs and the hills to the north of Goat Bluff as dolerite is exposed at 323062 and the hills rise to 350 feet without exposing the Risdon Sandstone.

Mt. Mather and Mt. Augustus are separated by the Rifle Range Fault which has a throw of approximately 500 feet at the northern end. However, although a zone of crushed rock exists at 315116, the throw appears to decrease towards the south, as Malbina Siltstone and Sandstone outcrops on both sides of the fault.

At 302140, a pronounced drag dip is present on the shoreline. This fault, with the south side upthrown, does not have a throw of more than 50 feet, but dolerite is intruded along the fault line. Dolerite at White Rock Point is separated by a fault from the Malbina Siltstone and Sandstone of Opossum Bay. Lewis (1946 p. 157) considered this to be part of a Mount Louis-Single Hill fault line, but this conclusion is invalid because no evidence exists for the south-easterly extension of the Single Hill (Single Hut) Fault.

The Rokeby Fault (Lewis, 1946) is concealed beneath Tertiary volcanic rocks and Quaternary sediments and downthrows at least 300 feet to the east. North of Tranmere Point, the Malbina Siltstone and Sandstone becomes progressively steeper in attitude as the Tranmere Fault is approached. The dolerite forming Hayes Hills, south of the fault, has been upthrown.

The steep dip of the sediments exposed in a small quarry (295182) behind the Rokeby Church suggests that the contact with the dolerite has been faulted. This fault may be of Jurassic age, as the sediments are hardened near the contact and the dolerite is fine grained and deeply weathered. Malbina Siltstone and Sandstone form a downthrown wedge against the Rokeby Fault.

On the north-eastern tip of Betsey Island Triassic sandstones have been downthrown by two parallel faults, and the southernmost fault contact is marked by opal veins.

The Form of the Dolerite Intrusions

As mentioned previously, the dolerite intrusions have a marked preference for one stratigraphic horizon, many of the contacts are sill-like but show a slightly transgressive relationship when examined in detail.

A steeply inclined intrustive contact is visible at ??1197, the Malbina Siltstone and Sandstone is not highly baked, but the dolerite becomes fined-grained and well-jointed in the direction of the contact. This contact then swings to the north and across the Rokeby Road at 268196 where the intrusion becomes a thin dyke. The northern boundary of this intrusion is less well defined and the intrusion appears to have rafted up a block of mudstone, as the mudstone in the quarry at 267197 is closely jointed and strongly thermally metamorphosed.

The dolerite beneath Mt. Mather is a gently shelving sheet; on the shoreline the contact dips at a low angle under the Grange Mudstone. At May Point, 353162, the Grange Mudstone is underlain by dolerite which rises in a series of steps to a conformable contact at the top of the intrusion.

Clarence Hills are composed of dolerite which intrudes Permian sediments and dips steeply to the west. The contact is clearly exposed only at a height of 680 feet at 311187 where it is a normal intrusive contact. Nearer sea level the steep dip of the sediments suggests that they have been dragged the sense of the movement being eastern side upthrown. This is in the opposite direction to that which would be expected if the dolerite has caused the drag dip, and later fault movement along the line of the contact is a possible solution. The intrusive contact is cut by several Tertiary faults, the dolerite-sediment contact being clearly displaced at 310194.

The sill north of Cape Deslacs is concordant with the Grange Mudstone and dips gently to the southeast, while the dolerite forming Calverts Hill also appears to be concordant with the sediments to the north of a fault contact, as the well developed subhorizontal joints have the same dip as that of the sediments.

On the Cape Contrariety Horst an intrusive boundary has a steeper contact and dips under Grange Mudstone at 347051. The northern end of this contact (351055) is markedly transgressive and may be a Jurassic fault boundary. A thin tongue of dolerite intrudes the Grange Mudstone nearby.

Joint Patterns.

A critical survey of joint patterns in the Malbina Siltstone and Sandstone was undertaken in an attempt to relate the well-developed jointing to the regional structure. The orientation of over 700 joints was determined in the field and plotted on a rose diagram (Fig. 4a.).

The most important are the near vertical joints striking at 250° (Set II), 295° (Set I) and 335° (Set III), and the same basic joint pattern is recognised over the entire area although the relative importance of individual sets varies from bed to bed. There is little evidence of horizontal displacement along the joints and joint planes cross pebbles without displacing them except for a tensional movement of approximately a millimetre in some joints of set III.

Differences in lithology are responsible for variations in the minor maxima but Set I are undeflected in passing through several beds. The joints of Set I are generally straight, have a maximum deviation of approximately 10° from the mean at any one locality and often occur in pairs about 9 inches apart. They have the characters of small shear joints. In exceptional cases this set may form a zig-zag pattern for a small distance.

A less well developed set of shear joints which are similar to Set I trend towards 250° (Set II) but show a maximum deviation of 15° from the mean. The prominent set of joints which follows the strike of the Tertiary faults (Set III) shows a considerable deviation from the mean and passes into feathery joints at the extremities. The surfaces of the joint planes are rough and these joints are parallel or sub-parallel to the strike of the strata.

Although the joints of Set I commonly truncate the others it has not been possible to determine a generalised sequence for the whole area. It is assumed that many of the joints are closely contemporaneous. In some cases Set I and Set II appear to be related, possibly as a conjugate pair of shear joints. At least some of the joints must be attributed to the intrusion of Jurassic dolerite, bu no distinction can be made.

Approximately 150 joints were measured during field mapping from the exposures of dolerite examined, the most important being vertical joints which trike at 230°, 10° and 320° and sub-horizontal joints. The near vertical joints tend to dip to the east at high angles.

The joints are irregular and of limited lateral extent. However, near intrusive contacts they are commonly parallel to the contact. Near such contacts the joints are often filled with silica, calcite and zeolites and occur as closely spaced plates.

There appears to be no correlation between Tertiary fault trends and the joints in the dolerite, but the joint pattern is rather similar to that produced for the Permian sediments, with one important addition, that of the joints striking at 230°.

Geological History

The Grange Mudstone (Upper Artinskian) was deposited on a stable shelf and intercalations of limestone and dolomite occur frequently. Towards the top of the section clastic material becomes more frequent and calcarenites and granule conglomerates are interbedded with the mudstone. A slight erosional break was followed by the deposition of the basal member of the Malbina Siltstone and Sandstone as a small-scale turbidite deposit on a mildly unstable shelf. The adjacent land mass was rising either isostatically due to the melting of an ice cap, or due to epeirogenic movements. Icebergs dotted the surface of the sea and deposited their load as erratics. The depositional area became more stable as member "C" was deposited and towards the top of this formation conditions became more favourable for marine life.

The Risdon Sandstone has formerly been described as a near-shore deposit, but it is possible that it marks a period of instability rather than a drastic change in sea-level. The basin of accumulation appears to have become more shallow and during the deposition of the Ferntree Mudstone may have been virtually deltaic. The adjacent land surface at

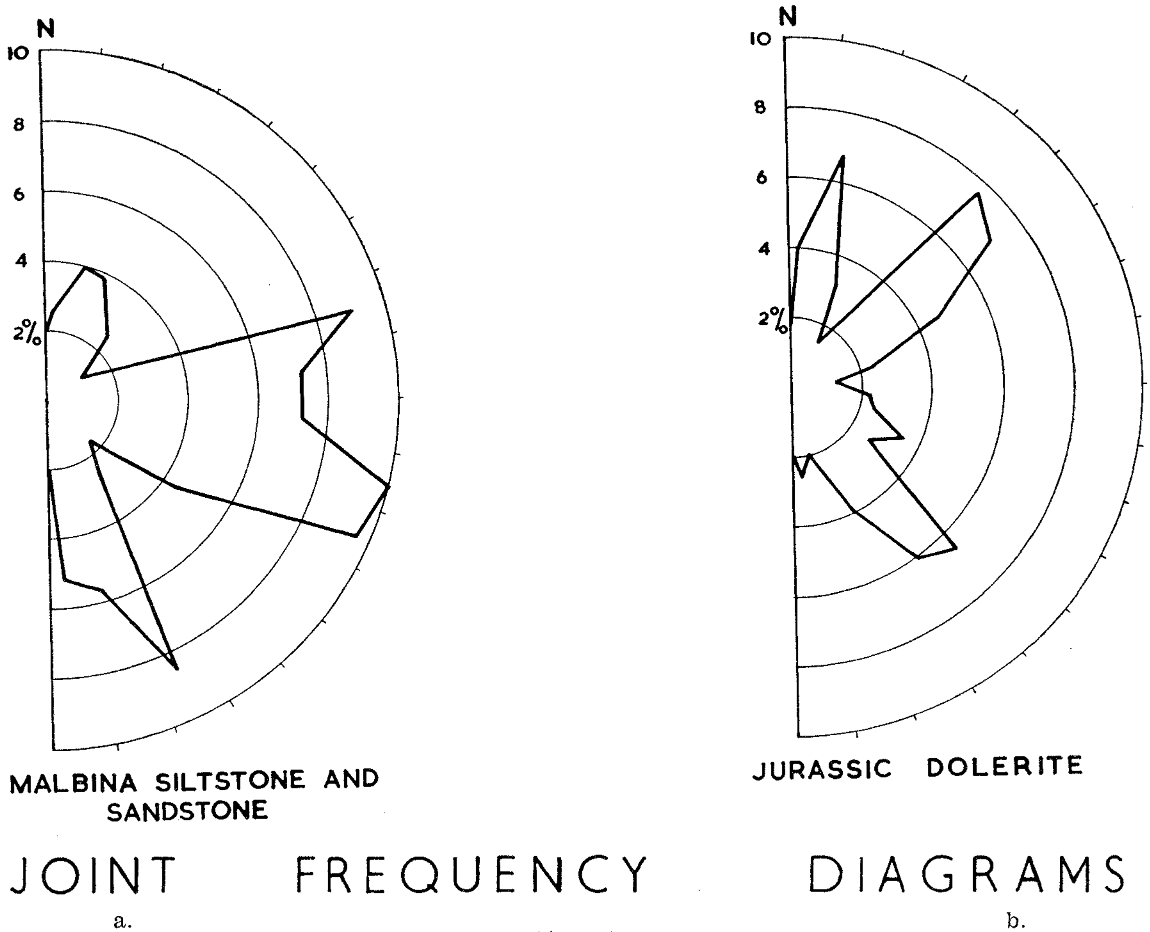

Figure 4.

this time was of low relief and the climate was becoming warmer as erratics are less frequent. Poorly-sorted sandstone bands, which occur at intervals show that periodically the area was slightly unstable.

The Ferntree Mudstone is separated from the basal Triassic grits by a possible disconformity. The quartz sandstones of the Triassic were probably deposited in lakes in a hot climates. The intrusion of Jurassic dolerite probably brought deposition to a close. The Permian and Triassic sediments were rafted in a sea of dolerite and the country rocks were thermally metamorphosed and silicified. The intrusion of the dolerite left the area with a considerable relief and it is likely that extensive erosion took place during the remainder of the Mesozoic, as it is probably that the topography of the early Tertiary landscape differed little from that of today. The Lower Tertiary conglomerates, sandstones, and clays were deposited at this point, probably in a series of lakes and lagoons.

The Lower Tertiary landscape was strongly disturbed by a series of northerly trending tensional faults. Explosive volcanic activity took place at centres which are situated near major Tertiary faults and the basalts flooded down the valleys left as a result of the Tertiary faulting. The basalts are deeply dissected. During the Pleistocene, extensive sand and gravel deposits accumulated over much of the area. Successive drops in sea-level have removed some of this material, but much of the area has been covered by Recent sand, which has been distributed by wind from both the present day and older shore dunes.

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Locality Index

(Referred to State grid.)

	N.	E.
Blinking Billy Point	716.7	521.3
Campania	747.8	527.3
Cornelian Bay	723.8	518.0
Jarvis Creek (Claremont Square)	736.3	504.0
Lindisfarne	725.0	521.5
Mt. Rumney	723.0	529.9
Rathbone's Quarries, Mt. Nassau, (Claremont Square)	736.8	506.3
Richmond	738.5	528.5
Single Hill	721.2	534.2

APPENDIX

Section in Cliffs at Cape Deslacs (386006)

Unit	ft.	ins.		ft.	ins.	
Top.						
5	above			91	6	pebbly sandstone-graded—as described by Brill (1956).
4	90	6	—	91	6	coarse mudstone with few pebbles.
3	88	7	—	90	6	conglomerate—medium sand grade matrix.
	80	3	—	87		inaccessible—this interval is covered in the section at the end.
60	70	4	—	71	2	shale—poorly fossiliferous.
59	70	0	—	70	4	pebbly limestone (? calcarenite).
58	69	1	—	70	0	dolomite—contains fenestellids and bryozoans.
57	68	3	—	69	1	mudstone with occasional fenestellids.
56	67	11	—	68	3	grey fine granule conglomerate—graded and shows infillings of scoops in the unit below.
55	67	8	—	67	11	mudstone.
64	67	5	—	67	8	grey granule conglomerate—dolomitic matrix.
63	66	10	—	67	5	mudstone—cream with occasional fossils.
62	66	7	—	66	10	very fossiliferous fenestellid mudstone.
51	66	6	—	66	7	grey pebbly mudstone.
50	65	10	—	66	6	mudstone with fenestellids.
49	65	0	—	65	10	dolomite impure)—Fenestella, Stenopora-pebbly base.
48	64	3	—	65	0	fenestellid mudstone.
47	64	0	—	66	3	pebbly calcarenite—fossiliferous.
46	61	1	—	64	0	mudstone with calcareous fossils in bands at 62′ 0″ and 63′ 3″.
45	61	0	—	61	0	heavily weathered shale band.
44	57	7	—	61	0	impure limestone—grey in colour fossiliferous—fenestellids in muddy bands—has dolomite in thin layers —spiriferids, *Stenopora*.
43	57	1	—	57	7	pebbly calcarenite.
42	55	3	—	57	2	limy mudstone—abundant (60%) productids.
41	54	11	—	55	3	limestone, unfossiliferous.
40	54	6	—	54	11	limy mudstone.
39	53	6	—	54	6	fossiliferous impure limestone.
38	53	1	—	53	6	dark green mudstone.
37	50	10	—	53	1	fossiliferous limestone—few pebbles —massively bedded—spiriferid calcirudite in part.
36	49	3	—	50	10	shaly mudstone with fine-grained dolomitic intercalations.
35	44	6	—	49	3	fossiliferous (productid) limestone, with a few bands of dolomite and thin shaly bands.
34	43	6	—	44	6	fine sandstone.
33	36	6	—	43	6	very fossiliferous white or light blue limestone—massively bedded—contains productids, spiriferids, fenestellids and *Stenopora* spp.—only few pebbles of quartzite.
32	36	5	—	36	6	fine sandstone.
31	35	6	—	36	5	pebbly coarse sandstone.
30	35	5	—	36	6	sandstone.
29	34	8	—	35	5	dolomitic granule conglomerate—possibly graded.
28	34	6	—	34	8	fine sandstone band—? quartz veining along base.
27	31	6	—	34	8	slightly recrystallised dolomitic granule conglomerate pebbles up to 1″—very pebbly at base—large spiriferids 4″-5″ in width—no bedding visible.
26	31	3	—	31	6	finely laminated sandstone—? quartz veining along base.
25	28	9	—	31	3	dolomitic granule conglomerate—abundant poorly preserved fossils.
24	28	0	—	28	9	mudstone—dark olive grey in colour.
23	27	0	—	28	0	pebbly dolomite—*Stenopora* spp., brachiopods pebbles up to 2″.
22.	25	0	—	27	0	limy mudstone, not well-bedded, Fe, Mn staining, apparently unfossiliferous.
21	24	10	—	25	0	pebbly band—calcareous matrix.
20	22	11	—	24	10	dolomite—a few pebbles up to 3″—mudstone intercalations 1″ in thickness—spiriferids.
19	20	10	—	22	11	mudstone—medium grey in colour—a few fenestellids.
18	19	6	—	20	10	very pebbly granule conglomerate—dolomitic matrix—pebbles up to 6″ (40%) very poorly sorted—thinly bedded mudstone at 20′ 4″.
17	18	7	—	19	6	slightly calcareous mudstone—½″ thick quartz vein at base.
16	17	4	—	18	7	pebbly mudstone—irregular base—pebbles up to 6″—most about ¼″—spiriferids at 17′ 7″.

Unit	ft.	ins.		ft.	ins.	
			—			Base of Malbina Siltstone and Sandstone.
75	79	6	—	80	3	fossiliferous mudstone contains few well-rounded quartz pebbles up to 1½ inches—fenestellids.
74	78	10	—	79	6	pebbly calcarenite or fine granule conglomerate.
73	78	4	—	78	10	? graded from coarse sandstone to mudstone.
72	77	10	—	78	4	? graded from coarse sandstone to mudstone.
71	77	2	—	77	10	? graded from coarse sandstone to mudstone—very pebbly—pebbles up to 2″—contains spiriferids.
70	75	11	—	77	2	dolomitic mudstone—shaly in part—few pebbles.
69	75	7	—	75	11	? graded—irregular base—pebbly coarse mudstone.
68	75	3	—	75	7	? graded pebbly mudstone.
67	74	10	—	75	3	limy mudstone.
66	74	1	—	74	10	pebbly granule conglomerate—few fossils possibly a dolomitic matrix.
65	73	0	—	74	1	mudstone with pebbly bands.
64	72	9	—	73	0	fossiliferous ? dolomite—grey in colour.
63	72	2	—	72	9	mudstone.
62	72	1	—	72	2	limy mudstone.
61	71	2	—	72	11	calcarenite—some quartz pebbles and fossils.
15	17	1	—	17	4	brown—dark grey medium-grained mudstone—poorly preserved calcite fossils with sheets of calcite.
14	16	7	—	17	1	? graded bed—coarse sandstone at base—calcareous matrix—fossils (fenestellids) at top of unit.
13	16	6½	—	16	7	recrystallised sheets of calcite—1/16″ thick.
12	14	10	—	16	6½	dolomite with *Stenopora*, fine mudstone bands at 15′ 10″ and 16′ 5″.
11	14	4	—	14	10	grey unfossiliferous mudstone—limestone.
10	14	3	—	14	4	lenses—limestone.
9	14	0	—	14	3	dark grey fine-grained mudstone—unfossiliferous.
8	12	2	—	14	0	dolomite white in colour.
7	11	11	—	12	2	heavily recrystallised green band (diopside).
6	10	0	—	11	11	recrystallised fossiliferous faint green dolomite mudstone—*Stenopora* in colonies—a few large spiriferids—replaced by prisms of diopside ?
5	9	7	—	10	0	light green very fossiliferous—productids—pebble of quartzite up to 4′.
4	9	3	—	9	7	grey mudstone—few fossils.
3	8	6	—	9	3	dolomite, white in colour, lenses of blue-grey limestone (2″) a few fenestellids.
2	8	0	—	8	6	blue grey limestone—richly fossiliferous—a few small pebbles—*Stenopora*—90% of *Strophalosia* spp. are orientated convex upwards.
1	0	0	—	8	0	impure dolomite—with mudstone bands contains spiriferids, productids, few *Stenopora*, fenestellids rare—fossil broken and not well preserved—only fossils effervesce.

Section begins approximately 5′ above L.W.M.

Supplementary section at Cape Deslacs.

(To cover missing interval).

Unit	ft.	ins.		ft.	ins.	
2	90	0				sandstone—cream to grey in colour—medium grained.
1	88	9	—	90	0	coarse-grained sandstone, pebbly at base—grades up into unit above—at base this rock is a poorly-sorted conglomerate—matrix sand grade—a few finer patches—boulders of granite up to 1′ diameter—angular pebbles of quartzite, schist, few of phyllite and mudstone—irregular base. This basal unit of the Malbina Siltstone and Sandstone.

Unit	ft.	ins.		ft.	ins.	
75	87	10	—	88	9	coarse-grained mudstone—possibly
71-74	87	10	—	88	9	possibly limy—up to 10% pebbles.
71-74	85	4	—	87	10	coarse-grained sandstone—almost a grit—a few fossils.
	79	5	—	85	4	massively bedded pebbly mudstone—sandstones grey, weather yellow—a few calcareous fossils—bands of shale at 82′ 3″ and 84′ 3″ and small band of dolomite—possibly graded—fewer pebbles at top.
	79	1	—	79	5	graded bed—pebbly base—almost a grit—fossils (brachiopods) at base which is irregular.
	79	1				pebbly mudstone—few pebbles.

Section Between West End of Hope Beach and Cape Direction (269008-267004)

Unit	ft.	ins.		ft.	ins.	
14	69					cliffs of pebbly mudstone at least 70′ in height and fine sandstone.
13	55	8	—	69	0	coarse-grained sandstone—unfossiliferous—matrix coarse sand—pebbles up to 2′—poorly sorted pebbles angular to subangular of quartzite and slate.—Pebbly layers at 55′ 8″, 57′, 58′ 1″, 59′ 6″, 61′ 0″, 63′ 0″, 65′ 6″.
12	55	1	—	55	8	thinly bedded medium grained sandstone—few pebbles.
11	53	10	—	55	1	sandstone with few pebbles—may have gradational boundary with unit below.
10	53	6	—	53	10	coarse-grained sandstone—pebbles of quartzite up to 3″.
9	52	6	—	53	6	massive pebbly sandstone—conglomerate at base matrix of sand grade—this unit is graded—pebbles of quartzite, slate and fenestellid mudstone.
8	49	7	—	52	6	fossiliferous mudstone—contains fenestellids and *Strophalosia* spp.
7	48	10	—	49	7	coarse sandstone—few fossils.
6	44	7	—	48	10	very fossiliferous mudstone—extremely rich in productids (*Strophalosia* or *Terrakea*).
5	37	10	—	44	7	unfossiliferous mudstone — few pebbles—massively bedded.
4	35	6	—	37	10	very fossiliferous mudstone—is hardened may have originally been calcareous rich in impressions of a spinose productid—possibly *Terrakea* ?—poor preservation precludes identification.
3	34	4	—	35	6	unfossiliferous coarse mudstone.
2	25	6	—	34	4	pebbly fine sandstone—bedding approximately 18″ thick—pebbly layer at 32′ 6″.
1	0	0	—	25	6	pebbly mudstone and fine sandstone—bedding 1′ 6″ to 2′ 6″ thick—pebbles appear to be more frequent at base of beds.

Section Along North End of Ralphs Bay near Ralphs Bay Canal 315174 *to* 308173.

Unit	ft.	ins.		ft.	ins.	
11	60	7	—	71	0	massive pebbly sandstone—coarse bands at intervals of 3″ to 1″.
10	60	5	—	60	7	granule conglomerate.
9	60	0	—	60	5	coarse mudstone, unfossiliferous.
8	59	7	—	60	0	pebbly granule conglomerate.
7	59	4	—	59	7	coarse mudstone.
6	59	0	—	59	4	pebbly granule conglomerate—matrix about ⅛″ diameter.
5	57	1	—	59	0	slightly pebbly fine sandstone—mudstone intercalations.
4	56	6	—	57	1	pebbly sandstone.
3	54	6	—	56	6	conglomerate—poorly sorted matrix of very coarse sand—mean size of boulders 4″-5″ and they make up 30% of the unit—one boulder is of granite 16″ diameter also quartzite—subangular, Permian mudstone—angular to subangular and quartz mica schist—rounded and 2-3″ in diameter.

Unit	ft. ins.		ft. ins.		
2	53 9	—	54 6	graded bed—coarse sand to mudstone —pebbles up to 3″ diameter.	
1	53 0	—	53 9	very pebbly sandstone—pebbles up to 6″ of quartzite and granite—finer towards top—probably graded—very irregular base—possibly some current markings on the base of this unit although no current directions could be measured.—this unit is probably the base of the Malbina Siltstone and Sandstone.	

Grange Mudstone.

Unit	ft. ins.		ft. ins.		
42	52 0	—	53 0	medium grained mudstone —fissile	one graded unit
41	51 0	—	52 0	coarse mudstone with one pebble 4″ diameter at base; few fenestellids.	
40	50 6	—	51 0	pebbly granule conglomerate.	
39	50 0	—	50 6	Graded bed, granule conglomerate to mudstone.	
38	48 6	—	50 1	fine-grained sandstone—fenestellids and spiriferids.	
37	45 5	—	48 6	pebbly calcarenite—with sandy bands pebbles up to 1″ at 46′ 0″, 46′ 8″, 47′ 2″.	
36	44 4	—	45 5	fine-grained sandstone — coarse-grained mudstone—few fenestellids pebbly at base—possibly graded.	
35	43 2	—	44 4	fine to medium-grained sandstone—pebbly base, graded.	
34	42 10	—	32 2	mudstone fissile.	
33	42 6	—	42 10	coarse mudstone.	
32	41 0	—	42 6	fissile mudstone.	
31	40 0	—	41 0	fine granule conglomerate.	
30	34 5	—	40 0	fissile mudstone, fossiliferous—contains bryozoans, productids and occasional molluscs.	
29	33 6	—	34 5	*Strophalosia jukesi*—*Fenestella* limestone.	
28	30 6	—	33 6	limy mudstone—extremely fossiliferous—*Strophalosia* spp., fenestellids, stenoporids molluscs and a few gastropods.	
27	27 5	—	30 6	sparsely pebbly fine-grained mudstone some bands calcareous.	
26	26 9	—	27 5	coarse grained mudstone—fossiliferous.	
25	24 10	—	25 9	mudstone with recrystallised calcite fossil shells—a few pebbles up to 1″.	
24	23 11	—	24 10	mudstone with rolled fragments of brachiopods.	
23	23 0	—	23 11	typical Grange fenestellid mudstone.	
22	22 0	—	23 0	fossiliferous coarse sandstone—pebbly at top productids and bryozoans.	
21	20 11	—	22 0	limy fenestellid mudstone—a few small grains of sand size.	
20	20 0	—	20 11	this bed contains an intact bryozoal mat (*Stenopora crinita*) 8″ in length but the remaining fragments appear to have been rolled.	
19	19 2	—	20 0	mudstone very rich in broken fragments of bryozoa—almost a coquina.	
18	18 10	—	19 2	coarse sand grade—contains small gastropod.	
17	17 11	—	18 10	coarse mudstone, unfossiliferous.	
16	17 0	—	17 11	slightly pebbly mudstone—calcareous fossils bryozoans, fenestellids.	
15	14 11	—	17 0	pebbly fine granule conglomerate—pebbles up to 1″ of quartzite, granite(slate, green schist—this unit appears to be graded and the base is irregular.	
14	13 9	—	14 11	coarse pebbly mudstone—a few pebbles up to 4″.	
13	13 2	—	13 9	slightly limy mudstone with spiriferids.	
12	12 7	—	13 2	granule conglomerate.	
11	12 6	—	12 7	fissile mudstone.	
10	10 11	—	12 6	blocky coarse mudstone—fossils in layers—productids and pectens—few pebbles up to 2″.	
9	7 9	—	10 11	mudstone, fairly fossiliferous—less than 3% pebbles (up to 2″)—contains brachiopods, fenestellids and stenoporids.	
8	7 7	—	7 9	white mudstone.	
7	6 9	—	7 7	limy mudstone—spiriferids, fenestellids and bryozoans towards top of bed.	
6	4 7	—	6 8	rather fissile mudstone.	
5	4 6	—	4 7	pebbly layer.	
4	3 6	—	4 6	graded unit, pebbly coarse mudstones at base (almost a granule conglomerate), mudstone, at top contains fenestellids.	
3	2 2	—	3 6	? graded unit—very coarse mudstone at base which contains a few brachiopods—fenestellids are restricted to upper part of the bed.	
2	0 9	—	2 2	fossiliferous mudstone—rather fissile —a few pebbles.	
1	0 0	—	0 9	very pebbly coarse mudstone-pebbles up to 6″—poorly sorted—10% of the pebbles are over 1″ in size. Section covered by pebble beach.	

Section Westwards Along Shore from Jetty, South Arm.

Malbina Siltstone and Sandstone.

above	45 0			coarse mudstone—few pebbles—bedded 18″ to 2′—fissile in places.
20	39 6	—	45 0	mudstone with a few pebbles, beds 13″ to 18″ thick.
19	38 6	—	39 6	typical cream mudstone.
18	38 0	—	38 6	coarse pebbly mudstone.
17	36 0	—	38 0	pebbly mudstone—few pebbles up to ½″.
16	34 6	—	36 0	blocky mudstone—rather fissile at base-pebbles up to 2″.
15	33 6	—	34 6	fine sandstone—many small pebbles.
14	27 6	—	33 6	pebbly coarse mudstone—not well-bedded—poorly exposed.
13	25 8	—	27 6	pebbly coarse mudstone—possibly has gradational boundary with unit beneath.
12	24 0	—	25 8	pebbly fine sandstone—pebbles in rows, many large pebbles up to 1′, most 3″-4″—massively bedded.
11	21 0	—	24 0	pebbly mudstone—a few pebbles up to 6″ most 1″-2″—elongated markings up to 4″.
10	20 0	—	21 0	mudstone—fewer pebbles.
9	19 7	—	20 0	coarse mudstone approximately 3% pebbles up to 1″—irregular wave-like bottom contact, wavelength 2′.
8	13 8	—	19 7	very pebbly mudstone—pebbly bands at 19′ 0″, 17′ 0″, 13′ 9″ very pebbly band (quartzite, sandstone, mudstone, and slate up to 4″) at 14′ 5″.
7	12 3	—	13 8	sparsely pebbly mudstone.
6	9 10	—	12 3	moderately pebbly mudstone, up to 3% pebbles over 1″—pebbles range from angular to well rounded—very pebbly base—quartzite pebbles up to 1′.
5	7 6	—	9 10	coarse mudstone—fissile towards top.
4	5 7	—	7 6	slightly pebbly mudstone.
3				
2	0 0	—	5 7	medium-grained mudstone — few pebbles in patches bedding from 1′ 3″ and 2″ thick.
1				

Section Along Shoreline Beneath Mount Mather, 313158 *to* 307155

Malbina Siltstone and Sandstone

48	120		above 120	coarse pebbly mudstone, bedding 8″-1′ 6″ thick.
47	90 0	—	120 0	pebbly sandstone—bedding 1′-2′ thick.
46	89 0	—	90 0	coarse mudstone.
45	87 0	—	89 0	pebbly sandstone.
44	85 0	—	87 0	sandstone.

Unit	ft. ins.		ft. ins.	
43	80 0	—	85 0	massively bedded sandstone—a few fossils (spiriferids)—few large pebbles up to 4", 1 or 2 of granite.
42	76 0	—	80 0	sandstone—few pebbles.
41	75 6	—	76 0	mudstone.
40	74 6	—	75 6	sandstone.
39	74 0	—	74 6	unfossiliferous mudstone.
38	71 9	—	74 0	slightly pebbly sandstone.
37	71 0	—	71 9	mudstone.
36	69 3	—	71 0	sandstone.
35	67 0	—	69 0	pebbly sandstone—massively bedded.
33	64 8	—	67 0	sandstone—a few pebbles.
32	64 5	—	64 8	unfossiliferous mudstone.
31	64 3	—	64 5	pebbly conglomerate.
30	63 10	—	54 3	fossiliferous coarse mudstone.
29	63 7	—	63 10	granule conglomerate.
28	62 8	—	63 7	fossiliferous mudstone—spiriferids, stenoporids and fenestellids.
27	62 4	—	62 8	pebbly conglomerate.
26	61 6	—	62 4	sandstone—few pebbles—well-sorted.
25	60 0	—	61 6	unfossiliferous mudstone.
24	59 0	—	60 0	sparsely pebbly sandstone.
23	58 1	—	59 0	fenestellid mudstone.
22	53 0	—	58 1	sparsely pebbly and fossiliferous mudstone few *Stenopora* and *Fenestella* at top.
21	50 2	—	53 0	massively bedded resistant very pebbly granule conglomerate, matrix coarse sand, pebbles up to 6" few fossils.
20	49 0	—	50 2	fine mudstone.
19	47 2	—	49 0	coarse pebbly mudstone—pebbly base.
18	46 7	—	47 2	mudstone.
17	45 7	—	46 7	pebbly granule conglomerate.
16	41 6	—	45 7	coarse fossiliferous mudstone—bedding about 1' thick—spiriferids in layers, also fenestellids, pebbly at base.
15	36 7	—	41 6	coarse pebbly fossiliferous mudstone—contains an alate spiriferid and *Fenestella* in finer bands.
14	36 0	—	36 7	fine fenestellid mudstone (also *Stenopora* spp).
13	35 1	—	36 0	pebbly fine granule conglomerate—angular pebbles.
12	31 0	—	35 1	fossiliferous mudstone—fossils of $CaCO_3$, fenestellids, stenoporids, spiriferids, *Ingelarella*—*Ingelarella* always associated with the coarser bands.
11	27 10	—	31 0	pebbly fine granule conglomerate with sandstone matrix—fossils in layers—specimen of *Ingelarella* in sandstone at top of bed—possibly graded.
10	27 0	—	27 10	mudstone, occasional pebbles.
9	26 11	—	27 0	granule conglomerate.
8	25 6	—	26 11	fossiliferous sandstone—contains pectens, bryozoans, spiriferids and an ingelarellid which is more bulbous than the more common species—preservation very poor.
7	23 6	—	25 6	pebbly mudstone—poorly exposed.
6	22 6	—	23 6	covered by sand and soil—no structural break.

Unit	ft. ins.		ft. ins.	
5	19 6	—	22 6	pebbly granule conglomerate—irregular bottom contact—matrix of sand grade—pebbles up to 4"—abundant moulds of spiriferids which are aligned—graded.
4	15 5	—	19 6	coarse-fine pebbly mudstone—few fossils—infrequent pebbles up to 2"—one or two brachiopods at 16' 7".
3	13 0	—	15 5	pebbly coarse sandstone—few large pebbles of quartzite and phyllite up to 1'—many spiriferids—poor preservation.
2	12 9	—	13 6	fine sandstone—granule conglomerate at base.
1	10 9	—	12 9	basal bed of Malbina Siltstone and Sandstone—matrix is sand grade—pebbles low sphericity, subangular, quartzite, slate and mudstone up to 1'—a few fenestellids at top—poorly preserved moulds of spiriferids aligned parallel to bedding—base is a calcirudite—many pebbles of underlying Grange Mudstone.
Grange Mudstone.				
15	10 7	—	10 9	calcirudite—only of limited lateral extent.
14	10 6	—	20 7	mudstone.
13	10 5	—	20 6	calcirudite—granule conglomerate—lens.
	6 10	—	10 5	partly covered by boulders, limy mudstone—many pebbles—calcarenite in part.
12	6 5	—	6 10	richly fossiliferous mudstone—fenestellids.
11	5 11	—	6 5	calcirudite, similar to that at Cape Deslacs.
10	5 6	—	5 11	fissile mudstone.
9	4 6	—	5 6	sparsely fossiliferous mudstone.
8	4 1	—	4 6	coarse mudstone—fossiliferous.
7	4 0	—	4 1	fossil coquina and calcarenite.
6	3 3	—	4 0	fenestellid mudstone—a few pebbles—appears to be graded—almost a calcarenite at base.
5	2 10	—	3 3	fossiliferous mudstone—faintly silicified contains alate spiriferid.
4	2 6	—	2 10	calcirudite—calcarenite, rolled fossil fragments.
3	1 10	—	2 6	mudstone, few pebbles or fossils.
2	1 0	—	1 10	richly fossiliferous unit, almost a coquina, contains *Fenestella* spp., *Polypora*, *Ingelarella*, spiriferids, productids, pectens and a small gastropod—preservation poor—a few quartzite boulders up to four inches in diameter.
1	0 0	—	1 0	thinly bedded limy mudstone—weathered green to yellow in colour at contact with dolerite. Gently shelving intrusion, rather irregular contact but contact effects not pronounced.
		—	? ?	Dolerite