THE GEOLOGY OF PORT STEPHENS.

PART I.—PHYSIOGRAPHY AND GENERAL GEOLOGY.
By C. A. SUSSMILCH AND WM. CLARK.

PART II.—PETROGRAPHY.

By C. A. SUSSMILCH, WITH ANALYSES BY W. A. GREIG.
(With Plates XIV-XVI and two Text-figures.)

(Read before the Royal Society of New South Wales, Sept. 5, 1928.)

The area described in this paper comprises the whole of the parish of Tomaree (County of Gloucester), together with part of the adjoining parish of Sutton. The north head of Port Stephens, which is part of the parish of Fens, is also included. Brief reference to some of the geological features of this area is made by Sir T. W. E. David in his memoir on the Hunter River coalfield,1 and part of the area is shown in his geological map.

PART I.—PHYSIOGRAPHY AND GENERAL GEOLOGY.

A. PHYSIOGRAPHY.

This region consists of a prominent group of isolated hills on the southern side of Port Stephens, rising above a swampy sand flat, the latter being elevated but little above sea level excepting where it is covered in part by low sand dunes. The hills are the summits of partly-buried ridges, consisting of lava flows of Carboniferous age.

When the submergence took place in late Pleistocene times which drowned the shore line and produced the inlet of Port Stephens, these ridges were partly submerged, only
the higher points remaining as islands; silting followed the subsidence, and the thickness of the silts, as shown by the bores put down near Anna Bay, is not less than 190 feet, thus indicating a subsidence of at least that amount. A more recent elevation of from 15 to 20 feet has lifted the area above sea level and produced the swampy plain, above which the one-time islands now rise as hills. Two of these hills, viz., Yacaaba (north head) and Point Stephens, are joined to the mainland by narrow sand spits which are sometimes awash at high tide. The islands which adjoin the entrance to Port Stephens, namely, Cabbage Tree Island and Boondalbah Island, are similar peaks which have not been rejoined to the mainland.

The majority of the hills above referred to rise to a general elevation of about 400 feet above sea level, and this level would appear to be an erosion level, corresponding in altitude to one which occurs in the Hunter River Valley, and which one of us (C.A.S.) has referred to elsewhere as the Charleston level. Three of the hills, however, rise above this level, namely:

Yacaaba (North Head), altitude 717 ft.
Tomaree (South Head), altitude 540 ft.
Ghan Ghan (Trig. Station), altitude 527 ft.

Similar isolated hills occur to the north and west of Port Stephens, such as Mt. Karuah (807 ft.), Mt. Gundain (833 ft.), Mt. Carrington (875 ft.), and Mt. Nerong (1,000 ft.). The whole region, therefore, appears to have been a Tertiary peneplain which was uplifted to form a tableland about 1,000 feet in altitude at the close of the Tertiary period, the various hills of to-day being residuals of this tableland.

Port Stephens is a typical drowned valley with its long axis (13 miles) in an east and west direction. It is divided into two unequal parts by the convergence of its north
and south shores at Soldiers Point, where the normal width of from 3 to 5 miles is reduced to less than a quarter of a mile. The narrowing at this point is due to the presence of massive acid lava flows forming a ridge striking approximately N.N. West and S.S. East.

Before the subsidence took place, which produced Port Stephens, this ridge formed the divide between the watersheds of the Karuah and Myall Rivers. The drowning submerged a col in this one-time divide and allowed the waters of the Karuah River to flow into the eastern part of Port Stephens, which is the drowned valley of the Myall River. Previous to this, the Karuah River continued its southern course and joined up with the Hunter River system. To-day there are only low-lying alluvial flats between the western part of Port Stephens and the Hunter River estuary.

Throughout the whole district raised beaches occur, both on the sea coast and on the coast of Port Stephens itself. These latter, at many places, form distinct contour lines around the water front. An interesting raised beach is that which occurs at the north end of Morna Point. A photo of this beach is given in Plate XIV. Here well-rounded boulders of Rhyolite occur up to an elevation of 20 feet above present high water mark. There are also included pebbles of chert, pumice and kerosene shale. Large trees (eucalypts and banksias) are now growing on this raised beach.

The Rhyolite boulders, particularly those at the back of the old beach, are quite kaolinised, indicating the long lapse of time since they were placed there. Associated with the pebbles are numbers of large gasteropod and pelecypod shells, also for the most part quite decayed.
### GEOLGY OF PORT STEPHENS.

#### B. General Geology.

The rocks of this region belong mainly to the Kuttung Series of Carboniferous age; but, as already pointed out, these are covered to a considerable extent with recent superficial deposits. The general structure is that of a large plunging anticline, the horizontal axis of which pitches to the south. The rocks consist mainly of a series of massive lava flows, apparently separated from one another by weaker sedimentary strata. A section of these strata, in descending order, is as follows:

<table>
<thead>
<tr>
<th>Layer Description</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherts and Tuffs (thickness unknown)</td>
<td></td>
</tr>
<tr>
<td>Rhyolite flow (Morna Point Flow)</td>
<td>300 feet</td>
</tr>
<tr>
<td>Cherts (with <em>Rhacopteris</em>)</td>
<td>10 &quot;</td>
</tr>
<tr>
<td>Tuff</td>
<td>30 &quot;</td>
</tr>
<tr>
<td>Tuffaceous Conglomerate with small Rhyolite Flow (No. 2 flow)</td>
<td>355 &quot;</td>
</tr>
<tr>
<td>Tuff</td>
<td>45 &quot;</td>
</tr>
<tr>
<td>Rhyolite (No. 1 flow)</td>
<td>165 &quot;</td>
</tr>
<tr>
<td>Tuffaceous Sandstone with fossil plants</td>
<td>600 &quot;</td>
</tr>
<tr>
<td>Conglomerates and tuffs</td>
<td>800 &quot;</td>
</tr>
<tr>
<td>Strata (no outercrops)</td>
<td>1,130 &quot;</td>
</tr>
<tr>
<td>Toscanite Flows</td>
<td>500 &quot;</td>
</tr>
<tr>
<td>Strata (no outercrops)</td>
<td>580 &quot;</td>
</tr>
<tr>
<td>Toscanite Flows</td>
<td>400 &quot;</td>
</tr>
<tr>
<td>Strata (no outercrops)</td>
<td>750 &quot;</td>
</tr>
<tr>
<td>Toscanite (Nelson’s Head Flow)</td>
<td>200 &quot;</td>
</tr>
<tr>
<td>Conglomerate (with large boulders)</td>
<td>300 &quot;</td>
</tr>
<tr>
<td>Andesite (No. 2 flow)</td>
<td>20 &quot;</td>
</tr>
<tr>
<td>Conglomerate</td>
<td>30 &quot;</td>
</tr>
<tr>
<td>Andesite (No. 1 flow)</td>
<td>100 ± &quot;</td>
</tr>
<tr>
<td>Conglomerate (thickness unknown)</td>
<td></td>
</tr>
</tbody>
</table>

**Total** . . 6,315 feet
The above figures must be taken as mere approximations as the incompleteness of the section makes the determination of actual figures impossible.

1.—The Andesites.

Nelson's Bay.

A well-defined flow of andesite (No. 1 flow) outcrops at intervals along the south shore of Port Stephens from Nelson's Bay to Corlette Point. This flow strikes about E. 20° N. and dips S. 20° E. at an angle of about 20°. The section adjoining the steamer jetty at Nelson's Bay, in descending order, is as follows:

Conglomerate (with very large boulders) ... 100 feet
Andesite (No. 2 flow) ... ... ... ... ... 20
Conglomerate ... ... ... ... ... ... 30
Andesite (No. 1 flow) ... ... ... ... ... 100

Here the No. 1 andesite flow occurs right at sea level. The lower part is quite glassy, the glassy phase merging upwards into a lithic variety. The rock is a hornblende-pyroxene-andesite and is described in detail in a later section. The full thickness of this flow is not exposed, but it is at least 100 feet thick. The No. 2 flow is similar in character to the No. 1 flow. The lower andesite gives a continuous outcrop westwards from the jetty to the eastern end of Dutchman's Beach, then follows a sand flat, followed by a smaller outcrop at the western end of Dutchman's Beach. From this point westwards nothing but sand can be seen until Corlette Point is reached. Here the andesite flow may be seen resting upon a bed of conglomerate, both dipping southwards. It is uncertain as to whether this flow represents the No. 1 or the No. 2 flow at Nelson's Bay. If it is the No. 2 flow, then the No. 1 flow will be found here, not far below sea level, underlying the conglomerates above referred to.
Tomaree or South Head.
A small outcrop of andesite occurs here at sea level on the west side of the headland, striking north and south, and dipping easterly. It is immediately overlaid by a massive toscanite flow.

Yacaaba Headland (North Head).
Here also, just at sea level, is an andesite flow outcropping along the northern shore of the headland. This flow strikes E. 25° N. and dips S. 25° E., with a massive toscanite flow resting immediately above it. As the andesite flow extends below sea level, it is impossible to determine its true thickness. An interesting feature here is the occurrence of a bar of toscanite cutting across the andesite flow and containing fragments of andesite. The andesite occurring at the three abovementioned localities are probably all parts of one and the same flow, but it is difficult to reconcile the strike at Tomaree with that at Nelson’s Bay and at Yacaaba headland.

Point Stephens Headland.
Point Stephens headland is an island consisting entirely of andesite, joined to the mainland by a narrow sandspit which is awash at high tide. A small outcrop of Andesite also occurs on the opposite mainland at the northern end of Fingal Head. This andesite is similar in character to that occurring at Nelson’s Bay. If part of a flow, it is higher in the series than the Nelson’s Bay flow. The shape of the outcrop, however, and the relation to the adjoining rocks is not suggestive of its being a typical sheet. We suggest that it may be, probably, an andesite lava cone extruded at the same time as the Nelson’s Bay flow, and afterwards surrounded and covered by the later toscanite and rhyolite flows and their associated sedimentary rocks, but the available evidence does not admit of proof one way or the other.
A similar andesite volcanic cone of Kuttung age, surrounded and covered by younger strata, and since partly re-exposed by the partial removal of the overlying strata, has been recorded as occurring at Blair Duguid, in the Hunter River Valley. 

2.—The Toscanites.

Numerous and massive flows of toscanite occur throughout the district, but as the outerops of these are isolated from one another by sand flats or by water, and as there has been, in places, considerable displacement of outerops by faulting, it is somewhat difficult properly to correlate the various outerops. There would appear to have been at least two distinct toscanite flows or groups of flows. These two groups are referred to respectively as (a) the Nelson’s Head-Yacaaba flow and (b) the Soldiers Point-Ghan Ghan group of flows.

(a) The Nelson's Head-Yacaaba Flow.

Nelson's Head.

The whole of Nelson’s Head consists of toscanite extending from low water mark to the top of the hill on which the lighthouse stands. The strike is about E. 20° N. and the dip to the south. On the northern face of the headland the rock at sea level is entirely glassy for a thickness of from 10 to 15 feet. Upwards, this glassy phase merges into a lithodal phase, the latter continuing to the top of the hill. The base of the flow is below sea level, but the thickness is not less than 100 feet.

Fly Point.

This is a low headland occurring to the west of Nelson’s Head. A similar occurrence of toscanite occurs here, with a glassy selvedge at the base of the flow, but this glassy phase is less well marked, and the flow, as a whole, is not so thick, much having probably been removed by denuda-
The base of the flow here is, however, exposed, and at low water a bed of conglomerate may be seen underlying the toscanite. This is similar in character to the conglomerate which overlies the andesite at Nelson’s Bay. A dip fault probably occurs between Fly Point and Nelson’s Head, which has displaced the strata to the north on the east side of the fault.

Yacaaba Headland (North Head).

The sequence of strata in this headland is given in fig. 1. It will be seen that the Toscanite flow here rests directly upon the andesite flow and has a thickness of about 1,000 feet. The toscanite flow here has a glassy selvedge at its base similar to that at Nelson’s Head. The most interesting feature here is a dyke or neck of toscanite which cuts through the underlying andesite flow. In the toscanite are numerous rounded fragments of a more basic rock which is much altered but which appears to have been derived from the Andesite. Whether neck or dyke, this would undoubtedly appear to be an opening through which the overlying toscanite found its way to the surface.

As has already been pointed out, this toscanite overlies the andesite at Yacaaba and Tomaree. No andesite is exposed at Nelson’s Head or Fly Point, but may well be below sea level at these points.

No outcrop of this toscanite flow can be found immediately above the andesites which extend from Nelson’s

Fig. 1.—Sketch section through Yacaaba Headland. A, Limestone with associated Tuffs; B, Conglomerates; C, Andesite; D, Toscanite. H, Fault.
Bay to Corlette Point. The flow may have pinched out in this direction, or if it occurs, its outcrop is covered by recent sand deposits. The fact that the flow is about 1,000 feet thick at Yacaaba Head and only about 40 feet thick at Fly Point suggests that it thins rapidly in a westerly direction. The great thickness of toscanite at Yacaaba may, of course, be due to the coalescence of the Nelson’s Bay flow with some of the overlying toscanite flows of that locality.

(b) The Soldiers Point-Ghan Ghan Toscanites (No. 2 Belt).

Lying to the south of Nelson’s Bay and extending from the sea coast westwards to Seamander Bay there is a belt of isolated hills all consisting of toscanite. The strike of this line of hills is approximately east and west. After crossing Seamander Bay, this toscanite belt is picked up again on the western side of the bay at Round Head, and continues from there in a north-north-west direction to Soldiers Point, as may be seen from the map. The various islands adjacent to Soldiers Point, including Middle Island, consist of the same rock. Toscanite also occurs on the north shore of Port Stephens opposite to Soldiers Point, very massive outcrops occurring here on either side of Fame Cove. This great belt of Toscanite undoubtedly includes a number of separate lava flows. At its eastern end the double line of hills suggests at least two massive lava flows. Throughout the whole belt the rock from all the outcrops is similar in character and looks like a typical Quartz-Porphyry. It also closely resembles the toscanites occurring at Nelson’s Head and at North Head. The numerous outcrops in this toscanite belt are separated from one another by sand dunes and sand flats, and no associated sedimentary strata are visible, so that no direct observations of either dip or strike could be made.
Fig. a.
Raised Boulder Beach (Present day beach centre-left), Morna Point.

Fig. b.
Raised Boulder Beach, Morna Point.
3.— The Rhyolites.

These lava flows outcrop in the southern part of the area mapped and form a belt whose outcrop curves sympathetically with that of the No. 2 toscanite belt. Outcrops occur on the sea coast (a) at Fingal Head and (o) at Morna Point, and further outcrops occur at Bob's Farm on the east side of Tilligherry Creek, and at The Gibbers on the west side of Tilligherry Creek. Snapper Island, in the west part of Port Stephens, is probably a continuation of this belt.

Fingal Head.

At the northern end of Fingal headland there occurs an outcrop of andesite, previously referred to. Immediately overlying this is a rhyolite lava flow, the outcrop extending from here to the southern end of Fingal Head, a distance of about 160 chains. The actual thickness of this flow cannot be measured, but it is something more than 200 feet.

Morna Point.

The outcrop here is exactly similar to that at Fingal Head, and this outcrop appears to have been separated from that at Fingal Head by a large dip-fault which has heaved the strata on its east side to the north. The rock both here and at Fingal Head is indistinguishable in hand specimens from the toscanites already referred to. At Morna Point the rhyolite flow appears to be dipping a little east of south.

Bob's Farm (Fenningham's Island).

Between here and Morna Point is an extensive swampy sand flat with no outcrops. The outcrop at Bob's Farm occurs at the western edge of this flat and at the eastern side of Tilligherry Creek, and the rock here has been quarried for road-making purposes. At this locality the L-Septemler 5, 1928.
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Bob's Farm (Fenningham's Island).

Between here and Morna Point is an extensive swampy sand flat with no outcrops. The outcrop at Bob's Farm occurs at the western edge of this flat and at the eastern side of Tilligherry Creek, and the rock here has been quarried for road-making purposes. At this locality the

L.—September 5, 1928.
rhyolite is underlain by well-stratified tuffs and cherty shales, the latter containing the fossil plant Rhacopteris. Underlying this again is another rhyolite flow.

The Gibbers.

This locality occurs on the other side of Tilligherry Creek, immediately west of Bob’s Farm, and gives one of the best geological sections of the district. (See fig. 2.) The details of this section in descending order are as follow:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhyolite (No. 3 flow)</td>
<td>300 feet</td>
</tr>
<tr>
<td>Tuffs</td>
<td>15</td>
</tr>
<tr>
<td>Cherty shales with Rhacopteris</td>
<td>10</td>
</tr>
<tr>
<td>Tuffs and Conglomerates</td>
<td>130</td>
</tr>
<tr>
<td>Rhyolite (No. 2 flow)</td>
<td>15</td>
</tr>
<tr>
<td>Tuffs and Conglomerates</td>
<td>200</td>
</tr>
<tr>
<td>Tuffs</td>
<td>40</td>
</tr>
<tr>
<td>Rhyolite (No. 1 flow)</td>
<td>160</td>
</tr>
<tr>
<td>Tuffaceous sandstones with fossil plants</td>
<td>600</td>
</tr>
<tr>
<td>Conglomerates</td>
<td>800</td>
</tr>
<tr>
<td><strong>Total thickness</strong></td>
<td><strong>2,270 feet</strong></td>
</tr>
</tbody>
</table>

It will be seen that there are three distinct rhyolite lava flows here. The whole succession of strata at this locality is very similar to that which occurs in the Paterson district. The top rhyolite flow would be the equivalent of that which occurs in the railway cutting at the Paterson railway station.

4.—The Sedimentary Rocks.

The Burindi Series.

Strata of Burindi (Lower Carboniferous) age are extensively developed in the Pindimar district on the northern side of Port Stephens, but these will not be described here; the occurrence of probable Burindi strata
occurring at Yacaaba headland might, however, be referred to here. These are shown in the section in fig. 1. These strata strike E. 35° N., have a steep dip, and consist of a massive bed of conglomerate overlying a thin bed of tuffaceous limestone. The limestone is very impure, contains crinoid stems, and is lithologically similar to limestones which occur in the Burindi series in other parts of the district. The conglomerates which overlie the limestone are very massive and are crowded with pebbles from 6 to 8 inches in diameter. This conglomerate may possibly be the equivalent of the Wollarobba conglomerate which, in another part of the district, occurs at the base of the Kuttung series. Strike faulting has brought these beds against the toscaanite, which is relatively higher in the series.

Fig. 2.—Sketch Section at "The Gibbers." A, Rhyolite; B, Cherty Shales; C, Tuffs and Conglomerates; D, Tuffaceous Sandstones; E, Conglomerates; H, Alluvium.

The Nelson’s Bay Conglomerates.

These are associated with the Andesites which occur at Nelson’s Bay, already referred to. They show very little stratification and contain well-rounded boulders of all sizes up to 3 feet or even more in diameter. These boulders consist mainly of granites of various kinds, Quartz-Porphyry and Felspar-Porphyry. The material in which the boulders are embedded is very largely tuffaceous. At Corlette Point similar conglomerates occur, associated with the andesite there, but the boulders are relatively fewer in number. These Nelson’s Bay conglomerates are very similar in their lithological characters to the conglomerates which are associated with the andesites on the same horizon in the Kuttung series at Martin’s Creek, near Paterson.
The Gibbers.

Particulars of the sedimentary rocks occurring here have already been given when referring to the rhyolite of the same locality. The occurrence in these of the fossil plant Rhacopterus (Aneimites) inequilatera proves that those strata belong definitely to the Kuttung series. These strata, with their associated rhyolite flows, correspond in character and horizon with what one of us (C.A.S.)\(^3\) has previously described as the Mt. Johnson series in the Paterson district, and they are quite similar to them in their lithological characters.

The Anna Bay Bores.

Some years ago several bores were put down in the southern part of this region for the purpose of prospecting for coal. Details of the strata penetrated by these bores are given by Sir T. W. E. David in his monograph on the Hunter River coalfield.\(^1\) No. 1 bore, which is 2\(\frac{1}{2}\) miles west of Morna Point, after passing through 192 feet of recent alluvial deposits, penetrated 126 feet into a Quartz Felspar-Porphyry. This is evidently the Morna Point Rhyolite flow; the angle of its dip is given as 23°. The No. 2 bore, after passing through 192 feet of recent deposits, penetrated 257 feet of cherty shales alternating with tuffaceous conglomerates and tuffaceous sandstones. These strata dip S.S.W. at an angle of 22° and apparently overlie the top rhyolite flow. The cherts contain the fossil plant Rhacopterus.

5.—Geological Structure.

Reference to the map will show that the outercrops of the Kuttung Series form a great curve, convex to the south. In the western part of the area the strike of the strata is approximately N.N.W., and the dip westerly; from Corlette Point to Nelson’s Bay the strike is nearly east and west, and the dip southerly, while in the eastern part
of the area the strike is E. 20° N. to E. 30° N., and the dip S. 20° E. to S. 30° E. It is evident, therefore, that the general structure is that of a great plunging anticline, the axis of which strikes approximately north and south, with a pitch to the south. This conforms to the general geological structure of the carboniferous formation right along the southern margin of New England from the Pacific coast to Scone.

The probable existence of faults has been referred to (a) at Nelson's Head between West Point and Fly Point, (b) between Fly Point and Nelson's Head, and (c) between Morna Point and Fingal Head; on the accompanying geological map these faults have been joined up as shown, but, of course, this joining up is, to a large extent, conjectural. These faults are all dip faults. The existence of a strike fault has been suggested as occurring at North Head, as shown in fig. 1. This strikes about E. 30° N.

II.— Petrography.

The Kuttung lava flows fall naturally into three distinct groups: (a) the andesites, (b) the toscanites, (c) the rhyolites, extruded (with perhaps one exception) in that order.

1.—The Andesites.

These are all hornblende-pyroxene-andesites, and they may be divided into two varieties: (a) the glassy variety, (b) the lithoidal variety.

a. The Glassy Andesite.

This occurs at West Point, Nelson's Bay, where it is found at the base of the lowest andesite flow; there is a similar occurrence at Corlette Point.

Megasopic Characters.—The fresh rock is black in colour with a resinous lustre, and shows abundant phenocrysts, of felspar, hornblende and pyroxene.

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