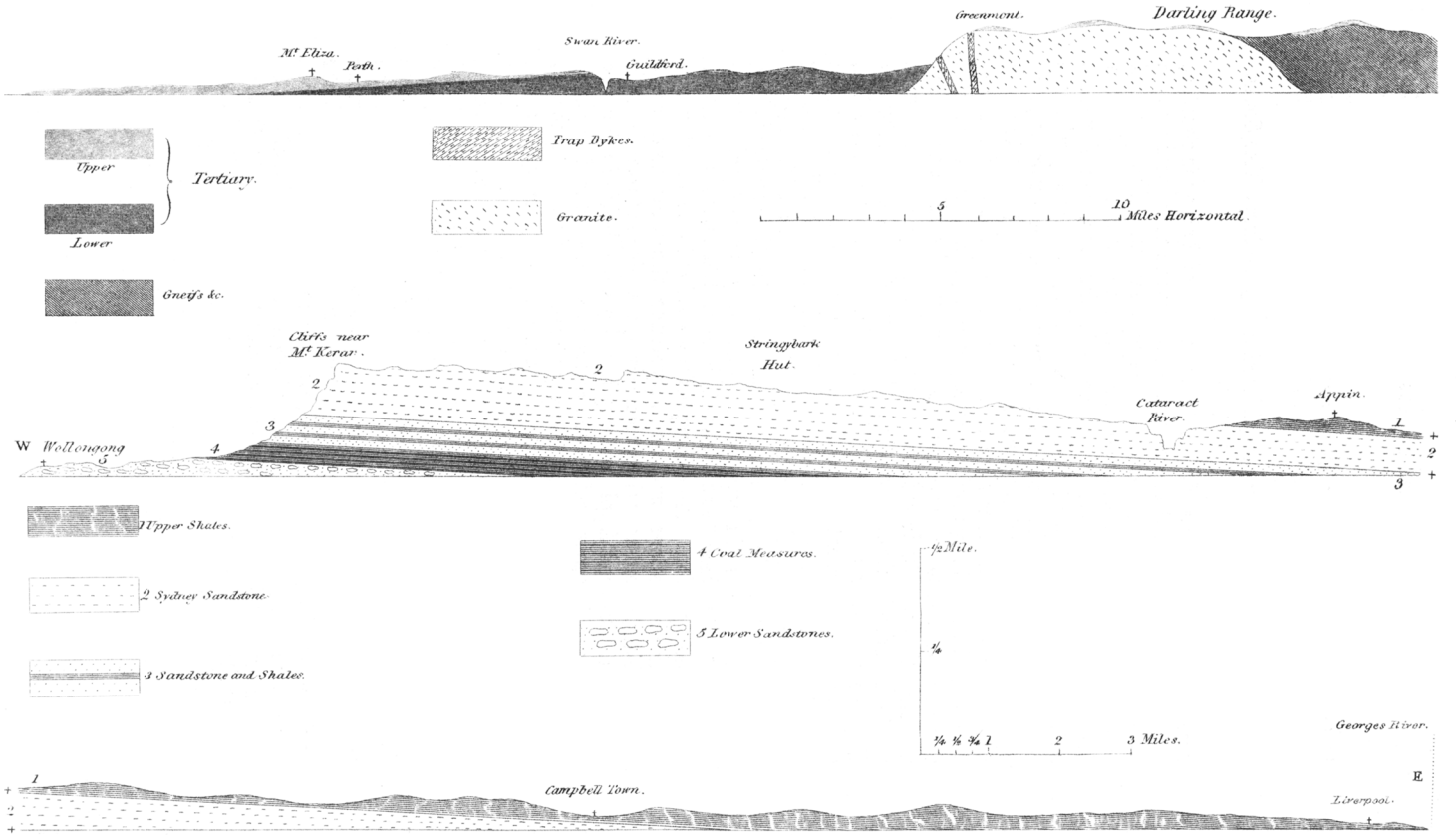


C. Wallis. Sculpt.

Notes on the PALÆOZOIC FORMATIONS *of* NEW SOUTH WALES *and* VAN DIEMEN'S LAND. By J. BEETE JUKES, M.A., F.G.S.

The Palæozoic Rocks of the neighbourhood of Sydney, New South Wales.

THE county of Cumberland, in which the city of Sydney is situated, and parts of the adjacent counties, are composed almost entirely of a palæozoic formation of great thickness and extent. The principal materials of this formation are certain shales and sandstones, with a few associated beds of coal. In the close of the year 1845 I made a short excursion across a portion of this district, in company with the Rev. W. B. Clarke. We carried with us a mountain barometer, and by taking the means of the two sets of observations made in going and returning, got such an approximate estimate of the heights of the ground and the thickness of the rocks, as to enable us to construct a section with a sufficient approach to accuracy to be relied on for my present purpose. This section runs from Liverpool (a town just at the head of the tidal waters of George's River, which falls into Botany Bay) by a slightly winding line, first S.S.W. for about twenty miles, through Campbelltown to Appin, and then about S.S.E. for about eighteen miles to Wollongong in the Illawarra district. Wollongong is on the coast about forty-five miles to the northward of Sydney.

From Paramatta by Liverpool to Campbelltown the country is low, gently undulating, and composed (Pl. VII.) almost entirely of (No .1) black and brown shales, with a few thin interstratified beds of sandstone in their lower portion. From Campbelltown to Appin the country rises into bolder undulations, and on approaching the latter town thick beds of (No. 2) sandstone show themselves, creeping out from beneath the shales. Beyond Appin nothing but this thick-bedded sandstone was to be seen for many miles, the ravine of the Cataract river showing precipices 200 feet high entirely composed of it. It rose very gradually in a wide gently sloping plateau, furrowed in every direction by innumerable winding and precipitous ravines, and covered by a forest of gum-trees, till on approaching the coast it ended in an abrupt escarpment 1200 feet above the sea. This bold escarpment stretches from the sea-cliffs of Bulli obliquely into the country, and sweeps round the valley of Illawarra, uniting towards the south with some lofty ranges which come out of the interior of the country, and which are, according to Mr. Clarke, composed of volcanic and other igneous rocks. In descending this escarpment between Mount Kerar and the Hat Hill of Captain Cook, we get the lower beds coming out from beneath the sandstone. These consisted of alternations of (No. 3) thick beds of shales and sandstone, with some conglomerate, (No. 4) shales with beds of coal, and lastly, of (No. 5) some beds of compact sandstone with calcareous concretions. These latter beds rose from the foot of the hills into a gently undulating country about the town of Wollongong. To the southward these latter rocks were cut off by a strong band of igneous rocks, principally greenstones, form-

ing a tract of country two or three miles wide, to the southward of which again were other sandstones of a dull red colour; but our time did not permit of our working out their relations with any approach to accuracy. I will now briefly describe this section in an ascending order, and glance at the extension of the rocks over the adjoining district, and at the position in which they now repose.

5. The lowest group of rocks, the Wollongong sandstones, are commonly thick-bedded, fine-grained, and either dark grey or reddish brown. They are often slightly calcareous, and contain many concretionary calcareous nodules, from two inches to two feet in diameter, which when broken open commonly disclose a fossil shell. Beds two or three feet in thickness often exhibit concentric bands of colour, or sections of spheroidal coats, and the rock has more or less a tendency to decompose along these coloured coats. This concretionary structure in one place exhibited itself on a much larger scale. A portion of the beds, twenty feet high by thirty feet long, and consisting of six or eight beds, exposed in the face of a cliff, showed on each side the coloured edges of concentric coats enveloping the whole mass. The lines of lamination of the beds passed through the enveloping coats without alteration. The coats were not more than a foot thick altogether, and peeled off as they decomposed, leaving the mass described above as a solid nucleus.

These Wollongong sandstones contained a few fragments of fossil wood and shells and corals, identified by our Curator Mr. Sowerby.

Fossils of Wollongong.

Stenopora crinita.
Producta rugata.
Spirifer subradiatus.
—— Stokesii.
—— avicula.
Pachydomus carinatus.
Pachydomus ovalis (*P. globosus*, Morris, not Sowerby).
Orthonota, sp. nov.
Pleurotomaria Strzeleckiana.
Bellerophon contractus, *MSS.*, sp. nov.

At Wollongong these beds dipped to the N. and N.N.W. at a slight angle, and in following them along the coast in that direction, as we rose on to the higher beds and approached the coal, the sandstone became charged with great quantities of fossil wood. In the level sheets of rock left by the tide at low water, great fragments of black fossil wood, with smaller chips scattered about, were exposed in the lighter-coloured sandstones, with their edges rounded and worn, and having been evidently drift-wood before they were enclosed in the rock. So like were they to common drift-wood on a beach, that I could hardly help fancying them so, until their hard siliceous substance and the difficulty of extracting them from the sandstones proved the contrary. The total thickness of these sandstones, as seen by us, was about 300 or 400 feet.

4. The coal-measures that show themselves in the cliffs, on the north part of the Illawarra district, are but very insignificant, the total thickness of the whole beds containing the coal not exceeding 200 feet. The actual thickness of the coal-seams themselves we did not ascertain, but from all we saw and heard of them, they must be but

unimportant beds in an economic point of view. Abundance of black silicified wood strewed the road where it crossed these coal-measures, and I have no doubt whole trees might be extracted with comparatively little cost and trouble.

3. Of the alternations of shales and sandstones above the coal, I can say nothing more, than that Mr. Clarke recognized them as resembling beds he knew in the valley of the Hunter, to the northward, which had the same position with regard to the coal. They were about 400 feet in thickness.

2. The thick mass of sandstone above them was called by Mr. Clarke provisionally "the Sydney sandstone." It consists of very thick beds of white and light yellow sandstones, in some places fine-grained, at others coarse, and containing small quartz pebbles. Lithologically it resembles the millstone-grit and the sandstones of the lower coal-measures of the north of England. Its beds are parted occasionally by thin bands of shale and contain no organic remains, so far as is known. Its thickness is fully 700 or 800 feet.

1. The upper shales contain a few small fragmentary vegetable impressions and bits of leaves, and I believe also some fossil fish. Their thickness must be at least 300 feet, but may be much more. The most conspicuous member of this series in the country around Sydney is No. 2, the Sydney sandstone. The districts composed of it are always rocky and barren, with a level or gently sloping outline when viewed from a distance, but when traversed are found to be eaten into or furrowed in every direction by innumerable ravines. These have almost invariably steep if not perpendicular sides, with projecting and overhanging ledges of rock. They are narrow in proportion to their length and depth, the latter often very great, and when the sandstone rises any height above the sea, becomes enormous*. The same character still continues however even below the sea-level, as it is this which gives their peculiar form to the harbours of Port Jackson and Broken Bay, with their many long winding narrow arms bounded by precipitous rocky cliffs.

The upper shales, as might be expected, form a country with very different characters, namely gently undulating plains and round-topped lumpish hills. This is shown in all the district between Paramatta and Emu Plains, Windsor and Campbelltown.

In a good physical map, such as Sir T. Mitchell's map of New South Wales, these characters become so distinctly marked, as to enable us to give at once a rough approximation to the boundary of the countries occupied by the two kinds of rock.

By this aid and by the description given me by the Rev. W. B. Clarke, joined to my own cursory observations, I am enabled to state that the country lying between Campbelltown, Paramatta, Windsor, and the Nepean River, forms a flat basin, being composed of the upper shales, from beneath which the Sydney sandstone rises out in

* See Mr. Darwin's description of two of the most celebrated valleys of this kind on the slope of the Blue Mountains (Darwin's Journal). Mrs. Meredith also describes them in her account of New South Wales.

every direction. To the westward this sandstone rises with a gradual slope high onto the range of the Blue Mountains, with the inferior rocks and the coal-measures exposed in the depth of some of its gullies. To the north it rises into a widely-spread rocky district, from beneath which come out the coal-beds now worked at Newcastle on the river Hunter. To the south, as already described, it rises into the sandstone ranges, the escarpment of which overlooks the Illawarra district, the inferior coal-measures being again exposed below it. Towards the east it rises with a very gradual slope, but before it has attained any considerable elevation is cut off by the sea, which, as before explained, has penetrated into its winding gullies in this portion and formed the harbours of Port Jackson and Broken Bay.

The city of Sydney stands, I believe, just on the uppermost beds of the Sydney sandstone, near the passage of that mass of rock into the upper shales. Considerable beds of shale are indeed to be seen around the town, resting on and interstratified with the sandstones. If this be correct, the beds of coal are about 1100 or 1200 feet below the city of Sydney, and still deeper at the town of Paramatta and in the central portion of the county of Cumberland.

The series of rocks now described are by no means set forth as representing the whole palæozoic formations of New South Wales. There are very probably higher beds than the upper shales here mentioned, as there are certainly much lower beds than the Wollongong sandstones. The limestones of the Yass country will probably be found to be below the whole of the rocks mentioned in this paper.

As a general observation, I would remark on the perfect conformability of the whole series of rocks here described and their gradual transition from one into the other. They evidently form part of one great and continuously deposited formation.

From a collection transmitted by Mr. Clarke to the Woodwardian museum of Cambridge, I have been permitted, by the kindness of Professor Sedgwick, to select the following fossils in addition to those already mentioned. They come chiefly from the valley of the Hunter; the vegetable remains from the coal-measures at Newcastle; but I do not know the precise geological or geographical locality of the other fossils.

Plants.

Glossopteris Browniana.
Vertebraria indica.
Pecopteris australis.
Phyllotheca australis.

Animals.

Favosites gothlandica.
One species of Crinoides, apparently related to Platycrinus.
A form belonging to the Radiata, and resembling an Echinoderm.
A small Trilobite.
Two new species of Spirifer.
Two species of Leptæna.
A Terebratula.
A Eurydesma.
An Inoceramus.
A Pleurotomaria.
And a Conularia.

2. *On the south-eastern portion of Tasmania.*

The two principal rock-masses of the south-eastern portion of Tasmania are a very massive rudely columnar greenstone, and the sandstone of the palæozoic formation. The igneous rocks vary from a crystalline dark greenstone, through fine-grained basalts, to a coarse cellular trap or scoriaceous lava-like pumice. The sandstones contain interstratified beds of clay, shale and loose sand, as also of limestone and coal.

From the want of a good physical map on a sufficiently large scale, and of time for a detailed examination of the country, I am unable to draw any section of any portion of Tasmania, or even to give an accurate and positive description of the order of superposition of the stratified rocks, or of their relations with the igneous rocks.

The interior of the country is rugged and broken, with many ranges of hills running in various directions, and the coast-line is indented by a multitude of bays, harbours and channels penetrating into the land with much irregularity. To the difficulty thus arising from the external features of the country, is added that resulting from great complexity in its internal structure. The sedimentary and the igneous rocks are so interlaced and entangled one with the other, and their apparent relations at the surface so different in different localities, that nothing but a careful and minute survey, laid down on maps of a large scale, will ever be able thoroughly to elucidate them.

A. *The Valley of the Derwent River.*

Along the S.W. side of the valley of the Derwent runs a bold range of flat-topped hills, of which one of the principal promontories is Mount Wellington, rising immediately behind Hobarton to a height of 4200 feet above the sea. The upper portion of this range is composed of massive greenstone, often forming rude columns of great size, frequently as much as ten feet in diameter. The lower slope of this range, and much of the country forming the opposite side of the valley, is composed of the palæozoic rocks. These lie generally in a nearly horizontal position, and I believe *abut horizontally against the greenstones*; but as I never found a clear section near the junction of the two, I cannot positively say that they do not pass under them, —that the greenstones of the hill-tops are not a thick capping resting on the palæozoic formation. In ascending Mount Wellington from Hobarton we first pass over a great thickness of white and yellow sandstones nearly horizontal; above these are shales and thin beds of limestone, likewise horizontal; over which again other sandstones are found. These rocks occur to a height of 2500 feet above the sea, and apparently form a solid mass of that thickness at least. Above this point greenstone alone is to be seen, forming a mass 1700 feet thick at least. Its total thickness depends of course on the undecided question, of whether it be a capping to the palæozoic rocks, or what I believe is much more probable, a solid mass with the sedimentary beds resting against its sides.

Both the sandstones and limestones are quarried at several points.

At Mr. Hull's limestone quarries at Tolosa, about four miles from Hobarton, I found dark grey limestone, sometimes compact, sometimes finely laminated, with fragments of shells and corals. The beds of limestone were about two feet thick, and in one place were some beds of soft brown sandstone interstratified with thin beds of limestone. These sandstones were scarcely consolidated, and fell to pieces on being taken from the quarry. They often contained fossil shells, both Spiriferi and Productæ, quite perfect in appearance, but so much decomposed as not to bear extraction, falling into white powdery fibrous carbonate of lime. I procured from other parts of these quarries the following fossils :—

Fossils from Mr. Hull's Quarries.

Corals.

Stenopora Tasmaniensis.
—— informis.
Fenestella ampla.
Fenestella internata.
—— fossula ?
Caryophyllæa.

Mollusks.

Producta rugata.
—— brachythærus.
Spirifer subradiatus.
—— Darwinii.
—— Tasmaniensis.
Spirifer Stokesii.
—— Vespertilio.
—— avicula.
Pecten squamuliferus.
—— Limæformis.

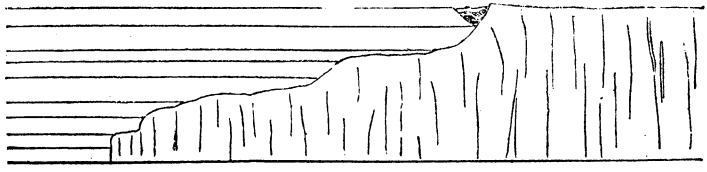
A few miles above New Norfolk, the banks of the Derwent showed cliffs consisting of alternations of sandstone with black and brown shales, producing a precise resemblance to parts of the English coal-measures. Much fossil wood, apparently parts of large trees, lay in these rocks.

Similar rocks to these were frequently observed in the cuttings of the road-side as far as Oatlands in the centre of the island, and they almost invariably lay in positions so nearly approaching horizontality, that their dip was not appreciable to the eye. Still their continuity did not appear to extend unbroken over any large district, as not only were dykes and other masses of intrusive trap rocks frequent, but solid ridges of crystalline greenstone often intervened, and evidently cut off one portion of the palæozoic rocks from the other.

In the immediate vicinity of Hobarton there were places, as near Stoke, and at the mouth of the valley of Risdon, where the palæozoic rocks had evidently been tilted up and altered by masses of trap rock, which could be traced to have a perfect passage from compact tabular or amorphous basalt into hills of solid crystalline greenstone.

In other places quarries were opened in sandstones of the palæozoic age, forming small patches either embosomed in greenstone, or resting upon it. About a mile from a place called Ralph's Bay Neck, on the S.E. side of North Bay, I found a cliff where the sandstones were shown clearly to be posterior to the igneous rock. In this case a dark, rudely columnar trap rock ended in a succession of small cliffs and terraces in one direction, upon which terraces and against which little cliffs rested the sandstone perfectly undisturbed, and evidently in the position in which it had been originally deposited.

Fig. 1.



A parallel instance was observed in the cliffs a little to the eastward of the entrance of Port Arthur.

It appears then that there are masses of greenstone both of more ancient and more modern date than the palæozoic rocks.

At Macquarrie Plains, about ten miles above New Norfolk, there is a large exhibition of igneous rock, which from its cellular character seems certainly to have flowed as lava in the open air. It forms a mass of considerable thickness, as shown in the brooks and ravines, and appears to have been gradually accumulated by successive accessions of melted matter. I infer this from the fact of its including fossil trees, apparently in the position of growth, which seem to have been enveloped while living in the lava.

There are two small patches of tertiary travertinous limestones: one mentioned by Mr. Darwin, and found in the outskirts of Hobarton, where it appears to have been tilted by the intrusion of an adjacent mass of trap; another in a little cove called James's Bay about three miles above Hobarton, on the opposite side of the Derwent. It rests here nearly horizontally, and is but little elevated above the level of the sea. A Helix and a Bulimus, and the leaves and portions of the stems of several plants, have been found in each locality.

Fossils from James's Bay.

Plants, unnamed: one figured by Morris.
Helix.
Bulimus.

There are very thick masses of gravel, consisting of pebbles as large as the fist, accumulated on the sides of the Derwent River at some places, and Count Strzelecki mentions great accumulations of loose sand from beneath which he procured a large Cypræa. This was at Newton, a short distance from Hobarton.

B. *Norfolk Bay and Tasman's Peninsula.*

The principal mass of Tasman's Peninsula appears to be columnar greenstone, forming the highest and most rugged of its hills, and the gigantic perpendicular cliffs of Cape Pillar and Cape Raoul and the intermediate shores round the entrance to Port Arthur. Just to the eastward of the mouth of that harbour, a mass of the sandstone of the palæozoic formation, a quarter of a mile across and 200 feet high, may be seen resting against these perpendicular cliffs of columnar greenstone with its beds quite horizontal and apparently unaltered.

Point Puer, one of the projections inside the port, is composed of a

white compact, rather argillaceous sandstone, which among others contains the following fossils :—

Fossils from Point Puer.

Producta rugata.	Pterinea macroptera.
Spirifer subradiatus.	Orthonota compressa.
—— crassicostatus, *MSS.*, sp. n.	Allorisma, *n.s.*
—— Stokesii.	Pachydomus carinatus.
—— Vespertilio.	Pecten squamuliferus.

Eagle Hawk Neck, the connecting link of Tasman's and Forrester's Peninsulas, is one of the celebrities of Tasmania, on account of the peculiar jointed structure of its rocks, forming what is called "the tessellated pavement." The rock is a very hard, brittle, fine-grained and compact grey sandstone or gritstone, lying in a horizontal position. It occasionally contains pebbles of granite, porphyry, or quartz rock.

The rocks abound in fossils, especially at the south point of Pirates' Bay. Among others I collected fine specimens of the following :—

Fossils from Eagle Hawk Neck.

Fenestella internata.	Spirifer subradiatus.
Producta rugata.	—— Vespertilio.
Spirifer crebristriatus.	Platychisma Oculus ?
—— Darwinii.	Pachydomus carinatus.
—— avicula.	

On the opposite side of Norfolk Bay is a small peninsula about three miles across, in which is a large convict-station called The Mines. The mass of this piece of land consists of sandstone with some trap, but immediately at the back of the station is a small colliery. A bed of coal of slight thickness and extent is here worked. The following was the shaft-section as given me by the overseer :—

	Yards.
"Ironstone" (a fine-grained trap rock) ..	20
Sandstone	20
Sandstone and shale	10
Coal	1½

This coal, which in the deepest part is about seven or eight feet thick, rises pretty rapidly in every direction from that point, and as it rises, it thins out to about two feet. It thus forms a small basin, not half a mile across, and its outcrop is everywhere covered by beds of loose sand. A little beyond its outcrop on the sea-shore was the following section :—

	Yards.
Trap (in small prismatic pieces)	7
Sandstone, formed of grains of some trap rock..	18
Sandstone, soft and rather shaly	6
Shale and bind	2
Coal	0½

Near this spot they had bored to a farther depth of nearly 100 yards and passed through one twenty-inch coal; but the rest of the mass was almost entirely sandstone. I got from these coal-measures fossil

plants, among which were *Pecopteris Australis*, a Sphenopteris and a Zeugophyllites.

There are other places in Tasmania where coal is worked, but they are chiefly detached and isolated spots separated by greenstone ridges one from the other. I was not able to visit any other of these localities, but I should fear that the beds of coal in Tasmania are comparatively insignificant in an economic point of view, that the true coal-measures of the country have no great thickness, and that the seams of coal contained in them are but partial, thickening and thinning out perhaps along the same horizontal lines, and thus forming limited cakes rather than regular and persistent beds.

C. *East Coast of Tasmania.*

Rocks of the palæozoic formation, chiefly sandstones, are found at various points of the eastern coast, but greatly broken and obscured by the usual greenstone ranges and local exhibitions of other trap rocks. In Maria Island are limestone quarries which I did not visit, but from which I procured fossils, among which were some of the large Pachydomi, of precisely the same species as those from Wollongong in New South Wales.

At Spring Vale, about ten miles above Great Swan Port, is a patch of palæozoic rocks, not more than a mile or two in extent, forming a low gently undulating ground surrounded by hills of igneous rock. No section is exhibited, but blocks of the rock protrude through the soil. It is a fine compact quartz rock, charged with the usual fossils of the formation in great abundance. The rock reminded me strongly of the quartz rock of the Lickey Hill. The fossils of this locality were—

Fossils from Spring Vale.

Fenestella ampla.
Producta rugata ?
Spirifer radiatus.
—— Darwinii.
—— Tasmaniensis.
Spirifer Stokesii.
—— crassicostatus, sp. nov.
—— three others.
Stem of a Crinoidal animal.

On a Section exposed by the excavation at the New Steam Basin, in PORTSMOUTH DOCK-YARD. By Capt. JAMES, Royal Engineers, M.R.I.A. F.G.S. &c.

THE principal fact which this section exhibits is one with which every geologist is familiar. Almost every writer who has examined any extent of our sea-coasts has alluded to submarine forests, and pointed to them as a proof of the subsidence of the land within a comparatively recent period, and I should hardly have thought it worth while to present this section to the Geological Society, if it did not exhibit the facts in a much clearer manner than usually occurs. I may however observe, that I have myself seen the remains of forests, not only along the coasts of England in localities which have been described, but also in many places along the coast of Ireland which I believe have not been previously noticed, as in the counties of