PLATE XVII.

- FIG. 1.—*Anomæodus Willetti*, sp. nov.; anterior portion of skull, viewed from the right and left (1a) sides, two-thirds nat. size. Also the left mandibular ramus, inner aspect (1b), and the dentigerous face of the vomer (1c). Lower Chalk; Glynde, Sussex. *ar.* articular; *e.* ethmoid; *fr.* frontal; *md.* left mandibular ramus; *p.op.* pre-operculum; *pas.* parasphenoid; *pt.* pterygo-palatine arcade; *qu.* quadrate; *spl.* splenial; *v.* vomer. [Willet Collection, Brighton Museum.]
- „ 2.—*Pycnodont Vomerine Dentition*, oral aspect. Greensand; Isle of Wight. [British Museum, No. P. 3758.]
- „ 3, 4.—*Pycnodont Vomerine Dentition*, oral aspect and side-view (3a). Cambridge Greensand; Cambridge. [Woodwardian Museum.]
- „ 5.—*Celodus inæquidens*, sp. nov.; left splenial. *Ibid.* [British Museum, No. 36157.]
- „ 6.—*Celodus fimbriatus*, sp. nov.; imperfect right splenial dentition. Lower Chalk; Halling, Kent. [British Museum, No. 43090.]
- „ 7.—*Pycnodus serobiculatus*, Reuss; vomerine dentition, twice nat. size. Chalk; Charing, Kent. [British Museum, No. P. 322.]
- Unless otherwise stated the figures are of the natural size.

ERRATUM.—On page 435 the numbers of the figs. of *Athrodon crassus* and *A. tenuis* are transposed; for Fig. 2 read Fig. 3, and vice-versa.

III.—ON A BED OF OOLITIC IRON-ORE IN THE LIAS OF RAASAY.¹

By HORACE B. WOODWARD, F.G.S.

[Communicated by permission of the Director-General of the Geological Survey.]

THE rocks of Raasay have attracted a good deal of attention from geologists, despite the fact that no house of public entertainment exists on the island. That portion of it which lies to the south of Brochel Castle, exhibits a base of Torridon Sandstone, above which there may be traced, more or less completely, in two faulted areas, an ascending series from the New Red rocks to the Great Oolite group. The Jurassic strata are finely exhibited in the eastern cliffs, but westwards they are largely covered by volcanic rocks, and especially by great sheets of Granophyre which descend in that direction to the sea-level. To the south-west there is a mass of Gabbro; in other parts there are sills and countless dykes of Basalt, while the summit of Dun Caan is formed of a bedded mass of that material. Coverings of Peat, of Boulder-Clay and Gravel, serve to add variety to the geology, and to obscure the outcrops of the Jurassic and other rocks.

Our knowledge of the geology is due principally to the labours of Macculloch and Murchison, followed by those of Sir Archibald Geikie, Dr. Bryce, Prof. Tate, and Prof. Judd.

Sir Archibald Geikie, in 1857, constructed a geological map of the island, on the Admiralty Chart, on the scale of about 2½ inches to a mile, but this work has not been published, except in a very reduced form on geological maps of Scotland.

In the summer of last year, I commenced the mapping of the Jurassic rocks of Raasay for the Geological Survey, on the scale of

¹ Read before Section C, at the meeting of the British Association at Nottingham.

6 inches to a mile. In the end, I have had the satisfaction of finding my work in harmony with that of previous observers; and that the main features depicted on Sir Archibald's map coincided well with the stratigraphical divisions and faults I had traced, while working independently on the far better (though by no means perfect) sheets of the Ordnance Survey.

It will be needless to refer in detail to the observations published by others, as my object is simply to record the fact that during the course of my work I came across a bed of oolitic iron-ore that has not been previously noticed.

This iron-ore occurs in the uppermost part of the Middle Lias, on top of the calcareous sandstones that yield *Ammonites spinatus*, *Gryphæa cymbium*, *Pecten æquivalvis*, *Rhynchonella tetrahedra*, *Terebratulæ punctata*, and *Walaheimia cornuta*; and beneath the dark shales of the Upper Lias that yield *Ammonites communis*, *A. serpentinus*, *A. exaratus*, etc.

The ironstone itself yields fossils, but not in abundance, and too poorly preserved for specific identification. They include *Ammonites*, *Belemnites*, *Astarte*, *Pecten*, *Rhynchonella*, and pieces of fossilized wood. The iron-ore is a greenish-grey oolitic rock, weathering brown at the surface and along the joints; and it attains a thickness of five feet. Occasionally a thin layer of oolitic ironstone occurs above the main mass, near the base of the Upper Lias shales; and from this horizon I have obtained *Ammonites annulatus* and *A. communis*.¹

The position of the Raasay ore therefore corresponds approximately with that of the Cleveland ironstone, although in Yorkshire the upper part of the Middle Lias contains a number of ironstone bands. Mr. George Barrow, to whom I showed a specimen of the Raasay ore, remarked that it precisely agreed with Yorkshire examples with which he is so familiar. In composition, as well as in other characters, the Raasay ore compares well with that of Cleveland, for analyses made by Mr. A. B. Dick show that they are practically identical. The Raasay ore yields 29 per cent. of metallic iron in the grey rock (carbonate), and 37 per cent. in the brown rock.

The iron-ore may be traced in several places on and near the footpath that leads from Loch a Mhuilinn, near Raasay Manse, towards Dun Caan, on the borders of the Inverarish Burn and its tributaries. It occurs near Macdonald's Glen, and some distance east of the main cascade, where the waters tumble over a mass of Granophyre that is faulted on the west against the Middle Lias. It may be traced for a mile at various points along this eastern outcrop; but further on towards Hallaig the strata are obscured by peaty coverings and *débris*, due to land-slipping. Again, the iron-ore may be found along the eastern slopes of Beinn na Leac, where the beds are much slipped, so that the true outcrop is almost wholly obscured. Nowhere along the grand cliffs below Dun Caan and onwards to Screapadal could I find any evidence of the iron-ore, nor was there

¹ The species of fossils collected by me were named by Messrs. G. Sharman and E. T. Newton.

any clear junction between the Middle and Upper Lias that was accessible. These cliffs rise in places, with an almost vertical face, to 800 or 900 feet; and if we include the higher steep slopes and the rough crag of Dun Caan, we have the somewhat dizzy height of 1455 feet. Hence the inaccessibility of the rocks in some places, and the landslips and tumbled blocks in others, render it impossible to follow everywhere the junction of Middle and Upper Lias. On this account it will be easily understood how the presence of the band of iron-ore escaped the notice of previous observers, who naturally devoted their chief attention to the coast-sections and to the strata displayed on the fore-shores. It was only by examining all exposures of the strata in banks and braes, and along the beds of burns, that I found the iron-ore *in situ*, and ascertained its persistence on the same horizon where the strata are exposed.

Dr. Bryce noticed the occurrence of "slightly ferruginous bands" in the Middle Lias, near Portree, in Skye; and he observed also, in the Upper Lias, a band of "nodular blue limestone, showing oolitic structure." These facts I can confirm from a general examination of the cliffs north and south of the entrance to Portree harbour; but I failed to find any evidence of a band of iron-ore equivalent to that of Raasay. The facts now brought forward, however, serve to strengthen the remarks of Dr. Bryce in reference to the Jurassic strata of Skye and Raasay, for he says: "The lithological characters of the beds have a remarkable similarity throughout, and a close resemblance to the structure of the beds on the Yorkshire coast."¹ I may add that I was greatly struck with the general similarity between the lithological characters of the several divisions of the Lias and underlying Red rocks in Raasay, and those familiar to me in the West of England; and among the fossiliferous rocks this similarity in lithology is accompanied by many identical organic remains. The Oolitic Series approximates more closely to the Yorkshire type.

IV.—THE RECENT GEOLOGICAL HISTORY OF THE ARCTIC LANDS.

By SIR HENRY H. HOWORTH, K.C.I.E., M.P., F.R.S., F.G.S.

SINCE writing my previous paper on the question of whether, during the so-called Glacial period, the Arctic lands had a milder and not a more severe climate, I have met with some evidence on the subject so important and suggestive that I feel sure it will be welcome to some of your readers, especially as it involves a considerable departure from conventional views. In 1861 Sir Joseph Hooker wrote his famous paper on the distribution of Arctic plants, in which he argued that the flora of Greenland is distinctly of European type; that Greenland is a sub-region, in fact, of the Scandinavian Botanical province. To state his own conclusion in his own words, "the flora of Greenland is almost exclusively Lapponian, having an extremely light admixture of American or Asiatic types." This view had already been maintained by Charles Martins in 1839, although he had not the same materials

¹ Quart. Journ. Geol. Soc. vol. xxix. p. 338.