

EXPLANATION OF PLATE XI

Fig. 1. *Palaeoniscus superstes* (from Rowington, Warwickshire), natural size.

Fig. 2. Ditto. Counterpart of the same.

Fig. 3. Anal fin, enlarged 4 times.

Fig. 4. *Palaeoniscus catopterus*, from Roan Hill, Tyrone.

7. *On the NEWER RED SANDSTONE, and on some other GEOLOGICAL PHENOMENA, near LOCH GREINORD, in ROSS-SHIRE.*
By JAMES NICOL, F.R.S.E., F.G.S., Professor of Natural History, Aberdeen.

Newer Red Sandstone.—In several passages of his work on the Western Isles, Dr. Macculloch refers to the occurrence on the shores of Loch Greinord of two small spots of a red sandstone of newer age than the great mass of similarly coloured rock which forms so conspicuous a feature on the western coasts of the Highlands*. In his memoir on the Geological Map of Scotland he also several times mentions this formation†, which he considered as the only undoubted instance of the occurrence of the “Red Marl” of English geologists in the northern part of the island. Although evidently regarding these beds with much interest, he has not given any detailed description of them. In their valuable memoir on the formations in the North of Scotland, Professor Sedgwick and Sir Roderick I. Murchison likewise mentioned this deposit, and pointed out its resemblance to the New Red of England, and also to some beds seen below the Lias in Skye‡. This sandstone does not seem to have been subsequently noticed by geologists, probably from lying in a region so seldom visited by the scientific traveller. I have therefore been induced to lay before the Society the following notes collected in an examination of this deposit in the autumn of last year (1856).

The great headland of the Ruimore or Ru Rea that separates Loch Greinord from Loch Ewe consists chiefly of the older red sandstone of the west coast, covered more or less deeply by drift or detritus. On the shore of Lake Greinord the sandstone is well seen in thick, undulating, or slightly curved beds, dipping at 40°–45° to E. 5°–10° S. It is usually a fine-grained grit, of a reddish-brown colour, occasionally with a tinge of green, but becomes black when weathered. As this rock was fully described in my paper on the Red Sandstones of the North-west coast of Scotland, its mineral characters need not be noticed further§. Near Sands and Udrigill, the newer sandstone

* Macculloch's Western Isles, vol. ii. pp. 65, 99.

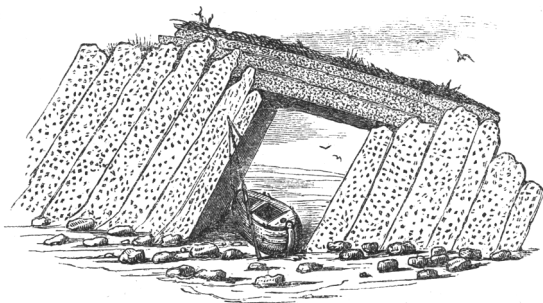
† Memoir on Map, pp. 31, 89, 94.

‡ Transact. Geol. Soc., New Series, vol. iii. p. 156.

§ Quarterly Journal of the Geological Society, vol. xiii. p. 17. In that memoir I considered this red sandstone as probably of Devonian age, or the equivalent of the true “Old Red” of other parts of Scotland. In the present paper, however, I have generally designated it only as the “Older Red Sandstone,” in contradistinction to the “Newer Red” resting on it; thus avoiding any assumption in regard to its age. Sir R. I. Murchison, however, regards it as the representative of the Cambrian of Wales.

formation referred to is well exposed, resting unconformably on these older beds at a low angle. The first bed seen in the cliffs is a coarse conglomerate or breccia, composed of slightly rounded fragments. Some of these were evidently derived from the older red sandstone below. I had no hesitation in identifying others with the quartzite of the neighbouring mountains, though often of a softer texture, and more like a white sandstone than the hard vitreous rocks of Ullapool and Assynt. More interesting were the fragments of limestone, often of a blue colour and compact, at others reddish white and more crystalline, which made up a large portion of some beds. These again I regarded as derived from the limestone that overlies the quartzite series; and as the fragments were from two to four inches in diameter, and had apparently undergone less alteration than the rock where still seen *in situ*, I had hopes that they might contain some recognizable petrifications. With this view I examined a large number, but did not succeed in finding any trace of organization.

Above this conglomerate or breccia, are strata of a soft friable sandstone, forming the larger part of the deposit. It is generally of a red colour, in other places reddish white, or again red mottled with green and blue. In some parts it contains much calcareous matter, effervescing strongly with acids, and appears to be easily acted on by the sea and atmosphere, the surface having that carious and corroded aspect so common among red sandstones.



These newer beds dip at about 10° to N.W. (true); and, as shown in the subjoined sections, have been deposited amid the broken ends of the older sandstones. The newer rock forms a natural archway (see fig.), supported on walls of the older rock, and partly converted by the fishermen on the coast into a rude hut to shelter themselves and their implements from the weather. As shown in the figure, the shore is here covered with huge boulders of the older red sandstones, of granite, and the green-coloured gneiss, or hornblende rock common in the mountains in the interior.

This newer sandstone is of very limited dimensions, being soon cut off towards the west by lofty cliffs of the older red sandstone forming the high land towards the extremity of the peninsula. It also does not extend far into the interior, where the older rock is soon

seen rising through thick masses of drift containing large angular boulders of gneiss. This covering of detritus and the frequent breaks in the sections render it difficult to estimate the thickness of the newer sandstone, but it probably does not exceed 100 to 150 feet.

Age of Beds. Lias Boulders.—The absence of fossils renders it impossible to determine the exact age of this curious deposit, and its mineral character throws no light on the question. The position of the beds and the fragments contained in the upper formation, prove that it belongs to a far more recent period than the underlying red sandstones. The wide interval that separates it from the newer secondary rocks of Skye will also scarcely permit us to trace out even a probable connexion. The only indication of these newer formations which I could discover in the vicinity was on the other side of the peninsula, on the shore near Tinafuline, opposite to Island Ewe. The coast there is strewn with great numbers of fragments (from one or two inches to a foot or more in diameter) of a compact white limestone, and so numerous that the farmers in the neighbourhood have collected them to burn for lime. This rock is clearly distinct from the older limestones, or that imbedded in the newer breccia. Though the fragments are apparently little worn by transport, and so abundant, I could not find any rock from which they were derived. The limestone contains pieces of black carbonized wood, and a considerable number of fossil shells. The latter almost all belong to one or two species of *Ostræa*. Some of them resemble the *Ostræa irregularis*, Goldfuss, of the lias, and others the *O. Hebridica*, described by Professor Edward Forbes in his paper on Loch Staffin*. Another shell is perhaps a fragment of the *Potamomya? Sedgwickii* of that paper. There can be little doubt, therefore, that these fragments belong to the same formation as the oolite of the north of Skye; and, as they have evidently not been transported from a great distance, their occurrence indicates that these rocks must formerly have had a much wider extension than they now possess, the distance from Loch Staffin being about thirty miles in a direct line†. They also render it probable that the red sandstones are of the age of the Trias, or perhaps of the Lower Lias. These fragments of the oolite are, I believe, the most northern traces of its existence on the western shore of the mainland yet observed.

Deductions.—Assuming this, therefore, as the more probable age of the newer red sandstone, it follows that the older red sandstone had been raised up on edge and undergone considerable denudation previous to the deposition of the lias-beds of the Western Islands. The softer and less metamorphic condition of the enclosed fragments of the quartzite and limestone, than of the same rocks now seen *in situ*, might lead to some curious speculations. It would, however, be wrong at once to infer that these changes in the older rocks have

* Journ. Geol. Soc. vol. vii. p. 110, plate 5. fig. 4.

† Besides the shells and carbonized wood, this limestone contains curious grey-coloured patches with white spots, like little masses of volcanic ashes. These seem to me to show that volcanic action was going on in the neighbourhood at the time these beds were being formed.

been effected subsequent to the deposition of the newer sandstone. It is evident that any process of denudation would necessarily first affect the higher, or outer, parts of the strata, which, if the metamorphic action came from below, as we must assume, would of course be the softer and less altered. The parts left behind would, for the same reason, and also from the greater power of resistance, be the harder and more metamorphic. In conformity with this view, we observe that the smaller fragments of the older red sandstone embossed among the gneiss mountains on the east are far harder than the larger and more continuous masses of the same rock.

It must also be remembered that the denudation of the older red sandstone, though begun at this early period, was continued long after its close, or, to speak accurately, is still going on even at the present time. These small spots of newer (Triassic) red sandstone are indeed but very inadequate representatives of the enormous mass of matter which has evidently been removed from the once continuous platform of the older sandstones. The amount of the calcareous matter in the newer beds is important, as showing that, at the time of their formation, the upper or limestone portion of the series was furnishing more than a proportionate share of the material, and hence probably that the denuding processes had only been going on for a short time. But the same agents of change which affect the higher and older rocks must have acted also on this newer deposit; and we are therefore justified in regarding the portion that is now seen as a mere fragment of what it may once have been.

Glacier-moraines.—I have several times already referred to the immense number of large boulders of gneiss and other primary rocks spread over the surface of this district. In general they are arranged in no apparent order. There is, however, one remarkable exception, which I must shortly notice, as probably indicating the mode in which some of them at least have been transported from their native mountains. Near the top of the acclivity between Loch Greinord and Loch Ewe, the road crosses an enormous ridge of stones rising up abruptly from the moor. It runs in a line from E.N.E. to W.S.W., and at its northern extremity is met nearly at right angles by another similar ridge, running S.S.E. towards the high mountains north of Loch Maree. The outer or north-western side of the ridge consists of large loose angular stones, and the interior of the mound of similar stones mixed with sand or clay. These stones were principally white and grey gneiss, hornblende-rock, and red sandstone, but I also observed one or two specimens of mica-slate, containing garnets. They thus consist of the very materials which the mountains on the south-east would furnish to any powerful denuding agent. And the form and arrangement of the stones left no doubt in my mind that this agent had been a glacier, cradled in the mountain-valley in which Loch Fuir now lies. The first ridge would then form the terminal, the other the lateral moraine. Some other peculiarities confirm this view. The ground behind the ridge slopes down to a small lake, lying as it were in the mouth of the opening in the mountains whence the icy stream has flowed. The stones therefore must have been

forced across this lake without filling it, and up the acclivity on which they now rest. Within the mound also, or between it and the lake, are many detached heaps of stones and detritus, as if left by the glacier in its retreat. The singular aspect of this remarkable accumulation of angular stones, at once arrests the attention of the spectator, and leaves no doubt that they must have been brought together by a very different agent (or, at least, acting in a very different manner) from the one, however powerful it might be, that laid down the large boulders irregularly scattered over the moor to the west.

8. *On the UPPER and LOWER BOULDER-CLAYS of the GORLSTON CLIFFS in NORFOLK.* By JOSHUA TRIMMER*, Esq., F.G.S.

DURING a recent visit to Norfolk, my friend, the Rev. Mr. Gunn, kindly drew my attention to a fact which cleared up some anomalies that had previously perplexed me while adopting the classification of previous observers respecting the tertiary deposits of the district, which are more ancient than the Boulder-clay.

The new fact then brought to my notice, while it removes those anomalies, confirms the views which I published in 1847 of the boulder-clay being the littoral deposit of an arctic sea advancing over sinking land†.

It appears that in the Gorlston Cliffs there are two boulder-clays separated by a mass of sand, which, on the authority of Woodward, has hitherto passed for the Crag, a term which has now become as indefinite as that of "drift" or "drifts." The lower boulder-clay is the tailing-off of that so well known for its blocks of Scandinavian origin, and which extends over the north of Europe and into the eastern side of England. The upper boulder-clay is characterized by an abundance of oolitic detritus. I had traced these oolitic boulders over the south of Norfolk to the point at which they crossed the chalk-ridge of the Swaffham Downs at Lopham Ford, and I had supposed that the oolitic and the Scandinavian erratics met on the same level; whereas Mr. Gunn's observations establish the fact that the former overlaps the latter, with a mass of sand interposed. In my examination of Norfolk during the three years preceding 1847, I had bestowed only a slight examination on those cliffs, as being out of the district on which I had undertaken to report; and the anomalies in the structures which had perplexed me were these. The base of the whole series at Cromer and Gorlston is the green fluvio-marine clay and the fossil forest which it supports; and, if the sands which succeed it are the Crag, we have the forest in one case above the Crag and in the other below it. This anomaly will be found noticed in my paper in the Journal of the Royal Agricultural Society, though I did not attempt to explain it.

* Owing to the lamented decease of Mr. Trimmer since the reading of this paper, it has not had the benefit of being revised by him previously to publication.—ED. Q. J. G. S.

† Journ. R. Agricult. Soc. vol. vii. part 2; also Quart. Journ. Geol. Soc. vol. vii. p. 19.