16. *The LIMESTONE of DURNES and ASSYNT.* By C. CALLAWAY, Esq.,
M.A., D.Sc., F.G.S. (Read January 5, 1881.)

It is well known that the late Sir R. I. Murchison based his determination of the Ordovician (Lower Silurian) age of the greater part of the Scottish highlands upon the discovery by Mr. C. Peach of Ordovician fossils in the Durness limestone. The views of Murchison were shared by many distinguished geologists, and have been generally accepted as one of the most assured and important conclusions of modern geological science. Wishing to ascertain for myself the truth of this opinion, I devoted a portion of last summer to the study of the limestone at Durness and Inchnadamff. I selected these localities because they alone are alleged to have yielded fossils from the limestone, and because Murchison regarded them as of primary importance in the construction of his argument. My researches led me to the conclusion, not only that the sections were broken, and therefore untrustworthy, but that the relations of the several rock-groups were inconsistent with the supposition that the limestone passed below any part of the newer metamorphic series. On my return from Sutherland, I found that many of my observations agreed very closely with those of Prof. Nicol; and I am glad to bear testimony to the accuracy of an author whose work has hardly received due recognition. It is certain that he made out many important points which escaped the observation of his distinguished rival; and I must, in candour, acknowledge that he has anticipated many of the results which I have now to submit to the Society. I can only claim to have ascertained some additional facts, which seem to me to strengthen the case against the received opinion.

DURNES.

a. *The Limestone in Relation to the Flaggy Gneiss.*—In his later papers, Murchison admitted that the limestone was separated from the flaggy beds* by a “great fault,” by which the “upper quartzite” was thrown down out of sight; but he, notwithstanding, held that the limestone was “overlain by the upper series of quartzose and gneissic rocks,” apparently on the ground that both dipped in the same direction, to the east. Admitting his facts, his reasoning is obviously fallacious, and might be employed to prove the most opposite conclusions. But I cannot accept his facts. Neither the limestone nor the flaggy group dips to the east. The true relations of the two formations are shown in the annexed plan (fig. 1), which is, in outline, a reduced copy of the new ordnance map. The most important dips are shown by arrows.

* These flags are a true schist, though they are far less coarsely crystalline than the Lewisian.

Fig. 1.—Sketch Map of the Durness Area.
(Scale, about $\frac{1}{4}$ inch to 1 mile.)

The fault f_1 runs from sea to sea, east and west, exactly at the base of Far-out Head, which is entirely composed of thin-bedded gneiss and quartz-schist, dipping steadily to the north-east, except at some points a mile north of the fault, where the dip is consequently unimportant.

West of the ruined church, where the limestone contains numerous fossils, the dip is north-east, so that it might seem as if it passed beneath the schist. But here the nearest exposure of the latter is over half a mile to the north-east, the intervening area being occupied by blown sand, so that no junction can be seen. Further examination proves that this dip of the limestone is exceptional.

Following the strike of the schist to the south-east, we trace it right up to the fault. Both rocks are here clearly exposed, the flags on the shore and in the adjoining field, and the limestone in a low cliff, which is an inland extension to the west of the precipice of Creag Chearbach. The fault runs along the base of the cliff. The flags dip uniformly to the north-east, the nearest section being only twenty yards from the limestone, which, at this point, dips east-

south-east. Several dips taken in this locality were the same, others veered round to the east, but none to the north of east.

Following the cliff along to the west, and noting the prevalence of south-easterly dips, we come, at about two furlongs east of Baile-nacille, to a small arch of limestone, with dips ranging from south-east to north-east. Such local variations are obviously unimportant. In the area south of the fault the dips are almost uniformly to the south-east, as may be seen at many points between the inn and Sangomor.

Coming back to the west of the old church at Bailenacille, we find the north-east dip soon changes to east, and then to east-south-east, and on the Kyle of Durness the limestone forms an escarpment over a mile long, striking south-south-west and dipping clearly to the east-south-east. At many other points in the area round Durness the same dip is seen.

It is then certain that the mass of limestone lying south of the flags, and in immediate contact with them, dips south of east, northerly dips being quite exceptional, and then occurring only at a distance from the schist. As the latter dips steadily to the north-east, it is difficult to see how it can be conformable to the limestone.

But a more comprehensive view of the district presents the received view in a still more incredible light. East of Sango Bay is the Smoo mass of limestone. Though separated from the Durness area by a faulted strip of gneiss, it preserves the same south-south-west strike. East of Sangomor it steadily dips east-south-east, at Smoo it is about horizontal, but west of Sangobeag it turns up to the south-east and a syncline is formed. On the promontory of Leirinmohr some of the dips are nearer south than east; but in no case have I observed in the Smoo mass the north-easterly dip of the altered series.

As Murchison himself admits that higher up the valley the limestone is faulted against the old gneiss on both sides, it is needless to follow it further.

b. *Gneiss of Sango Bay*.—Between the two limestone areas is a band of schist. On the shore it is well exposed, not “thrust about in dire confusion,” but forming a symmetrical half-dome facing to the north-east. On the east side, within a few yards of the limestone, and dipping towards it obliquely (that is, to east-north-east, at 40°), is hornblendic and chloritic gneiss. Towards the west the dip curves gradually round to north-east and north, and the gneiss is then underlain by dark mica-schist, which soon occupies the shore, the dip turning round to north-north-west, and finally to north-west, as if it would pass beneath the limestone which crops up in the shore close at hand, and is seen in the cliffs with its usual low south-easterly dip. There is no doubt that this strip is faulted (f_2 and f_3) against the limestone on both sides.

This gneiss is of the same kind as that which underlies the flaggy schist on Far-out Head and east of Loch Erriboll, and it must not be confounded with the Lewisian, which in this district is **very** massive, coarsely crystalline, and almost vertical in its dip. Accord-

ing to received views, this newer gneiss must overlie the limestone; and, if so, the force which contorted the former must also have affected the latter. But though the limestone comes up to the gneiss on both sides, its gentle south-east dip is not changed. It would appear to be more reasonable to infer that the limestone was deposited on the contorted gneiss, and that the latter was subsequently thrust up through the former between two parallel faults.

c. *The Quartzite.*—The bay between the limestone promontory of Leirinmohr on the west and the headland of Lewisian gneiss on the east is occupied by the quartzite, which is also seen sloping down from the flanks of Ben Keannabin to the bay and forms a small outlier on the headland just named. It dips uniformly to the north-east. In the western angle of the bay it is faulted (f_1) against the limestone. Both limestone and quartzite are crushed into thick breccias at the junction, and on the bank immediately above the limestone is seen dipping to the north-west, the strikes of the two formations being, as in the former case, nearly at right angles.

To sum up these results, it is clear that the metamorphic rocks, quartzite and schist, have been affected by a force tilting them up to the north-east, while the limestone forms a syncline whose axis strikes to the south-south-west. How the limestone can hold a conformable relation to the altered groups is a problem which the advocates of the received view may fairly be called upon to solve.

Though the metamorphic rocks occur in three distinct patches, it is probable that they form a true succession. To the east of Loch Eirriboll, the quartzite is overlain by gneiss of the Sango-Bay type, which is surmounted by the flaggy group on Loch Hope. In Durness the Sango-Bay gneiss must overlie the quartzite, since the latter rests on the Lewisian gneiss; and if the flags of Far-out Head were prolonged on the strike to the south-east, they would overlie the newer gneiss.

ASSYNT.

The section on which Murchison placed chief reliance is the succession on the south-west slope of Cnoc an drein, above the church. As I entirely differ in my reading, I submit a section of the ground (fig. 2), in which I have carefully excluded hypothesis and have simply inserted the facts observed.

Fig. 2.—Section above Inchnadamff Church.

Just above the road we come to a band of dark limestone, which is succeeded by a white zone. Beyond a little hollow, quartzose flags are followed by similar dark and white limestones, which are probably a repetition; then in succession we have felsite, limestone, and felsite. Hitherto the dip of the bedded rocks has been to the north-east. Above the felsite is a considerable thickness of quartzite dipping east, so that if it overlies the limestone it must be unconformable. Higher up the quartz-rock dips for some distance to the south-west. Approaching the summit of the hill, felsite appears, and just beyond is massive quartzite dipping steadily to the south-east for a considerable distance.

It is obviously unsafe to base a succession upon such a broken section as this. Passing over the intrusions, it is certain that more than one fault* occurs, and that the strike of the limestone is at right angles to the main mass of the quartzite. But a still more decisive refutation of Murchison's views remains.

Following the strike to the south-east it is seen gradually to recede from the quartzite ridge, while opposite dips by degrees come in on the northern side of the limestone band, which thus expands in the plateau of Stronchrubie into a broad syncline, the northern side of which dips away from the quartzite, that is, to the south-west. Towards the ridge the limestone dips grow steeper and at last approach the vertical. Climbing the face of the mountain above, the quartzite is seen to dip to the north of east, so that the dips of the two formations are in opposite directions. As the northern side of the syncline gradually disappears towards Cnoc an drein, it is obvious that it is cut out by a fault, so that the southern side of the basin is brought against the quartzite and appears to dip below it. These facts are illustrated in fig. 3.

Fig. 3.—Plan of Limestone and Quartzite at Inchnadamff.

* Almost certain at F₂ and F₃.

There is another difficulty in the reception of the old view. According to Murchison, the limestone is conformably overlain by the great mass of quartz-rock which rises into the lofty peaks of Ben More. If so, then the limestone basin of Stronchrubie must have been covered by an equal thickness of quartzite. It is for the followers of Murchison to show how denudation could have cleared off the entire mass of such an intractable rock as quartzite from the limestone, and yet have made so little impression upon the mountain-ridges which overhang.

The quartzite which slopes down from the south-eastern face of Queenaig passes up through a continuous quartzite ridge into Ben More. It is not pretended that the limestone occurs in this line of section; but it is very singular that it should have thinned out just where its presence would have been of decisive value.

One important and suggestive fact remains. At both Durness and Assynt the limestone forms a symmetrical basin, the axis of which does not agree with the normal strike of the rocks which are supposed to overlie, but which *coincides with the axis of the existing valley in which it lies*. In Assynt the axes strike to the south-east, at Durness to the south-south-west.

I do not at present press these conclusions beyond the districts observed, but submit them as an instalment towards the solution of a great question.

DISCUSSION.

The PRESIDENT said he had twice visited the area, and felt difficulties in tracing the succession of the rocks, especially as to the asserted recurrence of the quartzites. The fossils proved the limestone to be of about Arenig age; certainly the limestones seemed to lie in a synclinal basin on the quartzites.

Prof. Judd said that, after several visits to the district, he felt great difficulty in offering an opinion as to the succession of beds; he thought the simple sections commonly drawn to illustrate the geology of the country did not hold good. He considered that Prof. Nicol had made good his position as to there being only one quartzite and one limestone; but as to the relation of these to the gneiss, there was great difficulty in arriving at a satisfactory conclusion.

Dr. Hicks agreed that the limestone series sometimes lay in synclinal folds of the quartzite; but he thought there might be two quartzites, as in a case he had recently noticed in another region along the same line further south. He was thoroughly satisfied that the series was newer than, and did not underlie, the eastern gneiss.

Mr. HUDLESTON observed that Dr. Callaway's mapping of the Durness area coincided with Sir R. Murchison's section as to the limestone being troughed, and also as to the reversed position of the two gneisses. Further south the quartzites and limestones appeared to be intercalated, as at Loch Erriboll, where *Orthoceras* had

been obtained from the quartzite, tending to show that the two rocks hang together. The Assynt series, though less distinct than that at Loch Erriboll, was not inconsistent with such an idea. The unequal tension of the two rocks might in part account for local discordance of strike.

Dr. CALLAWAY could not agree with Mr. Hudleston as to his interpretation of the Durness section; such discordant strikes were incompatible with the idea of a conformable succession; nor did he agree with his view of the Loch-Erriboll rock. He accepted the age of the limestone.