(*Mr. J. W. Salter*). In the limestone at Ardwick, near Manchester, Upper Coal-measures (*Phillips, Binney, Salter*). In a bed thirty yards above the Arley Mine, Middle Coal-measures, at Bolton-le-Moors (*Mr. J. W. Salter*). These localities are in the Coal-measures of England and Wales.

(*To be continued in our next Number.*)

V.—ON THE PRE-CAMBRIAN ROCKS OF WEST AND CENTRAL ROSS-SHIRE.

By HENRY HICKS, M.D., F.G.S.

WITH PETROLOGICAL NOTES.

By T. DAVIES, F.G.S., of the British Museum.

PART III.

Glen Laggan and Glen Docherty.

THE rocks described by Mr. Davies in Notes 15–20 belong to the newer series, and were collected as nearly as possible at the points indicated in the sections. They are here described for comparison with the older rocks already referred to, and with the rocks to be further mentioned to the east of this line. I selected intentionally for examination those which appeared most highly altered, or otherwise to have any resemblance to the old rocks; as it is well known that Prof. Nicol considered them to belong to that series, and not to the newer groups. The petrological evidence as given by Mr. Davies proves that they are in no way allied to the gneiss rocks of the old formation, and that they are not sufficiently metamorphosed to be allied to any schists of known Pre-Cambrian age in these areas. These facts, combined with the physical evidence of the discordance in strike also almost everywhere apparent, seem therefore conclusively to prove that they cannot be of Pre-Cambrian age, but that they belong to a much younger series, and overlie the limestone group found along the west side of Glen Laggan.

Nos. 17 and 18 were collected almost immediately upon the limestone, in the line of Section III., and hence at a lower horizon in the succession than the others. There can be little doubt that these at least form a part of that group. They are flag-like in character, of a dark bluish tint, and sometimes of a very fine grain. They alternate, however, in some places, with almost pure sandstone bands. Near the diorite they are considerably twisted about and crushed. The usual dip is to the S.E., and here at a moderately high angle. There is distinct evidence of considerable disturbance and faulting at this point. The next series, *f*, though not actually seen here to repose upon the limestone group, appear undoubtedly to overlie some comparatively unaltered sandstones and flags, and, I believe, unconformably. If these belong to the limestone series, then the evidence seems to show that we have a physical break at this point in the succession. If this is a fact, much of the difficulty experienced in unravelling the sections to the N. and S. along this line is easily explained. In some it would appear as if the

limestone group was altogether absent, whilst in others this would be seen to spread out perhaps to a great thickness, and from all the evidence that has been collected this seems to be very much the case. Moreover, there are some indications also of an actual overlapping of the limestone beds by some flaggy sandstones towards the upper end of Glen Laggan, along the west side; but further examination is necessary before this can be accurately ascertained. In Section II. the unconformity between the series *f* and the sandstone below is tolerably well marked.¹

The rocks examined, belonging to groups *e* and *f*, seem to be about equally altered along this line, being most so when in contact with igneous dykes, or faults; and scarcely at all, or not more so than is usual in rocks of Silurian age in other areas, when unaffected by these causes.

Along the east side of Glen Laggan the groups *e* and *f* are seen at several places to rest upon the upturned edges of the Pre-Cambrian rocks. The latter composed mainly of granitoid gneiss and dark mica schists, as described in Notes 13 and 14. These strike from N.W. to S.E., and are therefore entirely discordant to those which repose upon them. This same discordance in the strike of the beds, and difference in mineralogical characters, may be traced eastward in Glen Docherty, with but slight interruptions only from want of exposures, for several miles. The lower rocks everywhere a highly metamorphic group, with a high dip and a strike from N.W. to S.E.; and the upper unequally altered, never for any distance truly metamorphic, and always at a low angle, and with a strike from N.E. to S.W. Towards the upper end of the Glen the lower rocks are seen to ascend to a considerable elevation, and are there cut through by the road where it begins to descend into the Glen. These lower rocks at this point consist chiefly of reddish highly felspathic gneisses, described in Notes 21 and 22.

[NOTE 21.—Is macroscopically exceedingly fine-grained, almost compact, of a reddish colour, consisting of felspar, and shows no indications of foliation. The microscope shows that it is composed of closely developed crystals of felspar, almost wholly orthoclase, which is much decomposed; the interspaces, which are small, being occupied with quartz and calcite. The latter also fills fissures, and is of secondary origin. No mica is present, unless a yellowish-grey nearly opaque substance may be regarded as representing this mineral. A pale-coloured garnet, in very small crystals, is scattered throughout. Indications of a tendency to a foliated structure, though not striking, are not wanting.—T.D.]

[NOTE 22.—A fine-grained rock, of a reddish colour, with much red felspar and a colourless mica.

A thin section discloses intimately crystalline quartz in wavy bands, with much decomposed felspar, which is principally orthoclase. The colourless muscovite, though occasionally in fairly continuous bands, is also generally distributed in isolated laminae,

¹ It is however too strongly indicated in the section, and carried up too high into the cliff.

which, however, are approximately parallel to the plane of foliation.—T.D.]

No one, I think, can read Mr. Davies's descriptions of the rocks 13 and 14, and 21 and 22, which mainly make up what I consider the Pre-Cambrian floor along this line, and not realize that they are petrologically very unlike those described by him in his Notes 15–20, from the higher beds along the same line. The latter in all cases, it matters not from what part they are selected, always contain fragments unchanged, and have their detrital origin still well marked; whilst the former are always crystalline throughout, and retain little or no indication of their original condition. It has been supposed by some, since I first pointed out this discordance in the strike of the upper and lower rocks in Glen Docherty, that it is entirely due to faulting, and that the upper beds with a low angle of dip and a N.E. strike have been twisted so as to appear below at the high angle and with a N.W. strike. If this occurred at one point, or for a short distance only, it might perhaps be possible; but that it should extend for several miles, and include both sides of the Glen, is, I venture to say, highly improbable, if not utterly impossible; and those who have made the suggestion could not, I think, have attempted to realize the physical difficulties of such an occurrence. Moreover, as explained above, the petrological evidence also is opposed to such a view.

I have to express some regret for having allowed the section in my former paper to appear without a fuller explanation, though I clearly stated in the discussion that it was "a rough diagrammatic one," and that the angle at which the beds were drawn was much too high. The dip intended to be shown also was only for the escarpment in Glen Laggan, and its continuation at that angle eastward was a pure mistake. Section II. in the present paper, taken further south in Glen Laggan than the former one, and more immediately along the Glen Docherty heights, will explain more clearly what was there intended to be shown. I believe, however, that few only of those who read my former paper intelligently have found any difficulty in realizing what was meant; but as some have apparently failed to comprehend what was intended, I trust the present illustrations will enable them to do so. The following passage, taken from my former paper,¹ appears to me sufficiently explicit on this point, and should have prevented any misapprehension, though the section was accidentally distorted:—"The question as to how the Silurian rocks could have been brought into the positions indicated in the latter part of the section, is a difficult one. Is it the result of a natural overlapping of the older rocks eastward by these newer rocks? or have they been brought into this position by faults? I saw no evidence of faults of sufficient magnitude to bring them to this position alone; but minor faults there are undoubtedly, and these have in some cases considerably altered the position of some of the beds. On the whole, however, the evidence seems to show that these Silurian beds have been deposited on the eroded edges of the

¹ Quart. Journ. Geol. Soc. vol. xxxiv. p. 816.

lower gneiss rocks nearly in the positions in which they are now found, the present inclination of the beds being dependent upon subsequent movements, accompanied by some faults. These upper beds are undoubtedly made out of such materials as would be derived from rocks similar to those which now underlie them, and to which they are unconformable; and hence it is that sometimes a superficial examination may possibly lead one to associate them. The persistent and equal metamorphism, the contorted character, and high N.W. strike of the lower series is so marked, however, that for any distance it seems almost impossible to confound them in any way with the comparatively undisturbed and unequally altered beds of the upper series, which also almost invariably strike in the opposite direction, or from N.E. to S.W., *at a low angle of dip.*"

That these beds gradually assume a more horizontal position as we ascend the Glen eastwards is undoubted. The high dip given to them in the section by Murchison and Geikie¹ is certainly not warranted by examination, except for a short distance near the escarpment; nor indeed would it appear at all reasonable, for the thickness required under these circumstances would be enormous, especially as these beds are indicated by them in other sections along this line to underlie the rocks composing the great mountains to the east. In some of the sections given by these authors the conformable thickness shown is truly appalling, and, I need hardly say, physically impossible, when we take into consideration the conditions which must have prevailed over these areas when the sediments were deposited. If these rocks were to underlie those to the eastward as supposed, one would naturally ask at first what would be the amount of faulting necessary for so sudden a change, if, as most agree, the old floor is still traceable as far at least as the east side of Glen Laggan. Considering also that the conformable sequence shown in most of their sections² cannot be less than ten miles (in one at least twelve miles), and usually at a dip of from 40° to 50°, and that all the sediments must have been deposited horizontally, one is not only astounded at the faulting necessary, but beyond all at the physical conditions required to allow such an accumulation of sediments. It seems to me perfectly clear that no attempt could have been made to realize the physical difficulties necessary to uphold this theory before it was propounded. That these sections also should have been so frequently reproduced, not only to show the supposed succession along this line, but also in a more or less modified condition for other areas, is truly remarkable!

These beds, according to my reading of the section, not only gradually assume a horizontal position, but terminate in the Glen which separates Craig Roy from Ben Fin; and instead of dipping under the latter mountain as supposed, overlie horizontally, or with a slight inclination only, the rocks near its foot, which form part of the Pre-Cambrian floor.

¹ Quart. Journ. Geol. Soc. vol. xvii. p. 191.

² Quart. Journ. Geol. Soc. vol. xv. p. 260; *ibid.* vol. xvii. p. 212; "Siluria," 4th ed. pp. 169 and 172; and Sec. i. in Geol. Map of Scotland (Geikie), 1876.

In the open ground which extends between the top of Glen Docherty and the western edge of Ben Fin, the old floor is traced with some difficulty ; but on reaching the latter point, it is seen with all the usual characters recognizable in the more western areas.

(To be concluded in our next Number.)

NOTICES OF MEMOIRS.

CONSIDÉRATIONS GÉOLOGIQUES SUR L'ORIGINE DU ZAND-DILUVIUM, DU SABLE CAMPINIEN ET DES DUNES MARITIMES DES PAYS BAS. Par Dr. T. C. WINKLER. Extrait des Archives du Musée Teyler, tome v. (Haarlem, 1878.)

IN the above paper on the drift deposits of the Netherlands, Dr. T. C. Winkler treats of the origin of the Drift sand, Campinien sand, and Maritime dunes of the Pays-Bas. These deposits had been previously described and divided, by Dr. Staring, in 1853, as the drifts (*diluvium*) of the Meuse and the Rhine, the northern drift, and that of Munsterland. Again, in 1860, the same author classed them in three categories, the sandy drift (*zand-diluvium*), gravelly drift (*grint-diluvium*), and loess. Subsequent researches and considerations by Dr. Winkler have led him to modify the views of Dr. Staring, and he proposes the following divisions for the diluvial deposits of the Netherlands: the northern, eastern, southern, mixed (*entremêlé*) and *remanié* drifts. The reasons for these subdivisions, and their lithological characters, are fully explained in the memoir, as also the nature and distribution of the maritime dunes. From the facts stated, and the reasonings based upon them, Dr. Winkler considers he has shown:—

1. That the *zand-diluvium* of Staring ought to be termed the *remanié* drift, and that it was not formed, as Staring said, by the action of rain and frost, nor as Godwin-Austen said, by the action of wind, but by the effects of the sea.

2. That the *remanié* drift of the Netherlands is analogous to the Campinien sand of Dumont, in Belgium.

3. That the southern drift of the Netherlands is analogous to the flinty drift of Dewalque, to the *silex et cailloux* of Dumont, to the Campinien sand with rolled flints of Omalius d'Halloy, to the lower stage of the Quaternary period, the rolled flints and gravelly sand, of Dupont.

4. That the deposits of the Campine ought not to be considered as being simply composed of sand with pebbles, and sand without pebbles, but that these two stages ought to be separated according to their very different origin; the one, lower, coming from the Ardennes and the Condroz by means of rivers; the other, superior, being a marine formation, derived from older drift deposits by the action of the sea.

5. That the Campinien sand is posterior to the Hesbayen clay.

6. That the sand which constitutes the maritime dunes is identical with the Campinien sand of Belgium, and to the *remanié* drift of the Pays-Bas.