prolonged in a south-westerly direction towards Croghan Kinshelagh. A specimen, collected from a spot one mile north of the summit of this mountain, proved, on examination with the microscope, to be a typical epidiorite. The rock forming the summit itself has undergone more alteration. It has a marked foliated character, and consists mainly of chlorite and "felspar-mosaic." Sphene is also present in abundant grains.

Specimens of epidiorite were also collected about a mile N. of Wicklow, on the S.W. side of Croghan Kinshelagh, and from a small patch of greenstone two miles east of Kilcavan House, to the east of Shillelagh (Sheet 138).

(f.)—In only one case was the occurrence of a serpentinous greenstone noted. My attention was drawn to this rock by Mr. Kinahan. A small patch of it occurs about half a mile west of the patch of epidiorite referred to above, two miles east of Kilcavan House, near Shillelagh. Unfortunately I was prevented by lack of time from visiting the locality myself, and the specimen examined was collected by Mr. Clark. The rock is of a variable green colour, and has the characteristically soapy "feel" of a serpentinous rock. A microscopic section discloses the serpentine in colourless layers, associated with grains of opaque iron-ore and a finely granular substance resembling calcite or dolomite. The powdered rock, treated with hydrochloric acid, effervesces only on warming; it contains, therefore, as we should expect, the magnesian carbonate.

The texture of the serpentine is well brought out between crossed nicols. It has rather the "netted" or "bladed" structure of serpentine derived from augite than the "lattice"-structure peculiar to that mineral when produced by the alteration of hornblende.

Whatever may be the nature of the alteration, there can be little doubt that we have here the final product of the alteration of a greenstone (dolerite). As we have seen above, the usual course of the metamorphism of the Wicklow dolerites is, first, the formation of a hornblende rock (epidiorite, hornblende-schist) and, finally, a chlorite-schist; but the case in point indicates that there are exceptions to this rule.

28, JERMYN STREET, S.W.

VI.—DEVONIAN GREENSTONES AND CHLORITE SCHISTS OF SOUTH DEVON.

By Miss C. A. RAISIN, B.Sc.

IN a paper published in the Devonshire Transactions for 1888 (p. 215), Mr. Somervail suggests the identity of the chlorite schists of South Devon with certain rocks to the northward. As this hypothesis (could it be established) would have a most important bearing on subjects of controversy, I took the opportunity in a few days this winter, to visit and collect from these localities, including the dyke nearest to Torcross. I was not rewarded by finding any striking similarity to the metamorphic rocks of the south. In that

series, the chlorite schists consist of clear and definite crystalline grains, among which I find felspar to be rare and have not yet certainly identified augite—while these northern greenstones are full of broken crystals of both minerals, together with viridite, dust resulting from the crushing, and a small amount of minute secondary hornblende and sericite (?), chlorite being generally rare, and often absent. The one rock is a true schist, the other nothing more than a schalstein. If Mr. Somervail ascribes the marked difference in character to more intense pressure, a very obvious difficulty would have to be met. As pointed out by Prof. Bonney, the chlorite schist exhibits at places not only a well-defined mineral banding, but also a cleavage cutting transversely across it, which appears to be in close relation with the general cleavage of Devonshire.¹ If, therefore, pressure metamorphism be invoked to account for the origin of the chlorite schist and its banding, the force must be relegated to an earlier period, and thus the rocks affected by it, even if originally igneous, cannot be of Devonian age.

Of themselves, however, these schistose rocks afford interesting study, as in the case of other west-country greenstones.² One type³ (from the coast near Redlap, and also from a quarry for road metal N.W. of Stoke Fleming), is clearly an ophitic dolerite,⁴ but exhibits changes which have resulted from the crushing of the rock. Much of the augite is still very fresh and clear, but it seems to have been brittle, and to have broken along cleavage planes, forming fragments with sharp straight boundaries. Often there is a border of a hornblendic mineral, partly an alteration product,⁵ although some is not unlike the serrate fringe of 'secondary enlargement' described by Van Hise,⁶ having cleavage planes continuous with those of the original crystal. A fibrous hornblende, which is probably asbestiform, also seems to have formed at places, where a fragment of augite has been drawn out in the shearing of the rock. Elsewhere, as Professor Bonney suggested to me, strands of a very pale viridite seem to be connected with remnants of augite crystals,⁷ and, in some cases, the viridite encloses small pieces, fragmental in outline, now converted into fibrous actinolite, which very probably have resulted from the crushing of a crystal of the pyroxene. Professor Bonney sug-

¹ Q.J.G.S. 1884, vol. xl. p. 8, fig. 4, p. 22.

² Q.J.G.S. 1876, vol. xxxii. p. 407, S. Allport. Q.J.G.S. 1876, vol. xxxii. p. 155, and 1878, vol. xxxiv. p. 471, J. A. Phillips. Q.J.G.S. 1880, vol. xxxvi. p. 285, and 1886, vol. xlii. p. 392, F. Rutley. Brit. Petrogr. J. J. H. Teall, p. 228.

³ Somewhat like the Carlin rock (No. 7) of Mr. Rutley, Q.J.G.S. 1886, p. 397. The augite resembles that of fig. 2, p. 398.

⁴ Cf. Mr. Allport, Q.J.G.S. 1876, p. 419.

⁵ As, for example, in the Lizard gabbro and basalt. Q.J.G.S. 1877, vol. xxxiii. pp. 904, 907, Prof. Bonney, "On the Serpentine and Associated Rocks of the Lizard." See also Q.J.G.S. 1885, vol. xli. p. 520, "On the so-called Diorite of Little Knott," and Q.J.G.S. 1883, vol. xxxix. p. 256, "On Hornblende Picrite from Anglesey," Prof. Bonney. Also Q.J.G.S. 1878, p. 493, J. A. Phillips. "Perimorphic," hornblende of Mr. Harker, Q.J.G.S. 1888, vol. xlv. p. 452.

⁶ Amer. Journ. Science, 1887, vol. xxxiii. p. 388, fig. 3; also U. S. Geol. Survey, 5th Rep. 1883-4.

⁷ Cf. Brit. Petrogr. J. J. H. Teall, pp. 216, 230.

gested that this difference, in the results of the transformed augite, might be due to an admixture of the constituents of felspar obtained in the crushing, either from ophitic plates or from the surrounding mass. The felspar in the slide has been completely decomposed, and the ophitic plates can be identified mainly by their sharp outlines, preserved within the surrounding augite. Rarely a granular crystalline aggregation seems to mark a former felspar now replaced. Thus this rock is actually in a condition of transformation, and seems to point out what may result from the crushing of an ophitic dolerite. Planes of schistosity have been formed, characterized by streaks of viridite, probably derived mainly from the pyroxenic constituent, and the larger films may mark the loci of what were once augite crystals. Secondary hornblende has formed by recrystallization, along the exterior of original crystals, or from the shearing, possibly of an unmixed augite. A dusty and granular ground-mass, partly kaolinitic, has resulted from the powdering up of other constituents, including the greater part of the felspar.

A slide from rock of a second type is crowded with plagioclase felspars, exceptionally well preserved, although they have been much broken and snapped by strains acting on the mass. Crystals of iron oxide are abundant, some being clearly ilmenite. The structure of this rock is difficult to interpret, but the felspars seem to have occurred as porphyritic crystals, and not to be pyroclastic. Professor Bonney has suggested to me, that the ground-mass might be that of a crushed glassy rock, possibly andesitic, and that the greenish mineral, which is abundant in it, might perhaps be best classed as a variety of palagonite. Mr. Rutley describes and figures certain rocks from Cant Hill, near St. Minver, which he believes have been derived from what was once a rather basic glass, and this slide from Redlap seems to have a ground-mass something like that of fig. 1—with broken felspar similar to that of fig. 3.¹ I have not, however, recognized in these Devonshire specimens the vesicular structure, which the other rocks exhibited.

In a third type of rock, the ground-mass seems to have been feldspathic, sometimes crowded with well-defined felspars, which are now altered to a filmy mineral (? sericite). Porphyritic crystals can be traced, which have undergone an aggregate replacement. Other groups in the slide, consisting possibly of an intergrowth of quartz and felspar, with some calcite, might represent a similar porphyritic mineral, or they are possibly amygdaloidal, like that figured by Mr. Phillips.² Sometimes associated with these, but distorted in form, are certain viridite or serpentinous strands, which may be examples of the crushed amygdaloids noted by Mr. Rutley, or possibly only the infilling of secondary cracks. They form the green films, which may be noticed on many of the schistose surfaces near Redlap, and in my specimens from that locality I searched in vain for any of the well-defined chlorite of the southern schists, with which mineral

¹ Q.J.G.S. 1886, vol. xlii. p. 393, pl. xii. figs. 1, 3.

² Q.J.G.S. 1878, vol. xxxiv. p. 483, pl. xx. fig. 2.

the rocks are said to be charged.¹ Mr. Somervail may, however, allude to some other specimens from these cliffs (since I did not attempt to make an exhaustive examination of the place). But, even if chlorite occurs, as it does, although not to a large extent, in the dyke further south, its presence is a rather slender argument for the identification of the schist and the diabase, since it is one of the commonest secondary products in basic igneous rocks of any age or locality.

I examined the associated sedimentary rocks at Redlap, and they are genuine phyllites of the ordinary Devonian character, with only the usual crystalline development of minute films along the lamination.² If the greenstones were the equivalents of the chlorite rock of the south, it would be strange, that these associated phyllites should present such wide and well-marked differences from the mica schists. They exhibit effects of pressure metamorphism, even more strongly than the phyllites just north of the fault, which bounds the crystalline series, and yet they are totally unlike the mica schists in that series. In one of the phyllites near Redlap, the laminae are puckered up into undulations, across which at places extends a succession of small brown films. These appear to have formed from a ferruginous infiltration, inserting itself and accumulating between the laminae, along the steeper slope of the waves. Just at this part, rupture has often taken place, thus forming an incipient strain-slip cleavage, marked only by a darker staining. The steeper slope of the undulations is almost universally in the same relative position—doubtless on that side towards which the thrust of the rocks was directed.

I must thank Mr. Somervail, for calling my attention to the deserted quarry of chlorite schist to the north of the Hall Sands streamlet, in consequence of which the boundary-line must be marked at that part of the valley as north of the stream.³ It is to be regretted, however, that Mr. Somervail does not withdraw his former untenable assertion, but attempts to renew it, by confusing together the correct indication of the boundary given by Professor Bonney on the coast, and any slight modification which I have to make in the direction I traced inland. The position on the coast would not be affected by the occurrence of the chlorite schist south of the valley, nor by this chlorite schist north of the valley. The hypothesis of a straight east-to-west line for the fault is quite gratuitous, since no

¹ Trans. Devon Assoc. 1888, p. 224.

² Thus these rocks in the direction of their micaceous constituent would agree with the phyllites described by Professor Bonney from near Morlaix, Q.J.G.S. 1888, vol. xlv. p. 13, and would differ from those near Torcross, Q.J.G.S. 1884, vol. xl. p. 17.

³ See map Q.J.G.S. 1887, vol. xliii. p. 715. The dotted line marking the junction of phyllites and metamorphic rocks should probably cross the stream about east of the / of Muckwell, before bending south-eastward or E.S.E. to the coast. This alteration does not, however, disprove the possibility that the fault may have determined the lower course of the valley, since there are no exposures which we can trust along the 400 yards between the quarry and the beach; and also in a continued erosion along a fault, a portion of one rock may often be left adhering at some spot to the mass against which it was faulted.

one attempts to draw such—how could the line in that case reach on the Salcombe estuary a position, which is considerably to the north of a line drawn due west from Hall Sands?

In connection, also, with the suggestion, that the chloritic rock near the fault-line was a "buffer, checking the northward spread of metamorphism,"¹ I should like to ask, why was this duty neglected by the much larger and more extensive mass near Prawle Point, and that overlooking The Barr?—to the northward of which, in both cases, lie well-marked mica-schists. I might take exception to many other statements, but I should not be justified in thus occupying space, for they are matters of detail, compared with the suggested identification of the two series of rocks. These may have some resemblance to each other—though I should have thought it so superficial as not to mislead any practised observer; but even if there be a vague resemblance, due to their having had the same origin, they cannot, as I have shown, have been manufactured at the same epoch.

VII.—ON SOME OSTRACODA FROM THE MABOU COAL-FIELD, INVERNESS CO., CAPE BRETON (NOVA SCOTIA).

By Prof. T. RUPERT JONES, F.R.S., and J. W. KIRKBY, Esq.

THIRTEEN specimens of black shale, crowded with Ostracoda, besides fish-scales, *Anthracomyæ* (?), and other small fossils, were sent in 1886 by Mr. J. F. Whiteaves, F.G.S., Palæontologist of the Geological Survey of Canada, for examination. They had been collected by Mr. A. H. Foord, F.G.S., of that Survey, in 1881.

In these coal-shales the Ostracoda are very numerous as individuals, but belong apparently to very few species of one genus. They are in a great degree similar to those mentioned in the *Geol. Mag.* Dec. II. Vol. VIII. 1881, p. 95, and Dec. III. Vol. I. 1884, p. 358, etc., as occurring in the black coal-shales of the South Joggins, Nova Scotia.

In the Mabou coal-fields we find:—

1. *Carbonia fabulina*, J. and K., very abundant. It is of rather smaller size than the Scottish forms figured and described in the *Ann. Mag. Nat. Hist.* ser. 5, vol. iv. (1879), p. 31, pl. 2, figs. 1–10. The innumerable minute Ostracoda imbedded throughout the shale seem to be small individuals of *C. fabulina*.

2. Among the foregoing is a variety larger than the Scotch specimens referred to, rather more oblong in outline, and with stronger marginal overlap, and a somewhat coarser punctuation of the surface. It may be termed var. *altilis* (well-nourished).

3. *Carbonia* (?) *bairdioides*, J. and K., also occurs, but far less abundantly than *C. fabulina*. The specimens more closely resemble fig. 24, pl. 3, "A. M. N. H." ser. 5, vol. iv. p. 38, than fig. 8, pl. 12 of the *Geol. Mag.*, Dec. III. Vol. I. p. 359.

Carbonia fabulina is abundant in the Upper and the Lower Carboniferous formations of Britain, wherever the conditions had been

¹ Trans. Dev. Assoc. 1888, vol. xx, p. 217.