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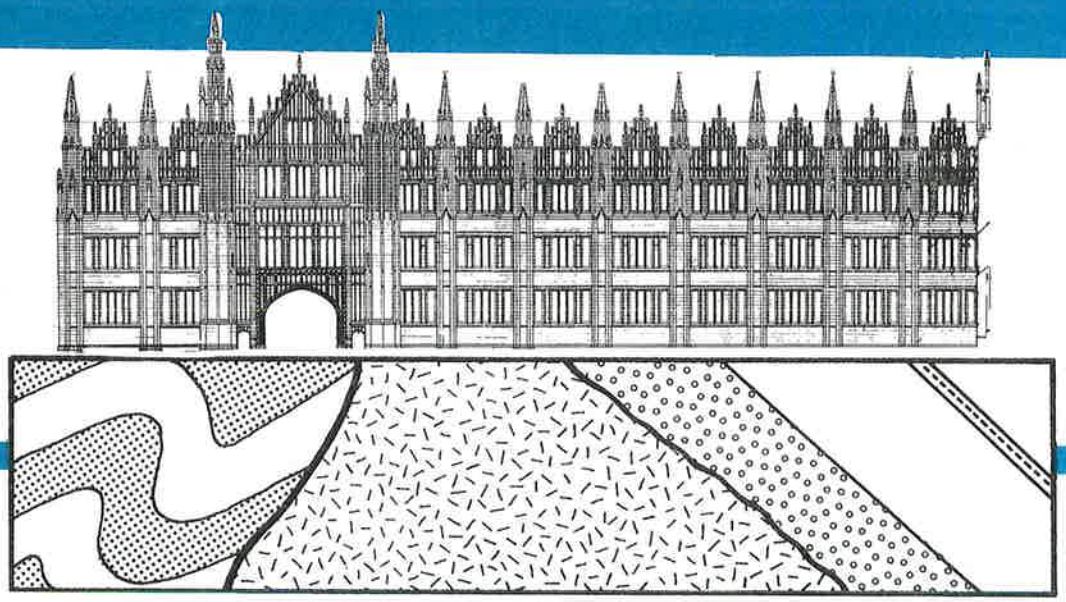

Discussion and Comments on Nicholson's 1872 Manuscript 'Contributions to the study of Errant Annelides of the Older Palaeozoic rocks'.

M.J. Benton and N.H. Trewin

Contributions to the study of Errant Annelides of the Older Palaeozoic rocks.

H.A. Nicholson

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DISCUSSION AND COMMENTS ON NICHOLSON'S 1872 'MANUSCRIPT 'CONTRIBUTIONS TO THE STUDY OF ERRANT ANNELIDES OF THE OLDER PALAEOZOIC ROCKS'.

M.J. Benton and N.H. Trewin

Introduction

The accompanying paper on "worm tracks" by H.A. Nicholson, written in 1872, was published in abstract only (Nicholson, 1873). The original manuscript submitted to the Royal Society of London in 1872 has been examined on micro-film and is reproduced in full. The original specimens that Nicholson used to illustrate his manuscript were recently identified within the Palaeontology collection of Aberdeen University, and thus we have been able to study the original material and make comments on Nicholson's interpretations and nomenclature. The notes and comments on the manuscript which follow are arranged with the same ordering and numbering as Nicholson's text and thus the two can be studied in parallel. A summary of Nicholson's work on trace fossils is also given.

Historical Note.

Professor Henry Alleyne Nicholson (1844-1899) wrote several short papers on trace fossils (see bibliography), but this paper, his major work on this subject, submitted to the Royal Society of London in 1872, was never published in full. This may seem surprising, but a comparison of the two referees' reports on the manuscript is interesting. On 5th November 1873, R. Etheridge wrote: "Dr. H. Alleyne Nicholson's paper . . . contains a great deal of new and valuable matter relative to these very obscure organisms", and he advised for publication of the text and illustrations in full. However, in a letter dated 2nd December 1873, P.M. Duncan wrote: "It does not appear that the author has advanced any new views which tend to clear up the difficulties of this subject" and he advised against publication. The opinion of the latter was, unfortunately, followed.

Since this was one of the earliest ichnological works to apply "non-fucoid' interpretations, we consider it would be of value to publish Nicholson's original text and figures. Much of the material is now of purely historical interest, but had the original manuscript been published in full the study of trace fossils might have gained a better start and confusion concerning such names as Planolites might have been resolved earlier. A review of Nicholson's work on trace fossils follows the discussion of his 1872 manuscript.

Notes on Nicholson's text and plates:

As far as possible, Nicholson's original spelling and punctuation is retained. It may be mentioned that Nicholson uses the following linear measures:

1 line = 2.12mm
12 lines = 1 inch = 2.54 cm

The illustrations are all reproduced to the size Nicholson drew them (natural size) except for fig. 4 and plates III and IV, to which scales have been added. The accuracy of the illustrations is rather variable. In some cases, Nicholson simplified a complex mass of tracks, thereby introducing an element of interpretation, in others he drew rather elusive traces as if they were clearly present, and in others he omitted some traces. However, the figures are all easy to match with the specimens.

Nicholson drew the figures in pencil and our copies are enlarged from a microfilm. Thus their quality is rather diminished and some are partly 'lost' in the binding of Nicholson's manuscript.

Statigraphy and localities.

Nicholson quotes his localities with varying degrees of accuracy. We have reproduced the data as it occurs on the specimen labels. This data is sometimes amplified by Nicholson's description in the manuscript. The reader should exercise caution with respect to quoted ages of formations since Nicholson was writing before the term Ordovician came into use. Thus the Skiddaw Slates of numerous Lake District localities are given as Upper Cambrian rather than Ordovician. The localities of Thornilee Quarry, Galashiels and Grieston Quarry, Innerleithen are both in strata of Llandovery age. Nicholson spelt the latter locality 'Greiston' but it appears on recent maps as Grieston.

Material used by Nicholson.

The following list follows the organisation given by Nicholson in his manuscript and lists all the specimens located in the Palaeontology collections of Aberdeen University together with their numbers and localities. Nicholson's original names are retained in this list.

A. Annelide Burrows.

I. Arenicolites Salter

1. Arenicolites sparsus Salter
   10605. Longmynd.
   10604. Barff. Nr. Keswick.

2. Arenicolites didymus Salter
   8828. Barff. Nr. Keswick.

3. Arenicolites robustus Nicholson ms. 1872
   10603. Rake Beck, Nr. Melmerby.

II. Scolithus Haldemand

4. Scolithus canadensis Billings
   10627. Stiperstones, Shropshire.

5. Scolithus linearis Hall

6. Scolithus verticalis Hall

III. Histioderma Kinahan

7. Histioderma hibernicum Kinahan

IV. Cruziana D'Orbigny

V. Planolites Nicholson ms. 1872

8. Planolites vulgaris Nicholson ms. 1872
   10624. Barff. Nr. Keswick.
   10625. Mirehouse, Nr. Keswick.
   10626. Outerside, Nr. Keswick.

9. Planolites granosus Nicholson ms. 1872
10618, 10619, 10621,10622, 10623. Outerside, Nr. Keswick.
10620, Ellergill, Nr. Millburn.

10. Planolites articulatus Nicholson ms. 1872
10617. Outerside (or Coldale), Nr. Keswick.

B. Surface tracks

VI Crossopodia M'Coy

11. Crossopodia scotica M'Coy
8819, 9224, 10606, Mus. Col. 957. Thornilee Quarry, Galashiels.
8820. Grieston Quarry, Innerleithen.
Mus. Col. 956. Location unknown.
Mus. Col. 909. 'Lake District'.

12. Crossopodia lata M'Coy

VII Nemertites MacLeay

13. Nemertites ollivantii Murchison

14. Nemertites major M'Coy
10613. Barff, Keswick.
10614. Mungrisedale, Nr. Troutbeck.

15. Nemertites minor M'Coy
10615. Outerside, Keswick.

VIII Nereites MacLeay
Species enumerated but not described by Nicholson
Mus. Col. 959. Thornilee Quarry.

IX Myrianites MacLeay

16. Myrianites tenuis M'Coy
10610. Thornilee Quarry
10329, 10612. Grieston Quarry.
10611, Scale Hill, Crummock.

17. Myrianites murchisoni Emmons
10607. Grieston Quarry.
10608, 10609. Barff. Keswick.

C Appendix

X Caridolites Nicholson ms. 1872

18. Caridolites wilsoni Nicholson ms. 1872
7059. Nr. Grieston Quarry, Innerleithen.
10674. Grieston Quarry.

Discussion of trace fossils described by Nicholson.

The following notes are arranged in the order given above and can be read in parallel with Nicholson's paper which follows these notes.

A. 'Annelide Burrows'

I Arenicolites

1. Arenicolites sparsus Salter 1857

Specimen 10605, Nicholson Pl. I fig. 1.
This work Pl. 1 fig. 1.

Part and counterpart are preserved and are illustrated in our P1. 1 fig. 1. Nicholson's remarks on the 'way up' of the specimen are correct, thus the traces occur as concave epireliefs and as convex hyporeliefs on the base of the overlying bed. The individual traces are round-oval, 1-2mm. in diameter, and may occur in pairs with a spacing of 1-3mm. There is some evidence in the specimen that the burrows were of a semicircular U shape with a depth up to 3mm.

Specimen 10604, Nicholson Pl. I fig. 3.

The specimen consists of laminated fine sand and shale, the sand-filled vertical burrows are paired, each circular, 2mm in diameter and generally separated by 3mm. More traces are present than those shown by Nicholson. No evidence of subsurface burrow morphology is seen in this specimen.

2. Arenicolites didymus (Salter 1856)

From Salter's original figures, it is clear that Arenicolites didymus is a bilobed resting trace, rather that the paired openings of a U-shaped burrow, and it is now generally included in Rusophycus. Nicholson expressed some doubt as to the specific distinctness of his A. didymus specimens from A. sparsus. One of his specimens from Barff, near Keswick (8828) is clearly not a Rusophycus trace. There are a number of pairs of 1-2mm. diameter, circular burrow sections, separated by 2-3mm. The trace appears identical with A. sparsus and is certainly not a Rusophycus.

3. Arenicolites robustus Nicholson ms. 1872

Specimen 10603, Nicholson Pl. I fig. 4.

This specimen appears to be Nicholson's intended holotype of A. robustus. The specimen is a fine blue-green slate with faint paired burrow sections from 2 to 5mm in diameter. Many are now slightly elliptical due to structural deformation of the slate. Separation of the paired sections ranges up to 3mm. Individual burrow sections are slightly convex on the surface with a shallow central hollow (way up not known). Bearing in mind the different lithology, there seems to be little to distinguish this 'species' from A. sparsus. Nicholson's assertion of the significance of the larger size of A. robustus is not convincing, especially with the small amount of material Nicholson used.

The name of A. robustus does not seem to have been used since 1873 when listed in the abstract (Nicholson, 1873, p289) A. robustus is a nomen nudum and should remain as such.

II Skolithos Haldemann 1840

Nicholson quotes the original reference of Haldemann (1840), but uses the incorrect later name Scolithus used by Hall (1847, p2) and all later authors until Howell (1943, p6). Nicholson describes 3 species: S. canadensis, S. linearis and S. verticalis.

4. Skolithos canadensis Billings 1865 (adv. sheets 1862)

Specimen 10627, Nicholson Pl. II fig. 2.

This specimen does not seem to represent the genus Skolithos. The main burrow is certainly J-shaped and possibly U-shaped and resembles Arenicolites. The burrow is preserved to a depth of 6.5cm. with a diameter of 3-4mm. It is preserved in a pale medium grained quartzite and the burrows are now open or

partially filled with quartzite. Two oblique burrows lead off the main burrow in its curved portion at the foot of the J and resemble the stowing structure observed by Schäfer (1972, fig. 217, p364) in Arenicola burrows where the feeding tube has to be continually reformed, not always in the same place. Schäfer's observations were in mud rather than the sand seen in this specimen. It is also possible that this specimen represents a branching U-shaped burrow somewhat similar to Lanicoidichna. Nicholson clearly did not think that S. canadensis was U-shaped, and more material will need to be studied to verify this point.

5. Skolithos linearis Haldemann 1840

6. Skolithos verticalis (Hall 1843)

Nicholson does not figure or describe any new material of these species and bases his descriptions on the work of Hall and Salter.

III Histioderma Kinahan 1858

7. Histioderma hibernicum Kinahan 1858.

Nicholson reproduces Kinahan's description and figure and agrees with his interpretation of the structure as a burrow.

IV Cruziana D'Orbigny 1842

Nicholson does not describe any new material. He refers to previous opinions of Hall, Salter and Dawson and doubtfully considers it to be produced by a worm. In 1889 (fig. 381D p525-526) Nicholson interpreted Cruziana as 'the casts of the burrows of trilobites'.

V Planolites Nicholson 1873

The major new genus erected by Nicholson in the 1872 manuscript is Planolites. In the Royal Society abstract (1873, 288-289), the only definition of Planolites is:

> "Other burrows are of a totally different nature from the preceding, and may reasonably be compared to the burrows of the recent lobworms. These burrows run more or less horizontally as compared with the laminae of deposition, or they penetrate the strata obliquely. They are not burrows of habitation, but are wandering tunnels excavated by the worm in its search after food. The fossils of this group, therefore, as preserved to us, are not the actual burrows themselves, but the burrows filled up with the sand or mud which the worm has passed through its alimentary canal."

In 1874 (not 1875, as (eg.) in Häntzschel 1975, W95,W233) Nicholson and Hinde published a paper on fossils of the Silurian of Ontario. On pp. 138-139, the genus Planolites is defined again, but more or less as in 1873. This later description is clearly not meant to be an original definition, since there is no figure and the text is mainly concerned with the occurrence of specimens in Ontario. The Royal Society abstract is referred to, and Nicholson was clearly expecting his paper and figures to be published in full. Thus the genus Planolites was never properly defined and its definition has remained rather confused. Despite this, Planolites is one of the most widely used trace-fossil names.

Alpert (1975) gave a good description of Planolites which agrees almost completely with Nicholson's description in the 1872 manuscript. Alpert also gave synonomies of the species he considered to belong to Planolites. His definition of Planolites is wider than that of Nicholson since he includes striated forms (P. striatus (Hall 1852), which could be a Scoyenia) and also annulated forms P. annularius Walcott 1890). Apart from this, Nicholson's unpublished description of Planolites is identical with Alpert's.

Summary of the characters of Planolites (according to Nicholson)

a) Burrows cylindrical or subcylindrical,
b) Curved or tortuous,
c) Formed by the filling up of worm burrows by the sand or mud which has been passed by the worm through its alimentary canal.
d) Different from matrix in texture and colour. Usually coarser and harder sand than matrix and burrows often stand out in relief.
e) Burrows not vertical to stratification; more or less horizonal or penetrating the strata obliquely,
f) May cross one another and appear to branch,
g) Surface smooth,
h) Formed by worms like present-day Arenicola.

Some authors (Chisholm 1970, p24, Webby 1970, p96-97, Alpert 1975, p517) have included simple burrows showing transverse annulation ("packing structure" or "back-filling") in Planolites. However, if the annulation is very pronounced, this does not seem to fit the characters of a true Planolites. Others (eg. Frey and Howard 1970, p146, fig. 2h) give block diagrams of Planolites in which the burrows clearly branch and travel vertically. Planolites should be restricted to the original definition of Nicholson and the redefinition by Alpert (1975, p 512).

Nicholson commented on the resemblance of Planolites to Palaeophycus Hall (1847), and frequently these genera have been confused. The usual distinguishing character being that burrow infill and host rock lithology are similar in Palaeophycus and different in Planolites. This distinction is not always clear and is dependent on the presence of different lithologies within the field of activity of the organism. Alpert (1975) suggests that the presence or absence of true branching is more useful, "branched burrows being Palaeophycus, and unbranched Planolites". However, this cannot be applied to short stretches of burrow or fragmentary pieces.

8. **Planolites vulgaris** Nicholson and Hinde 1874

This, the type species of Planolites, was described briefly by Nicholson and Hinde (1874 (not 1875) p 139) but not figured. This was clearly not meant to be a type description, which Nicholson had already included in his 1872 manuscript which had not been published. The first figure of P. vulgaris with a more detailed description appeared in Nicholson 1875 (Fig. 18 p42). The figured specimen (from the Clinton Group of Dundas, Ontario) appears to be a good representative of the species and is thus the holotype of Nicholson's species. Its present repository is unknown to us. Alpert's (1975) revision of Planolites gives an up-to-date synonomy of the various species which need not be repeated here. Alpert places P. vulgaris in the synonomy of P. beverleyensis (Billings 1862). It is thus interesting to note that Nicholson gives the same synonomy with P. beverleyensis in his discussion of P. vulgaris.

The specimens described and illustrated by Nicholson as P. vulgaris in the 1872 manuscript are not good representatives of the species on its current restricted definition. Nicholson obviously had a very broad view of this species.

Specimen 10624. Nicholson Pl. I fig. 2.

The specimen is a flake less than 5mm thick of a ripple lenticle of fine sand bounded by shale. The burrows are 2-3mm in diameter, circular is cross section and sand filled. The maximum length exposed is 2.0cm, and the burrows are slightly oblique to the lamination. The general character is closer to Alpert's description of P. montanus Richter than P. beverleyensis.

Specimen 10625. Nicholson Pl. II fig.1.

The burrows are preserved as convex hyporeliefs on the base of a bed of rippled sand 2-3cm thick. Nine sand filled burrows each 4-9mm wide, forming a radiating group appear to branch distally from their apparent origin. This specimen conforms with the definition of Phycodes given by Häntzschel (1975 pW93).

Specimen 10626. Nicholson Pl. II fig. 3.

This specimen also displays a series of divergent burrows, but individual burrows have a fairly constant width of about 3mm. Nicholson considered that the divergence of the burrows was fortuitous, but as in the case of 10625 we would place this specimen in the genus Phycodes.

9. **Planolites granosus** Nicholson ms. 1872

Since Nicholson's manuscript was not published, P. granosus is a nomen nudum, as pointed out by Alpert (1975). The six specimens of Nicholson's in the Aberdeen collection include the figured material and leave little doubt that this species is synonymous with Tomaculum problematicum Groom 1902. Nicholson realised that the structure was formed from fecal pellets and he gives a remarkably modern interpretation of this trace fossil.

Specimens. All from the Skiddaw Slates.
10618. Outerside nr. Keswick. Nicholson Pl. IV fig. 3.
10619. " " Pl. IV fig. 4.
10620. Ellergill nr. Millburn. Pl. VI fig. 5.
10621, 10622, 10623. Ellergill nr.Millburn.

Horizontal curved burrows of variable diameter up to 4mm, filled with a mass of small pellets, each pellet being 1.5-2.1mm long and 0.7-0.8mm wide. When well preserved, the pellets are clearly seen impressed on the burrow wall but when squashed, the pellets are obscure and the burrow surface appears rough. Constrictions representing gaps in the burrow fill frequently occur at points of sharp direction change (eg. 10618 P1.IV fig.3) and intermediate burrow sections are gently curved. Burrows may be fully or partially stuffed with pellets, thus there is a gradation to specimens with isolated patches and lines of pellets representing incomplete fill of the burrow as seen in 10619 and 10620 (Plate IV figs 4 and 5). The pellets in these specimens are well preserved and greenish in colour contrasting with the dark grey siltstone matrix.

The intermediate type showing a gradation from complete burrow fill to isolated pellets is seen in specimen 10623 which shows features very similar to the specimen of T. problematicum figured by Richter and Richter (1939) and refigured by Häntzschel (1975 fig. 85.5).

Groom (1902), following Barrande, believed Tomaculum represented trilobite eggs. However, many marine invertebrates cover their fecal pellets with mucus before expelling them and this might protect them during sedimentation especially within a burrow. Tomaculum has been widely reported from Europe, almost exclusively in the Ordovician (see Häntzschel, El-Baz and Amstutz 1968 for full details). Sizes of pellets vary greatly and may reach 4.0mm length. The animal which produced the Tomaculum trace is thought to have been a gastropod (see Schäfer 1953 for discussion). From the preservational aspect there would appear to be no way of distinguishing a poorly preserved fully filled burrow of Tomaculum which did not show pellets from a Planolites.

10. **Planolites articulatus** Nicholson ms. 1872

P. articulatus in a nomen nudum for the same reasons as given for P. granosus.

Specimen 10617. Nicholson Pl. II fig. 4.
This work Pl. 1 fig. 2.

Burrows 2-3mm wide, circular to elliptical cross-section, sinuous, with length visible to 7.5cm. Transverse cracks and short breaks in the burrows are accentuated by weathering but appear to be partly due to imperfections in the back fill of the burrow which is seen as a faint transverse structure. Other breaks are preservational due to veins and fractures affected by weathering. The specimen is re-illustrated since Nicholson's drawing shows the breaks as constrictions and is rather inaccurate. There is no cause for the erection of a new species on this single specimen. We consider it to be correctly placed in the genus Planolites.

B. Surface tracks.

Nicholson considered that Crossopodia, Nemertites Nereites and Myrianites were all surface trails, but recognised that Myrianites has a considerable depth to the trail which he was at a loss to explain.

The nomenclature of these genera is in a state of confusion which may be resolved when the study of more material recently obtained by us from Thornilee and Grieston Quarries is complete. It is now certain that the Crossopodia scotica traces of Nicholson, and M'Coy's type of this species are unlike the specimens figured by Häntzchel (1975 fig.34) although one of these (fig.34, 2b) is named as C. Scotia (M'Coy) (sic). It is also apparent from Nicholson's specimens in our collection that Myrianites is part of the same trace fossil as Crossopodia. Nicholson's Crossopodia is the basal burrow and Myrianites a section of the near vertical wall of a form of Dictydora Weiss. The reader is referred to Seilacher's (1967) illustrations of Dictyodora.

A further problem is that the type species of Myrianites (M. macleaii Murchison) (or spelt macleayi) is now included in the synonomy of Nereites. Nicholson in his manuscript considers it to be a species of Crossopodia.

Nemertites major is shown here to be a burrow with a thin vertical wall-like extension and thus also resembles Dictyodora. It appears that the Crossopodia, Nemertites and Myrianites species seen by Nicholson and here described are different preservational or specific variations of Dictyodora.

VI Crossopodia M'Coy 1851.

11. Crossopodia scotica M'Coy 1851.

Specimens 10606, Thornilee Quarry. Nicholson Pl. III fig. 1.
8820, Grieston Quarry. Nicholson Pl. VI.
9224, Thornilee Quarry, This work Pl. 2 fig. 1.
8819, 957. Thornilee Quarry.
956, Loc. unknown, probably Thornilee Quarry.

All specimens can be demonstrated to be burrows of a meandering type up to 5mm wide, which when preserved on the base of a slab have a narrow vertical extension up to 1.4cm high. They are thus interpreted as parts of a shallow Dictyodora trace. Specimen 9224 is illustrated and shows the removal of the flattened burrow on parts of the trace. Nicholson's figures are reasonable but the crossing relations of the burrow in Pl. III fig. 1 are incorrect. These specimens are C. scotica in the sense of M'Coy's original material, but not in the sense advocated by Häntzchel (1975 pW55).

12. Crossopodia lata M'Coy 1851.

Nicholson describes this species briefly from M'Coy's work. No new information is supplied, and we have no Nicholson material of this species.

VII Nemertites MacLeay 1839.

Nicholson describes three 'species' of this genus: N. ollivantii, N.major and N. minor. He interprets the trace as the cast of a worm track and not the body

of a worm as previously assumed by MacLeay and M'Coy. Since his Nemertites specimens were all preserved as raised ridges, Nicholson considered that to prove they were not actually tracks, it was only necessary "to show that they always occur on the lower surface of a stratum". Obviously this does not rule out the possibility that the traces are burrows, which they certainly are in one of our specimens (10614). Nicholson based his definition of N. major and N. minor on M'Coy's Palaeochorda major and P. minor of 1848. Palaeochorda is now placed in Gordia Emmons 1844. (see Häntzschel 1975 pW64). Specimen 10614 of N. major resembles in style the Gordia specimen figured in Häntzschel 1975 fig. 39. 1a, which also appears to be a burrow rather than a trail. Häntzschel (1975, pW58) places some Nemertites in the synonomy of Dictyodora and in the case of N. major this is reasonable on the basis of Nicholson's specimens (details below).

13. Nemertites ollivantii MacLeay 1839.

Nicholson had no specimens of this species and merely comments on the descriptions of MacLeay and M'Coy. Nicholson's notes seem to indicate that N. ollivantii is possibly also a Dictyodora.

14. Nemertites major (M'Coy 1848)

Specimens 10613. Barff, nr. Keswick. Nicholson Pl. III fig. 3.
10614. Mungrisedale. Nicholson Pl. IV fig. 2.

Both specimens show random curved traces which are 1.5-2.0mm wide in 10613 and up to 2.5mm wide in 10614 and have a relief of 0.5mm above the surface of the slab. A smoothed and etched vertical section reveals that the traces are sand-filled burrows preserved as convex hyporeliefs. The burrows are round in section with a narrow vertical extension 0.5mm wide which can be traced for 6mm above the basal burrow within the finely laminated mud and silt lithology. Thus this specimen of N. major appears to be a Dictyodora trace with the basal burrow filled with silt or fine sand.

15. Nemertites minor (M'Coy 1848)

Specimen 10615. Outerside, nr. Keswick. Nicholson P1.III fig.4.

This is rather a poor specimen, faithfully represented by Nicholson. The traces are of the same style as in N. major but with a width of 1.0-1.5mm. There appears to be no justification for the separation of N. major and N. minor on the basis of these specimens. The specimen is too thin to investigate internal structure.

VIII Nereites MacLeay 1839.

Nicholson offers no new information and lists the ten species described up to 1870. We have a single specimen (959) labelled Nereites from Thornilee Quarry which shows part of one meander of a track with a width of 1.2cm and displaying the leaf-like lobes on each side of the elevated median ridge. Dictyodora occurs on the same slab.

IX Myrianites MacLeay 1839.

As mentioned above, the type species, M. macleayi, is included in the synonomy of Nereites, whereas Nicholson considered it probably belonged to his Crossopodia. Our specimens show clear evidence that the Myrianites and Crossopodia described by Nicholson from Thornilee and Grieston are parts of a Dictyodora trace, Myrianites being a section of the thin steep sided wall that connects with the basal meandering burrow, as shown by Seilacher (1967 p77).

We consider both the following species to belong to Dictyodora. The two species are possibly distinct on the basis of Nicholson's material and some newly collected material from Thornilee and Grieston Quarries.

16. Myrianites tenuis M'Coy 1851.

Specimens 10610. Thornilee Quarry. Nicholson Text-fig. 7.
This work Pl. 2 fig. 2.
10612. Grieston Quarry. Nicholson Pl. IV fig. 1.
10329. Grieston Quarry.
10611. Scale Hill, Crummock. (Skiddaw Slates).

M'Coy's original specimens came from Grieston Quarry as does some of Nicholson's material. Specimens 10329, 10610 and 10612 agree with M'Coy's description and figure (1851 and 1851-5 Pl. 1D, fig. 13) and Nicholson's identification is correct in the sense of M'Coy. The traces vary from regular to irregular meanders, which are typified by 10610 (Nicholson 1872 ms. Text-Fig.7). 10612 is not very faithfully drawn by Nicholson and consists of several traces, one of which is possibly M. murchisoni. Specimen 10611 from the Skiddaw slates has a different form with open curves of more regular radius and may represent a section of the narrow vertical walls of the form described here under Nemertites major (specimen 10614) which also comes from the Skiddaw slates and is interpreted as Dictyodora.

17. Myrianites murchisoni Emmons 1846.

Specimens 10607. nr. Grieston Quarry. Nicholson Pl. V fig. 1.
10608. Barff, nr. Keswick. Nicholson Pl. IV fig. 2.
10609, Barff, nr. Keswick.

The specimens from Barff show a series of meanders on which is superimposed a secondary scalloping of the trace as seen in 10608. The specimen from Grieston (10607) shows irregular meanders of different appearance. Nicholson's figures are reasonable representations of the specimens. In all three specimens the traces display the steeply inclined wall of which the meandering trace is a cross-section.

C. Appendix

X. Caridolites Etheridge, Woodward and Jones 1890 (ex. Nicholson 1873)

18. Caridolites wilsoni Etheridge, Woodward and Jones 1890.

Specimen 7059. nr. Grieston Quarry, Innerleithen, Peebleshire, Nicholson Pl. V fig. 2.
This work. Pl. 3 fig. 1.
10674. Grieston Quarry, Innerleithen This work. Pl. 3 fig 2.

The name Caridolites wilsoni was mentioned in Nicholson(1873)and the only description was "some singular tracks apparently produced by Crustaceans belonging to the genus Ceratiocaris". Nicholson never again referred to it, and Häntzschel (1975, pW182) listed Caridolites among the "unrecognised and unrecognizable genera". In Moore (1969 pR330), Caridolites was classified in the Phyllocarida (uncertain genera).

In 1890, Etheridge, Woodward and Jones (p65) redescribed Caridolites wilsoni from Nicholson's original specimen (7059) as follows: "The marks are very narrow, some concave (furrows), some convex (casts); some nearly parallel, others differing in direction, and nearly all branching off at various angles to apparently tapering terminations. Their origin is obscure". This must serve as the type description.

The type specimen (7059) is a green shale slab which has been broken since Nicholson drew it. It is mounted on a card labelled in Nicholson's hand.

Nicholson's figure gives a reasonable impression of the trace but exaggerates its clarity; our figure shows what remains of the specimen and some of the traces.

The traces are generally 1mm wide and may consist of a slight central ridge bounded by hollows or a single ridge, or the counterpart of either. The traces are generally nearly straight for from 1 to 5 cms before disappearing or turning fairly sharply to another straight portion of trace. The traces appear to follow minor irregularities on the shale surface due to the fact that they may have a depth of at least 3mm, and in cross section are seen to be very small burrows with a basal tunnel that posesses a narrower vertical extension. They thus have a surprising resemblance to a very small Dictyodora.

The above features show Nicholson's interpretation, that they were marks made by the tail spines of a shoal of Ceratiocaris-like crustaceans, to be incorrect, despite the fact that he records Ceratiocaris from Grieston Quarry, an occurrence recently confirmed by us.

Caridolites is an abundant trace fossil at Grieston Quarry, Innerleithen, and at Thornilee Quarry. At both localities this trace occurs associated with forms described here under Myrianites and Crossopodia and interpreted above as Dictyodora.

Nicholson's other work on trace fossils.

Until about 1880, many of the trace fossils of worm-like creatures were regarded as "fucoids" (Algae) or as body-fossils of whole worms. In 1856, Salter had recognised Arenicolites as a burrow produced by a worm like the present Arenicola. In 1857 he regarded Helminthites and Skolithos as annelid in origin and in 1866 he described 8 worm traces.

From the first, Nicholson maintained these views, even though the "fucoid" theories were still strong in the early 1870s. In 1868 (p30), he says of Helminthites Salter, Scolites Salter, Palaeochorda M'Coy and Chondrites M'Coy these "are certainly not 'fucoids', and can hardly be of vegetable origin at all". In 1869 (p495), he affirms this and adds that they "are truly referable to the action of marine worms." However, in this paper he asserts that Buthotrephis is not an animal trace because "they are always more or less regularly branched." In this paper, Nicholson founded the new species Buthotrephis harknessi and B. (?) radiata. It is a great coincidence that in the same year, Rudolf Ludwig (1869, p114) also founded a species called Buthotrephis radiata (see Hantzschel (1975, pW79: now classified under Lophoctenium Richter 1859).

In 1872, in his Manual of Palaeontology, 1st edition (p141-143), Nicholson describes the "trails and burrows of Errant Annelides". He mentions as burrows, 'Scolithus', Histioderma and Arenicolites and as surface tracks, Crossopodia, Gordia, Myrianites, Palaeochorda, Nereites and Helminthites. This description is clearly based on his preliminary work for the present manuscript. This is possibly the first time that so many genera were listed as traces formed by worms, and not as body fossils or 'fucoids', and the first time that burrows and surface trails were clearly distinguished.

This dichotomy is followed in the present work and is possibly the earliest attempt to classify ichnofossils, the first classification mentioned by Häntzschel (1975, pW16-17) being that of T. Fuchs (1895). The full classification used by Nicholson in 1872 was as follows:

A. Annelide burrows

a) burrows which penetrate strata more or less vertically (Arenicolites, Skolithos, Histioderma)

b) burrows which are more or less parallel to beds of deposition (Planolites)

c) problematical (Cruziana)

B. Surface tracks

a) annelidous fossils which may be tracks or may be the mineralised worm (Crossopodia, Nemertites, Nereites)
b) trails which may have been formed by Annelides or Molluscs (Myrianites)
c) tracks of uncertain affinities (Helminthites)

C. Appendix

(Caridolites: ? formed by crustacean)

Considering the limited materials Nicholson had to work on, this classification is basically like many modern ones, despite the fact that most of his surface tracks are in reality burrows.

In 1873, Nathorst published the first of his great works in which he compared many of the 'fucoids' with tracks of marine animals, on the basis of neoichnological observations. This, and his later works (1881a, b) led to a violent controversy in the 1880s, between Nathorst and his opponents who maintained the plant origin of most trace fossils. Even into this century, many trace fossils have still been referred to Algae. If Nicholson's "Errant Annelide" paper had been published in 1873, palichnology may have advanced more rapidly in the past century.

In Nicholson & Hinde(1874), several trace fossils of the Clinton formation (Silurian) of Canada are described. Buthotrephis is still regarded doubtfully as a plant; Skolithos, Arenicolites and Planolites are all clearly burrows. In 1875, Nicholson gave an expanded version of this paper, with figures. As "Annelida", he describes Skolithos, Arenicolites Planolites and Spirorbis. As "Incertae sedis", he describes Licrophycus, Palaeophycus, Rusophycus, Buthotrephis ("a so-called fucoid") and Fucoides sp. ("It is extremely doubtful if this is of vegetable nature").

In 1877 (p122-4) Nicholson mentions upper Silurian annelide tracks and figures Planolites vulgaris (fig.63). Nicholson and Etheridge (1881 p304-318) described the worm tracks of Girvan (southern Scotland), together with some more general remarks on the subject. The genera described and figured (P1. 23-24) are: Nereites, Myrianites, Crossopodia, Eione and Nemertites. In the general discussion, reference is made to tracks of recent marine invertebrates and a gastropod trail from a nearby beach is figured for comparison with certain of the fossil tracks. Nicholson also figures a specimen of Myrianites in which a large extent of inner vertical wall is displayed on the top surface. He regards this as a plant-like phenomenon (it is a vertical Dictyodora-type wall, as discussed above) and retracts some of his earlier views as to the animal nature of certain tracks, referring them instead to plants.

He repeats this understandable, but backward-looking opinion in 1889 in an extensive discussion of worm traces (p480-490). His classification is now expanded to:

I. Burrows of habitation (Skolithos, Histioderma, Arenicolites)
II. Wandering burrows (Palaeochorda, Palaeophycus, Planolites)
III. Trails and tracks (Nereites, Phyllodocites, Myrianites, Crossopodia)

The producers of the tracks are discussed and it is suggested that some could be crustacean or molluscan in origin from observations of recent invertebrates by other workers.

A comment on the importance of Nicholson's work on trace fossils is given in Häntzschel (1975, pW14):

> "Astonishingly, some ethological or general genetic interpretations of certain trace fossils have remained valid for nearly a century. Nicholson (1873,p288-289) regarded Skolithos-structures as true burrows of habitation, whereas he explained horizontal burrows as wandering tunnels excavated by worms in search of food. Nicholson also declared that forms combined by him under the name Planolites were "not the

actual burrows themselves but the burrows filled up with sand or mud which the worm had passed through its alimentary canal." His interpretations were repeated, independently, decades later by subsequent authors. These early contributions must be recognised again, today."

Acknowledgements

We wish to thank most sincerely the Royal Society of London, firstly for supplying us with a microfilm copy of Nicholson's manuscript, which is held in their library, and secondly for very kindly allowing us to publish the full text of the manuscript.

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REFERENCES

Alpert, S.P. 1975. Planolites and Skolithos from the Upper Precambrian-lower Cambrian White-Inyo mountains, California. J. Paleont. 49, 508-521, 3 pls.

Billings, E. 1861-5. Palaeozoic fossils. Vol.1, containing descriptions and figures of new or little-known species of organic remains from the Silurian rocks: Canada Geol. Survey, 426p, 401 figs.

Chamberlain, C.K. 1971. Morphology and ethology of trace fossils from the Ouachita Mountains, southeast Oklahoma. J. Paleont., 45, 212-246.

Chisholm, J.I. 1970 Lower Carboniferous trace-fossils from the Geological Survey boreholes in West Fife (1965-6). G.B. Geol. Surv., Bull. 31, 19-35, 4pls.

Emmons, E. 1844. The Taconic System. 68p . 6 pls., Albany.

Etheridge, R., Woodward, H., and Rupert-Jones, T. 1890. Seventh report of the committee on the fossil Phyllopoda of the Palaeozoic rocks. Rep. Brit. Assoc. Adv. Sci. 1889 (1890), 63-68.

Frey, R.W. 1971. Ichnology - the study of fossil and recent lebensspuren: in Trace-Fossils, B.F. Perkins (ed.), Louisiana State Univ., Misc. Publ. 71-1, 91-125, figs. 1-21.

Frey, R.W. and Howard, J.D. 1970. Comparison of Upper Cretaceous ichnofaunas from siliceous sandstones and chalk, Western Interior Region, U.S.A. In: Trace Fossils, T.P. Crimes and J.C. Harper (eds.), Geol. Jour., Spec. issue no. 3, 141-166, Seel House Press (Liverpool).

Fuchs, T. 1895. Studien über Fucoiden und Hieroglyphen. Denkschr. Kaiserl. Akad. Wiss. Wien, math-nat. Kl., 62, 369-448, 9 pls.

Groom, T. 1902. The sequence of the Cambrian and associated beds of the Malvern Hills. Q. Jl. geol. Soc. Lond., 58, 89-135, figs. 1-35.

Haldemann, S.S. 1840. Supplement to number one of 'A monograph of the Limniades, and other fresh-water univalve shells of North America', containing descriptions of apparently new animals in different classes, and the names and characters of the subgenera in Paludina and Ancillosa 3p, Philadelphia.

Hall, J. 1843. Geological survey of New York; Report on the fourth district. 683p.

Häntzschel, W. 1975. Trace fossils and Problematica, in Treatise on Invertebrate Palaeontology, C. Teichert (Ed), part W, Wl-269, 912 figs. Geol. Soc. Amer., Univ. Kansas.

Häntzschel, W, El-Baz, F. and Amstutz, G.C. 1968. Coprolites, an annotated bibliography. Geol. Soc. Amer., Mem. 108, p vii + 132.

Howell, B.F. 1943. Burrows of Skolithos and Planolites in the Cambrian Hardyston sandstone at Reading, Pennsylvania. Publ. Wagner Free Inst. Sci. 3, 3-33, pls 1-8.

Kinahan, J.R. 1858. On the organic relations of the Cambrian rocks of Bray (County of Wicklow) and Howth (County of Dublin); with notices of the most remarkable fossils. J. geol. Soc. Dublin, 8, (1857-60), 68-72, pls 6,7.

Ludwig, R. 1869. Fossile Pflanzenreste aus den palaolithischen Formationen der Umgebung von Dillenburg, Biedenkopf und Freiberg und aus dem Saalfeldischen. Palaeontogr. 17, 105-128, pls 18-28.

M'Coy, F. 1848. Note on some Skiddaw slate fossils. Q.Jl geol. Soc. Lond., 4, 233-225.

--- 1851. On some new Protozoic Annulata. Ann. Mag. nat. Hist., (2) 7, 394-396.

--- 1851-5. A systematic description of the British Palaeozoic fossils in the Geological Museum of the University of Cambridge. In: A. Sedgwick, A synopsis of the Classification of the British Palaeozoic rocks. 661p 25 pls. J.W. Parker (London, Cambridge).

MacLeay, W.S. 1839. Note on the Annelida. In R.I. Murchison, The Silurian System, pt II, 699-701, London.

Moore, R.C. (Ed.) 1969. Treatise on invertebrate palaeontology. Part R. Arthropoda 4. p xxxvi + 651, 1762 figs, (2 vols).

Nathorst, A.G. 1873. Om några förmodade vaxtfossilier. Öfversigt af Kgl. Vetensk. Akad. Förhandl., 9, 25-52, (1874).

--- 1881a Om spår af nagra evertebrerade djur M. M. och deras palaeontologiska betvdeelse. (Mémoire sur quelques traces d'animaux sans vertèbres etc. et de leur porteé paléontologique.). K. Svenska Vetenskapsakad., Handl., 18, no. 7, 104p, 11 pls.

--- 1881b. Om aftryck af Medusor i Sveriges Kambrisks Lager. Kgl. Svenska Akad. Handl., 19, 1-34, 6 pls.

Nicholson, H.A. 1868. An essay on the geology of Cumberland and Westmorland, p viii + 93. London & Manchester: Robert Hardwicke.

--- 1869. On the occurrence of plants in the Skiddaw slates. Geol. Mag., 6, 494-498, pl 18.

--- 1872. A manual of palaeontology for the use of students. p xvi + 601, Edinburgh & London: Blackwood & Sons.

--- 1873. Contributions to the study of the Errant Annelides of the older Palaeozoic rocks. (abstract) Proc. Roy. Soc. London, 21, 288-290.

--- 1875. (2nd) Report upon the Palaeontology of the Province of Ontario. 96, 4 pls. Toronto: Hunter, Rose & Co.

--- 1877. The ancient life-history of the earth. p xviii + 407. Edinburgh & London: Blackwood & Sons.

--- 1879. A manual of palaeontology for the use of students (2nd edition). vol 1, 551.

Nicholson, H.A. and Etheridge, R. jun. 1878-1881. A monograph of the Silurian fossils of the Girvan district in Ayrshire. vol 1, p ix + 341, 24 pls. Edinburgh & London: Blackwood & Sons.

Nicholson, H.A. and Hinde, G.J. 1874. Notes on the fossils of the Clinton, Niagara and Guelph formations of Ontario, with descriptions of new species. Canadian Jour. Ind. Sci. Hist. (n. ser.), 14 (2), 137-152, 137*-144* (Mistake in pagination - repetition of p 137-160).

Nicholson, H.A. 1889 in Nicholson, H.A. and Lydekker, R. A manual of palaeontology for the use of students. vol. 1, 885p. Edinburgh & London: Blackwood & Sons.

D'Orbigny, A. 1835-47. Voyage dans l'Amerique meridionale . . . executé pendant les annees 1826, 1827, 1829, 1830, 1831, 1832 et 1833: vol 3, pt 4 (Paleontologie), 188p, 22 pls (1842), Pitois-Levrault (Paris), Levrault (Strasbourg).

Richter, R and Richter, F. 1939. Marken aus allen Zeiten. III. Eine Lebens-spur (Syncoprulus pharmaceus), gemeinsam dem rheinischen und böhmischen Ordovicium. Senckenbergiana. 21, 152-168, figs. 1-8.

Salter, J.W. 1856. On fossil remains in the Cambrian rocks of the Longmynd and North Wales. Q. Jl geol. Soc. Lond., 12, 246-252, pl 4.

--- 1857. On annelide-burrows and surface markings from the Cambrian rocks of the Longmynd. Q. Jl geol. Soc. Lond., 13, 199-206, pl 5.

--- 1866. Appendix on the fossils of North Wales: in A.C. Ramsay, The geology of North Wales. Mem. Geol. Survey G.B. vol 3, 236-363, 28 pls.

Schäfer, W. 1953. Zur Unterscheidung gleichformiger Kot-Pillen meerischer Evertebraten. Senckenbergiana, 34, 81-93, 6 figs.

--- 1972. Ecology and palaeontology of marine environments (Translation of Aktuo-Paläontologie nach studien in der Nordsee). Oliver & Boyd and Univ. Chicago Press, 568p.

Seilacher, A. 1967. Fossil behaviour. Sci. Am., 217, 72-80.

Webby, B.D. 1970. Late Precambrian trace fossils from New South Wales. Lethaia, 3, 79-109, 21 figs.

Weiss, E. 1884. Voregung des Dictyophytum liebeanum Gein.aus der Gegend von Gera. Sitz. - Ber. Ges. naturf. Freunde Berlin, 1884, 17.

Captions to Plates

Pl 1 fig. 1 Arenicolites sparsus Longmynd, Shropshire. 10605.

Pl 1 fig. 2 Planolites articulatus Nicholson ms. Skiddaw Slates. Outerside (or Coldale) nr. Keswick. 10617.

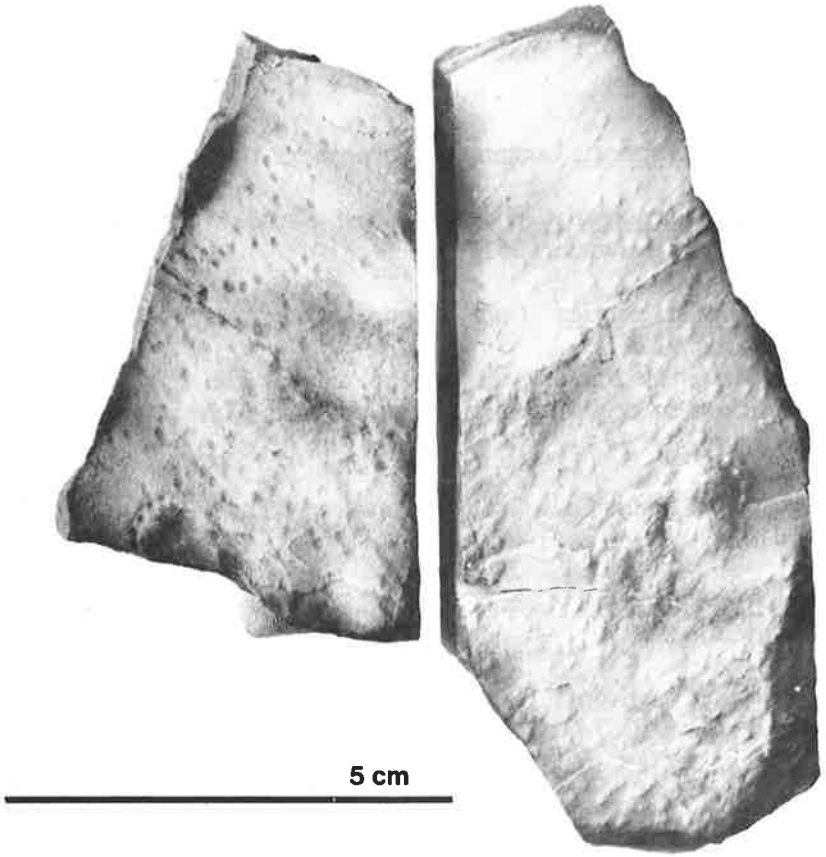
Pl 2 fig.1 Crossopodia scotica Gala Group (Llandovery) Thornilee Quarry, Galashiels, 9224.
The flattened burrow fill can be seen at the left of the specimen; transitions to the 'Myrianites' type of trace occur at the left and top of the figure.

Pl 2 fig. 2 Myrianites tenuis Gala Group (Llandovery) Thornilee Quarry, Galashiels. 10610.

Pl 3 fig. 1 Caridolites wilsoni Gala Group (Llandovery) Nr. Grieston Quarry, Innerleithen. 7059.

Pl 3 fig.2 Caridolites wilsoni Gala Group (Llandovery) Grieston Quarry, Innerleithen. 10674.

Plate 1



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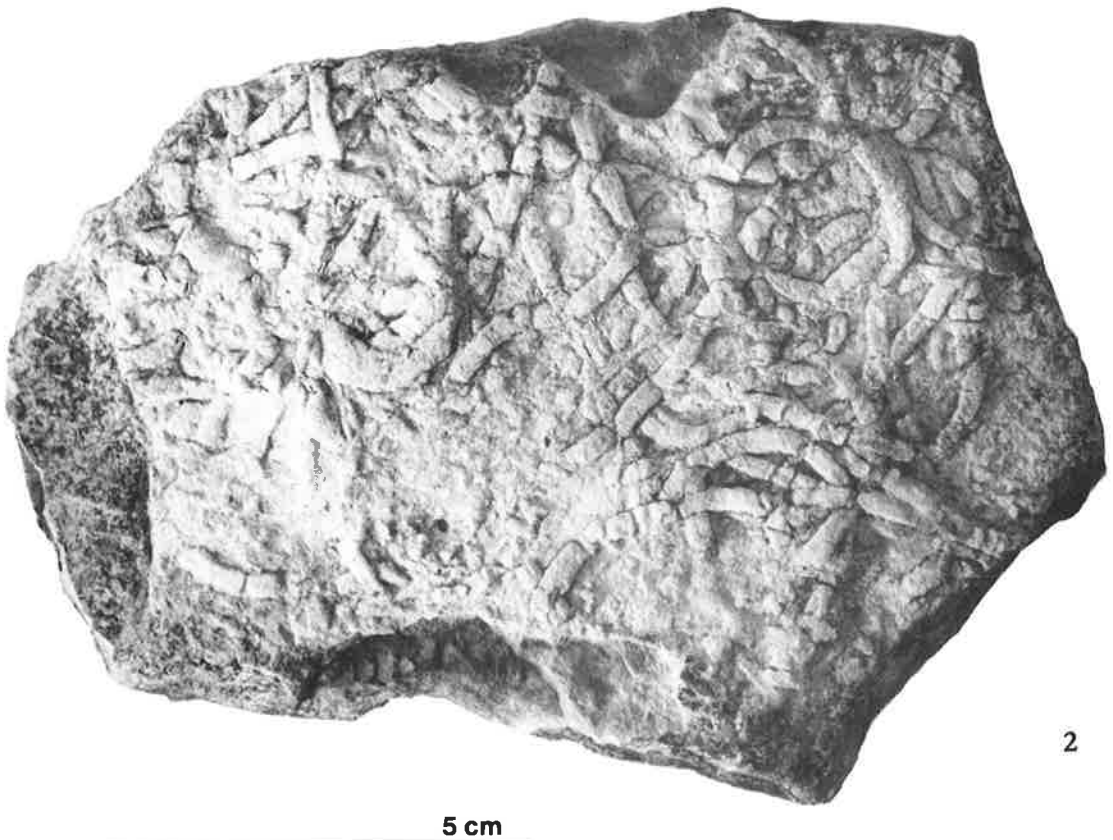

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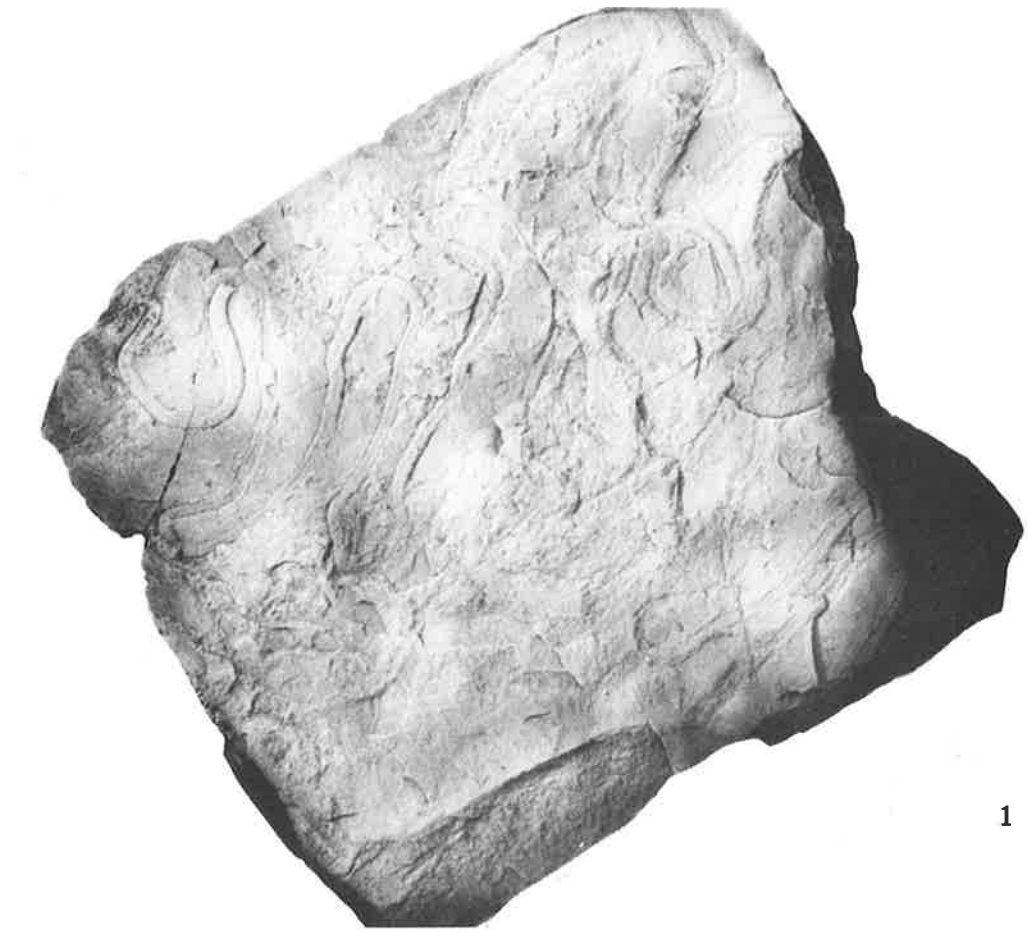

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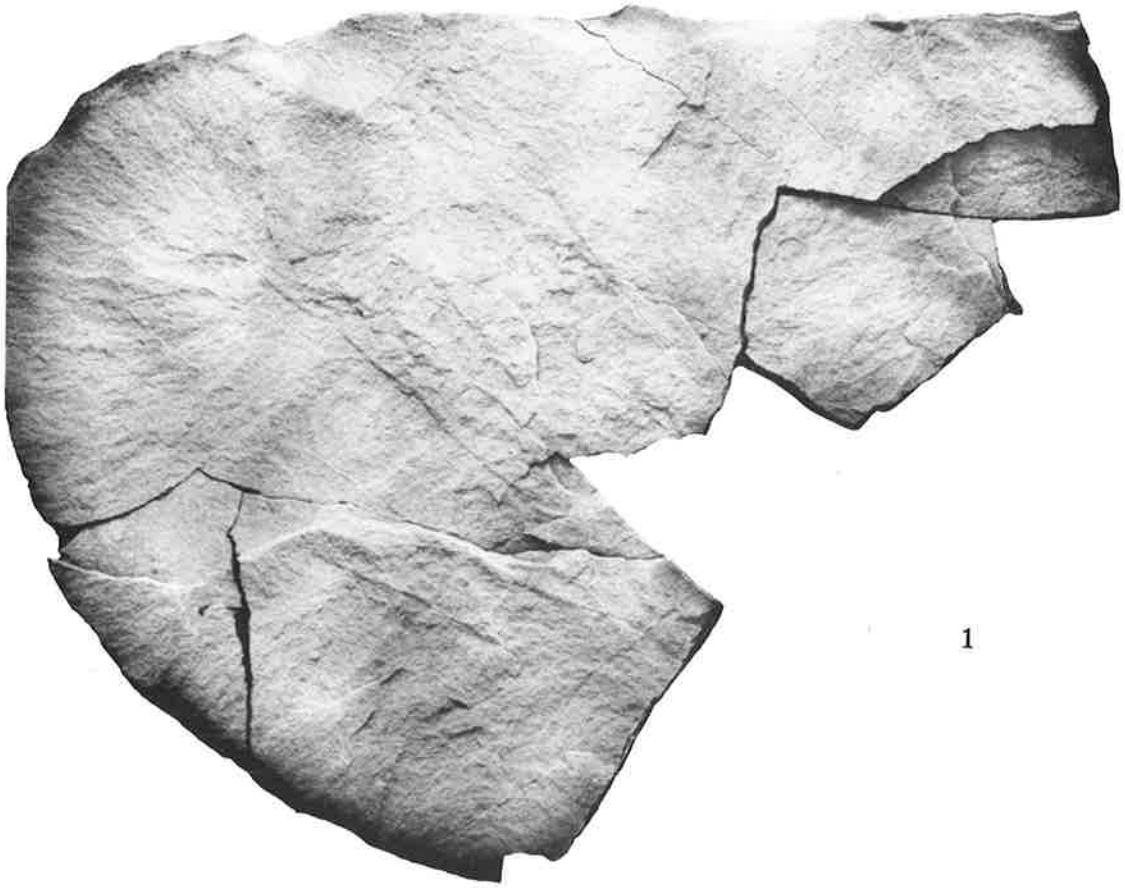

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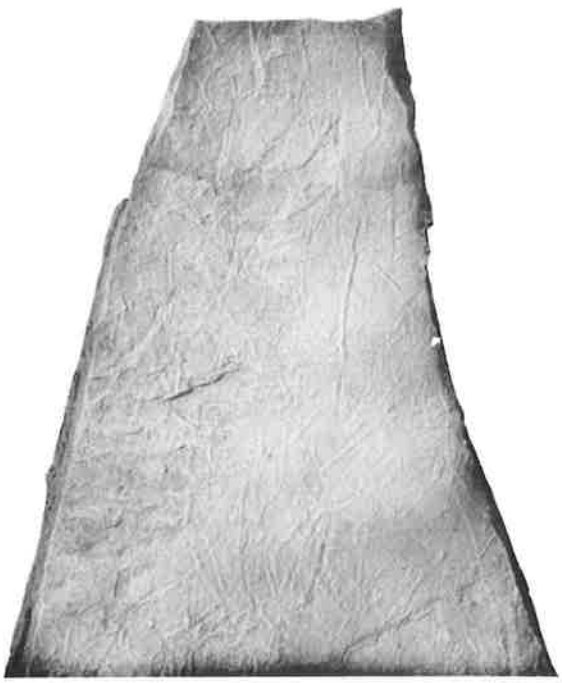

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CONTRIBUTIONS TO THE STUDY OF THE ERRANT ANNELIDES OF THE OLDER PALAEOZOIC ROCKS.

H.A. Nicholson

No fossils come more frequently under the notice of the student of the older Palaeozoic deposits than the ever-recurring and unintelligible remains which are usually termed "Fucoids", "worm tracks" and "Annelide-burrows" Though occurring often in vast profusion, the characters of these remains are often very indefinite, and much difference of opinion has in many cases obtained as to their true inerpretation. The difficulty of their study has been very much increased by the fact that fossils of very different affinities have in some cases been placed in the same group, or even in the same genus. Some of the fossils in question are probably truly the remains of marine plants, and these I do not propose to speak of at present. Others are undoubtedly the remains of marine animals, Annelidous or Molluscous: and it is to the elucidation of these that this communication is directed.

It may, perhaps, appear to some a work of supererogation to dignify these obscure and often indecipherable fossils with separate names, and to place them under distinct genera and species. I am, however, decidedly of opinion that these dubious groups of fossils are always likely to remain constituting so many palaeontological lumber-rooms, until some definite attempt is made to classify them and to split them up under distinct names. As a matter of course, the first attempts to arrange these groups are sure to be imperfect, and the characters which are relied upon to separate the different forms are certain in some cases to prove valueless as viewed by the light of later discovery and more extended research. Nevertheless, until the known forms are brought under something like a definite arrangement and a definite nomenclature, the palaeontological student has no fixed basis for his labours; but he is sure to content himself - if he takes the trouble to collect them at all - with labelling all such specimens "worm tracks" or "Fucoids", and thinking that there is an end of the matter. In the present memoir, therefore, I have endeavoured to describe the more striking of these curious but obscure bodies which have come under my notice in collecting in the Cambrian and Silurian formations. In order to give completeness to the paper, I have also briefly noticed the more remarkable allied forms which have been recorded by other investigators, but which have not come under my own immediate observation - when the published description has been sufficiently explicit to make quotation without an illustration, of any avail.

The fossils which I propose passing under review may, conveniently and naturally be divided into two primary groups:-

A. Annelide burrows - distinguished by the fact that the fossil is not confined to the surface of a single bed, but penetrates the laminae of deposition in an oblique or vertical direction. Some of them are more or less nearly vertical (Arenicolites, Scolithus, Histioderma); and they may be filled up in whole or part with the surrounding sediment, or they may be preserved in a hollow and almost unaltered condition, even in deposits as old as the Cambrian. Such burrows are of a more or less permanent nature. Others are more or less nearly horizontal, or run obliquely to the laminae of deposition of the rock; and these owe their preservation to their having been filled up in course of formation by the sand or silt passed through the alimentary canal of the animal (Planolites). Even when these burrows run parallel with the surface of a single bed, they are nevertheless younger in point of time than the bed which immediately rests upon them. Such burrows, also, are of a more or less temporary and wandering character, being formed by the worm as it bores its way at random through the sand or mud of the sea-shore.

B. Surface trails - distinguished by the fact that they are strictly confined to the surface of a single bed, and that they do not pass from one lamina of deposition to another (Crossopodia, Nereites, Myrianites, Nemertites). In some cases, the genuine trails themselves have been preserved, but other specimens merely present us with the **casts** of such trails. In complete specimens, we have the trail upon the upper surface of one bed and the cast of the trail upon the lower surface of the bed next above; and if such specimens are examined separately and without due care they may be easily referred to different species, or even to different genera.

In some cases, we have sufficient proof that these trails have actually been produced by Errant Annelides. In other cases, there is no evidence to show whether the trails have been produced by Annelides, by Molluscs or by some other class of marine animals. In no case, as I shall endeavour to show, is there any sufficient evidence to show that the actual body of the worm has been preserved to us, though eminent observers have adopted this view.

The following is a list of the genera and species which are described in this communication:-

A. ANNELIDE BURROWS.

The organic remains referable to the burrows of marine Annelides are much less ambiguous in their characters and nature than those referred to surface trails, though most of them have at one time or another been referred to the vegetable Kingdom, and some of them are still regarded as plants by good authorities. They are divisible into two well-marked groups according as they penetrate the strata more or less nearly parallel to the laminae of deposition. In the first group we have the genera Arenicolites Salter, Scolithus Hall and Histioderma Kinahan; in the second we have a group of forms for which I propose the generic name of Planolites (Greek, planos, wandering). In the former group the fossils are the actual burrows of marine Annelides, sometimes empty, but more commonly filled up with sand or mud. In the second group, the fossils are the fillings up of the winding and tortuous burrows of Annelides by "the excreta of the worm, as it bored its way through silt or sand, carrying the material of one bed into that of the next and threading them together into a pasty mass" (Salter, Mem. Geol. Survey, Vol III, p 243). These fossils are almost always of a coarser grain and lighter tint than the surrounding matrix, but with the single exception of Planolites granosus Nich., in which the ejecta of the worm had the form of little oval pellets, they show nothing which could be termed "structure".

Scolithus has been regarded as a plant by good modern authorities (Hall, Pal. N.Y. Vol.I, p 2, and Billings, Pal. Foss. Can. p 2). The fossils which I have here grouped under the name of Planolites, have also commonly been referred by palaeontologists to the vegetable kingdom - the late Mr Salter standing almost alone in his opposition to this view. They have been placed under various genera of so-called "Fucoids", being mostly described as species of Chondrites and Palaeophycus. I do not by this mean to assert that some of the forms included under these two genera are not really referable to the marine Algae; I merely mean that many filled-up Annelide burrows have been included under these names along with other remains which are doubtless truly of a vegetable nature. It is possible, also, that some of the forms included under M'Coy's genus Palaeochorda are in reality filled-up burrows, though, most of these forms appear to be rather referable to the filled up surface-trails of Annelides or Molluscs, and there is certainly no evidence in support of the view that they are plants. I shall, however, discuss these questions more fully in treating of each individual generic type.

I. Arenicolites Salter,

Quart. Journ. Geol. Soc. Vol XIII, p 203
Arenicola Binney, Mem Lit. and Phil. Soc. of Manchester, 2nd Series, Vol X, p 191.
Arenicola Salter, Quart. Journ. Geol. Soc. Vol XV, p 248.

> **Generic characters:** Burrow consisting of a loop-like or U-shaped tube, opening on the surface by two adjacent apertures, one for the exit and one for the entrance of the worm. The tubes more or less nearly vertical to the surface.

This genus was originally founded by Mr Binney for the reception of certain Annelide burrows from flaggy sandstones belonging to the Carboniferous rocks of Lancashire, for which he proposed the name of Arenicola, believing them to be generically identical with the common lob-worm of our coasts (Mem. Lit. and Phil. Soc. Manch. 2nd ser. vol X, p 191). He also demonstrated that the burrows were arranged in pairs, connected beneath the surface by a loop-like tube. Subsequently Mr Salter (op. cit. supra.) proposed to substitute for Mr. Binney's name Arenicola the slightly modified name Arenicolites - a change which should certainly be accepted, as the fossil forms have no close affinities with the recent Arenicolae. The

genus, as far as I am aware, has not been shown to have survived the Palaeozoic period; and I do not even know that it has hitherto been detected in any Permian deposit. Three species are known to me as occurring in the Cambrian and Silurian formations; viz. Arenicolites sparsus Salt., A. didymus Salt. and A. robustus Nich.

1. Arenicolites sparsus Salter
Quart. Journ. Geol. Soc. Vol XIII, p 203

Specific characters: Burrows in pairs, from one line to half a line in diameter, with circular apertures, usually more or less remote from one another (Pl. I, figs 1 and 3).

This is the commonest and most characteristic member of the genus. Considerable differences obtain in the size of the burrows, but these may, within certain limits, be reasonably set down to the age of the worm. The smaller burrows, which are especially abundant in the Cambrian rocks of the Longmynd, are generally found in immense numbers, covering large areas of the surface, but they can mostly be shown without difficulty to be arranged in pairs. Each orifice of the burrow is usually more or less circular, the width varying from a twenty-fifth to a twelfth of an inch, and the two openings being placed near together, separated by a space which varies from less than a fiftieth to as much as a twelfth of an inch. Sometimes one aperture is larger than the other upon which it may encroach. The mouths of the burrows appear on the surface of the bed as small rounded depressions, the casts of which are found on the lower surface of the bed above in the form of shallow rounded tubercles.

In larger specimens (as in some specimens from the Skiddaw Slates), whilst the burrows are very much the same in point of size, the space between the members of each couple is seldom less than a tenth of an inch.

In still larger specimens (as in Pl. I, fig. 3 from the Skiddaw slates), the orifices of the burrows are very regularly circular, about one line in diameter, and separated by interspaces of about two lines. In the specimen figured, also, the mouths of the burrows are very distincly filled with a sediment of a much lighter colour than the surrounding matrix.

Locality and Formation: Very abundant in olive-green shales and purple grits (lower Cambrian) in the Longmynd, near Church Stretton. Rare in the Skiddaw slates (upper Cambrian) of Barff, near Keswick.

2. Arenicolites didymus Salter
Arenicola didyma Salter, Quart. Journ. Geol. Soc. Vol XII, p 248

Specific characters: Minute burrows arranged in pairs, of an oval shape, and placed parallel with one another.

I should be inclined to doubt if a specific distinction can be maintained between this form and the preceding. When at the Longmynd, at any rate, I was unable to obtain any specimens which appeared to be distinct or to show any differential characters other than those of a merely trivial nature. In the meanwhile, however, I prefer to retain the species, as it may be distinct; and this seems better as a provisional arrangement, than placing all the forms of A. sparsus under the prior name of A. didymus, since the former is certainly a well marked type.

The characters which are relied upon by Mr Salter in distinguishing A. didymus are that the burrows are placed very near together, that their shape is oval and that they are arranged with their long axes parallel. They are likewise stated to consist

distinctly of two sets, one strongly impressed, and the other faint, as if subsequently effaced. If these characters can be shown to be permanent, they would doubtless be sufficient to warrant the separation of this form as a distinct species; but I imagine that a further examination will show that this is not the case.

Locality and Formation: Lower Cambrian of the Longmynd, near Church Stretton.

3. Arenicolites robustus Nicholson sp.

Specific characters: Burrow in pairs, sometimes partially confluent, separated from one another by interspaces varying from 1/50 to 1/5 of an inch. Apertures oval or circular, from 3/20 to 1/5 of an inch in diameter (Pl. I, fig.4).

The size of these burrows is so considerable that it is impossible to regard them as being merely aged forms of Arenicolites sparsus, with which they agree in all respects except in magnitude. I have, therefore, proposed for them the above specific name. They have been figured by Mr Salter, but no description of them is given, and they are confounded with the very different Scolithus linearis of Hall (Mem.Geol. Survey, Vol III, p 292). His figure (op. cit. p 203), which I here reproduce, exhibits a ripple-marked slab with numerous burrows of Arenicolites sparsus, along with a few pairs of the much longer burrows of A. robustus (see fig.1).

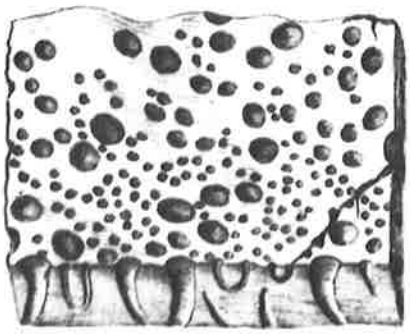

Fig. 1 Burrows of Arenicolites sparsus
and A. robustus (after Salter)

Again in Mr Salter's paper on the organic remains of the Longmynd rocks (Quart. Journ. Geol. Soc. Vol XIII, pl. V), I regard the so-called "rain-prints" represented in fig 1 of his plate as being the burrows, or casts of the burrows of A. robustus. Whether this be also the case with the rain-prints represented in fig10 of the same plate, can not be stated with any certainty without an actual inspection of the original specimen. It will be noticed, however, that, with hardly one exception, the rain markings in the former figure are arranged **in pairs**, whilst their size is very uniform.

The example of this fine species which I have selected to figure(Pl. I, fig. 4)is from the Skiddaw slates, and represents a slab covered with the casts of the burrows. The specimen, therefore, shows the under-surface of the bed, and the casts of the burrows are dotted over it, in the form of oval or circular eminences, arranged in pairs. Some of the casts show a depression in the centre, which must have

corresponded with a small papilla at the entrance of the burrow. It is also worthy of notice that the casts of these burrows, except for the fact that they are in pairs, might very readily be mistaken for the casts of rain-prints.

Locality and formation: Longmynd beds (lower Cambrian) of Yearling Hill, Church Stretton (Salter). Lower bed of the Skiddaw slates (upper Cambrian), Rake Beck, near Melmerby. Lower Silurian (Salter).

II. Scolithus Haldemand

Scolithus, Hall, Pal. N.Y. Vol.1, p.2, Pl. I
Scolites, Salter, Quart. Journ. Geol. Soc. Vol. XIII, p.204, and Mem. Geol. Survey, Vol. III, p.248.

> **Generic characters:** Burrows, which are usually of large size, and are always unpaired. The orifice of the tube somewhat trumpet-shaped, the burrow descending vertically through the rock and being usually bent or curved at its deeper extremity (Pl. II, fig.2.).

The genus was originally proposed by Haldemand as a subgenus of Fucoids, and was subsequently characterised by Hall as comprising simple free stems, "cylindric or subcylindric, vermiform or linear, never branched". Though the belief in the vegetable nature of Scolithus is still retained by eminent palaeontologists, little doubt can be entertained but that the fossils which it includes are veritable Annelide-burrows. That they cannot be the stems of plants is shown by their being,in most if not all cases, curved inferiorly, and by their gradually increasing in diameter as they are followed from below upwards. It is, also impossible to believe that vast numbers of the stems of cellular plants of such small dimensions should ever have been able to have retained a vertical position whilst the sediment was being accumulated round them. Some of them, on the contrary, would certainly be found in a prostrate or recumbent position.

The forms which should properly be included under Scolithus are those in which the burrow is single, and does not return to the surface by a loop, to open by a second aperture. This was originally pointed out by Mr. Salter, but this distinguished observer seems subsequently to have confounded these unpaired vertical burrows with those filled-up oblique burrows which I have separated under the name of Planolites. There does not, also, appear to be any valid reason for changing the older name of Scolithus for Scolites, as proposed by Salter, except that the nomenclature would thus be rendered more uniform.

Three species of Scolithus have been described, viz: S. canadensis Billings, from the upper Cambrian of Canada and England; S. linearis Hall, from the upper Cambrian of North America and S. verticalis Hall, from the upper Silurian of North America.

4. Scolithus canadensis Billings

Scolithus canadensis Billings, Pal. Foss. Can. p.96 and Geology of Canada, fig. 7
Arenicolites linearis Salter, Quart. Journ. Geol. Soc. Vol. XIII, p.205.

> **Specific characters:** Tube vertical, diameter from 1/8 to 1/6 of an inch; length from three to six inches. Burrow trumpet-shaped towards the orifice, curved and slightly tapering below. Hollow, or filled up with sediment. The internal surface smooth (Pl. II fig. 2)

All the examples of this species which have come under my notice are from the quartzose grits of the Stiper Stones; and I am completely satisfied as to their entire identity with the Canadian form, in which an excellent figure is given in the "Geology of Canada" (1863), where it is spoken of as a supposed Annelide-burrow. In the

"Palaeozoic Fossils of Canada" (1865), Mr. Billings, however, has placed Scolithus amongst the plants.

Mr. Salter originally placed these fossils with the Scolithus linearis of Hall, though with more or less doubt. They differ from the New York species, however, in several sufficiently marked characters. Thus the tubes of S. linearis vary in length from a few inches to "several feet" (Hall), and consist of simple "retilinear" stems, sometimes as much as half an inch in diameter, and sometimes apparently striated. They are also straight and parallel with one another. On the other hand, specimens of S. canadensis do not exceed six inches in length, are widest towards their mouths, and are more or less curved towards deeper extremities, whilst their diameter does not exceed two lines. These distinctions, it seems to me, are at any rate of specific value.

Whatever may be the nature of Scolithus linearis, little doubt can be entertained as to the Annelidous nature of S. canadensis. There is also plain evidence that the burrow in this species is not to be compared with the tortuous, wandering, and ever shifting canals of the lob-worms, but that it was a permanent habitation of the worm, and that its sides were rendered firm and smooth by a mucous secretion from the body. Hence, many of our specimens are hollow, instead of being filled up with sediment, and when split open, they are found to exhibit perfectly smooth walls, often stained brown with oxides of iron. None of the examples which I have examined could be shown to return to the surface by a second tube; nor do the mouths of the tubes on the surfaces of the beds exhibit any paired arrangement. Mr. Salter, however, (Siluria, p.41) seems to have believed that they were disposed in this manner.

The specimen which I have figured (Pl. II fig.2) is from the Stiper Stones of Shropshire, and is in hard siliceous grit. On the upper surface of the stone are seen the apertures of several of the burrows which are continued through to the lower surface; and on one side is seen one of the tubes split open along its length. It is probable, however, that the burrow was continued into an upper stratum, now broken away, and that its upper extremity as seen here does not represent its true external aperture. The tube is hollow, with a perfectly smooth interior, about three inches in length, with a width of one fifth of an inch at its upper and one tenth of an inch at its lower extremity - neither extremity, however, being perfect. In the upper inch and two-thirds, the tube is perfectly straight, but it then curves gradually, till it forms an angle of about 120° with the straight portion. The form of the tube is, very distinctly, not perfectly cylindrical, but on the contrary is sub-quadrilateral; two of the sides being much wider than the others, so that the section of the tube is an oblong with the angles rounded off. Other specimens, however, have a circular or oval transverse section; and some of them are not quite vertical, but penetrate the beds obliquely

Locality and formation: Common in the hard gritty sandstones (upper Cambrian) of the Stiper Stones of Shropshire. Also abundant in the Potsdam sandstone (upper Cambrian) of Canada.

5. Scolithus linearis Hall

Scolithus linearis Hall, Pal. N.Y. Vol. 1, p.2 Pl. I.

> **Specific characters**: "Stem simple, rectilinear; surface nearly even, cylindric or compressed, sometimes apparently striated. Diameter 1/8 to 1/2 an inch; length from a few inches to several feet." (Hall).

This singular fossil consists of linear stems often one or two feet in length, and presenting the appearance of "a series of small pins or pegs driven into the rock in a somewhat regular manner and at uniform distances". It does not seem possible that

this can be the remains of a plant, and upon the whole there can be little doubt as to its comprising the vertical burrows of Annelides, filled up subsequent to their formation by sand or mud. It differs from S. canadensis Billings, in its much greater length, its frequently larger diameter, its straightness, and the parallelism between different tubes. None of the English specimens which I have seen from the Stiper Stones can be referred to this species.

Locality and formation: Potsdam sandstone (upper Cambrian) of various parts of the United States and of Labrador.

6. Scolithus verticalis Hall

Scolithus verticalis, Hall, Pal. N.Y. Vol. II, p.6, Pl. II.

This species is very doubtfully distinct from S. linearis Hall, being apparently distinguished only by the smaller size and more slender proportions of its smooth round tubes. It is, however, from much more modern strata than the preceding; since it occurs in the Medina sandstone (upper Silurian). It seems not impossible that the specimen figured by Mr. Salter in the Memoirs of the Geological Survey, Vol. III, Pl. IV, fig. 13 may truly be referable to this form. Otherwise, the species has not as yet been detected in Britain.

Locality and formation: In the thick bedded sandstone (Medina sandstone) of Monroe County, State of New York.

III. Histioderma Kinahan

Histioderma Kinahan, Journ. Geol. Soc. Dublin, Vol. VIII, p. 71.

> **Generic characters**: Burrow commencing in a raised mound, in the centre of which is the external orifice; at first vertical, then becoming curved, and diminishing in size. The cast of the upper portion of the tube marked by a series of interlacing ridges.

The fossils included under this head are obviously Annelide-burrows, which agree with Scolithus Hall in being vertical and unpaired, but differ from it in the fact that the mouth of the burrow opens on an elevated mound, and also in the peculiar ridges which cross each other on the cast of the tube near its orifice. The genus is only known at present from the lower Cambrian rocks, in which but a single species has been as yet detected (H. hibernicum, fig. 2).

7. Histioderma hibernicum Kinahan

Histioderma hibernicum Kinahan, Journ. Geol. Soc. Dublin, Vol. VIII, p. 71.

> **Specific characters**: Burrow opening at a depression placed in the centre of a slightly raised mound, the diameter of which is about an inch and a half. The burrow passes vertically through the rock (fig. 2b) for a distance from one and a half to three inches, when it becomes slightly curved, decreasing in size and finally terminating in a rounded extremity.

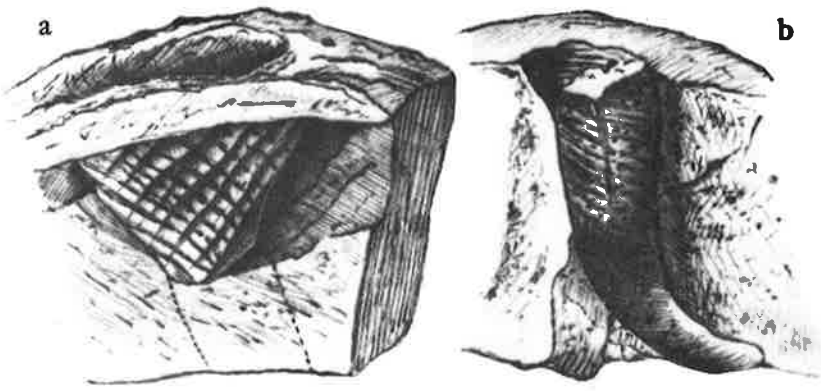

Fig. 2. Histioderma hibernicum Kinahan from the lower Cambrian of Bray Head, Wicklow (copied from Baily). a. Opening of burrow and commencement of tube, showing the interlacing ridges on its upper portion of curved extremity of the burrow.

No doubt can be entertained as to the nature of Histioderma, and it is of special interest as constituting the earliest known remain of the class of the Annelida. According to Dr. Kinahan, its dicoverer, H. hibernicum is "a tentacled sea-worm, evidently cephalobranchiate, and not very dissimilar to the common lug-worm (Arenicola) of our present seas".

Locality and formation: Greenish grits (lower Cambrian) of Bray Head, County of Wicklow, Ireland.

IV. Cruziana D'Orbigny

Cruziana D'Orbigny, Voyage dans l'Amerique Meridionale.
Rusophycus, Hall, Pal. N.Y. Vol. II, p.23
Rusichnites, Dawson, Acadian Geology, p.257.

Generic characters: Convex impressions, deeply furrowed down the centre, sometimes "bilobed", and marked with oblique plaits or ridges proceeding from the median furrow. Sometimes elongated, sometimes short and rounded (fig.3.).

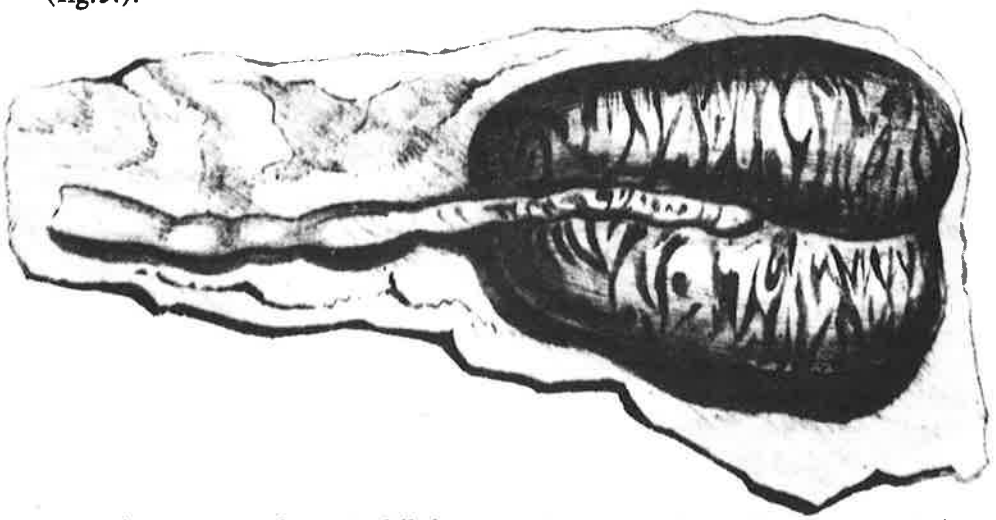

Fig.3. Cruziana (Rusophycus) bilobata Hall. From the Clinton Group (upper Silurian) of the State of New York (after Hall).

The true nature of the fossils belonging to this genus is so uncertain that I shall not discuss their affinities, having no suggestion to offer on the subject. The genus was originally referred to the Articulata and then to the vegetable kingdom. Vanuxem referred a species (C. bilobata) to the Algae, under the genus Fucoides (Geol. Report 1842, p.79). Hall also adopted the view that these problematical fossils are vegetable but proposed for them a new genus, under the name of Rusophycus (Pal. N.Y. Vol. II, p.23). By Mr. Salter Cruziana was also originally regarded as a "Fucoid" (Siluria, 3rd ed., p.46), but this opinion was subsequently exchanged for the more probable view that the genus is founded upon the filled-up burrows of Annelides (Mem. Geol. Survey, Vol. III, p.291). Lastly, by Dr. Dawson, these fossils, under the new generic name of Rusichnites, have been regarded as being the burrows of trilobites (Canadian Naturalist, new series, Vol. I, p. 363).

The genus is very widely represented in the upper Cambrian and Silurian rocks, being represented by very similar forms in the Silurian rocks of "Spain, Normandy, Britain, and North and South America" (Salter). The more important forms of the genus are Cruziana semiplicata Salter, of the lower Lingula Flags of Wales; C. (Rusophycus) clavata Hall, C. sub-angulata Hall, C. bilobata Vanuxem, and C. pudica Hall - all from the Clinton Group (upper Silurian) of the State of New York; C. (Rusophycus) grenvillensis Billings from the lower Silurian of Canada; and C. (Rusichnites) carbonaria and acadica Dawson from the Carboniferous rocks of Canada.

V. Planolites Nicholson

Scolites, Salter (in part), Mem. Geol. Survey, Vol. III, p. 292.
Chondrites, Auctorum, (in part)
Palaeophycus (in part) Hall, Pal. N.Y. Vol. I, p. 7.

> **Generic characters**: Cylindrical, curved, or tortuous, worm-like bodies, formed by the filling up of worm burrows - the filling consisting in general, if not universally, of the sand or mud which has been passed by the worm through the alimentary canal. The burrows, not vertical to the stratification, but more or less horizontal or penetrating the strata obliquely.

The fossils which constitute this genus consist, therefore, of casts of the burrowing of marine Annelides in the actual excreta of the animal, and they are consequently quite distinct from Scolithus. In the latter genus, the burrow is vertical and has been a more or less permanent habitation for the worm, whilst it is filled (if filled at all) by ordinary sediment deposited in its interior by water. In the former, on the other hand, the burrows are temporary, and are filled up as soon as formed by the sand which the worm passes through its intestine. Not only is the mode of formation thus quite peculiar, but the burrow is either tolerably horizontal or parallel to the bedding, or it penetrates the strata obliquely; and it is never vertical, unless it be at a bend in its course.

I have no hesitation in proposing the name of Planolites (Greek, planos, wandering; lithos a stone) for the group of fossils which are included under the above head, and which are very abundant throughout the sandy and shaly deposits of the older Palaeozoic period. They have been frequently noticed by palaeontologists, but their true nature has generally been overlooked. Mr. Salter, with his usual acumen, detected their real character, but he unfortunately united them with the vertical unpaired burrows of Scolithus, with which they have nothing in common. I can not, therefore, accept for them the name of Scolites proposed by Mr. Salter; since this (or the older Scolithus) nust be retained for the upright, single burrows which occur in the Stiper Stones in Britain and the Potsdam sandstone of North America.

Most commonly, the various forms of Planolites have been regarded as belonging to the vegetable kingdom, and have been referred to the loose and conveniently elastic group of "Fucoids". Thus the Chondrites informis and C. acutangulus of M'Coy (Quart. Journ. Geol. Soc. Vol. IV, p.223) undoubtedly belong here, as do, perhaps, some of the specimens of the Palaeochorda of the same author. Similarly some, at any rate, of the forms referred by American palaeontologists to the fucoidal genus Palaeophycus Hall, belong in reality to Planolites, and are not plants. This, for example, is the case with Palaeophycus tubularis Hall (Pal. N.Y. Vol. I, Pl. 2, figs. 1-4), and with the various species of Palaeophycus (viz: P. beverleyensis, P. funiculus, P. beauharnoisensis, P. incipiens and P. congregatus) described by Mr. Billings from the upper Cambrian and Silurian formations of Canada.

The origin and mode of formation of Planolites as an Annelidous fossil, can be readily understood. The fossil has been formed by Annelides essentially similar to the lob-worms (Arenicola) of the present day, eating their way through the sandy silt and mud of the sea-shore. The comparison of Planolites with the recent Arenicola probably expresses a genuine affinity, which is not the case with the genera Arenicolites, Scolithus or Histioderma, though all in turn have been likened to the same living form. The worm takes into its alimentary canal the sand or mud amongst which it burrows, for the purpose of extracting from the same any nutrient particles which may be contained therein. As it advances on its devious and wandering curve, it fills up its burrow behind it with its own excreta. These form a cast of the burrow and are readily preserved in a fossil condition. This being their mode of formation, it is easy to understand how these bodies should penetrate the strata, sometimes in straight lines, sometimes in flowing curves, sometimes obliquely, sometimes horizontally, and sometimes, for short distances, even in a vertical direction. It is easy also to understand how these bodies should cross one another in every imaginable direction, in many cases giving rise to the appearance of branching, or in other cases being matted together into a perfect network, resembling more or less perfectly the fronds of a sea-weed. This being their mode of formation also, they usually consist of a coarser or harder sand than the enveloping matrix. Hence, in weathered specimens they generally stand out in bold relief, looking like rounded and twisted stems.

The reasoning of Mr.Salter upon the nature of these bodies will, I think, be regarded as conclusive by anybody who has carefully studied their characters and mode of occurence. "That the long, cylindrical, and tortuous bodies found in the older rocks", remarks this eminent authority, "are not the remains of sea-weeds is certain from their form and structure; since by no conceivable process could sand or sandy silt be made to **replace accurately** a soft cellular mass. The late Professor Forbes was disposed to refer many of them to Alcyonarium zoophytes; but this explanation is unnecessary since we know of no remains of Alcyonaria in old rocks. Every requirement of the fossil is met by the suposition that we see the excreta of the worm as it bored its way through silt or sand, carrying the matrix of one bed into that of the next, and threading them together into a tough and pasty mass" (Mem. Geol. Survey, Vol. III, p. 243). It may be added that the process of fossilisation **by replacement,** which is commonly seen in fossil plants, is not applicable to the cases under consideration, since it implies that the replacing substance must be **in solution** in the water surrounding the original organic body. This cannot, however, have possibly been the case with the bodies in question, since they consist simply of the same sandy sediment as the surrounding matrix, only generally coarser and purer. It is not possible, therefore, to imagine that we have in these bodies a **replacement** of the stems and fronds of marine plants; and upon no other view can they be regarded as Fucoids, since they are not mere crushed and flattened impressions, but stand out in high relief as rounded, cylindrical stems. We

must, then abandon the belief in the vegetable character of the organic remains in question; at the same time that it is by no means meant to imply that **none** of the so-called "Fucoids" of the Cambrian and Silurian rocks may not be genuine plants. On the contrary, I believe that Mr. Salter was led too far in his reference of all, or almost all, of the remains of this class to the Annelida, and that some of the truly branched and compound forms are really the remains of marine Algae.

Whilst deciding unhesitatingly in favour of the Annelidous nature of the fossils here referred to Planolites, it must be freely confessed that it is often a matter of great difficulty, or impossibility, to separate them from the casts of **surface-trails** produced by marine animals of various kinds. It is often a matter of complete impossibility to decide whether a given specimen – fragmentary as it is sure to be – be the filled-up burrow or cast of the surface-track of an Annelide. Thus, the filled-up burrows often run for a space on the surface of a bed, and if the specimen be not a large one, they may not be seen to penetrate any upper or lower stratum. In these cases it may be impossible to determine the true nature of the specimen. Sometimes, however, (as in Pl. I, fig.2) the burrows, after running for a short distance parallel with the surface of the bed, plunge beneath its surface, showing that they were formed at a time when the bed was overlaid by the already deposited higher beds, and that they are not surface-trails.

From the difficulty just named, it arises that it is impossible always to determine with complete accuracy the true nature of fossils such as these which constitute the genus Palaeochorda of M'Coy. Some specimens which would ordinarily be referred to this genus, appear to be undoubtedly filled-up burrows, and thus belong to Planolites. The greater number of the examples of this genus, however, appear to be the casts of surface-tracks, and thus come under a different head, as having been clearly formed by Annelides of different habits to Planolites. Still other specimens can not be certainly determined or must be left in the meanwhile in an unsatisfactory and dubious position.

I am disposed, upon the whole, to establish three species of Planolites, the characters of which appear to be sufficiently distinct and constant. All three of them occur in the Skiddaw slates; and one of them (viz. P. vulgaris) is a common Silurian fossil, being expecially abundant in the sandy and shaly sediments of the lower division of the series, but passing upwards as high, at any rate, as the Carboniferous.

8. Planolites vulgaris Nicholson

Chondrites acutangulus M'Coy, Quart. Journ. Geol. Soc. Vol. IV, p.223, Pal. Foss. Camb. Pl. IA.
Chondrites informis, M'Coy, (op. cit.)
Chondrites Salter, Mem. Geol. Survey. Vol. III, p.243, fig.1 and Pl. 3, fig. 4.
Palaeophycus tubularis Hall, Pal. N.Y. Vol.I, Pl. 2, figs. 1-4.
Palaeophycus beverleyensis Billings, Pal. Foss. Canada, p. 97, fig.86.
"Trails of worms" (figured but not named) Dawson, Acadian Geology, 2nd ed., p. 256, fig. 79.
Scolites Salter, Mem. Geol. Survey, Vol. III, p.292, Pl. 12, fig. 2.

> **Specific characters**: Casts of the burrows of Annelides, usually of an irregular or cylindrical shape, sometimes thickened in parts, with a smooth surface, and having a diameter which varies from one to two or three lines or more (fig.4).

The number of fossils included under this head is very large, being especially abundant in the upper Cambrian and lower Silurian rocks, though extending from the lower Cambrian to the Carboniferous. Very probably many of the forms of P. vulgaris have been produced by different species of burrowing Annelides; but it does

not appear possible to establish any points of distinction, whereby the species might be satisfactorily broken up. **Size**, however, would offer one mode of separation, since the large forms maintained by Mr. Salter as attaining a diameter of two or three inches (Quart. Jour. Geol. Soc. Vol. XIII, p.205) can certainly not have been produced by the same species as the smaller ones. All the examples, therefore, which I would include under this species, vary from one line in diameter up to two or three lines.

The true nature of Planolites vulgaris hardly admits to a doubt, and I have already discussed this question in speaking of the genus. The species comprises more or less nearly cylindrical, sometimes lightly compressed, bodies which are the **casts** of the **burrows** (not of the tracks) of Errant Annelides. They run more or less horizontally, or penetrate the beds obliquely, but with no high inclination to the laminae of deposition. They often cross one another, and may thus appear to branch, but this phenomenon is, in my experience, uniformly deceptive. Very commonly, the tubes form matted or tangled masses, certifying to an extraordinary prevalence of Annelidous life on the shores of the Palaeozoic seas. The surface of the tubes is generally smooth, but their diameter varies, and they often exhibit irregular thickenings or nodosities in parts. They show no structure, and when their texture is in any way distinguishable from that of the surrounding matrix, it is simply in the fact, as first pointed out by Mr. Salter, that the fossil is composed of coarser and even purer material than the enveloping rock.

In the accompanying wood-cut, I have reproduced an admirable figure given by Mr. Salter of this common and variable species (Mem. Geol. Survey, Vol. III, Pl. 3, fig. 4). The specimens which I have figured myself are all from the Skiddaw slates, and each presents some peculiarity worthy of notice. The small specimen represented in Pl. I, fig. 2 is one in which the true nature of Planolites is shown to demonstration. On the surface of the slate are seen six burrows, each of which, after a short superficial course, finally penetrates the bed obliquely and is lost to view. In

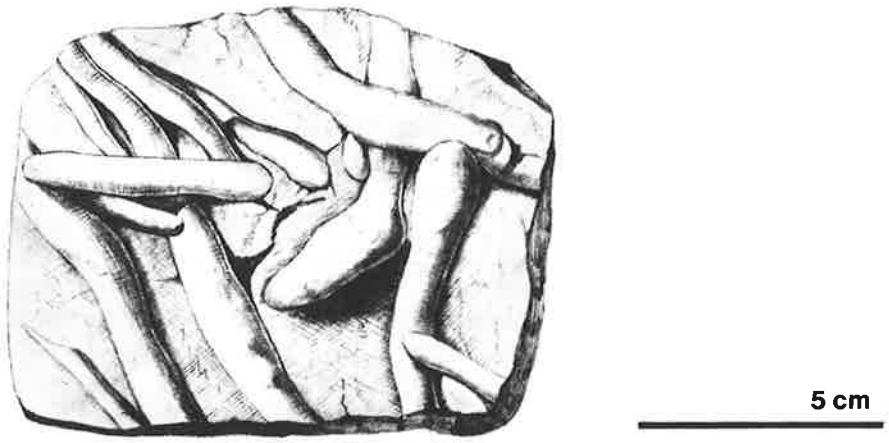

Fig. 4. Annelide-burrows (Planolites vulgaris Nicholson), from the Silurian rocks of Wales. After Salter.

the portion of each which is exposed on the surface, the cast of the burrow has been removed, leaving the hollow space formerly occupied by the burrow. In consequence of this, also, at the point where each burrow leaves the surface to penetrate downwards, is seen the broken end of the **filling** of the burrow. The tubes have a diameter of about one tenth of an inch, and their filling is of a much coarser grain than the matrix. The specimen is from the Skiddaw slates of Barff, near Keswick.

Pl. II, fig. 3 represents a larger specimen in which the casts of the burrows run along the surface of the bed, and appear to radiate from a single point. This appearance, however, is probably deceptive, and most likely, arises from the accidental arrangement of the burrows. In one of the burrows, in the centre of the specimen, the worm appears to have suddenly altered its course, and has then thrust its hinder extremity backwards for a short distance into the soft and yielding mud. This has given rise to the appearance as if a portion of the burrow had been broken off, when just filled with the excreta of the worm, and had then been placed diagonally to the main burrow. In this specimen these burrows are nearly straight and are gently curved, the longest of them being traceable for a distance of about four and a half inches, with an average diameter of nearly two lines. The surface of the cast of the burrow is sometimes slightly nodulated, and its texture differs in no way from that of the matrix, though slightly different in colour. In some places lastly, the cast of the burrow has been removed, and the sides of the actual burrow itself are seen. The specimen is from the Skiddaw slates of Outerside, near Keswick.

Pl. II, fig. 1 represents a singular specimen, as to the true nature of which I am not altogether certain. It consists of a number (nine) of nearly parallel or slightly diverging, cylindrical or sub-cylindrical bodies, more than half enveloped in the matrix, and in parts apparently flattened or crushed. They do not branch, although there is sometimes the appearance of branching, and the specimen is too fragmentary to render this observation of much value. Their diameter is about three tenths of an inch, though slightly greater in some places than others. Whether this specimen consists of a number of filled-up burrows, having the proximity and parallelism shown in the fossil merely fortuitously, or whether it may be truly the remains of some other kind or organism, I am not prepared to say positively. It is certainly organic, and I am inclined to think that it is only a large specimen of Planolites vulgaris, having the above peculiar arrangement as a matter of chance. It shows no structure, and the cylinders are simply of a somewhat coarser grain than the matrix. Whether rightly referred here or not, it presents a close similarity to the fossil figured by Hall under the name of Buthotrephis palmata, and believed by him to be a "Fucoid" (Pal. N.Y. Vol.II, Pl. 6, fig.1). The fossil is from the Skiddaw slates of Mirehouse, on Skiddaw.

It remains to say a few words about the various forms which I have here included under the name of Planolites vulgaris. To Mr. Salter, as before said, is due the credit of clearly discerning that these fossils are Annelidous and not vegetable. Unfortunately, however, he did not give them a distinct name; and in his latest writings upon the subject (Mem. Geol. Survey, Vol. III, p. 292), whilst retaining some of them under the simple name of "Annelide-burrows", he placed others of them in his genus Scolites, which he had formerly proposed for unpaired vertical burrows of a very different nature.

The Chondrites informis and Chondrites acutangulus of M'Coy, as long ago pointed out by myself (Geology of Cumberland and Westmorland, p.30), are not referable to plants, and are most clearly nothing more than filled-up burrows of Annelides of the nature of Planolites. The branching described by M'Coy (Quart. Journ. Geol. Soc. Vol. IV, p. 223) appears to be purely accidental and to be due to the fortuitous crushing of separate burrows. At any rate, after many years' collecting in the Skiddaw slates, from which three species were originally described, I have never met with any example, the apparent branching of which could not be shown to depend on this cause.

Some of the long cylindrical, worm-like fossils described by M'Coy under the name of Palaeochorda (Quart. Journ. Geol. Soc. Vol. IV, p. 224) may, perhaps, also belong to Planolites. Most of these however, possess peculiar features which induce

me to consider them in the meanwhile as belonging to the group of the surface-trails of Annelides.

In 1843, Professor Hall proposed the genus Palaeophycus, for remains supposed to belong to the group of the marine Algae, and very common in the upper Cambrian and Silurian rocks of North America (Pal. N.Y. Vol. I, p. 7). The stated characters of the genus are: "Stem terete, simple or branched, cylindric or sub-cylindric, surface nearly smooth without transverse redges, apparently hollow". Some of the forms included under this genus (which has since been very generally adopted by American palaeontologists) may very possibly be plants, and indeed, such would really appear to be their nature. Other examples of Palaeophycus, however, may with even less hesitation, be referred to the filled-up burrows of Annelides, and may be ranged under the genus Planolites. This, for example, is the case with Palaeophycus tubularis of Hall, and the P. beverleyensis of Billings, which can hardly be anything else than the burrow here described as Planolites vulgaris.

Locality and formation: Potsdam sandstone and Calciferous sand-rock (upper Cambrian) of North America. Common in the Skiddaw slates (upper Cambrian) of the North of England. Very abundant in the Lingula flags of Wales. Common in the lower Silurian in all suitable strata, and less so in the upper Silurian. Common in parts of the Devonian series (eg. in the Portage group of North America). Very abundant in the Carboniferous rocks of England, Scotland, Ireland and Canada.

9. Planolites granosus Nicholson.

Specific characters: The filled-up burrow of an Annelide, of a more or less cylindrical, tortuous form; the substance of the cast composed of the **rejectamenta** of the worm, aggregated into small oval pellets, and giving the fossil the appearance of being composed of small eggs. Diameter of burrow from one and a half to two lines.

The singular fossils included under this head were all obtained by myself from the Skiddaw slates, but I was long in doubt as to their true nature. I am now satisfied, however, from a comparison of a large number of specimens, that they belong to Planolites, and that they differ from the species above described only in one very important particular. In P. vulgaris, namely, the cast of the burrow is composed simply of the sand or mud which has been passed through the alimentary canal of the worm. In the present species the cast of the burrow, even more evidently, is taken in the same material, but the **ejecta** of the worm must have been extruded in the form of a succession of small oblong pellets, sufficiently consistent, and coherent to retain their form and shape after expulsion from the body. Hence, the cast of the burrow, instead of being composed of merely structureless sand or mud, is made up of an aggregation of little oval pellets, so closely resembling eggs, that I was long under the impression that I had to deal with the petrified chains of ova of some marine animal.

The specimen figured in Pl. IV, fig. 3 is a typical example of Planolites granulosus. It represents a winding burrow, of about two inches in length and one and a half lines in diameter, running, as far as visible, on the surface of the bed. Its surface is mostly rounded, but it is in parts thickened or flattened, whilst at one extremity it dwindles away and becomes disintegrated. The cast of the burrow is made up of little oval or cylindrical pellets, with an average length of from 1/30 to 1/25 of an inch and a breadth of about 1/50 inch, the two ends of each being rounded.

In Pl. IV, fig.4 a very common and characteristic variety of this fossil is represented. In this specimen there is not a complete cast of the burrow, but there is a dropping and irregular line of pellets, evidently let fall by the worm as it moved along. In some other specimens (as in Pl. IV, fig.5) there are simply little groups of pellets, two or three or four together, scattered at intervals over the stone, but always occupying a line - along which the worm must have moved. In both these classes of specimens, the size of the pellets is considerably larger that in the more typical forms - rising from as much as from 1/20 to 1/10 of and inch in length, with a breadth of from 1/30 to 1/25 of an inch.

In other cases, lastly, the cast of the burrow has been removed, and we have simply the hollow in the stone in which the cast was originally contained - these hollows showing distinctly the shape and arrangement of the pellets which compose the cast itself.

Locality and formation: Skiddaw slates of Outerside, near Keswick, (lower beds of the series), and the Ellerbeck, near Millburn (upper beds of the series).

10. Planolites articulatus Nicholson

Specific characters: Contorted and matted casts of worm burrows, broken at irregular intervals by transverse fissures, which divide the cast into a succession of short joints or pieces of varying lengths. Cast cylindrical or sub-cylindrical, with a smooth surface, and a uniform diameter of a little over a tenth of an inch.

The example of this form which I have figured (Pl. II, fig. 4) represents a slab of Skiddaw slate, about five inches in length by three in breadth, having its surface covered with the twisted and intertwined casts of the burrows of a marine Annelide. From the frequent crossing of the burrows, the appearance of branching is sometimes produced, but this is always deceptive. The most marked feature in this species is that the **ejecta** of the worm, as they filled the burrow just vacated by the animal, seem to have become broken into a number of short pieces separated from one another by transverse fissures. These fissures are sometimes complete, but, more commonly, they are merely transverses constrictions not involving the entire thickness of the cast. These constrictions or fissures may be placed at distances of about 1/5 inch apart, but they vary much in this respect. All the burrows appear to be horizontal, and conform with the surface of the bed, but they are so entangled and matted together, that it is very difficult to follow the course of any individual tube.

Locality and formation: Skiddaw slates of Coldale, near Keswick.

B. SURFACE-TRACKS OF ANNELIDES.

The fossils which may be regarded as the surface-tracks of Annelides or other marine animals constitute a group of petrifactions of a very obscure character, and often presenting the very greatest difficulty in their elucidation. In many, indeed in most cases, after the most careful study, I have still been left in some doubt as to the exact origin and mode of formation of the specimens which I am about to describe; and in no case, perhaps, is the evidence in our hands of such a decisive kind as to warrant the expression of an absolutely positive opinion as to what we may be dealing with.

For convenience of study, we may divide all the remains which I have

provisionally retained under the above title into the following three groups:- **Firstly**, we have fossils which have undoubtedly been produced by marine Annelides, but which have been variously regarded as being produced by the actual petrification of the body of the worm, or as being, on the other hand, nothing but the tracks of such worms or the casts of such tracks. Under this head we have to place the genera Crossopodia, Nemertites and Nereites. **Secondly**, we have fossils which are undoubtedly the trails of some marine animal, but which are just as likely to have been produced by Molluscs as by Annelides. Under this head, we have to place the genus Myrianites. **Thirdly**, we have a group of obscure fossils, which may be filled-up **burrows** or filled-up **trails**, but the nature of which is too uncertain to admit of profitable particularisation or description.

a. Annelidous fossils which may be tracks or may be the mineralised worm:

In this group are a number of fossils which can hardly be regarded as being anything else but the work of marine Annelides - such as Crossopodia M'Coy, Nemertites MacLeay and Nereites MacLeay - but the mode of origin of which is nevertheless very obscure. By M'Coy and MacLeay these fossils are regarded as being produced by the actual petrifaction of the **bodies** of Errant Annelides; so that what we see in them is the actual body of the worm **replaced** by sand or mud, and showing not only the body rings, but also in some cases, the foot-tubercles and the cirrhi. It is, however impossible to conceive of any process by which the soft body of an Errant Annelide with its appendages should be **replaced** by mud or clay, in such a manner as to preserve all the minutiae of its structure. Moreover, the segmentation of the body, if capable of being preserved at all, is certainly rarely seen; since I have never observed it in a single one of the many specimens of Crossopodia which have passed through my hands. Nor, do the figures given by M'Coy himself of the species of this genus bear out his description in these respects.

On the other hand, I am disposed to suggest that what we see in these cases is simply the **trail** of an Errant Annelide upon the sand or mud of the sea-shore, or in many specimens the **cast** of such a trail. On this view, some specimens present us with the **upper** surface of a bed, whilst others exhibit the **lower** surface; and the phenomena vary according to the surface exhibited by the specimen. The actual trail is as a rule in the main **depressed** below the surface of the bed on which it occurs, though often exhibiting a central depression or groove bounded by lateral ridges. On the other hand, the **cast** of the trail is necessarily mostly rounded and more or less cylindrical, projected above the surface of the bed upon which it occurs.

Fig. 5. Diagram to represent the formation of Crossopodia. a. Section of a stratum showing on its upper surface the actual trail of the worm, consisting of a central groove and two lateral elevations or ridges. b. Cast of the same on the lower surface of the bed above, showing a central ridge with two lateral depressions. For diagrammatic purposes the ridges and depressions of the trail and cast have been exaggerated to some extent.

If we take Crossopodia M'Coy as a typical example of this group of fossils, we may thus explain the phenomena with which we are presented :- The genus includes fossils which are both the surface-trails of Errant Annelides and also the casts of

such trails. The actual trail upon the surface of the sand or mud - as in the case of some living Annelides at any rate - has consisted of a central groove, bounded by two internal ridges or shallow eminences. The median groove (Fig. 5a) has apparently been formed in the passage over the soft mud of the central portion of the body of the worm, whilst the lateral ridges are due to heaping up of the sand or mud pushed out of the central groove by the body of the animal. In well-preserved specimens, the lateral margins of the two lateral ridges are slightly excavated and depressed in consequence of the action of the foot-tubercles; and the impressions of the cirrhi (if present at all) occupy these depressions. In some cases, these impressions occupying the extreme margins of the trail, appear to have been very deep and conspicuous - as in Crossopodia lata M'Coy, which is probably the cast of such a track. In other cases, the specimen has been split in such a manner that only the median groove of the trail is visible; and such examples, as pointed out by M'Coy might readily be mistaken for tracks produced by an altogether different kind of worm.

Such being the structure of the actual trail of Crossopodia it is obvious that the cast of such a trail, upon the lower surface of the superior layer of sediment must necessarily present a central, cord-like ridge, bounded by two lateral shallow depressions, outside which again, in good specimens are two ridge-like elevations (fig. 5b).

The only objection which can be made to the views here put forward, lies in the extreme regularity, closeness and complexity of the turns made by many of the tracks referred to Crossopodia (see Pl. VI). The comparatively limited opportunities which I have enjoyed of studying the tracks made by living Annelides have not, however, been sufficient to warrant me in offering any decided opinion on the validity of this objection. I can only say that no living Annelide which I have been able to observe, makes a trail at all so complex as Crossopodia, which passes rapidly and at short intervals from side to side in a succession of loops or reduplications.

In other cases, the original trail upon the surface of the bed appears to have been much simpler than in Crossopodia, and to have consisted merely of a shallow depression or groove, in some cases with slightly elevated margins, formed by the sand or mud which the worm pushed outwards by the passage of its body (Fig. 6a). In these cases, the cast of the track (Fig. 6b) will consist of a simple semi-cylindrical, worm-like body, which wanders over the lower surface of the superior surface of the sediment and which is sometimes bordered by shallow depressions.

a b

Fig. 6. Diagram of the trail of Nemertites. a. Trail of the worm, consisting of a broad and shallow depression, with slightly elevated margins. b. Cast of the trail, consisting of a shallow worm-like eminence or ridge, sometimes with somewhat depressed margins.

Such casts of such surface-trails I believe to constitute most of the forms referred by M'Coy to Palaeochorda, along with the Gordia marina of Emmons and Hall, all of which, together with some other forms, I have grouped provisionally under MacLeay's genus Nemertites.

Some of these forms are exceedingly like the filled-up burrows of the genus Planolites, and can only be distinguished by the fact that they keep accurately and constantly to the surface of a single bed, never penetrating the strata above or below.

That most of the tracks of this kind have truly been formed by Annelides is rendered almost a certainty by the fact that they for the most part occur in strata in which we have ample evidence of the existence of Annelidous life, but in which we have little or no evidence of the existence of Molluscs to which they could be attributed. Still, it is not impossible that some specimens of Nemertites have been produced by Gasteropods.

b. Trails which may have been formed either by Annelides or Molluscs:

In this group of surface-tracks we have fossils which may have been formed by Annelides, but which are just as likely to have been produced by Gasteropods, such as Natica or Littorina. As just said, some of the tracks alluded to in the preceding remarks may possibly be of this nature; but the only genus which I shall consider under this head is Myrianites MacLeay. These tracks present uniformly the character of being very narrow, of not being distinctly cylindrical, and of being exceedingly and irregularly tortuous.(It should be said that the Myrianites macleayi of Murchison is not here had in view). The tracks are, as a rule, very little or not at all elevated above the surface of the bed on which they occur; and they differ from the matrix in little except their darker colour and perhaps slightly coarser grain. As will be seen, however, subsequently, they show evidence of penetrating the rock to some depth below the surface, and they present some phenomena which are quite inexplicable in the light of our present knowledge. That they are the surface-tracks of some marine animal appears almost certain; but they are just as likely to have been produced by some Mollusc, or even by some Crustacean, as by an Annelide.

c. Tracks of uncertain affinities:

In this group of tracks are bodies the structure of which is dubious beyond the fact that they have been produced in all probability by Errant Annelides. It is, however, impossible to determine whether they are truly surface-tracks or only filled-up burrows. The obscure forms included under this head I shall dismiss here without further mention, as their characters are too indefinite and uncertain to admit of useful description. I would remark, however, that fossils of this kind are not uncommon in the older rocks, and I would propose that for them the general name Helminthites (proposed by Mr. Salter, Quart. Journ. Geol. Soc. Vol. XIII, p. 204) should be retained. We should thus have in the provisional genus Helminthites a group of forms, which have almost certainly been produced by the operation of marine Annelides, but which can not be positively referred to any of the genera here enumerated.

Age of surface-tracks: The surface-tracks of Annelides (and Molluscs) occur plentifully in the upper Cambrian and lower and upper Silurian rocks, wherever the nature of the rocks is such as to render it reasonable to expect their occurrence. They occur also in later deposits, but hardly any attention has been paid to them, except as occurring in the above-mentioned formations.

VI. Crossopodia M'Coy

Crossopodia M'Coy, Annals and Magazine of Natural History, 2nd series, Vol. VII, p. 395; Pal. Foss. Camb. p. 130.

Generic characters: Surface-trails of Annelides, which exhibit a central narrow groove, bounded by transversely-curved lateral ridges, outside which are sometimes lateral depressions of no great depth. Sometimes only the central groove is preserved; at other times the impressions of cirrhi are visible in the lateral depressions. The entire trail winds over the surface of the stone in a series of complex, parallel, loop-like folds, of small width as compared with their length (Pl. III, fig. 1 and Pl, VI).

Professor M'Coy (op. cit. supra) defines the genus as follows: "Body long, moderately slender, of excessively short, numerous, wide segments, from which arise very long, delicate, crowded cirrhi forming a broad, dense fringe on each side, completely concealing the feet (at least five or six times as long as a segment of the body, or interval between one cirrus and another)".

As before remarked, and as will be evident from the above definition, M'Coy, regards Crossopodia as comprising petrified Annelides, and upon this view there is no impropriety in describing the number of body-rings. I am, however, quite unable to concur in this view; and I regard the fossils described and figured by M'Coy as Crossopodia (Pal. Foss. Camb. Pl. ID, Figs. 14, 15) as being truly the trails of Errant Annelides, or in part the casts of such trails. The method in which I conceive the trail of Crossopodia to have been formed, I have already explained and it need not be repeated here.

Two species of Crossopodia have been described as British, viz: C. scotica M'Coy, from the upper (?) Silurian of Peebleshire, and C. lata M'Coy, from the upper Silurian of Wales; whilst there can be little doubt but that the Nereites loomisii described by Emmons (Agricultural Report, N.Y., P1. XI, fig. 3) from the Taconic slate also belongs to Crossopodia.

11. Crossopodia scotica M'Coy

Crossopodia scotica M'Coy, Annals and Mag. Nat. Hist., 2nd series, Vol. VII and Pal. Foss. Camb. p.130, Pl. ID.

Specific characters: Length unknown; trail consisting of a central groove, bounded by two low and rounded ridges which may in turn be bounded by slight depressions, sometimes exhibiting the marks of the cirrhi or bundles of setae. Cast of the trail consisting of a low cord-like ridge bounded by shallow lateral depressions, the margins of which may be raised. Width of cast or trail from 1½ to 2 lines; width of central groove or ridge about 1/30 inch. Both trail and cast arranged in a series of repeated loop-like folds or parallel reduplications, which, as a rule, are close together (usually from 1/5 to 1/4 of an inch apart).

As already remarked, different specimens of this fossil present differences in appearance, according as we are presented with a view of the cast of the trail or the trail itself, and according as we have only the central groove or ridge, or have also the lateral elevations or depressions. The depth of the median groove, formed by the body of the worm, is never very great, and the lateral ridges which bound it are not only very shallow, but they are commonly so indistinct as to be detected only with considerable difficulty. The cast of the trail rarely presents with any distinctness more than the central ridge, though in some cases the lateral depressions of the trail are exceptionally well-marked, so that the cast consists of a flattened worm-like body of considerable breadth comparatively speaking, but with only faint indications of the central ridge. In all cases the impressions are strictly confined to the surface of the beds. The most marked feature of the trail, and the one in which it differs most from any trails of recent Annelides with which I am aquanited, is the extreme

regularity and closeness of the loop-like folds of the trail, which usually wind backwards and forwards from side to side, with rapid turns, and in the most regular manner. In some cases, however, the trail takes a simply winding and sinuous course, and does not exhibit these regular reduplications.

The large specimen which I have figured (Pl. VI) exhibits the trail of Crossopodia scotica, with its beautiful and regular foldings. In this specimen, nothing but the median groove of the trail can be clearly recognised, and the lateral eminences which bound the groove can only be detected with difficulty and here and there. The depressions which are outside the lateral ridges can hardly be made out at all and are for the most part not exhibited.

The smaller specimen which I have figured (Pl. III, fig. 1) exhibits the lower surface of the bed with casts of the trail of Crossopodia scotica - two casts being seen, and both presenting different phenomena. The cast which crosses the specimen from side to side exhibits the most normal form of the cast, consisting of a cord-like body bounded by indistinct and shallow depressions, the margins of which are slightly elevated. These, however, are only visible in places; and the entire cast has the usual looped arrangement. The other cast, which runs in loops directed towards the top and bottom of the specimen, exhibits the central cord or ridge only in the most indistinct manner or not at all, but consists of a flattened worm-like body, very little elevated above the surface of the stone. It must be the cast of a trail in which the worm must have excavated its track more deeply than usual, whilst not forming such a distinct central groove.

It is to be observed that M'Coy's figures (Pal. Foss. Camb. Pl. ID) give to the trail of Crossopodia the appearance of being much more cylindrical and more elevated above the surface than is the case with any specimen which has come under my notice. This accords with the view that Crossopodia is the **body** of a marine Annelide; but in all the specimens which I have examined the ridges bounding the central groove have only the slightest possible elevation above the surface, and they are sometimes bounded in turn by small lateral depressions, which must have been produced by the foot-tubercles or setae.

It seems very probable, lastly, that the Myrianites macleayi of Murchison (Sil. Syst. P1. 27, fig. 3) has been founded upon a specimen of Crossopodia scotica M'Coy, in which only the central groove of the trail has been visible. If this were certain it would render necessary considerable changes in our nomenclature, since MacLeay's name has the priority, Having, however, only the published figure of M. macleayi to go upon, I do not feel justified in supplanting M'Coy's genus Crossopodia by the earlier genus Myrianites. At the same time, there is considerable inconvenience entailed in not adopting this course; since the well-marked and undoubtedly distinct Myrianites tenuis of M'Coy does not agree in any generic character with M. macleayi, upon which the genus Myrianites was originally founded. In the meanwhile, however, I shall draw the characters of Myrianites from M. tenuis M'Coy - merely noting that an investigation of the original specimen will probably show that M. macleayi is the same as Crossopodia scotica, in which case the latter must be placed in Myrianites, and M. tenuis, with its allied forms, must have a new genus constituted for its reception.

Locality and formation: Extremely abundant in the purple and greenish shales or slates (upper Silurian?) of Thornilee Quarry, near Innerleithen, in Peebleshire.

12. Crossopodia lata M'Coy

Crossopodia lata M'Coy, Ann. and Mag. Nat. Hist., 2nd series, Vol. VII, and Pal. Foss. Camb. p.130, Pl. ID, fig. 14.

Specific characters: Trail (or cast of trail?) consisting of a central narrow ridge, bounded by two narrow grooves, which are in turn bounded by broader lateral rounded ridges, the whole forming an approximately semi-cylindrical body. Length unknown.

According the Professor M'Coy, the length of the "body" is three lines, with a space of three lines on either side occupied by the cirri. It seems clear, however, that, judging from M'Coy's figure, the spaces occupied by the cirri can only be depressions in the mud formed by the action of the parapodia; and that these depressions appear in the specimen as elevated ridges, owing to the fact that the fossil is the **cast** of the trail itself. The length of the trail observed by Professor Sedgwick was upwards of three feet.

Locality and formation: Tilestone (upper Ludlow) of Storm Hill, Llandeilo.

VII. Nemertites MacLeay

Nemertites MacLeay, Silurian System, p. 700
Gordia Emmons, Nat. Hist. N.Y., Vol. V.
Gordia Hall, Pal. N.Y. Vol.I, p. 264.
Palaeochorda M'Coy, Quart. Journ. Geol. Soc. Vol. IV, p. 224; and Pal. Foss. Camb. Pl. IA.
Nemertites M'Coy, Pal. Foss. Camb., p. 128.
Nereograpsus, Geinitz, (in part), Versteinerungen, pp. 16, 27.

Generic characters: Cylindrical, or slightly flattened, worm-like bodies, usually more or less tortuous or coiled, and really consisting of casts of the surface-trails of Annelides (or perhaps Molluscs also).

By MacLeay (Sil. Syst.), the genus is defined as follows: "Animal marine, with a linear body of a Gordius or Filaria". By M'Coy (Pal. Foss. Camb.) the following more precise definition is given: "Body very long, linear, slender, of nearly uniform thickness throughout, without distinct articulations". Both these definitions imply that the fossils here included are the actual **bodies** of marine Annelides, replaced by sand or mud, though Mr. M'Coy suggests that they are possibly the remains of marine plants. My own opinion is that neither of these views is correct, but that Nemertites may by extended to include a number of fossils, very common in the older Palaeozoic rocks, which are really **casts of the surface-trails** of Annelides. In fact, if we reject the view that these fossils are referable to the marine Algae, there are only two conjectures which can reasonably be advanced to account for their peculiarities. They occur in the form of sinuous or winding, cylindrical, vermiform bodies, which are considerably elevated above the surface of the bed on which they occur, but which at the same time are strictly confined to that surface, and never descend below it. Either, therefore, they are the actual **bodies** of Annelides, **replaced** by sand or mud, an hypothesis which seems incredible, and which is negatived by the fact of their great profusion - or they are the **casts** of **surface-trails**, and this latter, I am convinced, is their true nature. They can not be the actual trails themselves, for there they would certainly be **depressed** below the surface of the bed, in whole or part. If however, they are the casts of such trails - as I imagine - then there is no difficulty in the phenomena which they present.

The only thing necessary to verify my conjecture would be to show that they always occur on the **lower** surface of a stratum - as they do, if they are casts. Many

however, as are the specimens which I have obtained from the Skiddaw slates, I have never been able to demonstrate this fact; since all my specimens were obtained from "screes", and I never succeeded in finding a single example in situ.

The species of Nemertites are distinguished from the filled-up burrows which constitute the genus Planolites in being confined to a single plane of deposition,and in never penetrating the strata obliquely at any part of their course. They are also never so markedly cylindrical or so highly elevated above the surface of the stone.

The specimens of Nemertites vary much amongst themselves, some being very uniform in thickness, others exhibiting slight and irregular thickenings; some being cylindrical, others being considerably flattened; some being very tortuous,others being tolerably straight. Owing to intercrossing, the tubes sometimes appear to branch; but this can, in my experience, always be shown to be a deceptive phenomenon. In spite of the above variations in form, it is very difficult to establish any specific distinctions in Nemertites; and though I shall retain three of the proposed species, I do not attach any great value to the differences between them.

With regard to the forms I have included under this genus, the Gordia marina of Hall and Emmons, from the Taconic slate, is certainly referable to this genus, and presents the closest resemblance to some of the specimens from the Skiddaw slates. The genus Palaeochorda was proposed by M'Coy for certain worm-like cylindrical fossils from the Skiddaw slates, which he imagined to be of a vegetable nature and to be comparable to the living Chorda filum. No doubt, however, can be entertained but that the Palaeochordae are produced by Annelides, and are of the nature of the casts of surface-trails. Lastly, the genus Nereograpsus was proposed by Geinitz (Versteinerungen) for a number of fossils referred by previous palaeontologists to the Annelida, but which he believed to be truly referable to the Graptolitidae. This view, however, is certainly untenable, and the fossils referred here by Geinitz are certainly the tracks of marine animals belonging chiefly to the genera Myrianites, Nemertites and Nereites.

As to the animals which have produced the fossils here referred to Nemertites, our present knowledge does not enable us to decide positively whether they are the tracks of Annelides or Gastropods. They occur, however, in rocks in which other Annelidous remains are found, and in which Gastropods are unknown or are very rare, so that they probably belong to the Annelida.

Examples of the genus Nemertites will doubtless be found — when looked for — in most of the older formations of the earth's crust. At present, however, I am only acquainted with them as occuring in the upper Cambrian and Silurian rocks.

13. Nemertites ollivantii Murchison

Nemertites ollivantii Murchison, Silurian System, Pl. 27, fig. 4.

> **Specific characters**: The worm-like body described under this name is figured by Murchison, but is not definitely characterised in the text of his great work. According to M'Coy (Pal. Foss. Camb., p. 128), it "occurs usually in long, loop-like folds, about half an inch apart, and three or four inches long. The diameter of the smooth, sub-compressed body is rather more than half a line, the length many inches, but unknown".

The distinguishing features of this species are the comparatively small width of the trail, and its arrangement in reduplicated, nearly parallel folds. This latter characteristic closely approximates to what is seen in Crossopodia scotica M'Coy and seems to be uniformly absent in the specimens from the Skiddaw slates, to which I

shall refer immediately. This form is almost certainly an Annelide-trail, and in no way resembles the track of any Gastropod which I have ever observed.

Locality and formation: "not uncommon in the fine olive slates of Llampeter, Pembrokeshire" (M'Coy).

14. Nemertites major M'Coy sp.

Palaeochorda major M'Coy, Quart. Journ. Geol. Soc., Vol. IV, p.225; Pal. Foss. Camb., Pl. IA, fig. 3.

Gordia marina Emmons, Agricultural Report, P1. XII, fig. 2. "Trails of Gasteropods", Hall, Pal. N.Y., Vol. II, Pl. 11, figs. 3 and 4.

Specific characters: Worm-like, cylindrical or sub-compressed fossils, irregularly tortuous and undulating, with occasional thickenings in some specimens; surface smooth; width from a line and a half to two lines; length many inches, but unknown.

This species is distinguished from the preceding by its greater width, and by its winding and meandering track, instead of its being thrown into parallel folds. It is almost certainly identical with the Gordia marina of Emmons and Hall; but this name is so inappropriate as to render its adoption impossible. The trails of Gasteropods above cited as figured by Hall, very probably also belong here; but I am not prepared to assert this positively, as Hall states that his specimens have shallow depressions on each side of the central ridge. I have, however, no doubt this species is really the Palaeochorda major of M'Coy.

That these fossils are not vegetable, seems certain; but it is not so easy to pronounce positively as to their real nature. They can not be filled-up burrows, as they never penetrate the laminae of deposition. They can not, also, be the actual trails of marine animals, as they are always more or less boldly elevated above the surface in the form of a cord-like ridge. It only remains to suppose that they are the casts of surface trails. The question still remains, even if this is admitted — By what kind of animal have they been produced? The very similar fossils just alluded to as mentioned by Hall, have been compared by this distinguished observer to the tracks of Littorina or Melania: and they certainly have much resemblance to the trails of the former. They abound, however, in the Skiddaw slates, in which absolutely no Gastropods (nor any Molluscs at all except one or two small Brachiopods) have ever been detected; so that I should rather believe that they are the casts of Annelide-tracks.

The specimens I have figured (Pl. III, figs. 2 and 3) are from the Skiddaw slates, and exhibit admirably the characters of this species.

Locality and formation: Abundant in the Skiddaw slates of Mungrisedale and Barff, near Keswick. Also in the Taconic slates of North America (Emmons). Also in the Clinton group (upper Silurian) of the State of New York (?).

15. Nemertites minor M'Coy sp.

Palaeochorda minor M'Coy, Quart. Journ. Geol. Soc. Vol IV, p. 225; Pal. Foss. Camb. Pl. IA, figs. 1 and 2.

Specific characters: Cylindrical, sub-cylindrical, or slightly compressed, vermiform bodies of an undulating, sinuous sometimes folded or coiled form, and of considerable, but unknown, length. Width one line or a little under (Pl. III, fig. 4).

The examples of this species which I have collected, differ from the preceding

chiefly in being uniformly smaller in their dimensions. From N. ollivantii it differs in never being in parallel, loop-like folds, though sometimes thrown into coils. The observations which I have made as to the nature of Nemertites major, apply with equal force to the present species, and I need not, therefore, further discuss its affinities. The specimen which I have figured is from the Skiddaw slates of Outerside, near Keswick (Pl. III, fig. 4).

Locality and formation: Skiddaw slates, in various localities, but only in the lower beds of the series.

VIII. Nereites MacLeay

Nereites MacLeay, Silurian System p. 700.
Nereograpsus, Geinitz (in part), Versteinerungen, p.27.
Nereites Emmons, Ag. Report, p. 68.
Nereites M'Coy, Pal. Foss. Camb., p. 128.
Nereites Salter, Siluria, 3rd ed., pp. 220, 221.

> **Generic characters**: "Body very long, of nearly equal width throughout, of upwards of one hundred nearly equal and similar segments; each segment with a thick, short, ovate lobe-like foot, surmounted by a slender cirrus exceeding the foot and the segment in length (or the distance between one cirrus and the next)". (M'Coy).

By MacLeay, no generic description is given, and the genus is only said to be "very near to Savigny's genus Lycoris".

Not being at present in a position to refer to any actual specimens of this genus, I shall not attempt to discuss its affinities. I will merely remark that, from what I have seen of the genus, I believe it to comprise the genuine **surface-trails** of Errant-Annelides, and not the actually petrified **bodies** of these worms, as imagined by MacLeay and M'Coy.

For the same reason, I shall not do more than simply enumerate the species of Nereites which have been described by various authorities:

a. Nereites cambrensis Murchison, Silurian System, Pl. 27, fig. 1.
b. Nereites sedgwickii ibid., Pl. 27, fig. 2.
c. Nereites multiforis Harkness, Quart. Journ. Geol. Soc., Vol. XI, p. 476.
d. Nereites jacksoni Emmons, Agric. Report., Pl. XV, fig. 1.
e. Nereites pugnus ibid., Pl. XV, fig. 2.
f. Nereites loomisii ibid., Pl. XV, fig. 3.
g. Nereites deweyi ibid, Pl. XVI, fig. 2.
h. Nereites gracilis ibid, Pl. XVI, fig. 3.
i. Nereites cancellata ibid, Pl. XVI, fig. 6.

IX. Myrianites MacLeay

Myrianites MacLeay, Silurian System, p. 700.
Nereograpsus Geinitz (in part), Versteinerungen, p. 27. "Trails of Gasteropods" figured but not named). Hall, Pal. N.Y., Vol. II, Pl. II, figs. 1a, 1b and Pl. 14, fig. 4.

> **General characters**: The trail of a marine animal (Annelide?) of an extremely slender and narrow form (from 1/50 to 1/30 of an inch in width), and characterised by its complex and tortuous character, being disposed in many and irregular tortuities, instead of being arranged in regular loop-like folds. The track forming a slightly elevated ridge (as a rule) above the surface of the stone.

By MacLeay the genus Myrianites is defined as follows: "body linear, very narrow, and formed of very numerous segments with indistinct feet and short cirri. As before remarked, however, the species upon which MacLeay founded the genus (viz: M. macleayi Murchison) would certainly seem to be a species of Crossopodia as indicated by the regularity and parallelism of its numerous loop-like folds. If this were absolutely certain, Crossopodia, of course, would have to be exchanged in favour of Myrianites. As it is, however, in the absence of undeniable evidence, I retain Crossopodia, and simply take the characters of Myrianites from the well-marked M. tenuis of M'Coy and M. murchisoni of Emmons.

By M'Coy the genus Myrianites is defined as follows: "Body longer and more slender than in Nereites; cirri of the feet short (scarcely as long as a segment of the body, or the distances between one cirrus and the next)". From the above definition, it will be seen that M'Coy agrees with MacLeay in regarding Myrianites as being the remains of Annelida, in which the actual body of the worm is preserved. For the reasons previously stated in discussing Crossopodia, I can not, however, possibly accept this view. Nor, in an examination of a very large number of specimens have I ever succeeded in finding traces of the existence of cirri, or lateral processes, or lateral impressions of any kind whatever.

In fact, there is more in the character and appearance of Myrianites to remind one of the trails of small Molluscs, such as the young of Littorina, than of any Annelides with which I am acquainted. Professor Hall, also, compares these tracks with the trails of the little living Crustacean, Idotea (Pal. N.Y., Vol. II, p. 28). Under any circumstances, the forms included under Myrianites are certainly the tracks of an animal, and not the animal itself.

The species of Myrianites so far as known to me, are confined to the upper Cambrian (Skiddaw slates and Taconic slates) and the Silurian rocks. Myrianites macleayi occurs in the lower Silurian of Llampeter; but I shall not describe it further, as I possess no specimen of it, and it appears to me to be essentially distinct from the forms which later palaeontologists have placed in this genus.

16. Myrianites tenuis M'Coy

Myrianites tenuis M'Coy, Ann. and Mag. Nat. Hist., 2nd series, Vol. VII; Pal. Foss. Camb., p. 130, P2. ID, fig. 13.

> **Specific characters**: Trail usually thrown into numerous irregular undulations of different sizes, rarely in nearly parallel folds. Length unknown; width varying from 1/30 to less than 1/50 of an inch (Pl. IV, fig. 1).

These trails are exceedingly numerous in certain beds, and often cross one another in every imaginable direction - circumstances which are absolutely inexplicable upon the view that they are the bodies of Annelides. They are usually very slightly, sometimes not at all, elevated above the surface of the stone, from which they can be distinguished chiefly by their darker colour alone. Their course is most erratic, and their windings mostly obey no regular law. It is rare, however, to find them dispersed in a succession of parallel loop-like folds. though this arrangement does occasionally obtain. They have been produced to all appearances by the wanderings over the surface of the mud of some very small Annelide, or some minute Gasteropod, of which vast numbers must often have been present in one place, but there is no evidence to decide positively as to the animal which produced them. As before remarked, however, I have never seen any traces of impressions which could be set down to the action of cirri or foot-tubercles; though such are alleged by M'Coy to be occasionally present.

Specimens of Myrianites tenuis M'Coy, often exhibit one curious phenomenon, the true significance of which I have in vain endeavoured to arrive at. In many cases, namely, the tracks appear to penetrate to some distance below the surface of the stone; so that the portion of rock included in a loop of the trail often comes out bodily at the extremity of the loop, leaving a curved and smooth surface which descends below the surface bed for perhaps the space of a line (Fig. 7.) This surface is not perpendicular to the bed, but is obliquely inclined towards the concave side of the loop. I am quite unable to explain how this singular appearance should be produced in what appears otherwise to be a mere surface-trail; but it is certainly a phenomenon of by no means rare occurrence.

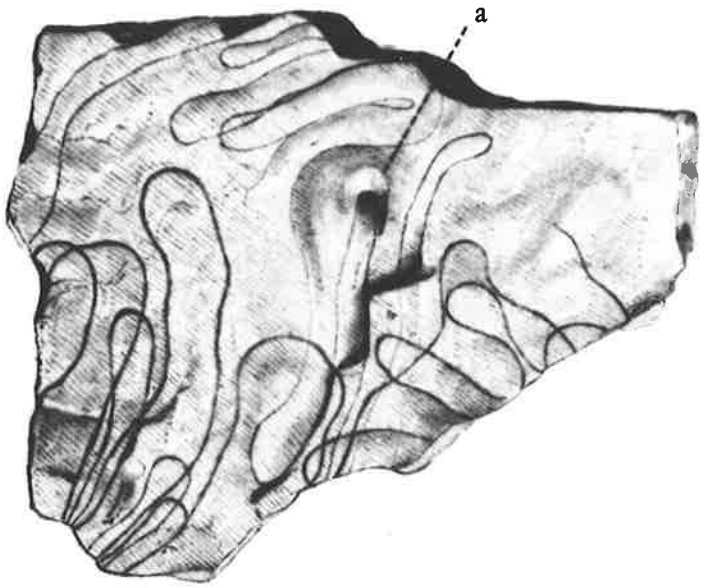

Fig. 7. Small specimen of Myrianites tenuis M'Coy from the Thornilee slates, near Innerleithen. Natural size. At a is seen the curved, smooth, oblique surface produced by the detachment of the rock at the end of one of the loops of the trail (A.U.G.D. 10610).

Locality and formation: Rare in the Skiddaw slates (upper Cambrian) of Scale Hill, near Crummock. Excessively abundant in a layer of olive slate near the Greiston Quarry, Innerleithen, Peebleshire (upper Silurian?).

17. Myrianites murchisoni Emmons

Myrianites murchisoni Emmons, Agricultural Report N.Y., Pl. XII, fig. 1.

Specific characters: Trail irregularly sinuous and undulating rarely in parallel folds, width from 1/25 to 1/30 of an inch (Pl. IV, fig. 2 and Pl. V, fig. 1).

This form differs from the preceeding solely in its larger size, bolder undulations, less crowded and complex nature, and its generally greater elevation above the surface of the stone. In other respects it exhibits all the phenomena recorded as characteristic of Myrianites tenuis M'Coy, rendering further description of it here unnecessary. In its origin it is probably Annelidous.

Locality and formation: Not uncommon in the Skiddaw slates of Barff, near Keswick. Also, in the Taconic slates (Emmons). Some of the trails figured by Hall as the tracks of Gasteropods from the Clinton group (upper Silurian) of the State of New York also probably belong to this species.

C. APPENDIX.

X. Caridolites Nicholson

Generic characters: Straight, or nearly straight, narrow grooves, with thread-like elevated margins. Length from one to two inches, rarely more.

The singular little tracks for which I propose the above generic title were found by myself abundantly in some olive slates near the Greiston Quarry, Innerleithen, Peebleshire. They clearly do not belong to Annelides; nor do they resemble the trails of any Gasteropod known to me. In fact, they have evidently been produced by some animal swimming at a short distance above the mud, and only occasionally touching the bottom with some part of its body. I believe that they have been formed by the tail-spines of Ceratiocaris; this Crustacean occurring not uncommonly in the Graptoliferous beds of Greiston Quarry itself. The tracks are numerous, and sometimes cross one another, but they are always approximately straight, never coiled or sinuous; and they are always short and discontinuous grooves, like the impressions which would result from the temporary application of a sharp instrument to the surface of the mud, and its subsequent withdrawal. For the present species (P1. V. fig. 2) I propose the name of Caridolites wilsoni, after Mr. John Wilson of Galashiels, in whose company I had the pleasure of finding the Ceratiocaris by which I believe the tracks to have been made, and who has done much towards elucidating the geology of the region.

18. Caridolites wilsoni Nicholson

Specific characters: Width of grooves from one-fourtenth to one-thirtenth of an inch; length usually about an inch to an inch and a half.

In the specimen I have figured (Pl. V, fig. 2) the tracks upon the surface of the stone are numerous, and for the most part run in one way, nearly parallel to one another, and as if they had been produced by a little shoal of these shrimp-like Crustaceans, swimming in shallow water, mostly in one direction.

Locality and formation: Olive slates, near Greiston Quarry, Innerleithen, Peebleshire (upper Silurian?).

LIST OF REFERENCES

1839. **Silurian System** by Sir Roderick Murchison. In this classical work, Mr. W. S. MacLeay described and figured (pp. 699-701, Pl, 27) several fossils believed to be referable to Annelides. He founded the three genera Nereites, Myrianites, and Nemertites, distributing amongst them Murchison's four species Nereites cambrensis, N. sedgwickii, Myrianites macleayi, and Nemertites ollivantii.

1846. In the **Natural History of New York, Vol. V, Agriculture,** pp. 68, 69, Pls. XIV, XV and XVI, Dr. Emmons described and figured a number of fossils from the "Taconic slates", which he believes to be referable to Annelides. He accepted MacLeay's genera Nereites and Myrianites and named the following species: Nereites loomisii, N. gracilis, N. jacksoni, N. cancellata, N. deweyi, N. pugnus, Myrianites murchisoni and M. sillimani. He also described and figured the peculiar worm-like bodies which be names Gordia marina; and he founded the genus Nemapodia, with the species N. tenuissima, upon a supposed fossil which Hall subsequently showed to be "the trail of an existing slug upon the slightly lichen-covered surface of the slates".

1847 Professor James Hall published the first volume of his great work on the **Palaeontology of New York.** In this volume he redescribed the Gordia marina of Emmons. He redefined Haldemand's genus Scolithus, referring it to the vegetable kingdom, and described the species S. linearis. He also founded the genus Palaeophycus for a number of fossils which he referred to "Fucoids", but some of which (e.g. P. tubularis, p.7) are certainly the filled-up burrows of Annelides.

1848 Professor M'Coy in a **Note on Skiddaw Slate fossils** appended to a paper by Professor Sedgwick in the Quart. Journ. Geol. Soc. Lond. Vol. IV, pp. 223-225, described Chondrites informis and Chondrites acutangulus, and founded the genus Palaeochorda, with the two species P. major and P. minor. These fossils he believed to be of a vegetable nature and referred to the marine Algae.

1851 In the **Annals and Magazine of Natural History, 2nd series,** Vol. VII, pp. 394-396, Professor M'Coy described a fresh species of Myrianites (viz: M. tenuis) and founded the new genus Crossopodia for the reception of the two new species C. lata and C. scotica.

1851 In his great work on the **"Palaeozoic Fossils of the Woodwardian Museum of Cambridge"**, Professor M'Coy redefined the genera Nemertites MacLeay, Nereites MacLeay, Myrianites MacLeay and Crossopodia M'Coy, and the following species: Nemertites ollivantii, Nereites cambrensis, N. sedgwickii, and Myrianites macleayi of Murchison, Myrianites tenuis M'Coy, Crossopodia lata M'Coy, and C. scotica M'Coy (pp. 128-131). He also figured the three last-named forms (Pl. ID), together with the species of Chondrites and Palaeochorda which he had previously described from the Skiddaw slates (Pl. IA).

1852 Professor James Hall published the second volume of his **Palaeontology of New York**. In this volume he described, but did not name, a number of tracks referable to Annelides, Gasteropods and other marine animals (pp. 26-37, Pls. 11-16), admirable figures being mostly apended. He also described a new species of Scolithus (S. verticalis) from the Clinton group;

and he founded the genus Rusophycus for a number of fossils which are essentially identical with D'Orbigny's genus Cruziana (bilobites), and which may possibly be referred to Annelides.

1852 Geinitz published his great work on the **"Versteinerungen der Grauwacken-formation"**, in which he founded the genus Nereograpsus to include the genera Nereites MacLeay, Nemertites MacLeay, Myrianites MacLeay, and Nemapodia Emmons (Heft I, Graptolithen, p.27). All these forms he referred to the Graptolitidae.

1855. Professor Harkness, in the **Quart. Journ. Geol. Soc. Lond.**, Vol.XI, pp. 473-476, described some fossils from the Silurian rocks of Barlas in the South of Scotland, amongst which are Crossopodia scotica M'Coy, Chondrites informis M'Coy, Palaeochorda major M'Coy, a form doubtfully referred to Palaeochorda under the name of P. teres, and a new species of Nereites described under the name of N. multiforis. No figures, unfortunately, are appended to this paper.

1856. Mr. Salter, in the **Quart. Journ. Geol. Soc.**, Vol. XII, announced the discovery in the lower Cambrian rocks of the Longmynd Hills of the little, looped Annelide burrows which he described under the name Arenicola didyma.

1857. Dr. J.R. Kinahan, in the **Journ. Geol. Soc. Dublin,** Vol. VIII, p.71, founded the genus Histioderma, with the species H. hibernicum, for certain Annelide-burrows from the lower Cambrian grits of Bray Head, County of Wicklow, Ireland.

1857. Mr Salter, in a paper on the "Longmynd Fossils" published in the **Quart. Journ. Geol. Soc. Lond.**, Vol. XIII, p. 199, proposed the change of the genus Arenicola (as applied to the little, looped burrows which he had previously described as A. didyma) to Arenicolites, and described the new species Arenicolites sparsus. He also discussed the general affinities of the Annelide-remains of the older rocks, and proposed that the general term Helminthites should be used for surface-tracks, that Arenicolites should be restricted to double vertical burrows, and that Scolithus or Scolites should be retained for single vertical burrows. He referred the burrows of the Stiper Stones to "Arenicolites (Scolithus) linearis of Hall".

1861-65. Mr. E. Billings, in the **"Palaeozoic Fossils of Canada"**, described a new species of Scolithus (S. canadensis), a new species of Rusophycus, and several species of Palaeophycus, all of which appear to be referable to the filled-up burrows of Annelides. The species of Palaeophycus are P. beverleyensis, P. beauharnoisensis, P. incipiens, P. congegatus, P. funiculus, and P. obscurus. All of these are referred by Mr. Billings to the vegetable kingdom.

1865. Mr. W. Hellier Baily, in a paper on the "Cambrian Rocks of the British Islands", published in the **Geological Magazine,** Vol. II, p.385, drew attention to the Annelide remains originally discovered by Dr. Kinahan in the lower Cambrian deposits of Ireland, and reproduced the figure of Histioderma hibernicum. He also drew attention to the occurrence of the burrows of Arenicolites didyma and of the surface-tracks of Annelides in the beds with Oldhamia.

1866. Mr. Salter, in the **Memoirs of the Geological Survey,** Vol.III, Appendix, discussed the true nature of the so-called "Fucoids" of the older Palaeozoic rocks, and showed that most of them must be referred to the operation of marine Annelides. Amongst the forms here discussed and figured, a more particular description is given of the genus Cruziana, and its British representative. C. semiplicata; and the genus is provisionally referred to the Annelida.

1868. Dr. H. A. Nicholson, (**"Essay on the Geology of Cumberland and Westmorland"**), pointed out that the Chondrites informis, C. acutangulus, Palaeochorda major and P. minor of M'Coy, from the Skiddaw slates, are not of vegetable origin, but are referable to the Annelida.

PLATE I.

Fig. 1. A fragment of greenish grit from the lower Cambrian rocks of the Longmynd Hills, covered with the orifices of the paired burrows of Arenicolites sparsus Salter. Natural size. Collected by the author.
(A.U.G.D. 10605)

Fig. 2. A small specimen of Planolites vulgaris Nicholson, from the Skiddaw slates of Barff, near Keswick. Natural size. The specimen exhibits several burrows which run for a space upon the surface of the slate, and then plunge obliquely below the surface. At the point where each burrow leaves the surface is seen the broken end of the filling of the burrow composed of the excreta of the worm. Collected by the author.
(A.U.G.D. 10624)

Fig.3. A specimen from the Skiddaw slates of Barff, near Keswick, exhibiting a few pairs of burrows of a large variety of Arenicolites sparsus Salter. Natural size. The burrows in this form are larger, and those of each pair stand further apart than is the case with the ordinary form of the species. The filling of the burrow is also decidedly lighter than the matrix, giving them a very conspicuous appearance. Collected by the author.
(A.U.G.D. 10604)

Fig. 4. A specimen from the Skiddaw slates of Rake Beck, near Melmerby, exhibiting the casts of the orifices of the burrows of Arenicolites robustus Nicholson. Natural size. The specimen shows the lower surface of the bed; and the casts of the mouths of the burrows might very readily be mistaken for the casts of rain-prints. With few exceptions, however, they are uniformly arranged in pairs. Collected by the author.
(A.U.G.D. 10603)

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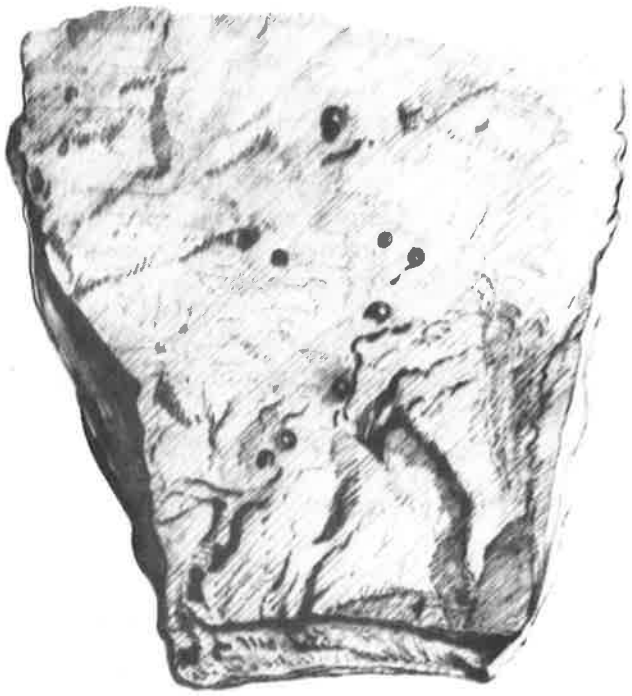

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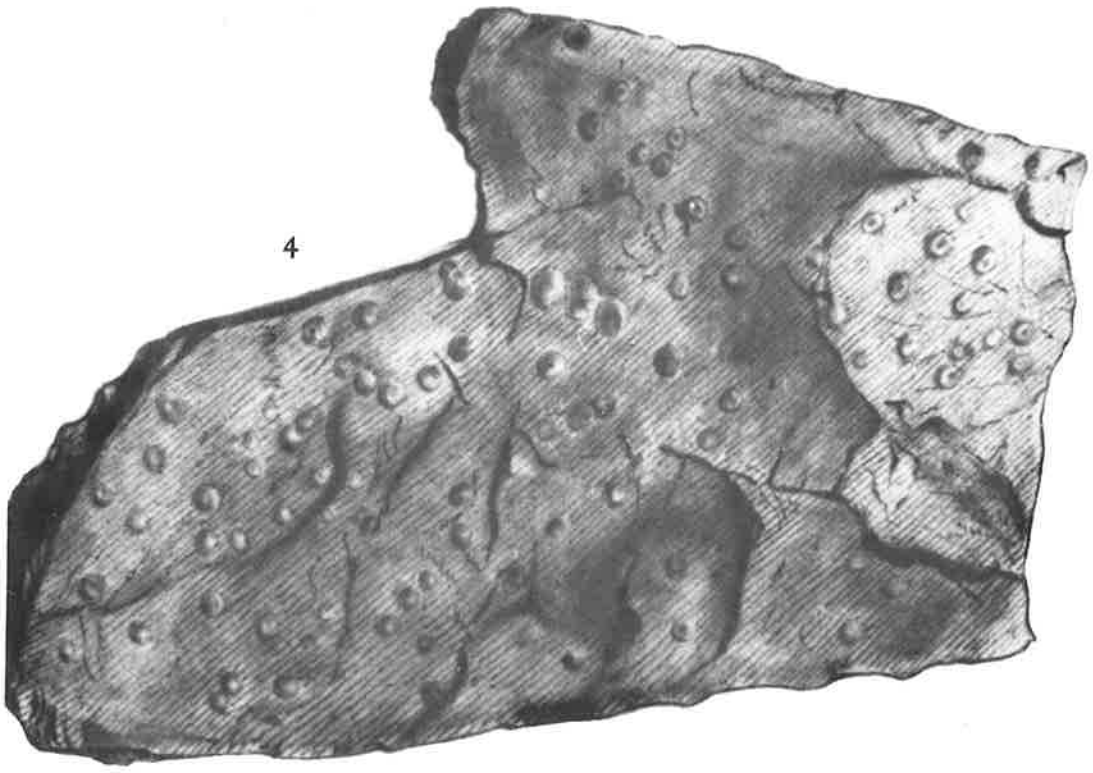

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PLATE II

Fig.1. A specimen from the Skiddaw slates of Mirehouses, near Keswick, exhibiting a number of parallel burrows of Planolites vulgaris Nicholson (?). Natural size. Whether this specimen shows a number of casts of burrows accidentally arranged in a parallel manner, and whether it may be otherwise explained, admits of doubt. The uppermost of the casts appears to be brached, but this appearance is deceptive and is due to crushing. Collected by the author.

(A.U.G.D. 10625)

Fig.2. A specimen from the Stiper Stones of Shropshire, showing the vertical unpaired burrows of Scolithus canadensis Billings. Natural size. The upper surface of the specimen shows the mouths of three burrows, whilst its front face exhibits one of the burrows split open longitudinally, showing its curved lower termination. Collected by the author.

(A.U.G.D. 10627)

Fig.3. A specimen from the Skiddaw slates showing several filled-up burrows of Planolites vulgaris Nicholson, which appear to radiate from a single point. In some cases, the filling of the burrow is preserved; in other cases the filling has been removed, and only the hollow space formerly occupied by the filling is left. Natural size. Collected by the author at Outerside, near Keswick.

(A.U.G.D. 10626)

Fig.4. A specimen from the Skiddaw slates of Coldale, near Keswick, exhibiting a surface covered with the curved and twisted burrows of Planolites articulatus Nicholson, with its transverse fissures and constrictions. Natural size. Collected by the author.

(A.U.G.D. 10617)

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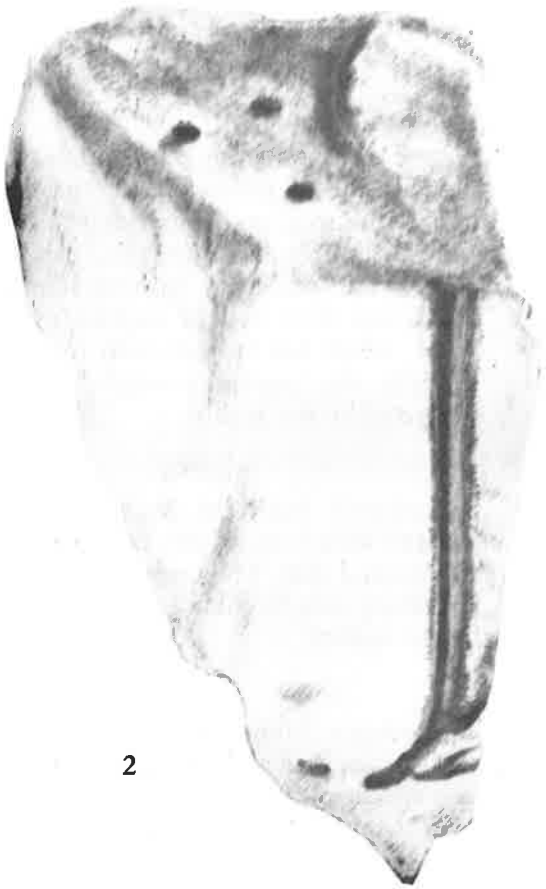

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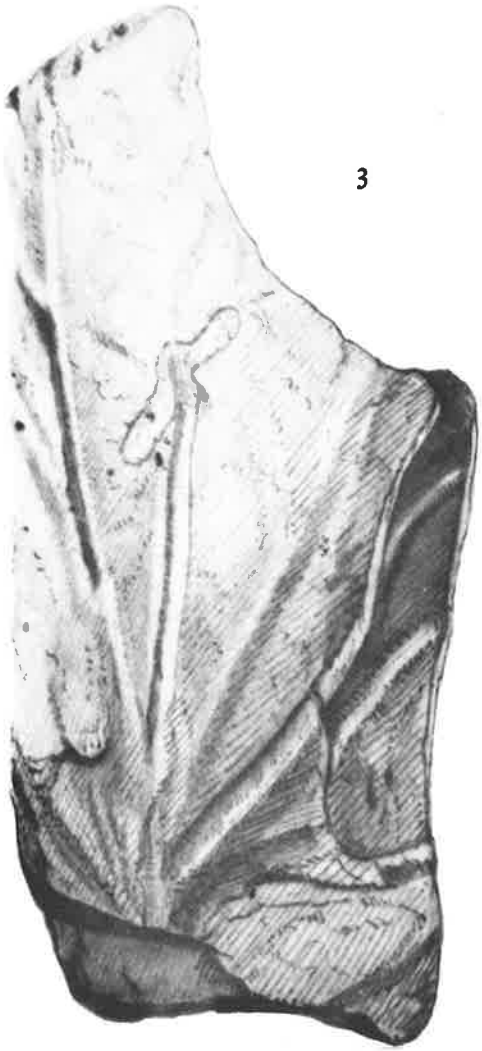

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PLATE III

Fig. 1. A specimen from the purple slates of Thornilee Quarry, near Galashiels, showing the under-surface of the bed, and exhibiting casts of the looped tracks of Crossopodia scotica M'Coy. Natural size. The cast, the loops of which run from side to side, exhibits a central cord-like elevated ridge, bordered in places by shallow lateral depressions. The cast, the loops of which run from top to bottom of the specimen, is a flattened worm-like body, which has been derived from a deeper trail than the preceding, and exhibits the central cord-like ridge only indistinctly and imperfectly. Collected by the author.

(A.U.G.D. 10606)

Fig.2. A specimen from the Skiddaw slates of Mungrisedale, near Troutbeck, covered with casts of the trails of Nemertites (Palaeochorda) major M'Coy sp. Natural size. The specimen shows excellently how the appearance of branching may be simulated in the worm-like fossils of this class. Collected by the author.

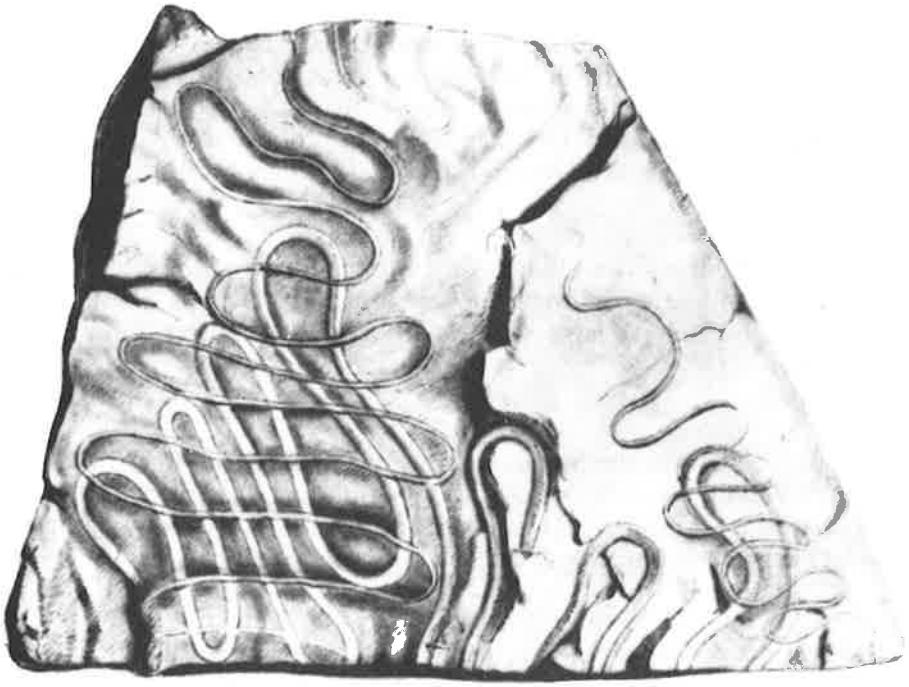
(A.U.G.D. 10614)

Fig.3. A specimen from the Skiddaw slates of Barff, near Keswick, exhibiting casts of the trail of Nemertites (Palaeochorda) major M'Coy sp. The casts in this specimen are not so cylindrical or so highly elevated above the surface as in the preceding. Natural size. Collected by the author.

(A.U.G.D. 10613)

Fig.4. A specimen from the Skiddaw slates of Outerside, near Keswick, exhibiting casts of Nemertites (Palaeochorda) minor M'Coy sp. Natural size. Collected by the author.

(A.U.G.D. 10615)



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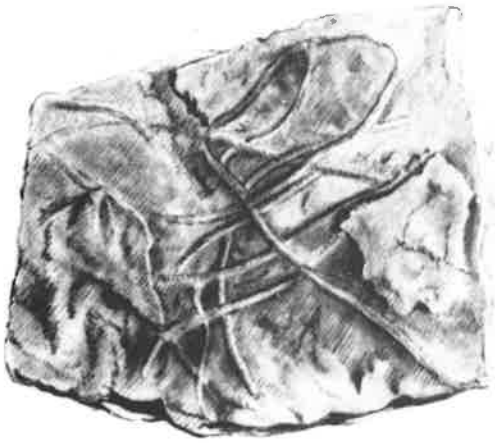

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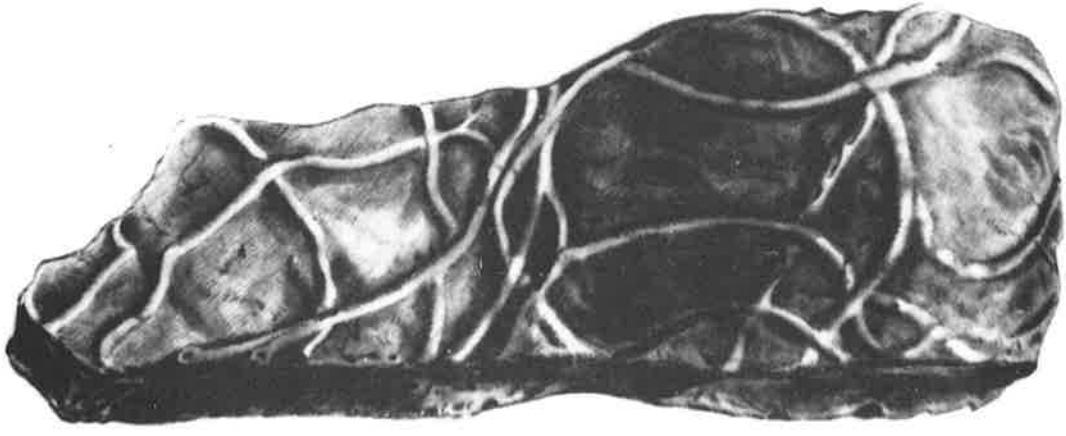


2

PLATE IV

Fig.1. A slab of olive-green shale from near the Greiston Quarry, Innerleithen, Peebleshire, covered with the tortuous tracks of Myrianites tenuis M'Coy. The tracks are hardly elevated above the surface of the stone, but are darker in colour than the matrix. Some of the tracks are much more delicate than the others. Natural size. Collected by the author.

(A.U.G.D. 10612)

Fig.2. A specimen from the Skiddaw slates of Barff, near Keswick, showing the tracks of Myrianites murchisoni Emmons. Natural size. These tracks may, perhaps, be only a large variety of M. tenuis M'Coy. Collected by the author.

(A.U.G.D. 10608)

Fig.3. A specimen from the Skiddaw slates of Outerside, near Keswick, showing the filled-up burrow of Planolites granosus Nicholson. Natural size. Towards its right-hand extremity the filling of the burrow dwindles away and becomes disintegrated, Collected by the author.

(A.U.G.D. 10618)

Fig.3a. A portion of the preceding, magnified, showing the filling of the burrow composed of little oval or oblong pellets aggregated together.

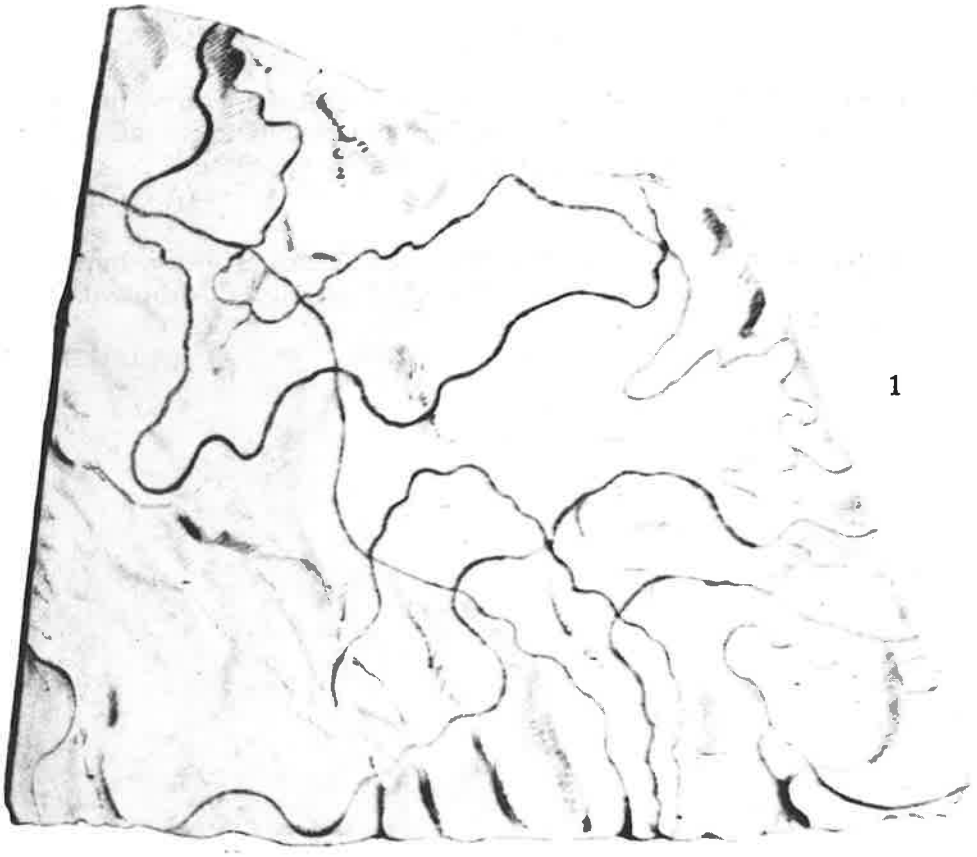
(A.U.G.D. 10618)

Fig. 4. A small piece of Skiddaw slate from Outerside, near Keswick, showing two dropping and irregular lines of the pellets ejected by Planolites granosus Nicholson. Natural size. Collected by the author.

(A.U.G.D. 10619)

Fig.5. A fragment of soft earthy shale from the upper beds of the Skiddaw slates, from Ellesgill, near Millburn, showing detached pellets of Planolites granosus Nicholson, occupying a broken line. Natural size. The pellets in this specimen are larger than in the preceding specimens. Collected by the author.

(A.U.G.D. 10620)



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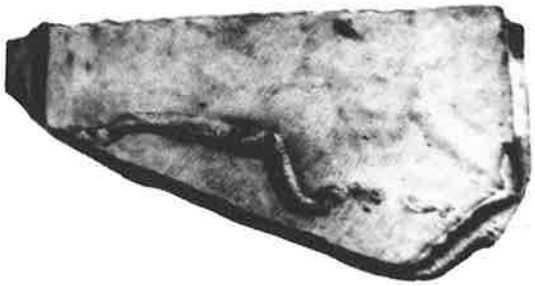
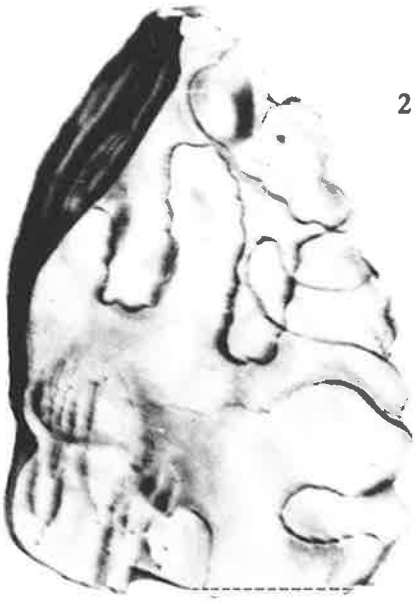




2

5

4

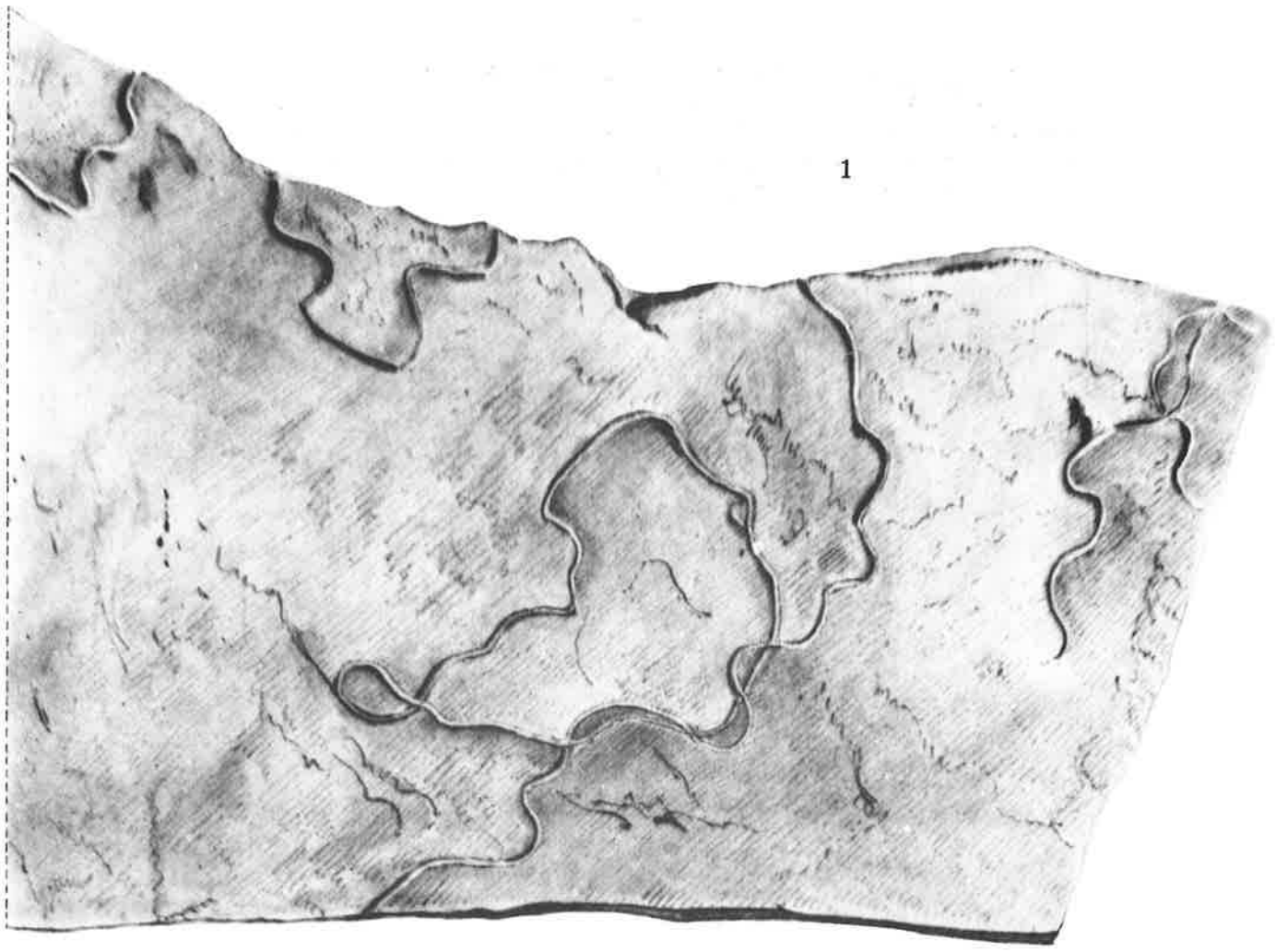
PLATE V

Fig.1. A specimen of olive-green shale from near Greiston Quarry, Innerleithen, Peebleshire, showing the meandering and sinuous tracks of Myrianites murchisoni Emmons. Natural size. Collected by the author.

(A.U.G.D. 10607)

Fig.2. A specimen of olive-green shale from near Greiston Quarry, Innerleithen, Peebleshire, showing the tracks of Caridolites wilsoni Nicholson. Natural size. Collected by the author.

(A.U.G.D. 7059)



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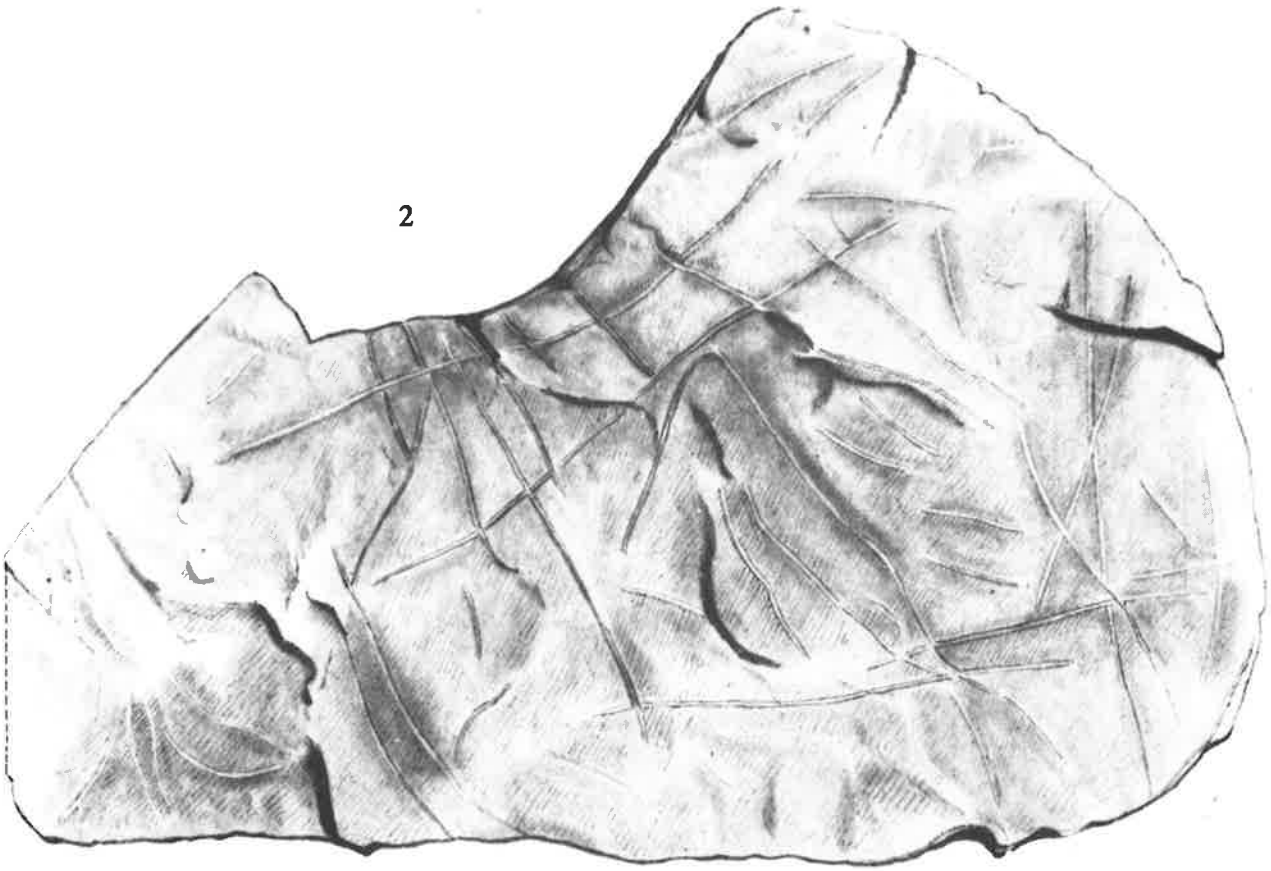

2

PLATE VI

A large specimen of greenish shale from Thornilee Quarry, near Galasheils, covered with the trails of Crossopodia scotica M'Coy, arranged in numerous parallel loop-like reduplications. The trail consists of a narrow median groove, which can be seen in places to be bounded by shallow ridges, sometimes with shallow depressions outside these again. Natural size. Collected by the author.

(A.U.G.D. 8820)