

NEW SPECIMENS OF *TRAQUAIRASPIS* FROM CANADA

by D. L. DINELEY

ABSTRACT. Lower Devonian rocks in British Columbia have yielded fragmentary remains of a number of ostracoderms, amongst which is a new species of *Traquairaspis*. The Knoydart Formation of Nova Scotia has provided new material of *Traquairaspis symondsi* (Lank.), a species hitherto recorded in Britain only. The stratigraphical and palaeogeographical implications of these new fossils are discussed.

THE genus *Traquairaspis* was erected by Kiaer in 1932 on the basis of a single dorsal disk of *Cyathaspis campbelli* Traquair from the 'Cowie Fish-band' at Cowie Harbour, Kincardineshire, Scotland. The fossil, showing the typical ornamentation, was figured (Kiaer 1932, pl. xi) but only the briefest of generic descriptions was possible. The identity of the English *Psammosteus anglicus* Lankester and the subsequently described *Phialaspis* Wills (1935) with *Traquairaspis* did not appear until 1948 (White and Toombs 1948; White 1950). In South Wales and the Welsh Borderland *Traquairaspis* has proved to be of stratigraphical value in marking the upper part of the Downtonian stage (White 1946, 1950, 1961; Ball and Dineley 1952, 1961; Dineley and Gossage 1959). White and Toombs (1948, p. 5) recognized two zones at the top of the stage:

2. *Traquairaspis symondsi* (Lank.)
1. *Traquairaspis pococki* White

The upper zone in the Brown Clee Hill area of Shropshire has been described in some detail by Ball and Dineley (1961, p. 201). In other parts of the Anglo-Welsh area the species *T. symondsi* occurs within the same fairly narrow stratigraphical limits (Dineley MS) and, although the dimensions of the individual plates and even their actual proportions within the carapace may vary considerably, the distinctive ornamentation and other features remain constant. The genus was also reported by Føyn and Heintz (1943) from north-west Vestspitsbergen and Ørving (1961, p. 523) called attention to specimens referred to *T. plana* (Brotzen) in the Lower Devonian Czortkow Group in Podolia. Gross (1961, p. 76), referring to similar new material from glacial erratics near Berlin as *Traquairaspis sp.*, has given a detailed account of the histology of *Traquairaspis* plates.

At the turn of the century H. W. Ami sent to A. S. Woodward a collection of ostracoderm fragments gathered from the Knoydart Formation of Nova Scotia. Amongst them was a specimen referred to *Psammosteus* cf. *P. anglicus* Traquair (Ami 1901, pp. 309, 311-12), this being virtually the only record of a possible *Traquairaspis* in North America to date. A. J. Boucot collected 'several specimens which Dr. Wolfgang Schmidt and Dr. Tor Ørving identified as an orbital plate with a dentine band resembling *Traquairaspis*' (Boucot 1960, p. 291). The writer has not seen this material. Now two new faunules yielding the material described below have been discovered, and are of great local importance in establishing the age of the formations. They also show that

the geographical range of the genus extends from north-west Europe, Spitsbergen, and Nova Scotia to northern British Columbia. Since the discovery of the British Columbia material, Dr. R. H. Denison has reported (1963) an unusual new ?*Traquairaspis* species in a heterostracan fauna in the Yukon.

SYSTEMATIC DESCRIPTIONS

Order HETEROSTRACI

Family TRAQUAIRASPIDIDAE

Genus TRAQUAIRASPIS Kiaer 1932

Traquairaspis denisoni sp. nov.

Plate 38; text-figs. 1-4

Diagnosis. A *Traquairaspis* of large size with dorsal disk reaching a length of about 10 cm., of generally oval outline and lacking a dorsal spine. External ornamentation similar to that of other species but with tubercles drawn into long fine ridges, continuous and running apparently parallel to the edge of the plate.

Name. After Dr. R. H. Denison, Curator of fossil fishes, Chicago Natural History Museum.

Holotype Internal mould of dorsal disk with parts of plate adhering. National Museum of Canada fossil vertebrate catalogue number 10371.

Locality and horizon. Thirty miles north-west of Muncho Lake, British Columbia (mile 450 on the Alaska Highway); 59° 07' 30" N.: 126° 22' W. This material comes from a horizon yielding many other ostracoderms and which is probably equivalent to a horizon high in the British Downtonian or lower Dittonian (Lower Devonian).

Material. The collection consists of nine large fragments or nearly complete plates of *Traquairaspis* (nos. PF 3683B, PF 3731, PF 3732, PF 3733, PF 3734, PF 3735, and PF 3736 in the collections of fossil fish, Chicago Natural History Museum, and nos. 10371 and 10372 in the fossil fish collections, National Museum of Canada). It was made available to the author by Dr. Denison, having been collected by geologists of the California Standard Company. The rock in which the fossils are preserved is a hard, fine limonitic and slightly calcareous silt, locally preserving the surface details of the fossils. It is extremely indurated and may even have suffered a very low degree of metamorphism. Unfortunately the plate tissue itself is extremely and unusually thin and badly carbonized and has largely flaked away so that the fossils are casts and moulds. The pieces are identified as follows:

One dorsal disk, almost complete internal mould (holotype, N.M.C. no. 10371).

One dorsal disk, almost complete external cast (N.M.C. no. 10372).

Two ? dorsal disks, large pieces of external mould (PF 3731, PF 3732).

Two ventral disks, large pieces of external mould (PF 3733, PF 3734).

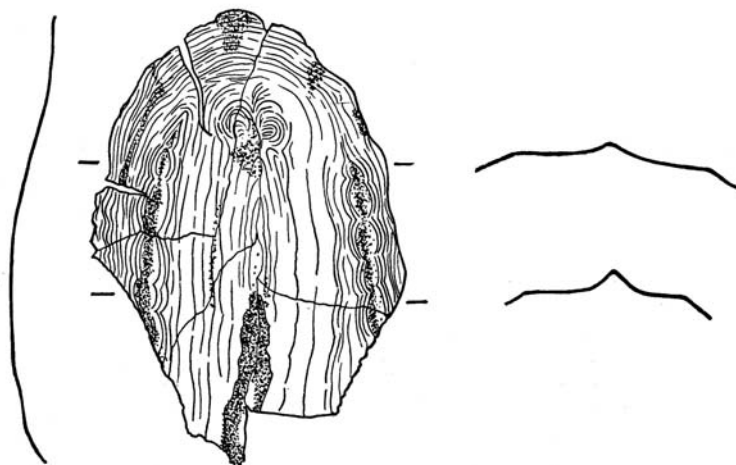
One ventral disk, large part of internal cast (PF 3683B).

One orbital plate, incomplete (PF 3735).

One ? branchial plate, large fragment (PF 3736).

Description. DORSAL DISK (text-figs. 1 and 2; Pl. 38, figs. 1 and 2). The two almost complete specimens (N.M.C. nos. 10371 and 10372) are disks of large dimensions and generally oval outline. Both have been slightly distorted in the rock: the holotype is arched more sharply to one side of the median line than the other. Along the (incomplete) median line the length is almost 9 cm., and the greatest width is 6.5 cm. The other specimen has been slightly torn during flattening by rock pressure (see text-figs. 1 and 2).

Although in each case the hind margin is imperfect, the shape is very reminiscent of *T. pococki*. Only specimen 10371 shows the faintest suggestion of a sinus in the anterior margin. The plates are vaulted, but the crest of the arching is sharply marked by a low ridge which arises some 3 cm. from the front margin of the disk and persists unbroken to the hindmost part of the plate. Although there are signs that the plates have been very slightly distorted in the rock, the maximum height of the disk, which occurs three-quarters of the way back along the median line, is 1.6 cm. in 10371 and 1.0 cm. in 10372. Two lateral carinae are developed in the posterior two-thirds of the disk and extend



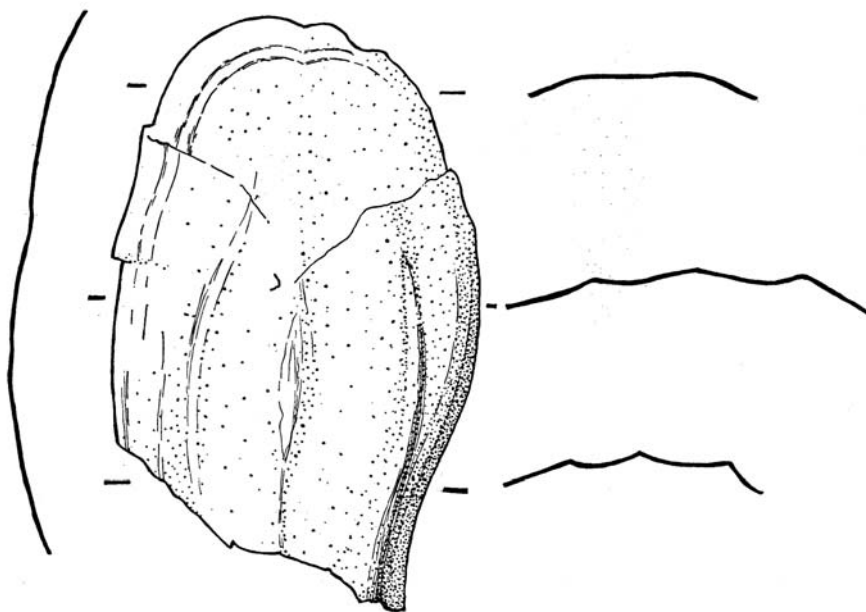
TEXT-FIG. 1. *Traquairaspis denisoni* sp. nov. Dorsal disk (N.M.C. no. 10371) outline and profiles, general pattern of ornamentation shown diagrammatically. $\times 1$.

roughly parallel to the lateral margins. They lie about half-way across each flank of the disk and appear to be produced by a sudden change in the angle of lateral slope from the median line rather than by any local thickening or ridging of the tissue.

There is no sign of a dorsal spine comparable to that known in *T. symondsi*, and here again the features are more like those of the smaller species *T. pococki*. Unfortunately the preservation of this part of both specimens has suffered, but it seems fairly certain that there was little or nothing on the exterior surface to take the place of a dorsal spine, except perhaps a somewhat enlarged single tubercle. The inner surfaces of the disks are smooth, showing none of the imperfect ridges that lie beneath the sensory canals of the disks in the two British species. There is, however, in each specimen a continuous zone of faint 'growth-lines' which extends inwards 1.5 cm. from the margins.

VENTRAL DISK (text-fig. 3; Pl. 38, fig. 3). The ventral disk in *Traquairaspis* possesses a smooth flat central area and a brim ornamented with tubercles. Specimens PF 3683B and PF 3733 show that the most distinctive smooth central portion also occurs in the new species. The largest fragment (PF 3683B) consists of the internal cast of the greater part of the smooth flat central area and most of the front and left portions of the brim.

It is 7 cm. in length and when complete must have been 9 to 10 cm. long. In outline it is indistinguishable from the disk of British species with the central area fairly sharply defined on the inner surface, flat and showing a very slight median indentation of the anterior margin. The brim also is flat and slopes very gently away from the central area. It has a remarkably constant width, reaching about 1.8 cm. near the front left 'corner' and only slightly less over the rest of its extent. Faint growth-lines occupy a zone up to 1 cm. wide along the lateral margin.



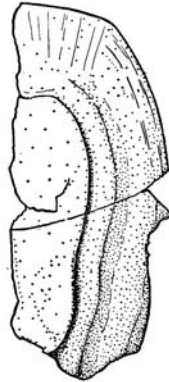
TEXT-FIG. 2. *Traquairaspis denisoni* sp. nov. Dorsal disk (N.M.C. no. 10372) outline and profiles of holotype. $\times 1$.

ORBITAL PLATE (text-fig. 4). The irregular and broken margins of the only specimen of this plate (PF 3735) give little indication of its true shape and size. It is, however, remarkably flat and measures 2 cm. across its greatest dimension. The orbit is round and 0.3 cm. in diameter.

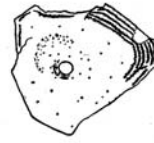
? BRANCHIAL PLATE. A narrow, somewhat bowed fragment, 4.7 cm. long, may represent part of a branchial plate. It is not well preserved and reveals no unusual features.

SENSORY CANAL SYSTEM (text-fig. 1). Only in specimen 10371, the external mould of the dorsal disk, is there any trace of the sensory canal system, and this is restricted to short lengths of canal showing tubuli under the lateral carinae. As in the material described by White (White 1946, p. 218, figs. 3 and 4; p. 229, fig. 39A), the canals seem to be just under the outer surface of the plate rather than in the cellular middle layer.

ORNAMENTATION. The ornamentation of *Traquairaspis denisoni* appears to be very uniform and distinctive. It consists of very fine somewhat crimped ridges or extremely long and thin tubercles running roughly parallel to the margins of the plates. It is rather reminiscent of the ornamentation in *Cyathaspis* and a density of twenty to twenty-two tubercles per centimetre across the disk seems to be fairly constant. The tubercles on the carinae on specimen 10372 are deflected into a series of short curves concentric upon ? single short tubercles spaced about 1 cm. apart along each carina. This is an arrange-



TEXT-FIG. 3



TEXT-FIG. 4

TEXT-FIG. 3. *Traquairaspis denisoni* sp. nov. Ventral disk (C.N.H.M. no. PF 3683B) sketch made from latex pull of original. $\times 1$.

TEXT-FIG. 4. *Traquairaspis denisoni* sp. nov. Orbital plate (C.N.H.M. no. PF 3735). $\times 0.8$.

ment very similar to that of the ornamentation around the enlarged tubercles or bosses seen in *T. pococki* (White 1946, figs. 1 and 2) and *T. symonysi* (White 1946, figs. 52 and 54).

An additional feature of note in specimen 10371 is the double 'whorl' of ridges near the front end of the disk (Pl. 38, fig. 2). Behind this whorl the ornamentation runs directly back parallel to the median line. White (1938, figs. 16 and 17) illustrated a similar occurrence in the dorsal disk of *Pteraspis dixonii* White from South Wales, and Stensiö (1958, p. 278, text-fig. 14C-F) has commented on them (as *Penygaspis dixonii* (White)) and on other similar specimens. It seems probable that the 'whorls' and bosses are remnants of the cyclomerial structure of the disk—the initial units which fused together

EXPLANATION OF PLATE 38

Fig. 1. *Traquairaspis denisoni* sp. nov. Lower Devonian, Muncho Lake area, B.C. Internal mould with attached portions of plate (N.M.C. no. 10372). $\times 1$.

Fig. 2. *Traquairaspis denisoni* sp. nov. Type specimen. Lower Devonian, Muncho Lake area, B.C. Dorsal disk, external mould showing distinctive ornamentation (N.M.C. no. 10371). $\times 1$.

Fig. 3. *Traquairaspis denisoni* sp. nov. Lower Devonian, Muncho Lake area, B.C. External mould of part of ventral disk showing part of the smooth flat central portion and typically ornamented brim (C.N.H.M. no. PF 3733). $\times 1$.

to produce the disk. The ridges or tubercles near the margins indicate the last growth stage when bony material was added peripherally.

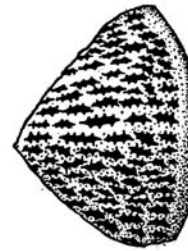
The smooth central area of the ventral disk, like that in *T. symondsii*, is seen in specimen PF 3733 not only to be raised but slightly to overhang the ornamented brim.

Microstructure. The actual plate tissue is not well preserved, being badly carbonized and compressed. Where it has been possible to examine the structure the middle cancellous layer seems to be reduced to about 0.02 cm. in thickness and the complete thickness of the plate excluding tubercles is only 0.06 cm. The tubercles in the holotype are up to about 0.05 cm. high. Post-depositional changes in the rock appear possibly to account



TEXT-FIG. 5

TEXT-FIG. 5. *Traquairaspis symondsii* (Lankester). Dorsal disk (N.M.C. no. 10373) reconstructed profile. $\times 1$.



TEXT-FIG. 6

TEXT-FIG. 6. *Traquairaspis symondsii* (Lankester). ?Flank scale (N.M.C. no. 10374) sketch of external mould. $\times 4$.

for compression of the tissue. In the British specimens of *Traquairaspis*, where the rock matrix has suffered little change, the dorsal disk is 0.05 cm. to 0.1 cm. thick. The pro-taspids from the western U.S.A., on the other hand, have carapaces which are almost as thin as the British Columbian material.

Remarks. This species of *Traquairaspis* shows a number of similarities to *T. pococki*, notably in the shape of the dorsal disk, the absence of a dorsal spine and the fineness of the ornamentation. It is similar to *T. symondsii* in its overall size. The ornamentation, however, is in detail quite distinctive: the great length and thinness of the individual tubercles and the absence of the stellate tubercles found in *T. pococki* and *T. symondsii* being sufficient to set it apart from these species. The presence of the 'whorled' ornamentation on specimen 10371 may be regarded as a primitive feature on a par with that seen in certain pteraspids. The absence of a dorsal spine perhaps also denotes an early stage of evolutionary development.

Traquairaspis symondsii (Lankester)

Plate 39; text-figs. 5, 6

Diagnosis. White (1946, p. 237) gives the diagnosis for *Phialaspis symondsii*, and, apart from the name, this remains unchanged for *T. symondsii*.

'A *Traquairaspis* of large size. Ventral disc attaining a length of nearly 10 cm.,

generally roughly oval but truncated in front and irregularly scalloped behind. External ornamentation composed of numerous tubercles, each ringed at base by conspicuous groove or shelf where dentine ends. On upper surface of branchio-cornual plate tubercles are short and more or less evenly distributed in longitudinal rows, especially along free margin; those on brim of ventral disc longest in front and along sides of central area, and shortest behind. Radial extensions of central area short.'

'Sensory canal system partly discontinuous; anterior V-shaped canal of ventral disc absent'.

To this may now be added:

Dorsal disk roughly quadrate but with produced median posterior margin at base of dorsal spine. Dorsal spine broadly triangular in side view with large tubercles on flanks aligned at about 45 degrees to front end of spine base.

Locality and horizon. The field immediately south of the main Arisaig-Merigonish road and 250 yards east of McArras Brook, Antigonish Co., N.S., was marked in 1961 by a shallow excavation for road metal. On the western side of this pit an outcrop of hard dark red silty mudstone yielded a large number of small fragments of vertebrate material, including that described here. This bed lies approximately 450 feet above the base of the Knoydart Formation.

Material. The most important piece of the *Traquairaspis* material is the left half of a dorsal disk (National Museum of Canada no. 10373): other fragments are small and of uncertain position in the *Traquairaspis* carapace. Two virtually complete scales (Nat. Mus. of Canada nos. 10374, 10375) are also present. Each of these fossils was exposed in the matrix with the ornamented side downwards and has been developed by etching in hydrochloric acid.

Description. DORSAL DISK (text-fig. 5, Pl. 39). White (1946, p. 229) gave a description of the dorsal disk based on three moderately large fragments (together with a possible fourth) from different localities in the Welsh Borderlands. Subsequent discoveries by White and Toombs in Monmouthshire and by the present author in Shropshire (White 1961, pp. 246-7) have confirmed the description and show the plate to be generally similar in outline to that of *T. pococki*.

The present specimen measures 7.5 cm. in length and 2.4 cm. across its flank, thus corresponding in general size with the British specimens. In outline the complete plate is sub-rectangular with only gently convex lateral margins, a rather wavy anterior margin and a posterior margin with a blunt median angle. The dorsal spine has a blunt triangular outline with an almost vertical anterior edge. In front of the spine there is evidence of a single small 'boss' of tubercles, but the median row of large tubercles seen in the British specimens is not apparent.

The sensory canals are discontinuous, possibly owing to imperfect preservation, and the characteristic tubuli project alternately to right and left. Parts of the periorbital canal and the inner longitudinal canal remain; the outer one is missing, and fragments of the transverse canals survive.

The ornamentation is typical and the disk bears lines of 'bosses' of tubercles on each side of the median line, in corresponding positions to the lateral carinae in *T. denisoni*.

EXPLANATION OF PLATE 39

Traquairaspis symondsii (Lankester) Knoydart Formation, MacArras Brook, Nova Scotia. Dorsal disk, etched external mould of left half of the plate with adhering haematite-filled portions of the sensory canal system (N.M.C. no. 10373). $\times 2.7$.

Two similar 'bosses' occur at the lateral extremity of the hind margin. Stensiö (1958, pp. 285-9) has interpreted these 'bosses' as being originally cyclomerial scales fused at an early age in the ontogeny.

SCALES (text-fig. 6). Amongst the many small fragments collected are two reasonably complete and quite different scales. One (Nat. Mus. of Canada no. 10374) is a thick flank scale, roughly triangular in outline and with gently convex margins. The interior surface was badly weathered so that its features could not be described, but since the tissue has been etched away the exterior surface shows an ornament-free margin behind which occur approximately parallel lines of small elongate tubercles.

The other scale (Nat. Mus. of Canada no. 10375) is much less well preserved and etching has further damaged the outline. The front margin is square to the laterals and the hind margin is pointed. The ornamentation is of tubercles arranged parallel to the lateral margins and with a line of very small stellate tubercles near the front edge. In relief the scale is rather pyramidal, rising to a focal tubercle. The position of this scale in the squamation is uncertain, but it probably lay on the flank.

STRATIGRAPHICAL POSITION

In Britain *Traquairaspis* has a narrow stratigraphical range at the top of the Downtonian stage and in the lowest part of the Dittonian (Dineley and Gossage 1959). It is a typical member of the highest Downtonian faunas but is rare in the Dittonian where the pteraspids are the most conspicuous fossils. A similar situation appears to obtain in Spitsbergen and other parts of Europe. Ami (1901) quoted A. S. Woodward on the identification of the ostracoderm fragments found in the Knoydart Formation of Nova Scotia at the end of last century. *Pteraspis* cf. *P. crouchi* and *Psammosteus* cf. *P. anglicus* Traquair are included in the list of identifications, but it is not certain that they came from the same stratum. The synonymy of *Traquairaspis symondsi* (Lank.) includes Traquair's *Psammosteus anglicus* (1898, p. 67, pl. i, figs. 1, 2) and it seems possible that the Knoydart specimen examined by Woodward would today be referred to *Traquairaspis*. The pteraspid material was subsequently allocated to a new species *P. novae-scotiae* by White in 1935 with the remark that it resembled *P. leathensis* White (1935, pp. 444-6). *Pteraspis (Simopteraspis) leathensis* is now regarded as the earliest British pteraspid, its range overlapping that of *Traquairaspis symondsi*. In 1955 Denison described further pteraspid fossils from the Knoydart Formation. He erected the species *P. (S.) whitei* for this material from a horizon estimated by the present writer to be less than 100 feet above the new *T. symondsi* locality. Thus the stratigraphical occurrence of the Knoydart *T. symondsi* and *Pteraspis (Simopteraspis)* seems to duplicate very closely the range of these forms in Britain. With the discovery of a British species of *Traquairaspis* in Nova Scotia the problem of migration and dispersal of the ostracoderm fishes is sharply underlined. White (1958, pp. 219-23) has considered this problem and argues convincingly that localities for *Pteraspis* as widespread as Spitsbergen, Belgium, Britain, and Nova Scotia were accessible to ostracoderms as a result of the animals' ability to live in shallow coastal waters. Each of the mentioned areas of Old Red Sandstone deposition was in direct communication with the sea and was reached by ostracoderms swimming in from the coastal waters. This idea is discussed and supported in a recent article by L. B. Tarlo (1962, pp. 152-3).

Dineley (1962) has made a detailed comparison of the Knoydart Formation with the Downtonian and Dittonian rocks of England and Wales and found a remarkable correlation of lithological, sedimentological and (other) palaeontological characters between them. There is no doubt that the same kind of environment, which produced a peculiar and distinctive combination of lithologies, sedimentary structures, &c., was present in both areas. That these two regions were directly connected by an area of at least not very different sedimentation seems likely. Denison (1963) has described a probable *Traquairaspis*, ? *T. angusta*, from the Yukon. It is a member of a large and interesting fauna suggestive of a very late Silurian age. The stratigraphical position of *T. denisoni* from British Columbia is as yet less certain than that of either the Nova Scotia specimens or the species from the Yukon. The Lower Devonian formations of the Canadian Rocky Mountains frequently appear to rest on a transgressive diachronous base, locally with the development of basal red sandstones or yellowish ferruginous siltstones. The age of these basal members is usually uncertain and although fish remains have been found at a number of points in the Rabbit River area of B.C. not far from Muncho Lake (Gabrielse 1961), they are of little correlative use and the field relations of the strata are obscure. Undoubtedly the fossil vertebrates from the Muncho Lake locality are Lower Devonian and Denison's study of the ostracoderms associated with *Traquairaspis* should help to establish a close correlation with other regions. In the meantime it seems highly probable that *T. denisoni* is of Upper Downtonian or lowermost Dittonian age. This is somewhat older than the Beartooth Butte and Water Canyon formations of Colorado and Wyoming, which are regarded as uppermost Dittonian or Breconian (lower Siegenian).

It is unlikely that a route for the westward dispersal of *Traquairaspis* existed south of the present Canadian Shield area, though it is interesting to find the upper Dittonian *Pteraspis carmani* as far west as Ohio (Denison 1960). Ostracoderms of both Upper Silurian and Lower Devonian age have been found in the Canadian Arctic Islands (Thorsteinsson 1958, pp. 76-78; Thorsteinsson and Tozer 1964), and open-water routes between the north-eastern and the north-western regions of North America could have persisted north of the Canadian Shield (see Thorsteinsson and Tozer 1960). Work in progress on the ostracoderm faunas of the Canadian arctic will be valuable in assessing the extent to which that region was linked with the north-west European ostracoderm province. Ostracoderm migration and movement across this part of the western arctic may have been a frequent if not continuous activity.

Acknowledgements. The material from Nova Scotia was collected while the author was under contract to the National Museum of Canada. Dr. L. S. Russell, Director of the Museum, kindly gave permission for the notes on these fossils to be published. Dr. R. H. Denison generously made available the material from British Columbia. At the British Museum (Natural History) Dr. E. I. White and Dr. H. W. Ball cast kindly and critical eyes over the manuscript and their comments and suggestions have much improved it. To each of these gentlemen the writer tenders his best thanks.

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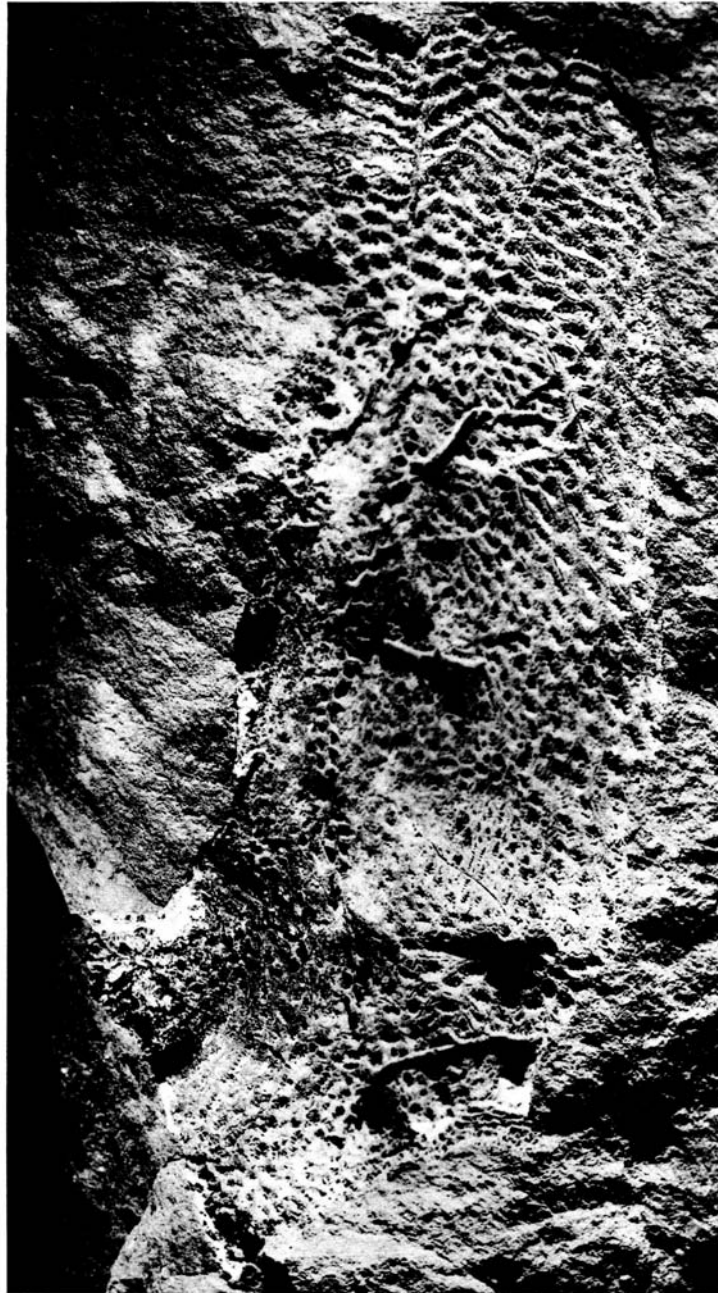
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D. L. DINELEY
Department of Geology,
University of Ottawa,
Ottawa, Ontario, Canada

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DINELEY, *Traquairaspis*



DINELEY, *Traquairaspis*
