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The Cambrian Fauna of the Leny Limestone, Perthshire, Scotland

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ABSTRACT: Dark limestones in the old quarries at Leny, Perthshire contain sparse beds with tiny fossils. They are poorly preserved and, though barely affected by the Ordovician Grampian Event tectonism, there is some taphonomic distortion and many are corroded along stylolitised horizons. The fauna mainly comprises trilobites of two types, open-ocean miomerids and polymerid shelf dwellers. Miomerids *Condylopyge* cf. *eli* and *Kiskinella cristata* indicate a stratigraphical position equivalent to the base of the paradoxidid Amgan Stage of Siberia; traditionally regarded as 'Middle Cambrian'. However, the bulk of the Leny miomerids, notably species of *Pagetides*, are forms described from the outer edge of Laurentia, within the *Bonnia–Olenellus* Zone, where it is considered to be 'Lower Cambrian'. The Leny polymerids were likely transported off-shelf and some are conspecific with taxa in the Laurentian allochthonous Quebec and New York successions of the Early–Middle Ordovician (Taconic) Appalachian Orogen. The Leny Limestone and Shale Member of the Keltie Water Grit Formation is part of the Dalradian Supergroup deposited in an off-shelf Caledonide Grampian Terrane of the Humber Tectonostratigraphical Zone, midway between the North American successions and the Greenland Caledonides.

Additional to the trilobites, brachiopods, sponges, hyoliths, bradoriids and a selection of indeterminable organic fragments occur; none of which has any particular age significance.

KEY WORDS: Dalradian, Humber Tectonostratigraphical Zone, Laurentia, *Pagetides*, trilobites.

The 'Leny Limestone' (Nicol 1863) [Kilmahog Limestone of Jehu & Campbell (1917) and Pringle (1940a, b)] in the Callander area of south-western Perthshire, Scotland (Figs 1–4) is a generalised term for thin dark limestone layers (Francis *et al*. 1970) in a lithostratigraphical unit, named Leny Limestone and Slate Member, within the Keltie Water Grit Formation of siliceous turbidites (Tanner 1995). Although initially placed in the Southern Highland Group (Tanner 1995; British Geological Survey 2005), it is now regarded part of the younger Trossachs Group (Tanner & Sutherland 2007, p. 115, fig. 3).

The succession and its fauna have been subjects of geological speculation since the discovery of fossils in the 'Leny Quarries' in 1938 (Pringle 1940a, p. 252, 1940b, p. 120, 1945 [two unpublished reports in BGS Archive]; Tanner & Bluck 1999). Three main questions have been posed. Is the formation a component of the metamorphosed and tectonised Dalradian Supergroup? What is the age of the limestone? What is its palaeogeographical affinity? On structural grounds, the turbidite formation is now considered to be part of the Dalradian Supergroup (Pringle 1940a; Harris 1969; Tanner 1995; Harris *et al*. 1998) abutting the northern side of the Highland Boundary Fault (Fig. 3), within a discrete Highland Border Complex (Bluck *et al*. 1984; Bluck & Ingham in Bluck *et al*. 1997) at the interface between two major crustal blocks, the Grampian and Midland Valley terranes (Tanner & Sutherland 2007, fig. 1).

Some fossils were noted also in this Leny Member by Pringle in the nearby stream sections of Leny Glen (Fig. 2) and Keltie Water (Fig. 3), but they are not identified in his British Geological Survey (BGS) registered collection and the present authors did not succeed in confirming his finds in those stream sections. Therefore, the present account deals mainly with the trilobite fauna collected from rocks in the western 'Leny Old Lime Quarry', 950 metres north and 8 degrees east of the northern corner of Leny House (Fig. 2), that help to resolve the palaeontological questions.

1. Previous work

Harkness (1861) was the first to refer to the rocks of Leny Quarry when he regarded their blackness as of similar 'anthracitic aspect' to the Lower Silurian shales in the Southern Uplands, i.e., 'The South of Scotland' geological region in the British Geological Survey's British Regional Geology series (Fig. 1 Inset, Region 6). However, he was unable to find fossils at the site. Two years later, Nicol named the beds in Leny quarries and provided a cross-section showing the main limestone and a separate interval of interbedded thin limestone and black shale in the western workings (Nicol 1863, fig. 4), as well as noting a thick limestone unit in the smaller eastern workings. At that time, he remarked on their similarity to dark carbonaceous Carboniferous formations, in contrast to his earlier conclusion that the strata of the Southern Highlands are more ancient than those in the Southern Uplands (Nicol 1844).

In 1882, the Geological Survey of Scotland published One-inch Geological Sheet 39 (Stirling) and established the stratigraphical continuity between the rocks at the eastern end of the Leny quarries and metamorphic rocks in the nearby Keltie Water section, thus initiating a long-lasting debate on the age of the Leny Limestone and its relationship to the metamorphosed and tectonised Dalradian succession (Geikie 1891; Clough in Geikie 1897, p. 28; Macnair 1908; Gregory 1910,

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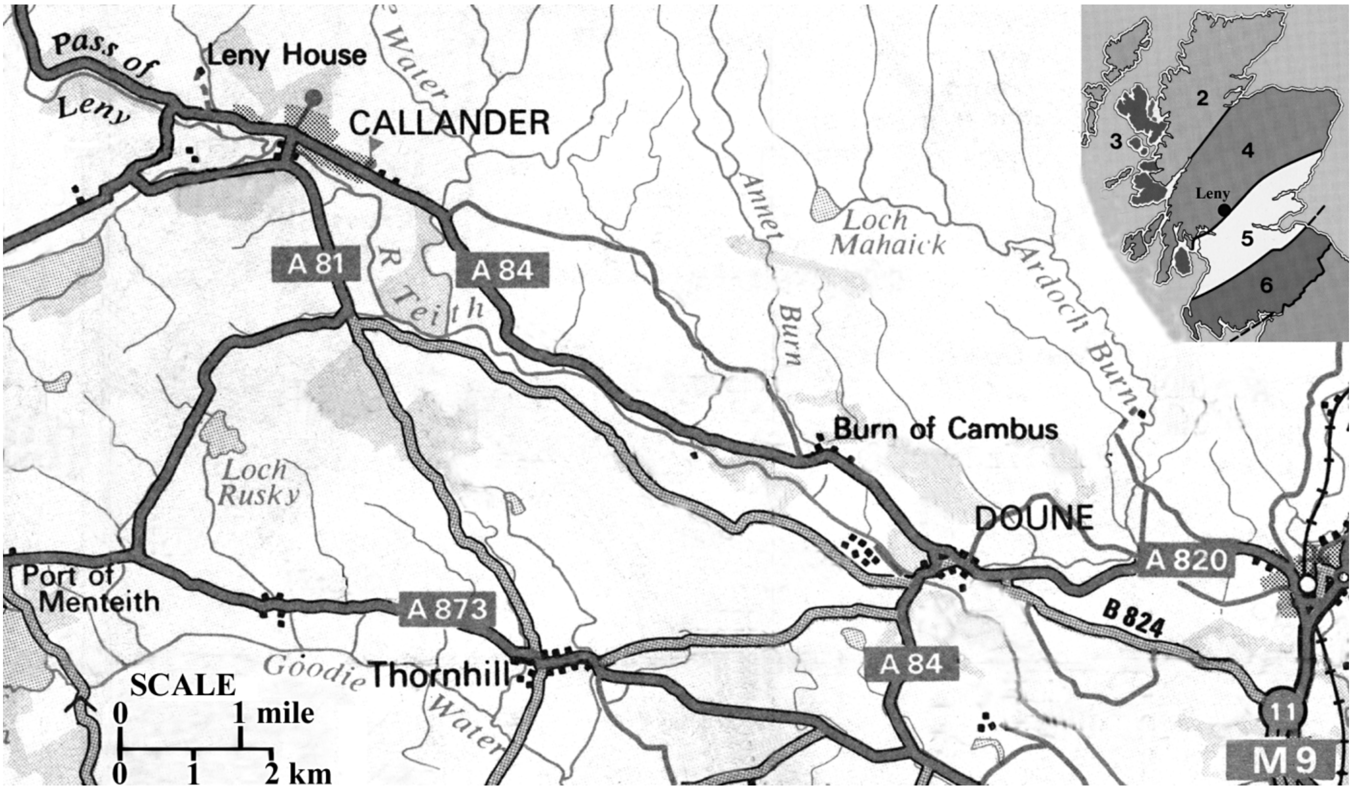

Figure 1 Location of the Leny district. Inset map shows the main BGS geological regions of Scotland and the position of the Leny Quarries on the northern side of the Highland Boundary Fault: (2) The Northern Highlands; (3) The Tertiary Volcanic Districts; (4) The Grampian Highlands; (5) The Midland Valley of Scotland; (6) The South of Scotland. Road map reproduced with permission from The Reader's Digest Association Limited 'New Book of the Road' © 1980.

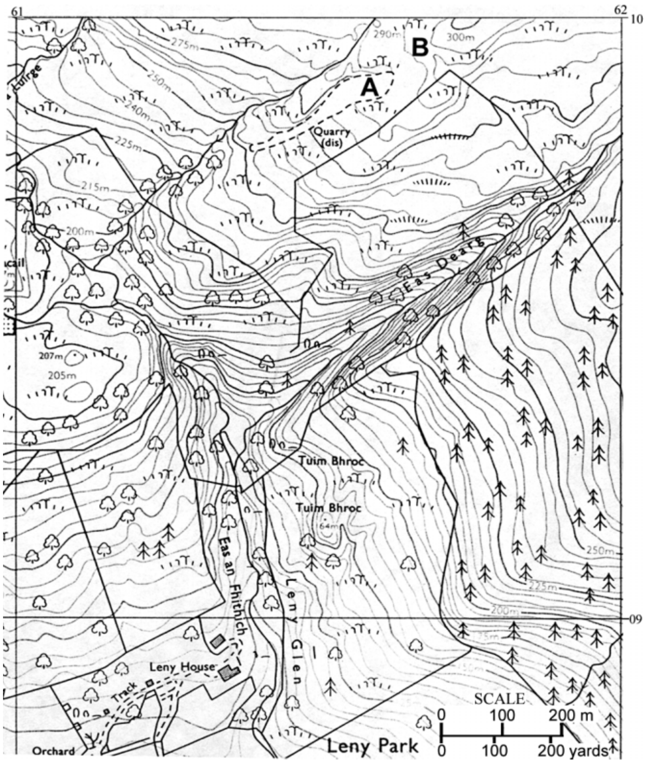

Figure 2 Site of the Leny Quarries at National Grid Reference NN 6157 0987. A: Western Quarry. B: Eastern Quarry. Part of the 1978 revised topographical base map 1:10, 000 Sheet NN60. © Crown copyright Ordnance Survey. All rights reserved.

1931; Stone 1957; Harris & Fettes 1972; Tanner 1995; Harris *et al.* 1998). Note that the more westerly 'Leny Old Lime Quarry' appears at the eastern edge of the adjourning One-inch Geological Sheet 38 (Loch Lomond) published in 1901; no explanatory memoirs were prepared for these sheet-areas.

Subsequent discoveries of Ordovician fossils along the northern side of the Highland Boundary Fault at Stonehaven (Campbell 1911, 1913) and Aberfoyle (Jehu & Campbell 1917) renewed interest in the limestones of the Highland Border, but it was not until the 1938 discovery of trilobites at Leny that fossiliferous rocks as old as Cambrian were recognised along this tectonised belt (Stubblefield in Pringle 1940a, b). At around the time of Pringle's discovery, the well-known Scottish collector, James Begg (1874–1958), made his own collection (Lamont 1975, p. 199); it is possible that the two collectors co-operated, though there is no record that they did so.

Stubblefield (in Pringle 1940a) originally assigned most of the trilobites in Pringle's collections to new, undescribed species of *Pagetia* Walcott, 1916, then considered to be a Middle Cambrian taxon in the Laurentian Faunal Realm of North America. However, following Rasetti's (1945) description of the new genus *Pagetides* from the *Bonnia*-bearing Lower Cambrian 'Sillery' Formation near Lévis, Quebec, Stubblefield (1956, p. 29; in Brown *et al.* 1965, pp. 116, 133) revised the identification of the principal Leny trilobites to *Pagetides* and the age to late Lower Cambrian.

In the 1960s, small fossil collections were made from the south-eastern side of the 'Leny Old Lime Quarry' by Dr W. S. McKerrow for the University Museum Oxford and by officers of the Geological Survey of Scotland. However, despite the obvious relevance of the Leny fossils, they have not been properly described. Dr J. W. Cowie studied the available collections in the 1960s, but did not publish his observations.

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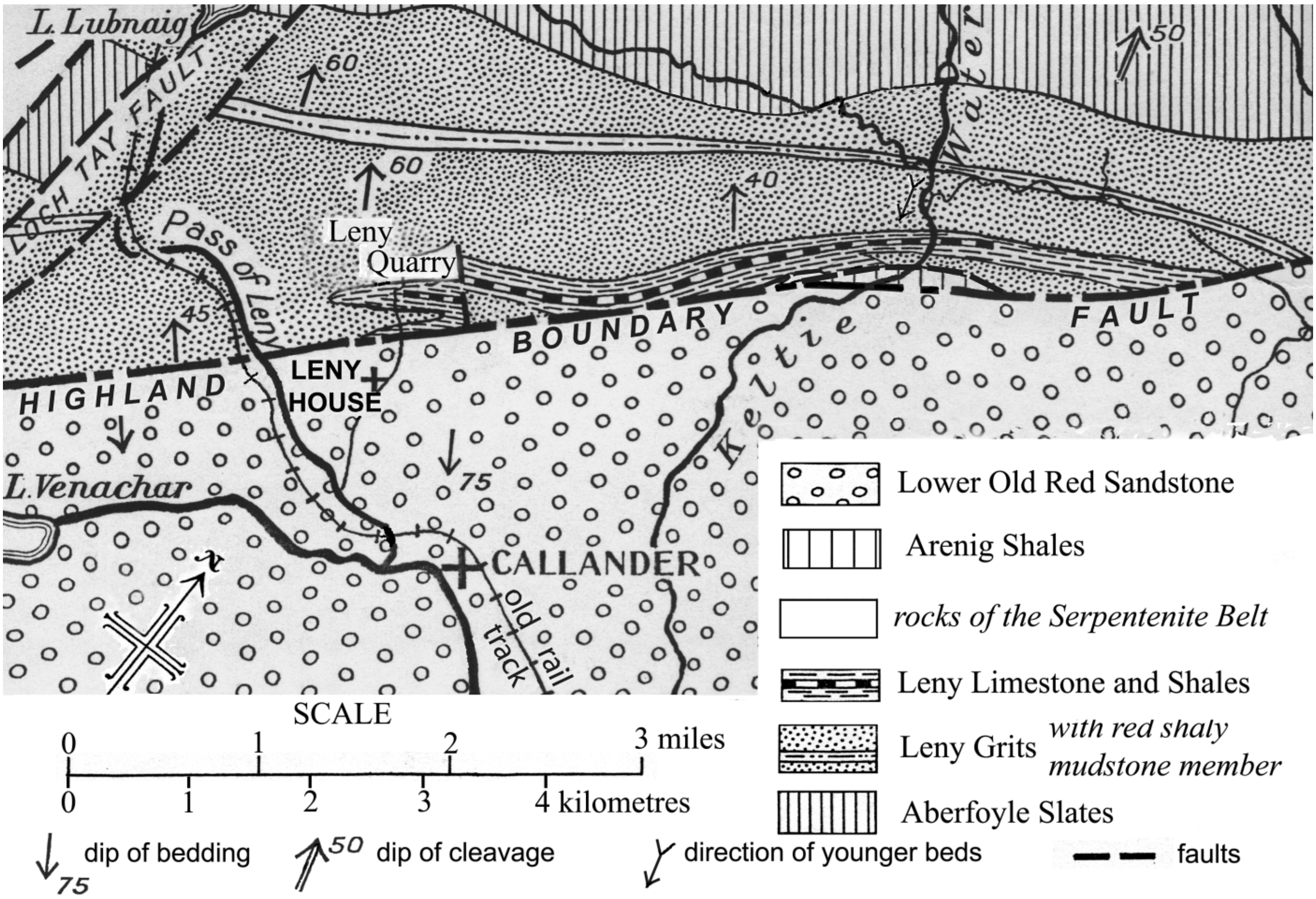

Figure 3 Geological map of the Leny district from Pringle's unpublished 1945 manuscript.

A second edition of Geological Sheet 39 (Institute of Geological Sciences 1974) was released to accompany a memoir of the Geology of the Stirling District (Francis *et al.* 1970), but there was no descriptive faunal work until Lamont (1975) published in an unrefereed journal of greatly restricted circulation. His work involved the Begg Collection housed in the Hunterian Museum in Glasgow and some of his own material; he made no attempt to examine the British Geological Survey collections in London and Edinburgh. Lamont proposed 13 new trilobite taxa comprising five 'pagetiids', two eodiscids and seven supposed polymerids. The attribution of his newly named *Neilsonella agnesae* to the Family Daguinaspidae Hupé, 1953a (p. 137) and his *Nicoljavius minans* to the Gigantopygidae Harrington, 1959 (p. O204) implied affinity with much older peri-Gondwanan faunas of the Moroccan Cambrian.

In a stratigraphical account of British trilobites, Rushton (in Thomas *et al.* 1984) noted that the 'pagetiids' in Leny Limestone collections are associated with a few polymerid trilobites that include a corynexochoid and a ptychopariid possibly related to *Antagmus* Resser, 1936. Later, Fletcher (1989) made a preliminary study of the Leny Limestone fossils in the Geological Survey of Scotland's Palaeontological Collection together with a few selected specimens from the Pringle Collection in the British Geological Survey at Keyworth, Nottinghamshire. This indicated the presence of five miomerid trilobites (Agnostina and Eodiscina), four polymerid trilobites, a bradoriid, some sponge spicules and two species of brachiopod (Fig. 5). Although the fauna is largely of Laurentian affinity, Fletcher recognised the presence of a more cosmopolitan eodiscid, *Kiskinella*, that has the potential to make a more globally significant correlation and provide a guide to the environmental setting. Unlike Lamont's interpretation of Begg's material, none of the faunal elements can be assigned to the Moroccan suprageneric taxa noted above. In a subsequent account of Leny Quarry, Rushton (in Rushton *et al.* 2000, fig. 13.2) illustrated, but did not describe, examples of 'pagetiid' trilobites from the Leny Limestone.

In recent decades, much new information has been garnered on the sedimentological, lithostratigraphical and structural aspects of the rocks around Callander, notable among which is that published by Tanner and co-workers (Tanner 1995; Tanner & Bluck 1999; Tanner & Pringle 1999; Tanner & Sutherland 2007). A resurvey by the British Geological Survey of the eastern half (Aberfoyle) of One-inch Geological Sheet 38 was published as a map in 2005 and shows the Leny outcrop, but, as yet, there is no explanatory memoir for that district.

In curatorial comments on the Begg and Lamont collections in the Hunterian Museum, Ingham (unpublished written report, 1996; see Appendix 1) mentions that 'an undeformed Tommotian or Atdabanian (Lower Cambrian) microfossil' from Leny Quarry was collected by G. M. Whelan (unpublished Ph.D. thesis, University of Glasgow); such a date is in conflict with the much younger trilobite evidence, and the significance of the microfossil remains to be resolved. Although disseminated organic matter is evident in the Leny Member, as yet, no taxa have been identified in prepared residues (Tanner & Sutherland 2007, p. 114).

2. **The Leny Quarries** [National Grid Reference NN 615 098]

Due to the present relatively degraded state of the long-disused excavations at Leny, the descriptions given in the present

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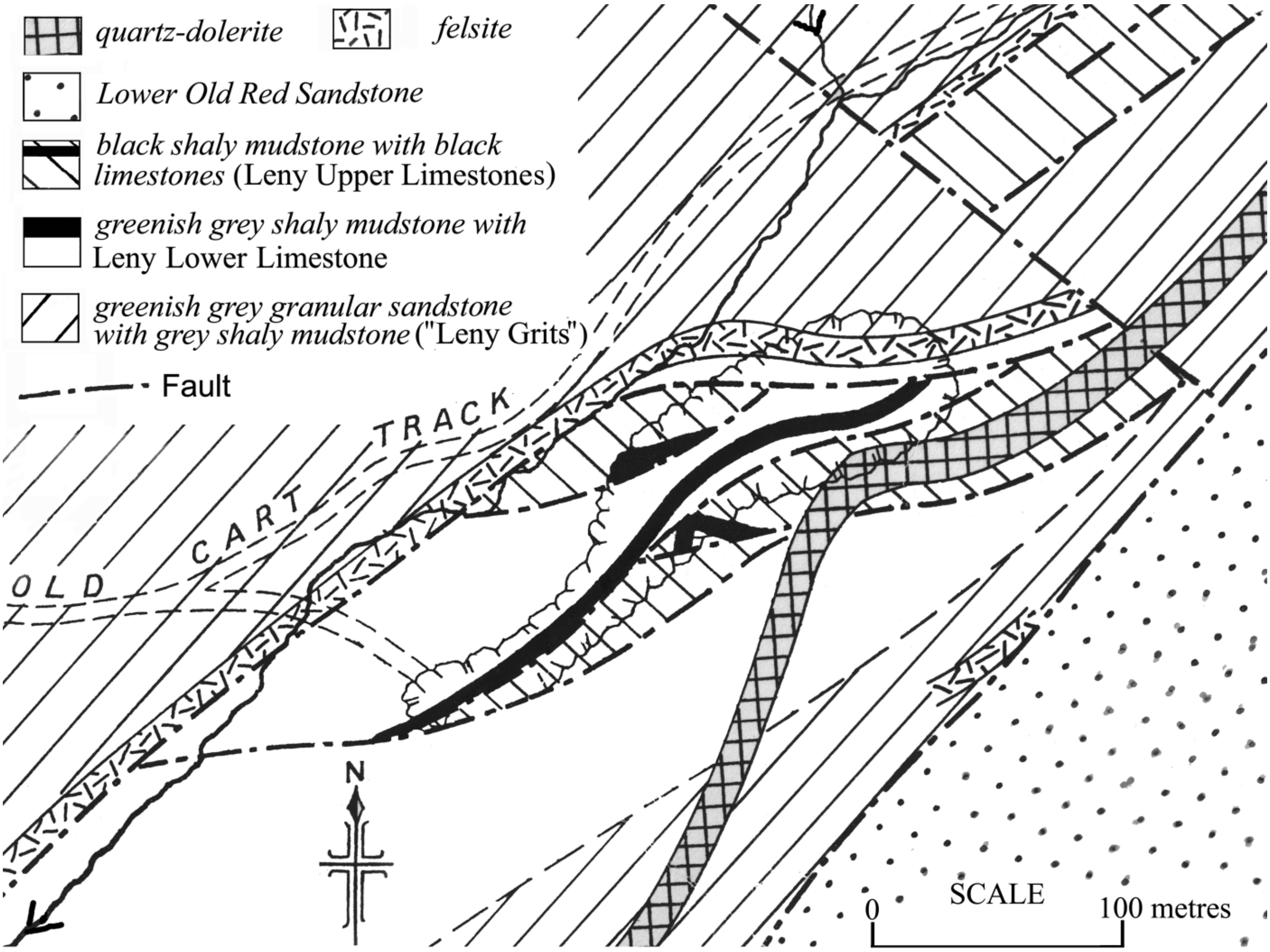

Figure 4 Geological map of the Leny Western Quarry from Pringle's unpublished 1945 manuscript. The site of the Eastern Quarry lies near the north-eastern corner of the map.

paper are those of their condition at the time of the fossil discovery and is based on Pringle's maps (Figs 3–4) and descriptions in his unpublished manuscripts held in the British Geological Survey Archive. In his report, Pringle distinguished a Western Quarry and an Eastern Quarry. These descriptions supplement those given more recently by Tanner & Pringle (1999, p. 1207, fig. 3).

The original Leny Quarry is a ravine-like excavation about 265 m long, more or less striking with the rock layers SW–NE, terminating at a fault trending NW–SE (Figs 3 and 4). Quarrying dates back to about 1745, when a nearly vertical thin bed of brown-weathering, grey, sandy limestone was taken out for burning in two on-site limekilns. Subsequently, the workings were widened and thin limestones about 135 m from the entrance were extracted from higher levels and burnt at nearby Kilmahog. The quarry was little exploited after the coming of the railway to Callander in 1858.

2.1. Western Quarry

The Western Quarry is Pringle's 'Leny Old Lime Quarry' and is a v-shaped hollow about 270 m long extending eastwards to an area of faulting that has the effect of broadening the outcrop of workable limestone by a repetition of beds between the two igneous intrusions shown in Figure 4 (see also Tanner & Pringle 1999, fig. 3). The dark, unevenly bedded limestones are closely associated with cleaved and fractured blackish, lensoid-bedded, graphitic shaly/slaty mudstones (Fig. 6) in a complex, faulted, 'isosynclinal trough', where they were intensely compressed between grit sequences during the Ordovician Grampian Orogeny. Other metamorphic and tectonic complications were later introduced by the intrusions of a Devonian quartz felsite dyke and a Permo-Carboniferous quartz dolerite dyke, and by faulting prior to the injection of the latter; at the north-eastern end of the quarry, the felsite dyke is offset 73 m to the NW by the NW–SE fault, whereas the doleritic dyke crosses the fault without any deflection (Fig. 4). The present authors noted the presence of a metabentonite at the north-eastern end of the quarry, in faulted contact with the felsite dyke (Rushton in Rushton *et al*. 2000, p. 320, fig. 13.1).

Pringle (1945 unpublished report) described the overturned succession exposed along a NW–SE line across the middle of the quarry as follows, starting with the oldest unit:

1. Greyish-green grits and grey shales traversed by a sill of felsite near junction with
2. Highly cleaved, greenish-grey shales with thin beds of fine-grained quartzite
3. Brown-weathering, grey, sandy limestone
4. Black shales with thin bands of calcareous mudstone
5. Thin beds of greyish-black limestone
6. Black shales traversed by a dyke of quartz dolerite
7. Highly cleaved, greenish-grey shales with thin beds of fine-grained quartzite
8. Greenish-grey grits and grey shales, well exposed in the Leny Glen north of the boundary fault.

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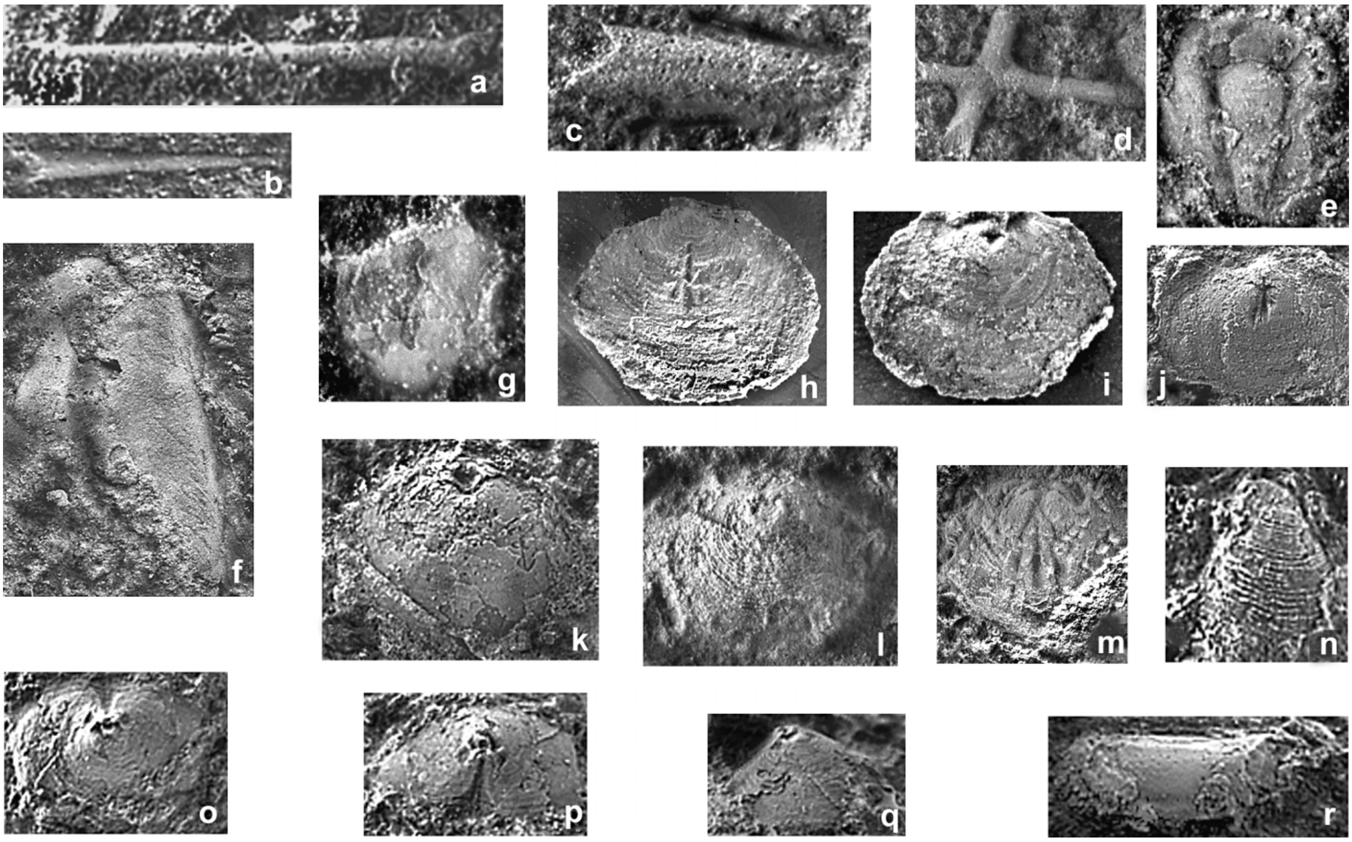

Figure 5 Non-trilobite fauna. (a) *Hyolithellus* sp., Zf 4456B from Bed B1, × 15. (b–c) Hyoliths: (b) latex cast of external mould, Zf 3879H from Section B, × 15: (c) Zf 4456A from Bed B1, × 10. (d) Sponge spicule, GSE 15253B, × 15. (e–g) Undetermined fragments: (e) No. 1, Zf 3873C from Section B, × 15: (f) No. 2, GLAHM 103019–2 [A/6708/17] (figured as a librigena of *Perthiellus pringlei* Lamont, 1975, pl. 23, fig. 15), × 10; (g) No. 3, GSE 15265, × 15. (h–q) Brachiopods: (h, i, l, o–q) Acrotretids. (h–i) dorsal and ventral views, Zh 652 from Bed B1, × 15; (l) Zf 3879 from Section B, × 15; (o–q) ventral, posterior and lateral views, Zf 4670B from Bed F1, × 10: (j, k, m, n) Lingulates. (j) Zf 4687 from Bed F2, × 10; (k) Zh 662 from Bed B3, × 10; (m) Zf 4675B from Bed F1, × 10; (n) Zf 4670A from Bed F1, × 15; (r) Bradoriid, Zh 652A from Bed B1, × 15.

Figure 6 Lensoid-bedded, slaty mudstones on the south-easterly face of the present-day Western Quarry at Leny.

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Note that the numbering of these units is introduced here to aid later description.

Units 1–2. The gritty unit generally fines upwards into pale-weathering, greenish-grey shaly mudstones (as occurring at the quarry entrance). The lower part of the main, highly cleaved, mudstone sequence is interbedded with fine-grained, siliceous sandstone and virtually occupies the whole north-western quarry wall. The higher levels of Unit 2 contain thin seams of black, shaly mudstone that, in the middle section of the quarry where cleavage and bedding more nearly coincide, yielded to Pringle a well-preserved fragment of an '*Obolella*-like shell' and obscure organic debris.

Unit 3. This is the almost vertical limestone layer originally hewn along the whole length of the quarry and named 'Leny Lower Limestone' by Pringle to distinguish it from younger black and greyish-black limestones. It is a grey, sandy limestone interleaved with black shaly films and cut by numerous calcite veins. Noted by both Harkness (1861) and Nicol (1863) as of variable thickness, at the north-eastern end of the quarry, it was measured as 1·22 m thick. Pringle and Begg collected rare, black, calcareo-phosphatic fragments of tiny brachiopod shells from this unit.

Units 4–5. These units form the south-eastern wall of the quarry and the limestone layers (Fig. 4), named by Pringle 'Leny Upper Limestones', contain one of the main known faunal assemblages. The layers lie within the axis of the closed isoclinal fold, the northern limb of which is inverted. The basal contact of Unit 4 is not exposed due to faulting, but there is an upward change into progressively more calcareous strata, as indicated by layers of limy mudstone and black, platy limestone. Pringle noted a thin conglomeratic bed 'in black shales below Pagetia Limestone on S face of western quarry'; this contains rounded clasts of indurated black argillite, 5 mm in diameter, with grains of quartz and pyrite in a grey calcareous matrix. Unit 4 is overlain by Unit 5, manifest as black and greyish-black limestones interbedded with black shaly mudstone.

Pringle's draft manuscript contains details and photographs of the folding, faulting and thrusting exhibited on the various quarry walls and he estimated the combined thickness of such units as no more than 7·6 m. In addition to the fossiliferous limestones layers, he noted that some of the brown-weathering, calcareous mudstones contain angular pieces of brachiopod shell, shale, limestone and grains of quartz as well as a layer with 'numerous worm-burrows filled with a yellowish gritty sediment'. These he regarded as evidence of syndepositional erosion and breaks in the succession, in addition to being the features demonstrating the inverted nature of the bedding.

Pringle's fossil collecting commenced in a lenticle of limestone about 137 m from the south-western quarry entrance with hard, black, shaly partings between greenish-grey shales below and highly cleaved, brownish-black shales at the top of the northern wall. Together, these beds occupy a small oval-shaped area between two converging thrusts, detached from the main exposed sequence. Although similar to other dark limestones in the quarry, the seams are more fossiliferous, and yielded one of the main fossil assemblages from the Leny Limestone and Slate Member.

2.1.1. Four separate fossiliferous levels were identified in Pringle's measured Section B:

	Inches	Metres
Highly cleaved, grey and brownish-black shales exposed beneath the surface soil	24	0·61
Dark grey, speckled limestone with small black phosphatic grains, tiny flakes of shale and quartz; unfossiliferous	15	0·38
Hard black shale	6	0·15
[B1] Greyish-black, fine-grained limestone with thin seams of black phosphatic pellets and small quartz grains. '*Pagetia*' in upper 2 inches [BGS specimen numbers Zf 3892–3896, 4042–4056, 4115–4146, 4424–4443, 4454–4463, 4530–4539, Zh 648–660]	12	0·31
[B2] Hard black limestone with '*Pagetia*' [Zf 3897–3903]	1	0·03
Crushed black shale	1	0·03
[B3] Fine-grained, dark grey limestone, much veined with calcite, with coarser seams containing many well-preserved cranidia and pygidia of '*Pagetia*' [Zf 3904, 4616, Zh 661–714, 2914]	6	0·15
Dark grey, speckled limestone with quartz grains and small pyrite cubes scattered throughout the matrix; unfossiliferous	2	0·06
[B4] Brown-weathering, dark grey, speckled limestone veined with calcite and containing several fossiliferous seams. '*Pagetia*' [Zf 3905–3907, 4444–4446]		0·12
Hard, dark, fine-grained limestone; unfossiliferous	1	0·03
THRUST PLANE		
Greenish-grey shales with ?*Obolella* fragment		

Pringle collected the following specimens from unspecified beds in this section: Zf 3827–3891, 3908–3012, 4611–4615, 4617–4620, Zh 1397–1403, 2915–2917.

2.1.2. In the highest part of the quarry face on the south-eastern side of the quarry, Pringle measured the following Section F across the axis of the isoclinal fold:

	Inches	Metres
(1) Highly cleaved and shattered, black shales; junction disrupted	6	0·15
(2) [F1] Greyish-black limestones with thin bands of shale and veined calcite. Well-preserved trilobites and brachiopods [Zf 3995–4030, 4057–4062, 4077–4114, 4447–4453, 4540–4544, 4582–4588, 4666–4678, Zh 715–716]	14	0·36
(3) Black limestone; unfossiliferous	4	0·12
(4) Black shaly limestone; unfossiliferous	4	0·12
(5) Fine-grained, black limestone in two layers; unfossiliferous	9	0·23
(6) Black shaly limestone; unfossiliferous	4	0·12
(7) [F2] Black, fine-grained, splintery limestone with a few brachiopod shells and rare trilobites. '*Pagetia*' [Zf 4063, 4545–4548, 4589, 4679–4687]	$2\frac{1}{2}$	0·06
(8) [F3] Greyish-black limestone, veined with calcite. In upper part, the rock is speckled and contains well-preserved trilobites and brachiopods [Zh 717–718, 1390–1396]	15	0·38
(9) Fine-grained, greyish-black limestones; unfossiliferous	4	0·12
(10) Hard cleaved black shales, seen to	10	0·25

Pringle regarded Beds 2–4 on the inverted limb to be Beds 6–8 on the under limb with Bed 5 lying within the axis of the fold and the equivalent of Bed 9 thrust out between Beds 1 and 2. He highlighted Bed 2 [=Bed 8] as conspicuous, because it is more calcareous and so soft, that when struck, it breaks down into rock flour.

This quarry yielded fossils to the British Geological Survey collectors in 1960 from the following section '1040 yds N8°E of N corner of Leny House':

	Feet	Metres
Black phyllitic shale	10	3·05
Limestone, coarse bands separated by irregular shaly mudstone partings: fossils EJ 9013–9046	$2\frac{1}{2}$	0·76
Shale, irregularly bedded, contorted in part	10	3·05

2.2. Eastern Quarry

The Eastern Quarry lies to the north-east of the Western Quarry and comprises two small workings (Tanner & Pringle 1999, fig. 3, localities 3 and 4) in 'black, thin-bedded limestones

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and black shales'. This area of workings is separated from the Western Quarry by a fault throwing down to the north-east, where the beds are offset about 73 m to the north. Pringle noted that the larger north-western working is traversed by three parallel faults and that the 'shales are brought up against the felsite sill' on the north-western side; he also noted that, 'on the south-eastern side, the black shales are cut by the dyke of quartz dolerite', i.e., the dyke presently marking the southern side of the 'barren pit' (Tanner & Pringle 1999, p. 1207). At the time of the present authors' site examination, these workings were too much degraded for fossil collecting.

3. Fossil material

3.1. Lithologies and specimen size

Fossils represented in the collections are restricted to two main limestone lithologies. The predominant one is a dark, bluish-grey, calcitic micrite, commonly with the bedding marked by irregular, ochrous, jagged, stylolitic solution horizons; the other is a slightly coarser grained, grey, sparry limestone, clearly indicative of secondary recrystallisation and described by Tanner & Pringle (1999, p. 1207) as a mosaic of calcite crystals associated with crystals of zoned euhedral dolomite, graphite, quartz, feldspar and pyrite. (Pringle noted that where the intrusive bodies approach the limestone, fossils are obliterated by recrystallisation). Fossils in both types of limestone are similarly preserved: disarticulated, commonly broken, but generally in full relief and retaining some surface sculpture; some pygidia have been taphonomically flattened, e.g., pygidia EJ 9030 (Fig. 12m) and GLAHM 103022–2 (Fig. 12y). However, fossils from the stylolitic levels are considerably corroded, e.g., cranidium Zf 3873A (Fig. 8r). Some miomerid cranidia and pygidia are almost complete with only palpebral lobes and axial spines broken away; except for the very poorly preserved pleuron GLAHM 103012–1 [Lamont Collection 509] assigned as the holotype of *Pagetides*? *caltraid* by Lamont (1975, p. 203, pl. 22, fig. 9), no describable thoracic segments have been recognised. By any standards, the miomerid cranidia and pygidia are tiny, commonly little more than 2 mm long and 3 mm wide and many are smaller. Although miomerid trilobites are generally very small, the quarry material may be considered to be the stunted fauna of a depleted oxygen environment (Allison & Brett 1995; Fletcher & Collins 2003, p. 1833) rather than an assemblage of juveniles. In contrast, some of the polymerid trilobites, brachiopods and spicules are larger and of regular size. However, they are extremely fragmentary and most specimens are impossible to identify precisely. Such contrasts probably indicate that the polymerid debris was swept from the shallower shelf into deeper waters of restricted circulation inhabited by miomerids under stress.

3.2. Collections

The present authors have examined fossil collections in the British Geological Survey (BGS) at Keyworth and Edinburgh, the Hunterian Museum of The University of Glasgow and the University Museum, Oxford.

3.2.1. British Geological Survey, Keyworth, Nottinghamshire. John Pringle, (1878–1948), after a career with the Geological Survey of Great Britain during which he had made great contributions as a fossil-collector, retired to his native Scotland. He spent much of his retirement searching for fossils at key localities, for example in the Dalradian Supergroup and in the rocks of the Highland Boundary Fault-complex. He first discovered fossils in the Leny Limestone in 1938, and over the next four years collected systematically from eight beds in Leny quarries. Between 1939 and 1942, he sent eighteen batches of fossils, amounting to about 400 fossiliferous blocks, to the Geological Survey Museum in London, where Dr C. J. Stubblefield examined them. Pringle's collection is by far the largest from Leny, and is the only one recorded with detailed stratigraphy. His collection is now housed at the BGS, Keyworth, Nottinghamshire, registered with the symbol prefixes **Zf** and **Zh**. The Keyworth Office also contains a collection presented by Dr A. Ritchie to the Geological Survey in 1967; his ten specimens are registered under the symbol **Zo** and occur in a slightly different lithology from those in Pringle's collections.

3.2.2. Geological Survey of Scotland (BGS), Murchison House, Edinburgh. The Palaeontological Collections in the BGS Office in Edinburgh include two from the Leny site. Six blocks presented by Dr Pringle in 1939 and registered under the symbol $\mathbf{V^c}$ and 33 blocks collected in 1961 by Geological Survey officers, P. Brand and D. K. Graham, registered with the symbol **EJ**. Part of the latter collection was made from the south-eastern side of the Western Quarry.

3.2.3. University of Glasgow Hunterian Museum. According to Lamont (1975, p. 199), at the time of their joint discovery, Begg collected 60 specimens from the quarry; these were donated to the Hunterian Museum. Seventeen of his fossiliferous blocks were loaned to Dr A. Lamont for study and were broken up along with material collected by Lamont in the late 1960s or early 1970s. For the purpose of Lamont's publication, specimens from Begg's blocks were registered as **A**/6708/1–32 and those of the author as **Lamont Collection** 500–514. When such material was returned to the Hunterian Museum after Lamont's death, Dr J. K. Ingham, guided by the scanty surviving documentation and the sometimes-fanciful drawings in Lamont's 1975 publication, undertook the difficult task of sorting these collections and identifying the specimens figured by Lamont. At that time, all the material was re-registered with prefixes **PAL**: 93.17–**GLAHM** 103008–23, 103033–61; **A**4550; and PAL: 106.07–GLAHM 103024–32. See Appendix 1.

3.2.4. University Museum, Oxford. Dr W. S. McKerrow's collection was made in 1960 from high up on the south-eastern side of the Western Quarry, 'about 100 yards' from the south-western entrance. It consists of 25 blocks, now held in the geological collections of the University Museum and numbered **OUM A**.1525–1542; the only recognisable trilobite is *Pagetides amplifrons* Rasetti, 1945 (OUM A.1525b, Fig. 10c).

3.3. Faunal list

Listed here are the trilobite taxa recognised from each of Pringle's fossil beds, and at the end are added a few taxa recognised only from unspecified levels in the Leny Limestone and Slate Member or quarry scree. Each list gives in this order: miomerid trilobites; polymerid trilobites; other fossils. From these lists, it appears possible to recognise a '*Pagetides* Fauna' from beds in Section B and a '*Kiskinella* Fauna' from Section F. There are, however, species in common to the two faunas, which are not likely to be very different in age.

No use has been made of Lamont's (1975) taxa: some are regarded as junior synonyms and others are unrecognisable, partly because of inadequate diagnosis and partly because his type specimens were missing when the material was returned to the Hunterian Museum. A few names do not meet the requirements of the ICZN Code and are regarded as technically unavailable. Our interpretations of Lamont's taxa are listed in Appendix 2.

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Bed B1 *Neopagetina* aff. *taconica* Rasetti, 1967 (Fig. 8k–l)
Bathydiscus cf. *dolichometopus* Rasetti, 1966a (Fig. 8p)
Pagetides amplifrons Rasetti, 1945 (common, e.g., Fig. 10a–b, j; Fig. 11h–i)
P. minutus Rasetti, 1945 (common, e.g., Fig. 12o–p)
Poulseniella sp. nov. (librigena, Fig. 13k)
Hyolithellus sp. (Fig. 5a)
hyolith (Fig. 5c)
brachiopods, including acrotretids (Fig. 5h–i)
sponge spicules (some cruciform)
bradoriid (Fig. 5r)
Bed B2 *P. amplifrons*
P. minutus (Fig. 12w)
Bed B3 *Condylopyge* cf. *eli* Geyer, 1998 (one pygidium, Fig. 8a)
P. amplifrons (common)
P. minutus (few, e.g., Fig. 12c)
Poliella? sp. (librigena, Fig. 13h)
librigenae and pleurae
brachiopods, including lingulates (Fig. 5k)
spicule or rod
Bed B4 *Pagetides* sp.
Bed B5 brachiopod
'B Series' (undifferentiated beds and loose blocks)
Neopagetina aff. *rjonsnitzkii* (Lermontova, 1940) (Fig. 8b)
N. aff. *taconica* (two)
Semadiscus? (cephalon, Fig. 8q)
P. amplifrons (several, e.g., Fig. 10i, k–l, t–u; Fig. 11g, j–k)
P. minutus (several, e.g., Fig. 12a, d, n, r, t–u)
Kiskinella cristata Romanenko & Romanenko, 1962 (rare)
Zacanthopsis? sp. (Fig. 13a)
Corynexochida? (hypostome Fig. 13e)
Poulseniella sp. nov. (Fig. 13m–o)
hyolith (Fig. 5b)
brachiopods, including acrotretids (Fig. 5l)
Undetermined Fragment No.1, plate of unrecognised organism (Fig. 5e)
Bed F1 *Kiskinella cristata* (Fig. 9b–e, h–i)
Pagetides sp. indet. (rare)
Prozacanthoides? sp. (pygidium, Fig. 13d)
Corynexochida? (granulose fragments)
Poliella? sp. (pygidium, Fig. 13i)
Poulseniella sp. nov. (cranidium, Fig. 13l)
brachiopods including acrotretids, lingulates (Fig. 5j, m, q)
echinoderm? fragment
phosphatic tube
Bed F2 *Pagetides* sp. indet.
Kiskinella cristata (Fig. 9f–g)
Poliella? sp. (pygidium, Fig. 13j)
brachiopods
Bed F3 *Pagetides* sp. indet.
Kiskinella cristata (Fig. 9j–k)
Corynexochida? (granulose/pustulose fragments)
brachiopods

Beds unrecorded. Many of the taxa listed above from particular beds in Pringle's sections are known also from the other collections, whose stratigraphical positions were not recorded exactly, i.e., those specimens prefixed EJ, V^c, Zo, GLAHM and OUM. Among the EJ collection by Brand & Graham, granulose fragments (Fig. 13f–g) assigned to Corynexochida? are common.

4. Correlation, age and palaeogeographical setting

The presence of both miomerid and polymerid trilobites in this fauna is important for assessing the correlation, age and palaeogeographical setting of the sedimentary environment. Generally, miomerid Agnostida were open-ocean benthic forms with pelagic larval stages (Chatterton & Speyer 1990) capable of global distribution, as later graptolites and ammonites. Along with oryctocephalid trilobites, they provide the main framework for correlating Cambrian pericontinental sequences (Fletcher 2003) and, not being tied to specific continents, they can indicate the time relationships between different continental successions, wherever these creatures migrated on to shelf regions. Polymerids, on the other hand, were mostly benthic, continental-shelf dwellers evolving parochially with the vast majority of species being endemic to a particular continental region. Hence, the identification of the Leny Limestone trilobites should allow the particular Cambrian continental mass around which they were deposited and their relative chronostratigraphical age to be determined.

4.1. Correlation

The key miomerids in the Leny Limestone fauna are *Condylopyge* cf. *eli* (Fig. 8a) and *Kiskinella cristata* (Fig. 9), because of their relatively widespread global distribution. The former occurs in early-paradoxidid sequences of Morocco (Geyer 1998), Braintree, Massachusetts (Fletcher *et al*. 2005, fig. 2; Fig. 7), on the Cape St. Mary's Peninsula of Newfoundland (Fletcher 2003, p. 88; 2007, pl. 27.43; Fig. 7) and in Siberia (Savitsky 1976, pl. 50, fig. 12); the latter, originally described from the basinal deposits of the Siberian Gorno–Altayskaya (Kiska River) region in the *Oryctocara* Zone (Romanenko & Romanenko 1962), is known also in the Acado–Baltic Faunal Realm [Avalon Tectonostratigraphical Zone (Williams 1995; Fig. 7)] in south-eastern Newfoundland (Fletcher 2003, p. 96; 2007, pl. 34.18) and in the Braintree area of Massachusetts (Fletcher *et al*. 2005, fig. 2). Except for the specimen doubtfully referred to *Semadiscus* (Fig. 8q), all other miomerids in the fauna match more closely the oculate eodiscids of the *Olenellus*-bearing, Laurentian Faunal Realm in the Humber Tectonostratigraphical Zone (Fig. 7) of North America, notably in allochthonous successions of the Early-Middle Ordovician (Taconic) Appalachian Orogen in Quebec Province, Canada and New York State, USA (Williams 1995, p. 4). Such miomerids associated with the polymerid forms occurring in the Leny Limestone characterise successions on the southern side of St. Lawrence River, between Lévis (Fig. 7) and Grosses Roches in the western part of the Gaspé Peninsula, where they occur in the thin, dark grey, lenticular limestones and shales of the upper member of the Charny Formation and in Cambrian-limestone boulders within the Early Ordovician conglomeratic Lévis Formation (Rasetti 1945; North 1971, p. 246–248); in the klippe sequence of Columbia County, New York State (Fig. 7), they characterise olenellid-bearing thin dark limestones (Rasetti 1966a, 1967; Bird & Rasetti 1968).

4.2. Age

Correlations of the Leny fauna with both mid-olenellid and early-paradoxidid sequences further emphasises the temporal overlapping of these Cambrian trilobite families that has questioned the long-recognised subdivision of the system into olenellid Lower Cambrian and paradoxidid Middle Cambrian ages (Robison *et al*. 1977). Currently, the series and stage divisions of the Cambrian are under review by the International Subcommission on Cambrian Stratigraphy. The recent decision by the Cambrian Stage Subdivision Working Group to recognise four series subdivisions of the Cambrian System (Babcock *et al*. 2005; Peng *et al*. 2006) renders it inappropriate to assign a Lower or Middle Cambrian age to this Scottish fauna as these are now redundant terms; simply put, the age of the Leny fauna lies close to the boundary of those divisions as traditionally conceived.

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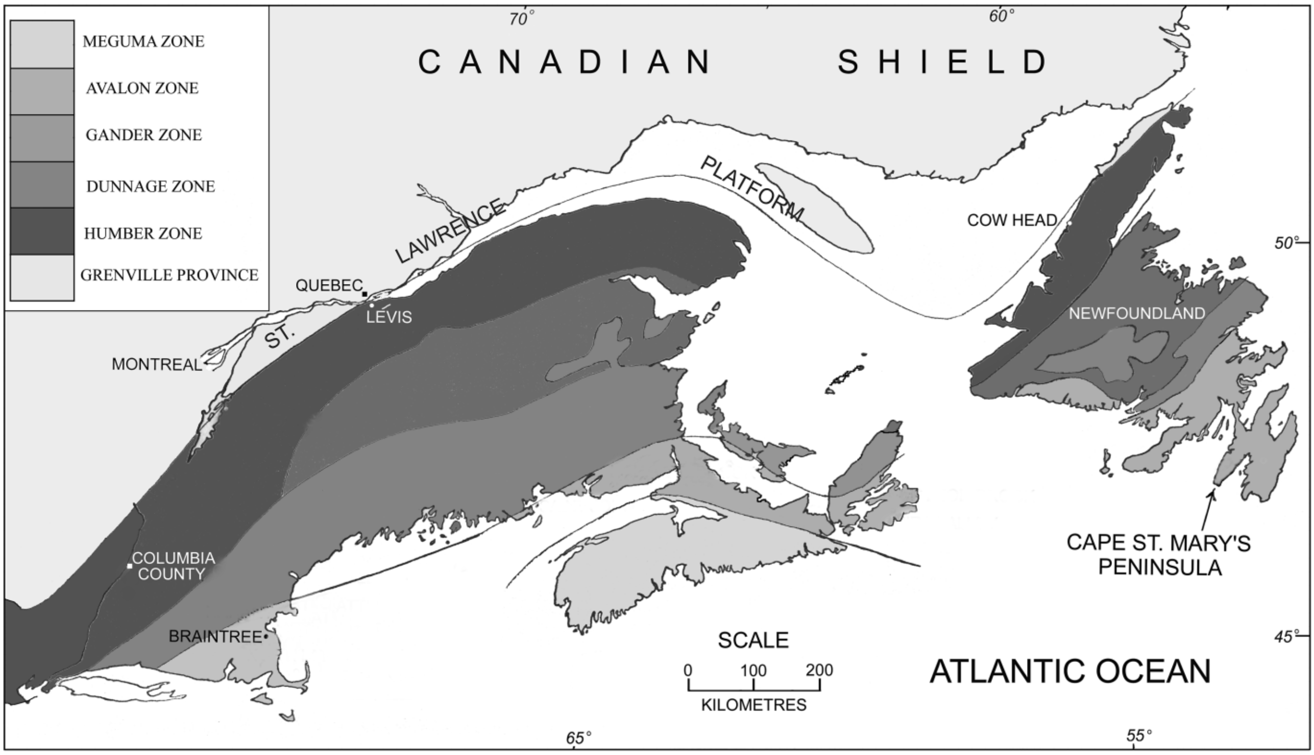

Figure 7 Map of the accreted tectonostratigraphical zones of the north-eastern part of the Appalachian Orogen (after Williams 1995, fig. 1.3) showing some important Cambrian sites containing trilobites related to those in the Leny Limestone and Slate.

In comparison with paradoxidid sequences, the fossils of the Leny Limestone and Slate Member are the same age as the late *Cephalopyge notabilis*–early *Kiskinella cristata* zonal sequence of Newfoundland and its correlatives in Morocco, Massachusetts and Siberia (Fletcher *et al*. 2005, fig. 2); in olenellid sequences, it correlates with the mid-*Bonnia–Olenellus* zonal sequences of North America, e.g., in Greenland (Blaker & Peel 1997) and the *Neopagetina taconica* faunule at the top of the *Acimetopus* Fauna in north-eastern Laurentia (Rasetti 1966a, p. 19).

4.3. Palaeogeographical setting

The general turbiditic disposition of the *Pagetides*-bearing, very dark, relatively thin-bedded limestones, shaly mudstones and thin quartz arenites of the Leny Limestone and Slate Member (Fig. 6) closely matches beds in the sedimentary successions of southern Quebec, e.g., the upper member of the Charny Formation (North 1971, p. 48), and New York State (Bird & Rasetti 1968, pls. 1–3). Those were deposited initially on the south-eastern-facing outer shelf slope of the St. Lawrence Platform, peripheral to the stable interior craton of the Canadian Shield (Williams 1995; Fig. 7) and prior to the Taconic accretionary event in the Early-Middle Ordovician episode of the Appalachian Orogen. Palaeogeographically, the Leny Cambrian succession may be regarded as a Caledonide part of the Appalachian miogeoclinal Humber Tectonostratigraphical Zone, intermediate in position between the North American successions and the Greenland Caledonides (Williams 1995, fig. 1.4), where the local Dalradian lithostratigraphical components and effects of later tectonic events are clearly parochial. Compared with the Quebec Cambrian greywacke succession, the sediments of the Leny Member were likely deposited in a more distal setting.

5. Systematic description of the trilobites

The prefix letters of the Scottish specimen numbers are identified in section 3.2, but specimens transferred to the BGS type collections have been assigned GSE numbers. Other comparative specimens in Laval University, Quebec, Canada are prefixed **Laval Univ**., e.g., Laval Univ. 300a; in the Institut für Paläontologie der Universität Würzburg, Germany prefixed **PIW**, e.g., PIW 97II37c; in the Royal Ontario Museum, Toronto, Canada prefixed **ROM**, e.g., ROM 56128; in the Central Siberian Geology Museum, Novosibirsk, Russia prefixed **TsGM**, e.g., TsGM 34/5156; in the United States National Museum, Washington, D.C. prefixed **USNM**, e.g., USNM 156634 and in the Museum of the Territorial Fund for the Kemerova Region, Novokuznetsk, Russia prefixed **ZSGU** e.g., ZSGU 1328/1958.

5.1. Miomerid trilobites

Order Agnostida Salter, 1864
Suborder Agnostina Salter, 1864
Superfamily Condylopygoidea Raymond, 1913a
Family Condylopygidae Raymond, 1913a
Genus *Condylopyge* Hawle & Corda, 1847

Type species. *Battus rex* Barrande, 1846 from the *Paradoxides pusillus* Zone at Týřovice, Bohemia, Czech Republic.

Diagnosis. See Shergold & Laurie 1997, p. 383.

Remarks. The stratigraphical series of *Condylopyge* species is marked by significant pygidial changes to the axis and postaxial field. Each species exhibits slight variation, but the trend from the earliest forms having relatively short (sag.), wide (tr.), parallel-sided, unfurrowed axes and prominently long (sag.), divided postaxial fields, to the youngest, e.g., the type species, with a long (sag.), narrower (tr.), medially constricted, furrowed axis almost extending to the posterior border furrow possibly reflects a phylogenetic sequence (Fletcher *et al*. 2005, p. 317).

Condylopyge cf. *eli* Geyer, 1998
Figure 8a.

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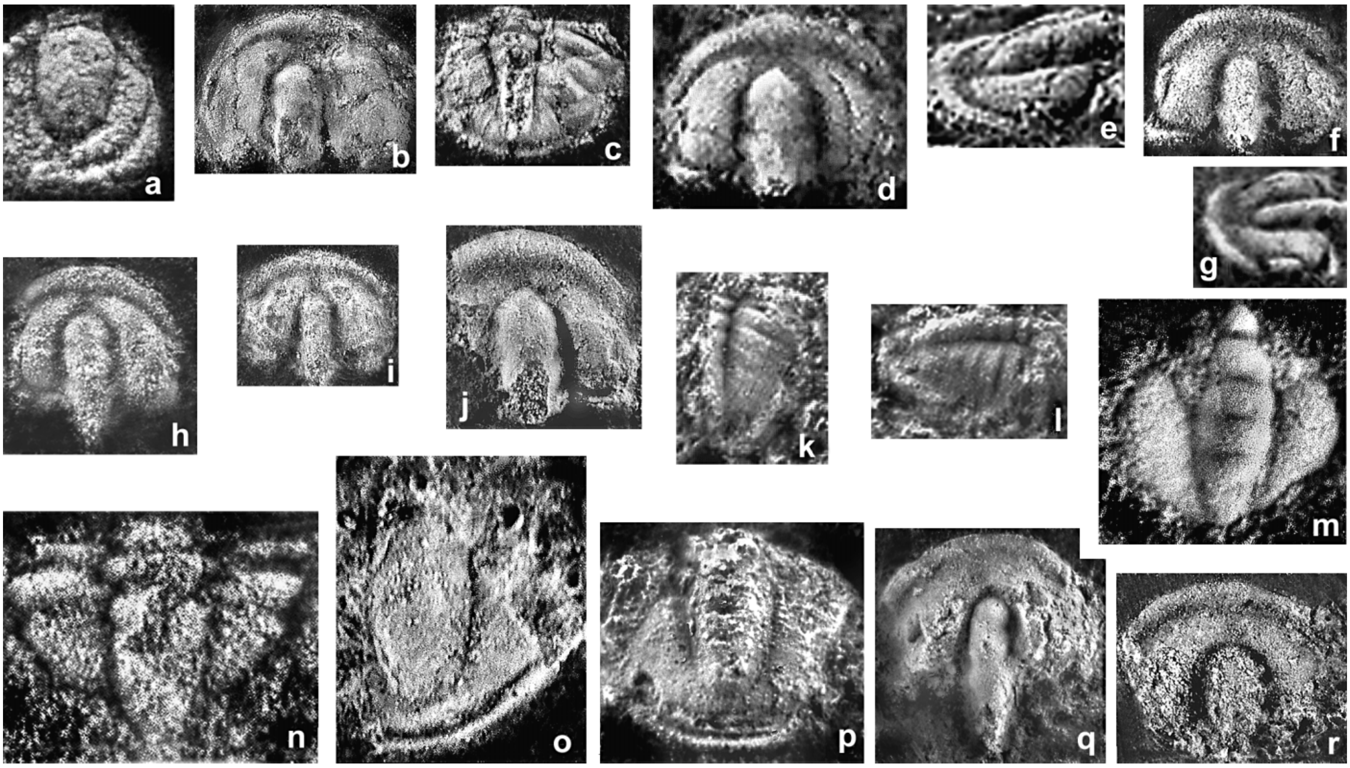

Figure 8 Miomerid trilobites; (a) *Condylopyge* cf. *eli* Geyer, 1998, pygidium Zf 4616 from Bed B3, × 30. (b–c) *Neopagetina* cf. *rjonsnitzkii* (Lermontova, 1940): (b) cranidium Zf 3850 from Section B, × 10; (c) pygidium GSE 15261, × 20. (d–l, r) *Neopagetina* aff. *taconica* Rasetti, 1967; (d–e) cranidium, dorsal and lateral views, GSE 15268A, × 10; (f–g) cranidium, dorsal and lateral views, GSE 15268B, × 10; (h) cranidium Zf 4675A from Bed F1, × 15; (i) cranidium GLAHM 103020 [A/ 6708/9] (figured as holotype of *Kilmahogia jamesbeggi* Lamont, 1975, pl. 23, fig. 2), × 10; (j) cranidium GSE 15255B × 10; (k–l) pygidial fragment possibly of this species, dorsal and lateral views, Zh 648A from Bed B1, × 20; (r) cephalic fragment Zf 3873A from Section B, × 10. (m) Calodiscid, pygidial fragment, latex cast of external mould, GSE 15262B, × 20. (n) *Pagetia*? sp., pygidial fragment GSE 15266, × 20. (o–p) *Bathydiscus* cf. *dolichometopus* Rasetti, 1966: (o) pygidial fragment GLAHM 103019–3 [A/6708/18] (figured as holotype of *Robroyia andersoni* Lamont, 1975, pl. 23, fig. 16), × 20; (p) pygidium Zh 658 from Bed B1, × 20. (q) *Semadiscus*? sp., cephalon Zf 3879G from Section B, × 10.

Holotype. Pygidium PIW 97II37c from the *Cephalopyge notabilis* Zone in the Tarhoucht Section, northern Jbel Ougnate, eastern Anti-Atlas, Morocco.

Diagnosis. See Geyer 1998, p. 379.

Material. Only one incomplete specimen assigned to *Condylopyge* has been recognised in the Leny collections. It is a poorly preserved pygidium Zf 4616 damaged by diagenetic solution of the carbonate. Despite the preservation, the relatively short (sag.), unfurrowed axis and divided postaxial field are features typical of one of the oldest species as exemplified by an early form of *C. eli* (specimen ROM 56128 in Fletcher 2003, pl. 1, fig. 11) occurring in the basal beds of the *Cephalopyge notabilis* Zone in south-eastern Newfoundland.

Occurrence. Pringle collected specimen Zf 4616 from Bed B3 in the Western Quarry at Leny.

Suborder Eodiscina Kobayashi, 1939
Superfamily Eodiscoidea Raymond, 1913b

Remarks. Since Stubblefield (in Brown *et al.* 1965) revised his early identification of the Middle Cambrian genus *Pagetia* in Pringle's Leny fauna to the Lower Cambrian genus *Pagetides*, Jell (1975; 1997) has revised the Suborder Eodiscina Kobayashi, 1939 and the family Pagetiidae Kobayashi, 1935 is no longer recognised. Therefore, it is not appropriate to refer formally to 'pagetiids'; the relevant genera in the Leny limestones have been assigned to the Family Eodiscidae Raymond, 1913b and may be described generally as eodiscids or, more particularly, as 'oculate eodiscids'.

Family Hebediscidae Kobayashi, 1944
Genus *Neopagetina* Pokrovskaya, 1960

Type species. *Pagetina rjonsnitzkii* Lermontova, 1940, p. 121, pl. 35, figs 7a–7b from the *Paramicmacca siberica–Bergeroniellus expansus* Zone in the Botomian Stage Kutorgina Formation of the Peleduy River, on the north-east Siberian Platform.

Diagnosis. Hebediscidae with short (sag.) anterior border slightly thickened posteriorly over the axis; globose genal areas extending well above the front of the glabella and separated by a narrow median preglabellar furrow. Pygidium with six axial rings and well-impressed pleural furrows.

Remarks. With reservations, Rasetti (1967, p. 66) recognised a difference between *Pagetides* Rasetti, 1945 and *Neopagetina* without specifying any significant feature. In Jell's (1997) review of the Eodiscoidea, *Neopagetina* is essentially differentiated on the character of the well-segmented pygidium; such a decision is compatible with Rasetti's assignment of *N. taconica* Rasetti, 1967. However, without an association of a well-segmented pygidium, it may be difficult to differentiate poorly preserved cranidia of these genera, because the short anterior border and close approach of the elevated genal fields in front of the glabella are similar. Comparison of the relevant type specimens shows that the axial deflection of the short anterior border of *P. elegans* is more boss-like and the separation of the elevated genal fields in *Pagetides* is more of a wider depression than the more pronounced median preglabellar furrow of *Neopagetina*. However, Blaker & Peel

(1997) recognised that the distinctions between these genera are not very decisive and they took the view that *Neopagetina* should be treated as a synonym of *Pagetides* (Family Eodiscidae); but, provisionally, *Neopagetina* is retained in the present paper for species characterised by furrowed pygidial flanks.

Neopagetina cf. *rjonsnitzkii* (Lermontova, 1940)
Figure 8b–c.

Material. Cranidium Zf 3850 and pygidium GSE 15261.

Remarks. Although not well preserved, the characters of the anterior border and globose genal areas of cranidium Zf 3850 closely resemble those of the lectotype (no. TsGM 34/5156, figured by Jell 1997, fig. 244, *2a*). Well-segmented pygidium GSE 15261 is damaged, but the relatively narrow pygidial axis with slightly longer postaxial field is a closer match to the paratype pygidium figured by Jell (1997, fig. 244, *2b*) than to *N. taconica* as illustrated by Rasetti (1967, pl. 6, figs 23, 25).

Occurrence. The Leny cranidium assigned to this species derives from Bed B3 in the Western Quarry. The bed that yielded the pygidium was not recorded.

Neopagetina aff. *taconica* Rasetti, 1967
Figure 8d–j, r, k?, l?

Holotype. USNM 156634, *Neopagetina taconica* Rasetti, 1967, p. 66–67, pl. 6, figs 20–22, from the *Neopagetina taconica* faunule of the *Pagetides* fauna in the Columbia County Route 32 road cut, one mile west of Malden Bridge, New York State, USA.

Material. GSE 15255B, 15268A, B, GLAHM 103020, GLAHM 103031, GLAHM 103036–2, Zf 3873A, Zf 3873J, Zf 3879, Zf 4675A, V 1567[c]. Pygidium Zh 648A is doubtfully referred to this taxon.

Remarks. The cranidium of this species differs from the type species in having an evenly short (sag.) anterior border (i.e., not slightly swollen over the axis) and better-defined palpebral lobes. In the pygidial fragment assigned to this taxon, the pleural furrows are fewer in number and less distinct than in Rasetti's specimens (Rasetti 1967, pl. 6, figs 23–25).

Occurrence. In Pringle's collection from the Western Quarry at Leny, this species occurs sparingly in Beds B1–4 and also rarely in Beds F1 and F2.

Family Calodiscidae Kobayashi, 1943

Diagnosis. Pygidia with wide, tapering axis of fewer than six segments.

Calodiscid pygidium
Figure 8m.

Material. One poorly preserved pygidium GSE 15262B.

Remarks. A small pygidium with margin largely missing, but with unsegmented pleural fields and a distinctive axis about as wide as a pleural field, comprising the articulating half-ring, four axial rings and terminal portion. Of the described calodiscid genera, the Leny pygidium most closely matches that of *Chelediscus* Rushton, 1966. It differs from the type species *C. acifer* Rushton, 1966 from the 'Lower Cambrian' Purley Shales of Warwickshire, England (Rushton 1966, Locality 2A, pl. 2, figs 26a–e) in its much narrower (tr.) axis, but is more like the pygidium referred to *C. chathamensis* Rasetti, 1967 in the *Acimetopus* Fauna of the Taconic Sequence of New York (Rasetti 1967, Locality cs-9a, pl. 3, figs 16, 17), though the axial rings in that species are shorter in proportion to their length.

Occurrence. Unspecified bed in the Leny Quarries.

Family Weymouthiidae Kobayashi, 1943

1975 Robroyidae; Lamont, p. 207.

Diagnosis. See Jell 1997, p. 392.

Genus *Bathydiscus* Rasetti, 1966a

1975 *Robroyia*; Lamont, p. 207.

Type species. *Bathydiscus dolichometopus* Rasetti, 1966a, p. 17, pl. 9, figs 1–3, from the *Acimetopus* Fauna at Griswold Farm, one mile SE of North Chatham, Columbia County, New York State.

Bathydiscus cf. *dolichometopus* Rasetti, 1966a
Figure 8o–p.

cf. 1966a *Bathydiscus dolichometopus* Rasetti, new species, p. 17–18, pl. 1, fig. 3, pl. 9, figs 1–16.
1975 *Robroyia andersoni* gen. et sp. nov.; Lamont, p. 207, pl. 23, fig. 16 only.
cf. 2003 *Bathydiscus dolichometopus* Rasetti, 1966; Fletcher, p. 92, pl. 1, figs 30–34.

Figured material. Incomplete pygidia Zh 658 and GLAHM 103019–3.

Remarks. *Bathydiscus* is a distinctive weymouthiid. The cephalic border has an anterior arch and the pygidial border makes a corresponding depressed coaptive flange medially (Rasetti 1966a, pl. 9, figs 9–11). Though fragmentary, the two pygidia from the Leny Limestone show this feature, although they are too incomplete for exact identification.

Occurrence. Originally recorded from the *Pagetides* Fauna at Griswold Farm, Columbia County, New York State (Rasetti 1967), and since recorded by Fletcher (2003, p. 92) from the *Ovatoryctocara granulata* horizon at the top of the *Cephalopyge notabilis* Zone in the Branch Cove Marl Member of the Brigus Formation, south-eastern Newfoundland. Pringle's Leny specimen is from Bed B1 in the Western Quarry.

Genus *Semadiscus* Romanenko in Repina & Romanenko, 1978

Type species. *Semadiscus sollennis* Romanenko, 1978, from the Lower Cambrian (Botomian), Sema River, Altai Mountains, Russia.

Diagnosis. See Jell 1997, p. 398, fig. 246, *3*.

Semadiscus? sp.
Figure 8q.

Material. One fragmentary cephalon (Zf 3879G).

Remarks. Cephalon Zf 3879G has an indistinctly furrowed glabella that extends back into a thick glabellar-occipital spine. Occipital furrow not distinct, but its lateral parts appear to indent the base of the glabellar-occipital spine. The genae are confluent in front of the glabella, the preglabellar field being scarcely depressed; the border is relatively narrow and of even width. The posterior and lateral parts of the genae are broken away and it is not known whether there were eyes and palpebral lobes, or whether the animal was blind; no eye-ridges are evident.

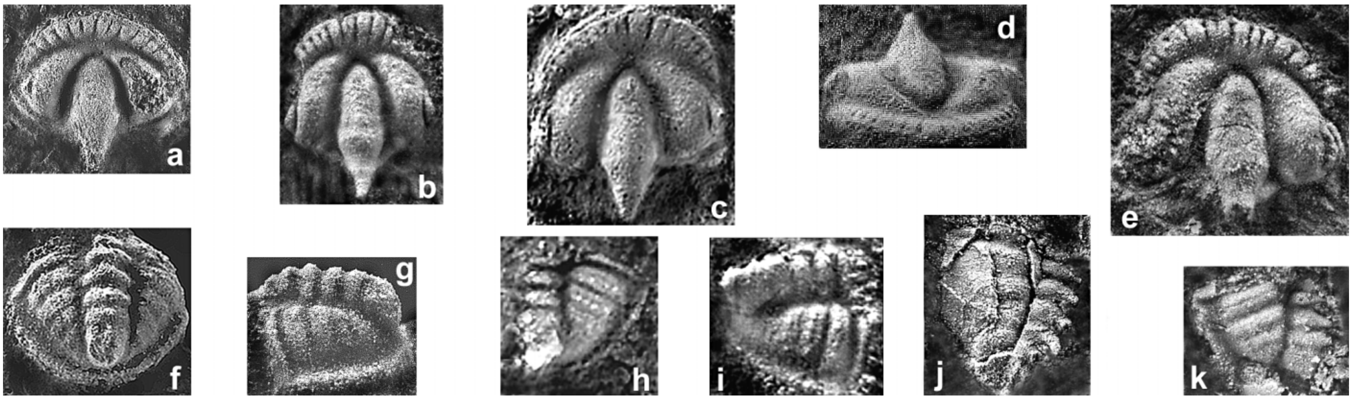

Figure 9 *Kiskinella cristata* Romanenko & Romanenko, 1962: (a) cranidium GLAHM 103029, × 10; (b) cranidium Zf 4078 from Bed F1, × 10; (c–d) cranidium, dorsal and anterior views, Zf 3995 from Bed F1. × 10; (e) cranidium Zf 3997 from Bed F1, × 10; (f–g) pygidium, dorsal and lateral views, Zf 4682 from Bed F2, × 15; (h–i) pygidial fragment, dorsal and lateral views, Zh 1391 from Bed F3, × 20; (j) pygidial fragment Zf 4004 from Bed F1, × 15; (k) pygidial fragment Zf 4011 from Bed F1, × 15.

The lack of a distinct depressed area in front of the glabella (such depression as is seen in Zf 3879G is asymmetrical and is thought to be a feature of imperfect preservation) is practically unknown among oculate Eodiscina. It is, therefore, supposed that the specimen is a weymouthiid showing some resemblance to *Semadiscus*. The part that is preserved differs from *S. sollennis* in having a more parallel-sided glabella, a longer preglabellar field, wider genae and a wider, less well-incised border furrow. It is less similar to the Taconic form *Calodiscus occipitalis* Rasetti, 1966a in the *Acimetopus* Fauna of New York (Rasetti 1966, Locality cs-4, pl. 9, figs 22–23), which has a distinct occipital furrow.

Occurrence. The specimen was collected from Pringle's Section B in the Western Quarry, though the individual bed was not specified.

Family Eodiscidae Raymond, 1913b
Genus *Pagetia* Walcott, 1916

Type species. *Pagetia bootes* Walcott, 1916, from the *Bathyuriscus–Elrathina* Zone of the Burgess Shale Formation, British Columbia, Canada (Fletcher & Collins 1997).

Pagetia? sp.
Figure 8n.

Material. One poorly preserved pygidium EJ 9043.

Remarks. A small pygidium with damaged margins with relatively long (sag.), wide axis comprising the articulating half-ring and traces of five rings and terminal portion. The axial rings are narrow and the pleural fields exhibit traces of pleural furrows. An important feature is the suggestion that the axis extends backwards over the posterior border as a projection reminiscent of species of *Pagetia* (see Rasetti 1966b).

Occurrence. Unspecified bed in the Leny Quarries.

Genus *Kiskinella* Romanenko & Romanenko, 1962

Type species. *Kiskinella cristata* Romanenko & Romanenko, 1962, from the basal Middle Cambrian (Amgan), Kiska River, Altai Mountains, Russia.

Diagnosis. See Jell 1997, p. 401, emended by Fletcher (2003, p. 96).

Kiskinella cristata Romanenko & Romanenko, 1962
Figure 9a–k.

Holotype. Cranidium ZSGU 1328/1958 from the basal Amgan Stage in the Kiska River Section in the Altai Mountains, Siberia.

Synonymy. See Fletcher 2003, p. 96.

Diagnosis. See Fletcher 2003, p. 96.

Remarks. Cranidia and pygidia from the Leny Limestone compare well with Newfoundland material figured by Fletcher (2003, pl. 3, figs 3–9), though the palpebral lobes are slightly more conspicuous in the Leny specimens and the axial spines on pygidium Zf 4004 (Fig. 9j) bear backwardly curved spines not as well developed in other specimens, e.g., Zf 4682 (Fig. 9f–g, h–i) and ROM 56153 (Fletcher 2003, pl. 3, fig. 9).

Occurrence. Fletcher (in Fletcher *et al.* 2005, p. 319, fig. 4) discussed the distribution of this species, which is known from Siberia, Hainan (China), south-eastern Newfoundland and Massachusetts. It is a key species in strata currently under review as containing the boundary between the proposed Cambrian Series 2 and Cambrian Series 3 (Babcock *et al.* 2005). In Pringle's collection from the Western Quarry, *K. cristata* is the commonest trilobite in Section F, especially in Bed F1; two specimens are noted from F3.

Genus *Pagetides* Rasetti, 1945

1975 *Discomesites*; Öpik, p. 32. [fide Jell 1997, p. 403].
1975 *Eilidh*; Lamont, p. 206.
1975 *Ellesides*; Lamont, p. 204.
1975 *Kilmahogia*; Lamont, p. 203.
1975 *Macnairides*; Lamont, p. 204.
1975 *Perthiellus*; Lamont, p. 205.

Type species. *Pagetides elegans* Rasetti, 1945, from a late Lower Cambrian boulder in the Ville Guay conglomerate, east of Lévis, Quebec, Canada. Holotype cranidium Laval Univ. 304a and paratypes cranidium Laval Univ. 304b and pygidium Laval Univ. 394c.

Diagnosis. Eodiscidae with parallel-sided glabella, with a strong, erect glabellar spine, genae with proparian sutures, well-developed palpebral lobes and furrows; pygidium lacks axial spine.

Remarks. Blaker & Peel (1997, p. 34–37) gave a thorough discussion of the genus, and especially the placement of Siberian taxa. They took a wider view of the genus than we have here. The present authors consider that species are best differentiated on the characters of the anterior cephalic border, the glabella and the anterior part of the genal field; also, the

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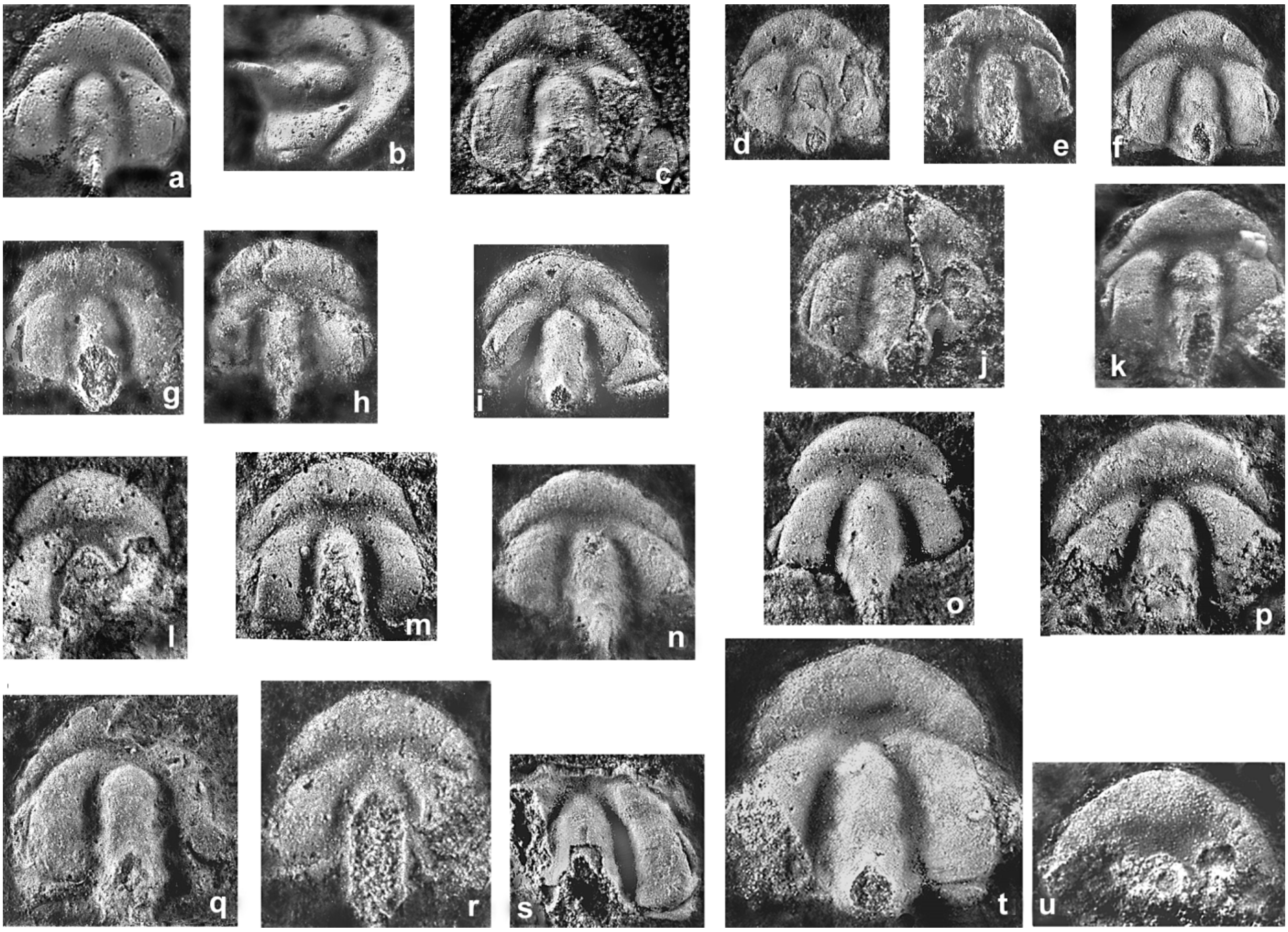

Figure 10 Cranidia of *Pagetides amplifrons* Rasetti, 1945: (a–b) dorsal and oblique views, Zh 652C from Bed B1, × 10; (c) OUM A1525b, × 15; (d) GLAHM 103019–1, × 10; (e) GLAHM 103033, × 10; (f) GLAHM 103008–1 [Lamont Collection 510] (figured as holotype of *Pagetides napoleon* Lamont, 1975, pl. 22, fig. 1), × 10; (g) GLAHM 103027–1, × 10; (h) GLAHM 103014 [A/6708/10] (figured as *Kilmahogia jamesbeggi* Lamont, 1975, pl. 23, fig. 11), × 10; (i) Zf 3828A from Section B, × 10; (j) Zf 4144 from Bed B1, × 10; (k) latex cast of external mould, Zf 3882 from Section B, × 10; (l) Zf 3873B from Section B, × 10; (m) GLAHM 103042A, × 10; (n) GSE 15254A, × 10; (o) GLAHM 103039B, × 10; (p) GLAHM 103032 × 10; (q) GLAHM 103044, × 10; (r) GLAHM A/6708, × 10; (s) GSE 15256, × 10; (t) Zf 3873D from Section B, × 10; (u) Zf 3828D from Section B, × 15.

pygidial outline and the axial features. However, as stated by Rasetti (1967, p. 64), when specimens are imperfectly preserved or immature, it is not possible to identify all the material with certainty.

Pagetides amplifrons Rasetti, 1945
Figures 10a–u, 11a–n.

1945 *Pagetides amplifrons* n. sp.; Rasetti, p. 314, pl. 1, figs 1–6.
1948 *Pagetides amplifrons* Rasetti; Rasetti, p. 12, pl. 1, figs 8, 9.
1967 *Pagetides amplifrons* Rasetti; Rasetti, p. 65, pl. 6, figs 15–18.
1975 *Pagetides napoleon*, sp. nov.; Lamont, p. 201 (part), pl. 22, figs 1, 2, 8?
? 1975 *Ellesides altaterra* gen. et sp. nov.; Lamont, p. 204, pl. 23, fig. 18.

Holotype. Cranidium Laval Univ. 300a from the 'Lower Cambrian' Boulder O-20 on the southern shore of the Island of Orléans in the St. Lawrence River, south of Quebec City, Canada, associated with paratype cranidia and pygidia, Laval Univ. 392b–f.

Material. There are numerous cranidia assigned to this species from Pringle's Western Quarry sections, especially Beds B1 and B3. Three specimens are recorded from Section F, two of them from Bed F1.

Remarks. The commonest form of *Pagetides* in the Leny Limestone has a salient frontal border whose outline is semi-elliptical and most sharply rounded at the midline, as in *P. amplifrons* (Fig. 10a, f, r) and the associated *P. leiopygus* Rasetti, 1945 and *P. rupestris* Rasetti, 1948 in boulders within the 'Lower Cambrian "Sillery Formation"' near Lévis, Quebec (Rasetti 1945, pl. 1, figs 1–10; 1948, pl.1, figs 15–21). The border tends to form a median swelling or boss (Fig. 10a, c, u); this is not always preserved as a strong feature, but shows when obliquely lit, as in Rasetti's original figures of *P. amplifrons* and *P. rupestris* (Rasetti 1945, pl. 1, figs 1–3, 6; 1948, pl. 1, figs 15–18). Such an anterior border distinguishes these taxa from *P. minutus* Rasetti, 1945 in a 'Lower Cambrian' boulder within the 'Sillery Formation' on the Island of Orléans, Quebec (Rasetti 1945, pl. 1, figs 11–12), which has a semicircular outline and no discernible median boss. The border commonly shows traces of fine radiating scrobicules, e.g., Figure 10f, u, though these are not as distinct in the Leny specimens as in some of Rasetti's material; they are much less conspicuous than those of associated *Kiskinella cristata* (Fig. 9a–e). There is a broad depressed furrow behind the boss and in front of the glabellar area separating the genae, but this is somewhat narrowed (tr.) in laterally tectonised

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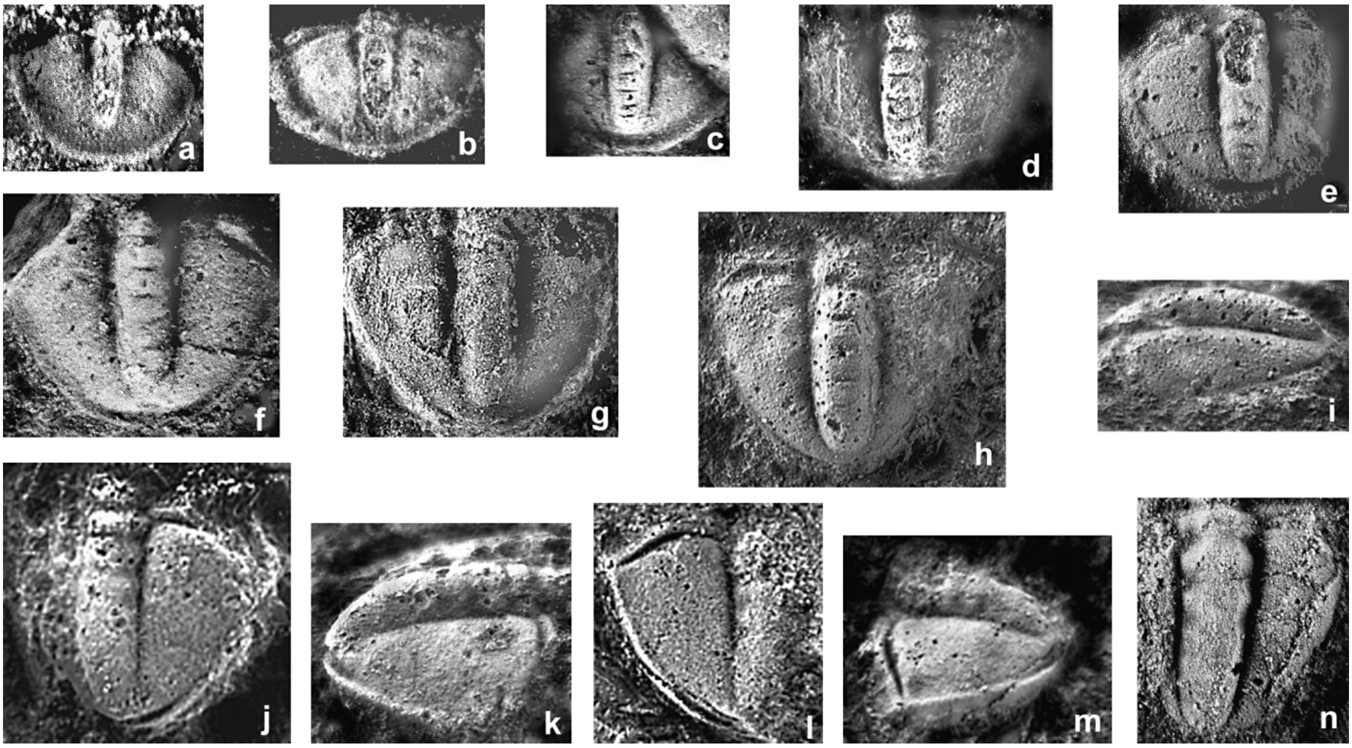

Figure 11 Pygidia of *Pagetides amplifrons* Rasetti, 1945: (a) GSE 15258, × 20; (b) GLAHM 103016 [A/6708/11] (figured as *Kilmahogia jamesbeggi* Lamont, 1975, pl. 23, fig. 7), × 15; (c) GLAHM 103054B, × 15; (d) GLAHM 103024, × 15; (e) GLAHM 103045, × 15; (f) GLAHM 103049–2, × 15; (g) Zf 3873E from Section B, × 15; (h–i) dorsal and lateral views, Zf 4053A from Bed B1, × 15; (j–k) dorsal and lateral views, Zf 3871B from Section B, × 15; (l–m) dorsal and lateral views, Zf 3871A from Section B, × 10; (n) GLAHM 103019–5 [A/6708/20] (figured as monotype of *Ellesides altaterra* Lamont 1975, pl. 23, fig. 18), × 10.

specimens, e.g., GLAHM 103039B (Fig. 10o). The overall shape of the glabella in the Leny specimens varies from almost parallel-sided with well-rounded anterior front, e.g., GLAHM 103044 (Fig. 10q) to pyramidal with a more pointed anterior front, e.g., GLAHM 103039B (Fig. 10o) and the glabellar furrows are generally less distinct than in *P. rupestris* (Rasetti 1948, pl. 1, figs 16, 17). An erect basal glabellar spine is generally broken off and, while in some specimens, e.g., Zf 3873D (Fig. 10t), it appears to have had a subcircular cross-section like *P. amplifrons*; in others, e.g., Zh 652C (Fig. 10a), the spine is laterally compressed or 'pinched' as in Rasetti's (1948, pl. 1, fig. 17) figured *P. rupestris*. In undistorted specimens, the fixigenae are wider (tr.) than the glabella, but taphonomic or tectonic distortion seems to affect not only the relative widths, but also the shape and relative position of the palpebral lobes. Well-preserved specimens, e.g., GLAHM 103008–1 (Fig. 10f) have narrow (tr.), long (sag.) palpebral lobes, in contrast to some laterally compressed cranidia with slightly thickened lobes in more posterior positions, e.g., GLAHM 103039B (Fig. 10o).

Although some of the smaller Leny cranidia are similar to those of *P. leiopygus* (Rasetti 1945, p. 314, pl. 1, figs 7–10), that species has an effaced pygidial axis, whereas pygidia from the Leny Limestone are not effaced and resemble those of *P. amplifrons* in having a parabolic outline (Fig. 11g, h, j) and a relatively longer (sag.), nearly parallel-sided axis with more axial rings, e.g., GLAHM 103024 (Fig. 11d), 103049–2 (Fig. 11f) and Lamont's monotype of *Ellesides altaterra* (Fig. 11n). The axial rings generally extend across the axis, as in *P. amplifrons*, rather than become obsolete along the sagittal line, as in *P. rupestris*.

The holotype of *Pagetides napoleon* (Lamont 1975, pl. 22, fig. 1; Fig. 10f) has a less inflated frontal area than is generally displayed in *P. amplifrons*, but its outline, and its length, which is nearly half that of the glabella, are typical of *P. amplifrons*. The pygidium of *Ellesides altaterra* (Lamont 1975, pl. 23, fig. 18; GLAHM 103019–5) is fragmentary, but the long axis is only slightly tapered and resembles that of *P. amplifrons*. The missing holotype specimen of *Perthiellus pringlei* (Lamont 1975, pl. 22, fig. 10) was implausibly described as an asymmetrical glabella with eight to ten pairs of glabellar furrows. It seems likely that it is the pygidial axis of a *Pagetides*, but the specimen is not available for examination.

Occurrence. *Pagetides amplifrons* is recorded from Ville Guay and Orléans Island, Quebec, and from the *Pagetides* Fauna at Griswold Farm, Columbia County, New York State (Rasetti 1967). The numerous Leny specimens in Pringle's collections from the Western Quarry are from Beds B1, B2 and B3; two poor specimens were recognised in Bed F1.

Pagetides minutus Rasetti, 1945
Figure 12a–y.

1945 *Pagetides minutus* n. sp.; Rasetti, n. sp., p. 313, pl. 1, figs 11, 12.
1948 *Pagetides minutus* Rasetti, p. 12, pl. 1, figs 13, 14.
1967 *Pagetides minutus* Rasetti, p. 64, pl. 6, figs 1–10.
1975 *Pagetides adharc* sp. nov; Lamont, p. 203, pl. 22, fig. 5.
? 1975 *Pagetides napoleon*, sp. nov.; Lamont, p. 201 (part), pl. 22, figs 3?, 4?; pl. 23, fig. 5?
? 1975 *Eilidh macgregori* gen. et sp. nov; Lamont, p. 206, pl. 24, fig. 3.
? 1975 *Kilmahogia jamesbeggi* get. en sp. nov. [sic]; Lamont, p. 203, pl. 23, figs 2, 3?, 4?
? 1975 *Macnairides munitatus* gen. et sp nov.; Lamont, p. 204, pl. 24, fig. 1.

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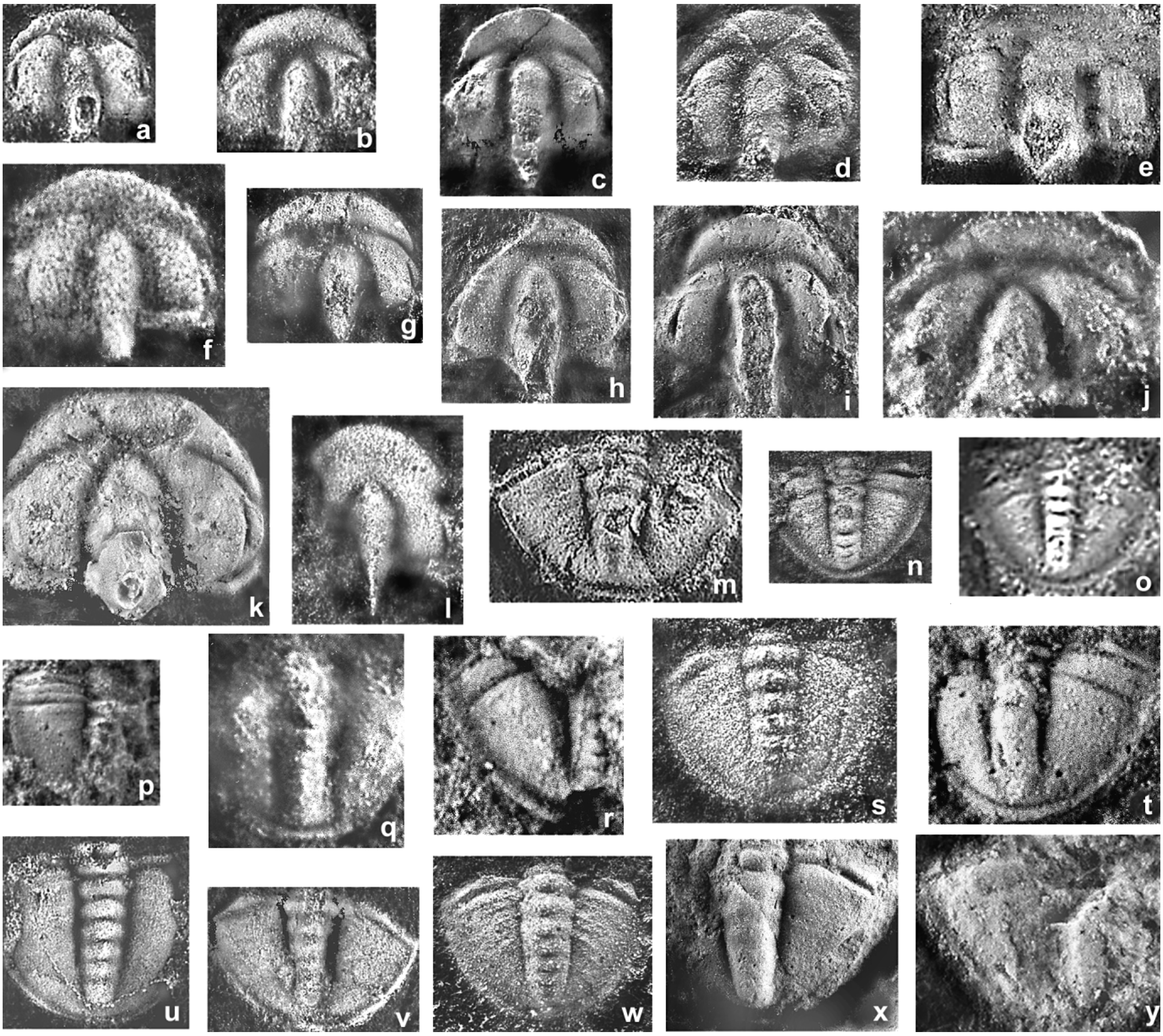

Figure 12 *Pagetides minutus* Rasetti, 1945: (a–k) cranidia; (m–y) pygidia. (a) Zf 3873F from Section B, × 20; (b) GSE 15253A, × 15; (c) Zh 697 from Bed B3, × 15; (d) Zf 3828C from Section B, × 15; (e) GLAHM 103013–2 [A/6708/9] (figured as holotype of *Kilmahogia jamesbeggi* Lamont 1975, pl. 23, fig. 2), × 15; (f) GSE 15269, × 15; (g) GLAHM 103048, × 10; (h) GLAHM 103039A, × 10; (i) GLAHM 103051, × 10; (j) GLAHM 103010 [A/6708/4] (figured as holotype of *Pagetides adharc* Lamont, 1975, pl. 22, fig. 5), × 10; (k) GLAHM 103022–1 [A/6708/ 23] (figured as holotype of *Macnairides munitatus* Lamont, 1975, pl. 24, fig. 1), × 10; (l) *Pagetides* aff. *minutus* Rasetti, 1945, partial cranidium GSE 15267, × 15; (m) GSE 15260, × 25; (n) Zf 3883 from Section B, × 20; (o) Zf 4053B from Bed B1, × 20; (p) pygidial fragment, latex cast of external mould, Zh 648B from Bed B1, × 20; (q) GLAHM 103011 [Lamont Collection 500a] (figured as *Pagetides adharc*? Lamont, 1975, pl. 22, fig. 7), × 20; (r) partial pygidium, latex cast of external mould, Zf 3879A from Section B, × 15; (s) Zf 4546 from Bed F2, × 15; (t) Zf 3873G from Section B, × 20; (u) Zf 3879F from Section B, × 15; (v) latex cast of external mould, GSE 15263, × 10; (w) Zf 3897A from Bed B2, × 10; (x) GLAHM 103050–1, × 10; (y) GLAHM 103022–2 [A/6708/25] (figured as holotype of *Eilidh macgregori* Lamont, 1975, pl. 24, fig. 3), × 10.

Holotype. Cranidium Laval Univ. 302a from the 'Lower Cambrian' Boulder O-1 on the southern shore of the Island of Orléans in the St. Lawrence River, south of Quebec City, Canada, associated with paratype pygidium Laval Univ. 302b.

Diagnosis. See Rasetti 1945, p. 313.

Material. Numerous specimens from Pringle's Section B, especially Beds B1 and B3. A few are recorded from Section F.

Remarks. The cranidium of *Pagetides minutus* is wider (tr.) than long (sag.) and has a more evenly rounded frontal outline and a less extended frontal area than in *P. amplifrons*, which is longer than wide. The border of *P. minutus* lacks a median boss and radial scrobicules have not been described. The glabella is generally sharply rounded anteriorly, like some forms of *P. amplifrons*, but the genae tend to extend nearer to the midline in front of the glabella, so that the anterior depression is smaller. The pygidium differs from that of *P. amplifrons* in being proportionally wider and less sharply rounded posteriorly; the axis is more tapered and ends more forward of the posterior border furrow; the border is commonly wider than in *P. amplifrons*.

The holotype of *Pagetides adharc* (GLAHM 103010, Lamont 1975, pl. 22, fig. 5; Fig. 12j) is incompletely preserved, but the anterior border and front of the glabella are typical of *P. minutus*. The holotype of *Eilidh macgregori* (GLAHM 103022–2, Lamont 1975, pl. 24, fig. 3; Fig. 12y), though illustrated as a cephalic fragment, is clearly part of a pygidium like that of *P. minutus*. The holotypes of the species *Kilmahogia jamesbeggi* (Lamont 1975, pl. 23, fig. 2; GLAHM 103013–2;

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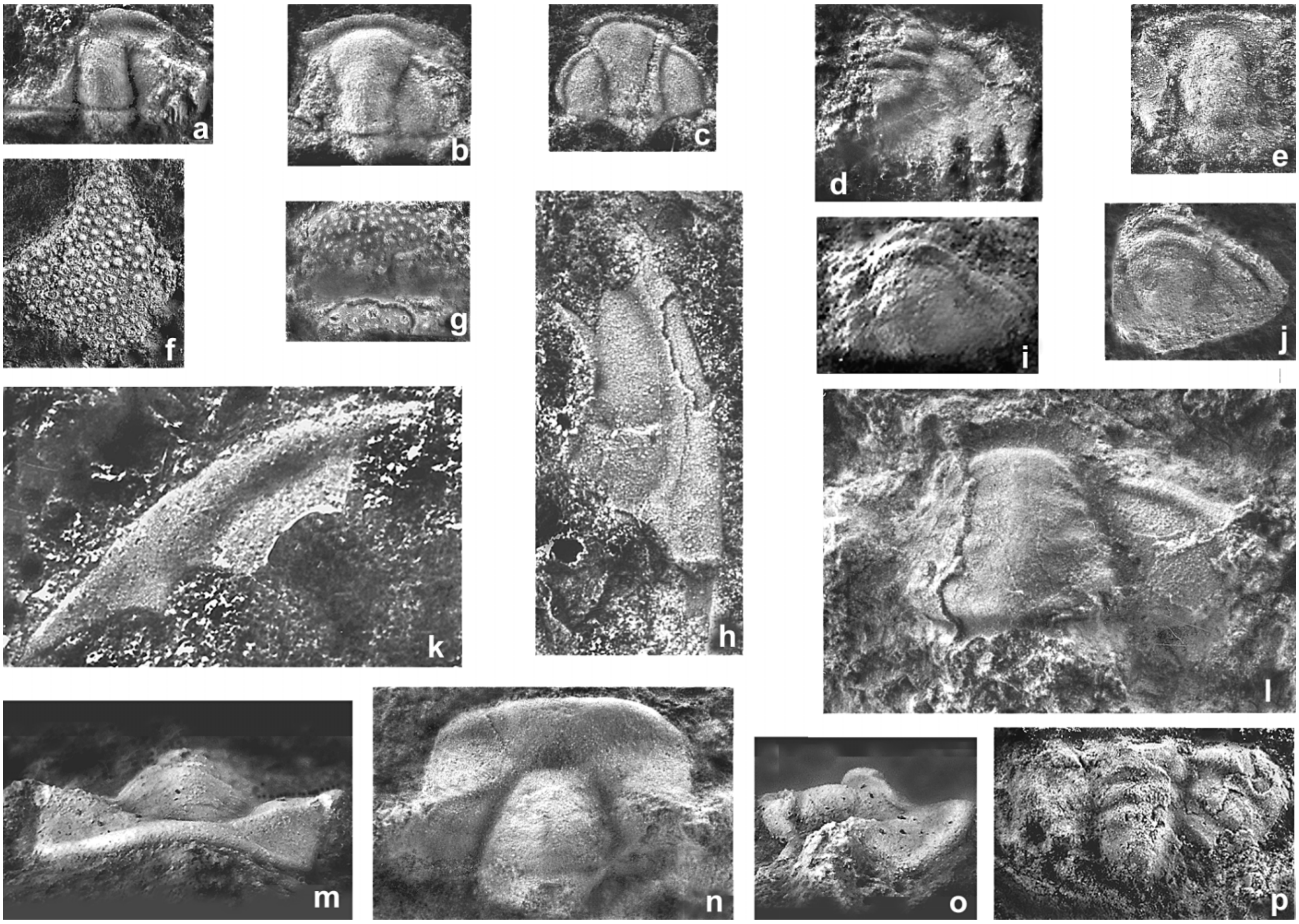

Figure 13 Polymerid trilobites. (a) *Zacanthopsis*? sp., cranidium Zf 3857B from Section B, × 10. (b–d) *Prozacanthoides*? sp.: (b) cranidium Zo 4457, × 15; (c) cranidium Zo 4461 × 15; (d) pygidium Zf 4079 from Bed F1, × 10. (e–g) Corynexochida? *incertae sedis*: (e) hypostome Zf 3870C from Section B, × 10; (f) pustulose fragment GSE 15257, × 5; (g) pustulose fragment GSE 15254, × 5. (h–j) *Poliella*? sp.: (h) librigena, latex cast of external mould, Zh 669 from Bed B3, × 10; (i) partial pygidium Zf 4669 from Bed F1, × 10; (j) partial pygidium Zf 4679 from Bed F2, × 10. (k–o) *Poulseniella* sp. nov.: (k) librigena Zh 653 from Bed B1, × 15; (l) partial cranidium Zf 4082 from Bed F1, × 15; (m–o) cranidium, anterior, dorsal and lateral views, Zh 1397 from Section B, × 10. (p) Ptychoparioid, partial pygidium GSE 15264, × 10.

Fig. 12e) and *Macnairides munitatus* (Lamont 1975, pl. 24, fig. 1; GLAHM 103022–1; Fig. 12k) are both, so far as they are preserved, close to each other and to *P. minutus*, but in each, the frontal area is ill-preserved, making close comparison impossible. We regard *Macnairides munitatus* as a junior synonym of *P. minutus*, because the cranidium is not sagittally elongate as in *P. amplifrons* and the anterior border extends farther backwards than in any of the associated Leny specimens of *P. amplifrons*.

Occurrence. *Pagetides minutus* is recorded from rocks assigned to the Laurentian Lower Cambrian in Quebec Province, Canada and from the *Pagetides* Fauna at Griswold Farm, Columbia County, New York State (Rasetti 1967). In Pringle's collection from the Leny Limestone, it occurs in Beds B1 (several), B2, B3 and F1 (two or three specimens) in the Western Quarry.

5.2. Polymerid trilobites

Fragments of polymerid trilobites occur in most fossiliferous beds of the Leny Limestone and Slate Member, but almost all the sclerites are too fragmentary to be identified. There are a few relatively complete cephalic specimens, but they are small, around 2 mm long. Although they are likely to be juvenile forms, the possibility that they represent the stunted forms of a depleted oxic environment cannot be ruled out.

Order Corynexochida Kobayashi, 1935
Family Zacanthoididae Swinnerton, 1915
Genus *Zacanthopsis* Resser, 1938

Type species. *Olenoides levis* Walcott, 1886, from the *Bonnia–Olenellus* Zone of the Pioche Shale Formation, Nevada, USA.

Zacanthopsis? sp.
Figure 13a.

Material. One fragmentary cranidium (Zf 3857B).

Remarks. The cranidium is 2·5 mm long and has a parallel-sided glabella, divergent preocular sutures and oblique eye-ridges. It is not known whether an occipital spine was present. The specimen is only doubtfully compared with *Zacanthopsis*, because the characteristic narrowing of the glabella at its mid-length (Rasetti 1948, pl. 2, figs 17–19) is not present, whereas in a specimen as small as the present example such narrowing might be expected.

Occurrence. The Leny specimen is from an unspecified bed in Pringle's Section B in the Western Quarry. *Zacanthopsis* is known from the *Bonnia–Olenellus* Zone in several places in the North American Cordilleran areas of Nevada and British Columbia and in the Laurentian areas of Virginia and Quebec.

Genus *Prozacanthoides* Resser, 1937

Type species. *Olenoides stissingensis* Dwight, 1889, from the Stissing Formation of New York, above the *Olenellus* Zone.

Prozacanthoides? sp.
Figure 13b–d.

Material. A cranidium from Ritchie's collection, Zo 4457; a juvenile cranidium from the same collection and two pygidial fragments may possibly be referable to the same genus.

Remarks. The larger cranidium, 1·5 mm long (Fig. 13b) is comparable to a cranidium about 3 mm long figured by Rasetti (1967, pl. 7, fig. 21). In Rasetti's specimen the glabella is less narrow posteriorly, but this may well be a function of its larger size. The smaller cranidium (Zo 4461, Fig. 13c) is 1 mm long and shows the glabellar furrows less clearly; this specimen resembles specimens of *Chilometopus citer* Suvorova, 1964 of about the same size (Suvorova 1964, pl. 2, figs 9, 10), but differs in having longer palpebral lobes. The pygidial fragment (Zf 4079, Fig. 13d) has a short conical axis with two rings and broad-based marginal spines, much like the specimens of similar size figured by Rasetti (1967, pl. 7, figs 20, 22).

Occurrence. *Prozacanthoides* was originally described from beds assumed to be of early Middle Cambrian age in Duchess County, New York and in Virginia. Resser (1939, p. 11) described several supposedly Middle Cambrian species from limestones below the Spence Shale Formation in the Wasatch Mountains, Utah. Rasetti's specimens are from *Pagetides* faunules from Columbia County, New York State (Rasetti 1967). In the Leny Limestone and Shale Member, the cranidia are from an unknown horizon and the referred pygidium is from Bed F1 with *Kiskinella cristata* in the Western Quarry.

Family Dolichometopidae Walcott, 1916
Genus *Poliella* Walcott, 1916

Type species. *Bathyuriscus* (*Poliella*) *anteros* Walcott, 1916, from the Spence Shale Formation of Idaho, USA.

Poliella? sp.
Figure 13h–j.

Material. An incomplete librigena from Bed B3 and two pygidia, one from each of Beds F1 and F2 in Pringle's collections.

Remarks. The pygidia have a wide, but short, axis with one distinct axial ring. The anterior edge of the pleural regions is not transverse, as in many ptychoparioids, but curves backwards; there is one distinct pleural furrow and a trace of a second one, both dying out before reaching the margin; there is no border and the margin is entire.

These pygidia (Zf 4669 and 4679, Fig. 13i–j) resemble those of *Poliella*, as figured by Walcott (1916, pl. 46, fig. 5), Rasetti (1951, pl. 12, figs 11, 12) and Palmer & Halley (1979, pl. 11, figs 5, 6). None of the corynexochoid cranidia known from the Leny limestones shows the steeply inclined eye ridges that make an acute angle with the axial furrow, as is typical of *Poliella*.

A librigena (Zh 669, Fig. 13h) from Bed B3 in Pringle's collection has a long ocular incisure and a well-marked border. It resembles the librigena of *Poliella anteros* Walcott (1916, pl. 46, fig. 5) and *P. germana* (Resser, 1939) figured by Palmer & Halley (1979, pl. 11, fig. 1) and is tentatively assigned to the same genus.

Occurrence. Specimens assigned to this taxon were collected from Beds B3, F1and F2 in the Western Quarry.

Corynexochida? *incertae sedis*
Figure 13e–g.

Material. One obscure hypostome (Zf 3870C, Fig. 13e) has been provisionally identified as that of a corynexochoid. It is similar in shape to a dorypygid (Suvorova 1964, pl. 13, fig. 6) or a zacanthoidid (Palmer & Halley 1979, pl. 9, fig. 22), but it is too indistinct to see if the hypostome is fused with a rostral plate.

There are several fragments of a strongly granulose trilobite. As some of them are 5 mm across and show few or no natural edges, it is supposed that they originate from trilobites that were substantially larger than the identifiable forms that occur in association. The fragments show no interpretable morphological features, but the sculpture of closely spaced tubercles of various sizes, some of which are large and pustulose, i.e., perforated at the summit, as in GSE 15257 (Fig. 13f), GSE 15254 (Fig. 13g); are reminiscent of taxa such as *Dorypyge* Dames, 1883. Definite identification demands more complete specimens.

Occurrence. These fragments are common in Brand and Graham's [EJ] collection, and in Pringle's collection they occur at Bed F1 with *Kiskinella cristata* in the Western Quarry.

Order Ptychopariida Swinnerton, 1915
Family Pychopariidae Matthew, 1888
Subfamily Antagminae Hupé, 1953b

Remarks. The Subfamily Antagminae is poorly characterised and is in need of critical revision, though this is not attempted here. Harrington *et al.* (1959, p. O235–7) assigned 13 genera to the subfamily, but Jell & Adrain (2003), who employed the family name Antagmidae, listed twice that number, despite having synonymised some genera and transferred others to the independently recorded Family Ptychopariidae. Rasetti (1955, p. 6) retained *Poulsenia* Resser, 1936 in the Antagminae and considered the genus to be restricted to species described from NW Greenland.

Genus *Poulseniella* V. Poulsen, 1964

Type species. *Poulseniella groenlandica* V. Poulsen, 1964, from the *Glossopleura* Zone (early Middle Cambrian), east of Blomsterbaekken, north-western Greenland.

Remarks. V. Poulsen described *Poulseniella* as of 'antagmine type' and considered that it is most closely similar to the Early Cambrian species of *Poulsenia* Resser, 1936, and was probably derived from it or a closely related form.

Poulseniella sp. nov.
Figure 13k–o.

Material. One fairly complete and two more fragmentary cranidia; one librigena referred to the species.

Description. The most complete cranidium Zh 3197 (Fig. 13m–o) is 3 mm long (sag.). The glabella (including LO) has a length about equal to its basal width, is two-thirds of cranidial length, tapers forward and is truncate anteriorly. SO transverse, distinct; glabellar furrows very weak, but clearer in the larger fragmentary cranidium (whose pre-occipital glabella is 2·5 mm long); this shows furrows S1 and S2 to be short and roughly transverse; S3 and S4 oblique inwards and forwards, S4 being weakly incised. Palpebral lobes elevated, far back, their centres opposite S1, at about the posterior third of the cranidial length. On the less well-preserved, largely exfoliated, cranidium Zf 4082 (Fig. 13l), the glabellar furrows are marked by distinct scars. On the Zh 1397, the width of the fixigena opposite the palpebral lobe is about two-thirds of the width of

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the glabella at the same level. Eye-ridge long, thin, oblique, nearly straight and prominently exposed on Zf 4082. Frontal area long (sag.), fairly flat, not clearly divided by anterior border furrow; there is a change of slope resembling a weak border furrow that, in front of the glabella, bends back towards the glabella simulating a plectrum. Surface appears to be smooth.

One librigena assigned to *Poulseniella* (Zh 653, Fig. 13k) is narrow, with a broad border furrow and a rather short genal spine. The postocular suture is shorter than the preocular suture, indicating that the eye lay far back on the gena.

Discussion. The Leny material resembles *Poulseniella groenlandica* V. Poulsen (1964, p. 36, pl. 2, figs 1–6) in having a short, conical glabella, the eyes set far out and well back, and in the form of the frontal area. It differs from *P. groenlandica* and also *P. crassilimbata* (C. Poulsen, 1927, pl. 17, figs 5–6), because the fixigenae of the Leny species slope downwards and inwards from the elevated eye to the glabella, whereas, in the species from Greenland, the interocular genae are nearly level, but slope down slightly from the glabella outwards to the eye. Among the Laurentian Antagminae recorded as from the early Cambrian, the most similar is *Periomma gaspensis* described from a Lower Cambrian boulder at Grosses Roches, Quebec by Rasetti (1955, p. 25, pl. 4, figs 11–15). It is especially like the specimen in his fig. 11, which is, however, nearly three times the size of Zh 1397. Compared with the Leny species, the glabella in *P. gaspensis* is a little longer in proportion, whereas, in smaller cranidia, the glabella is less tapered and more rounded in front, the eye is less elevated, and the border furrow is more distinct. Although the Leny species appears to differ from similar antagmine trilobites, the material so far collected is insufficient to be formally named.

Occurrence. *Poulseniella* sp. nov. occurs in Beds B1 and F1 in the Western Quarry at Leny.

Ptychoparioid
Figure 13p.

Material. A poorly preserved pygidium with a transverse outline (GSE 15264, Fig. 13p) is typical of a ptychoparioid and possibly referable to *Poulseniella*.

Occurrence. Unspecified locality in the Leny Quarries.

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7. Appendices

7.1. Appendix 1. Dr J. K. Ingham's curatorial observations on Lamont's publication.

During Lamont's study of specimens loaned from the Begg Collection, much of the original material was broken up and many more, smaller, pieces were returned to the Hunterian Museum. However, taxonomic complications have arisen, because the returned material does not include certain specimens (including some types) figured by Lamont (1975); such lost specimens are listed by Dr J. K. Ingham as:

1. pygidium of *Pagetides napoleon*, pl. XXII, fig. 4 (as A/6708/3)
2. pygidium of *Pagetides adharc*?, pl. XXII, fig. 6 (as A/6708/5)
3. Holotype of *Trossachia pammicra* (on *Pagetides* cf. *napoleon*), pl. XXII, fig. 8 (as A/6708/6)
4. Holotype cephalon of *Perthiellus pringlei*, pl. XXII, fig. 10 (as A/6708/7)
5. Librigena of *Robroyia andersoni*?, pl. XXIII, fig. 17 (as A/6708/19)
6. Partial cephalon (?) of *Mial lanaigh* (presumably the holotype, not stated), pl. XXIII, fig. 19 (as A/6708/21)
7. 'Segmented appendage incertae sedis', pl. XXIII, fig. 20 (as A/6708/22)
8. Pygidium of *Macnairides munitatus*?, pl. XXIV, fig. 5 (as A/6708/27)
9. Holotype glabella and eye(!) of *Nicoljarvius minans*, pl. XXIV, fig. 6 (as A/6708/28). Old label etc. found in empty box and retained (with rest of known type and figured material in PAL 93.17)
10. Holotype partial cephalon of *Chambersiella conditor*, pl. XXIV, fig. 7 (as A/6708/29)
11. Holotype partial cephalon of *Neilsoniella agnesae*, pl. XXIV, fig. 8a (as A/6708/30), together on the same slab with cephalon of *Robroyia*? and a supposed agnostid, pl. XXIV, fig. 8b (as A/6708/31)
12. Holotype segments (!) of supposed malacostracan *Reochius cenectisis*, pl. XXIV, fig. 9 (as A/6708/32)

7.2. Appendix 2. The authors' interpretations of Lamont's species and his extant specimens.

GENUS	SPECIES	HOLOTYPE	STATUS OF NAME	IDENTIFICATION IN THIS ACCOUNT
Pagetides	*napoleon*	GLAHM 103008–1, pl. 22, fig. 1	available	*Pagetides amplifrons*
Pagetides	*adharc*	GLAHM 103010, pl. 22, fig. 5	available	*Pagetides minutus*
Pagetides?	*caltraid*	GLAHM 103012–1, pl. 22, fig. 9		unrecognisable
Kilmahogia	*jamesbeggi*	GLAHM 103013–2, pl. 23, fig. 2	available	*Pagetides minutus*?
Macnairides	*munitatus*	GLAHM 103022–1, pl. 24, fig. 1	available	*Pagetides minutus*?
Ellesides	*altaterra*	?GLAHM 103019–5, pl. 23, fig. 18	not available	*P.* cf. *amplifrons* (pygidium)
Perthiellus	*pringlei*	holotype missing, pl. 22, fig. 10	available	pygidium of *Pagetides*
Neilsoniella	*agnesae*	holotype missing, pl. 24, fig. 8a	available	
Nicoljarvius	*minans*	holotype missing, pl. 24, fig. 6	available	
Chambersiellus	*conditor*	holotype missing, pl. 24, fig. 7	not available	
Eilidh	*macgregori*	GLAHM 103022–2, pl. 24, fig. 3	available?	*P. minutus*? (pygidium)
Mial	*lanaigh*	monotype? missing, pl. 23, fig. 19	available	
Robroyia	*andersoni*	GLAHM 103019–3, pl. 23, fig. 16	available	*Bathydiscus* cf. *dolichometopus* (pygidium)

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