THE UPPER CAMBRIAN TRILOBITE *IRVINGELLA NUNEATONENSIS* (SHARMAN)

by A. W. A. RUSHTON

ABSTRACT. *Irvingella nuneatonensis* (Sharman 1886), of which the complete dorsal exoskeleton is known, is redescribed, illustrated for the first time, and distinguished from other species. The ventral cephalic sutures and rostrum are like those of *Dunderbergia* (family Elviniidae). Three abnormally developed individuals are described. *I. nuneatonensis* comes from the upper part of the Zone of *Olenus* (above the base of the Subzone of *Olenus dentatus*) and its horizon is not below the upper part of the *Elvinia* Zone of the Upper Cambrian sequence in the U.S.A.

IN the course of the Geological Survey's investigation of the pre-Carboniferous rocks in the neighbourhood of the Warwickshire coalfield in the English Midlands (Strahan 1886), several specimens of a trilobite were collected from the Upper Cambrian shales ('Lower Silurian' in the original account) exposed in the Midland Railway Cutting between Nuneaton and Stockingford; they were described by Sharman (1886, p. 565) as a new species, *Olenus nuneatonensis*. Lapworth (1898, p. 347), apparently recognizing that the species was not a true olenid, referred to it as 'an Olenoid form, *Olenus* (?) *nuneatonensis*', but its affinities were not made known until Stubblefield (1932, p. 65) assigned it to the genus *Irvingella* Ulrich and Resser (*in* Walcott 1924). Palmer (1965, pp. 20–21, 45–46) showed that *Irvingella* is a widely distributed genus, and is a useful index for inter-continental correlation since it has a short stratigraphical range; *I. nuneatonensis* is of particular importance in this connexion because it provides the clearest evidence so far found for the stratigraphical position of *Irvingella* in the Upper Cambrian succession of Europe, correlation of which with the coeval succession in the United States of America is notoriously difficult. *I. nuneatonensis* is also of interest in being the only described species of the genus in which the rostrum and entire thorax are known.

The techniques and terminology employed in this study are the same as those given by the writer in an earlier work (Rushton 1966); in particular it should be noticed that the occipital and glabellar furrows are referred to respectively as S0, S1, S2, etc. (counting from the back forwards), and the occipital ring is excluded from the glabella.

Genus IRVINGELLA Ulrich and Resser *in* Walcott 1924

Type species, by original designation. *Irvingella major* Ulrich and Resser *in* Walcott 1924.

The genus *Irvingella* has been discussed by Palmer (1960) and Öpik (1963), and the species of the genus were reviewed by Palmer (1965), who considered the following valid: *I. major* Ulrich and Resser, *I. angustilimbatus* Kobayashi, *I. flohri* Resser, *I. suecica* Westergård, and *I. transversa* Palmer and, with some doubt, *I. nuneatonensis* (Sharman), *I. platycephala* Rusconi, and *I. tropica* Öpik; he reserved comment on *I. taitzehuensis* Lu, *Komaspis* (*Parairvingella*) *convexa* Kobayashi, and *K.* (*P.*) *megalops* Kobayashi.

According to Kobayashi (1954 and elsewhere) *Irvingella* is a genus of the Komaspididae, which family he regarded as descended from a relative of the genus *Bathynotus* Hall. However, as discussed by Öpik (1963, pp. 94, 95) and Palmer (1960, p. 73), the concept of the Komaspididae, based upon the inadequately known *Komaspis* Kobayashi (type species *K. typa* Kobayashi), is of doubtful value, and Palmer has advocated the grouping of *Irvingella* with the ptychopariacean family Elviniidae, suggesting that *Elviniella laevis* Palmer is the direct ancestor of the *Irvingella* species in the Great Basin region of the U.S.A. (Palmer 1965, p. 20). This idea receives some further support from the discovery that the rostrum and ventral sutures in a species of *Irvingella* (text-fig. 1*b*) are exactly like those of *Dunderbergia* (Palmer 1960, p. 64, fig. 8*c*), the latter being a genus of the Elviniidae and possibly directly related to *Elvinia* itself (Palmer 1965, p. 17); the ventral cephalic sutures of *Bathynotus* have a different ('Bathynotid') pattern (Harrington *et al.* 1959, p. O65, fig. 48 *I* and p. O67), and according to Lochman (1953, p. 890), the Bathynotidae are not related to *Irvingella*.

Irvingella nuneatonensis (Sharman 1886)

Plate 52, figs. 1–12; text-figs. 1, 2

1886 *Olenus Nuneatonensis* Sharman; Strahan, p. 548. (*Nom. nud.* in list).
1886 *Olenus Nuneatonensis*; Sharman, p. 565 (described, no figure).
1898 *Olenus* (?) *nuneatonensis* Sharman; Lapworth, pp. 347, 348 (mentioned and listed).
1932 *Irvingella nuneatonensis* (Sharman); Stubblefield, p. 65 (species transferred to *Irvingella*).
1954 *Irvingella nuneatonensis* (Sharman 1866 [*sic*]), [also attributed to 'Shorma (1731)']; Kobayashi, pp. 25, 27, 35, 41 (remarks, listed).
1965 *Irvingella nuneatonensis* (Sharman); Palmer, p. 46 (mentioned as possibly distinct from *Irvingella major*).

Material. Sharman's original material was all collected from one locality and is in the collection of the Institute of Geological Sciences (formerly Geological Survey and Museum), nos. GSM 50280–6,

---

EXPLANATION OF PLATE 52

Irvingella nuneatonensis (Sharman 1886).
Fig. 1*a–d*. Cranidium, GSM 50285–6. *a*, dorsal view (latex cast); *b–d*, dorsal, lateral, and anterior views. × 2·5.
Fig. 2. Cranidium showing palpebral lobe, GSM JR3134. × 2·5.
Fig. 3*a–d*. Cranidium, GSM JR3137. *a*, dorsal view with S3 distinct; *b*, left side viewed obliquely from above; *c*, anterior view showing supposed S4; *d*, right lateral view. × 2·5.
Figs. 4, 5. Immature cranidia showing anterior border, GSM JR3143, GSM 50282. × 5.
Fig. 6. Small axial shield, GSM 50283. × 5.
Fig. 7. Thorax of small individual with two free cheeks (slightly retouched), GSM 50284. × 5.
Fig. 8. Lectotype, small dorsal shield with free cheeks displaced (slightly retouched), GSM 50280. × 5.
Fig. 9*a*, *b*. *a*, Pygidium, posterior part of thorax and ventral aspect of a free cheek (latex cast), GSM JR3126; *b*, the same free cheek, lateral (abaxial) view of interior surface. × 2·5.
Fig. 10*a–c*. Part of thorax and pygidium, GSM JR 3125 (counterpart of JR3126, fig. 9). *a–c*, dorsal, lateral, and posterior views. × 2·5.
Fig. 11. Complete thorax with deformed pygidium, GSM JR3127 (latex cast). × 2·5.
Fig. 12*a*, *b*. Fragment of thorax and pygidium, GSM JR3149. *a*, *b*, dorsal and posterior views. × 2·5.
All the specimens are in the collection of the Institute of Geological Sciences (formerly Geological Survey and Museum) and are internal moulds unless otherwise stated; for locality see text. All photographs by the writer; specimens whitened before photography except that in fig. 7, which was taken under alcohol.

JR3120–44, and JR3147–9. It consists of fragments of twenty-eight specimens including one dorsal shield (the lectotype), one axial shield, a cephalon, about six useful cranidia, and three or four fairly complete examples of the thorax, mostly with the pygidium attached. At a different locality the writer collected a small axial shield associated with part of a very large thorax, part of another thorax and a small pygidium with three thoracic segments attached; these specimens, thought to be of this species, are in the collection of the Sedgwick Museum, Cambridge, Nos. SM A57283–6.

All the specimens are preserved as internal and external moulds in grey or greenish silty and slightly micaceous shale. Much of their original convexity is preserved, the exoskeleton being thick and strong, but there are cracks in some of the specimens (e.g. Pl. 52, fig. 1b, in the occipital ring; fig. 3a, in the left cheek) which are probably due to the compression of compacting sediment. Morphologically, their effect is to increase the width and reduce the convexity of the affected part in relation to other parts. The lectotype has suffered adventitious frontal pressure which has fractured and foreshortened the cranidium, as stated by Palmer (1965, p. 46).

Lectotype. The lectotype is the small dorsal shield described by Sharman, GSM 50280 (Pl. 52, fig. 8).

Diagnosis. A species of *Irvingella* with a tapered glabella, the second and third pairs of lateral glabellar furrows (S2 and S3) distinct, the frontal area undivided in holaspid cranidia more than about 2–3 mm. long, the anterior ends of the eyes further apart than the width of the occipital ring, and interocular cheeks about half as wide as the glabella across a line through the anterior ends of S1.

Description. Cranidium approximately semicircular, convex in mature individuals. Cephalic axis long, tapering forwards, roughly parabolic in outline, slightly truncate in front but with the anterolateral corners rounded, strongly convex longitudinally and moderately convex transversely; the width is about five-sixths of the length. S1 deep, wide, lateral parts oblique backwards and slightly convex forwards, joined across the glabella by a transverse median portion; S2 distinct, less oblique, convex forwards, short; S3 nearly transverse, convex forwards, weak on external moulds but distinct on internal moulds, short; one specimen, GSM JR3137 (Pl. 52, fig. 3c), has a pair of pits which may represent S4. Occipital ring about one-sixth of the cephalic axial length. S0 deep, simple, concave forwards. In smaller specimens the glabella is relatively narrow and less convex.

Frontal area short, one-tenth or less of the cephalic axial length, bending down vertically in front. Two small cranidia (Pl. 52, figs. 4, 5, about 2·5 and 2·0 mm. long respectively) have a relatively longer frontal area divided into a preglabellar field and anterior border—a feature of immaturity, as in some other species of *Irvingella* (Palmer 1965). Preocular cheeks narrow. Interocular cheeks fairly flat, widening backwards, the width from the axial to the palpebral furrow at the level of the anterior ends of S1 just over half the glabellar width at the same level. Postocular cheeks short, bent down abaxially, mostly occupied by the posterior border and furrow. Smaller specimens have relatively wider cheeks. Palpebral furrow shallow. Palpebral lobe long, its chord two-thirds or less of the length of the cephalic axis; depressed below the level of the inter-ocular cheeks, curved (most sharply near the mid-length), and horizontal except at the ends which are bent abruptly down through a right angle; anterior ends opposite S3 and situated slightly further apart than the greatest width of the cephalic axis. Preocular facial sutures very short, converging forwards, just submarginal in front of the glabella. Postocular sutures divergent with a downward course behind the eye, curving inwards and upwards again across the posterior border, continuing adaxially for a short distance before curving forward to cut the doublure (text-fig. 1b, c).

Free cheeks narrow anteriorly, wider behind, with straight spine which is almost round in cross-section; ocular surface steep; border-furrow weak or absent. Doublure curled under, tube-like (a feature of the Elviniidae; cf. Palmer 1960, p. 64), extended adaxially beyond the dorsal surface at both ends (Pl. 52, figs. 9a, b; text-fig. 1b). One cephalon (GSM JR3121) shows that the rostrum is about as wide as the anterior part
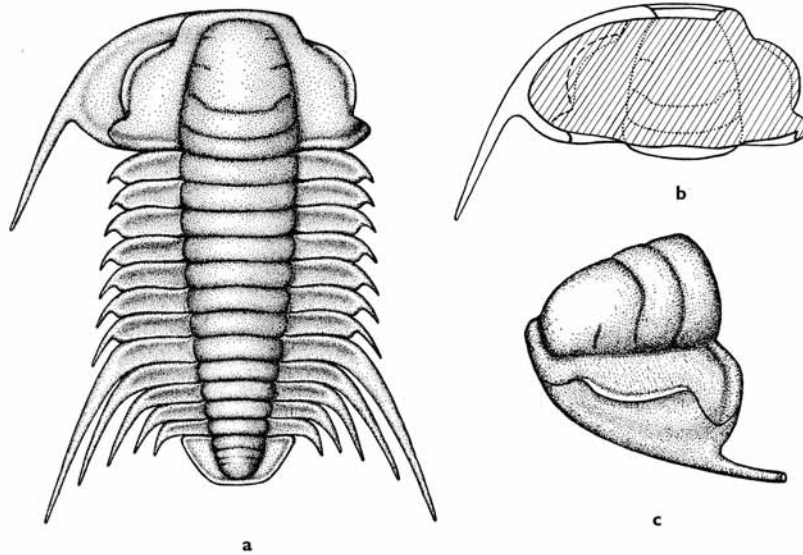
TEXT-FIG. 1. (a) Reconstruction of *Irvingella nuneatonensis* (Sharman), ×4 approx.; (b) Diagram of the ventral aspect of the cephalon, showing rostrum; (c) Sketch of side-view of a young cephalon, ×8 approx.

of the glabella and is slightly less long sagittally than the doublure of the free cheeks (text-fig. 1b). Hypostome not known.

Thorax of twelve segments, parallel-sided for the first seven, the eighth segment macropleural, the remainder narrowing to the pygidium. Axis convex, broad anteriorly, narrowing evenly behind. Anterior pleura about half as wide as the axis with a short spine springing from the anterior edge; in the second to seventh segments the pleurae are progressively wider and the spines longer. The spines on the remaining pleurae are broad and strong; the macropleurae on the eighth segment extend back to or beyond the pygidium, but the spines on the ninth to twelfth segments are progressively shorter.

Pygidium small, trapezoidal, about twice as wide as long. Axis occupies half the total width and most of the length of the pygidium, strongly convex, rounded and almost vertical behind, in larger specimens composed of three rings of which the last is only weakly marked off from the terminal part; in smaller specimens there are only two rings besides the terminal part. Pleural regions flat, furrowed obscurely or unfurrowed but

with a narrow, weakly marked border. In rear view the posterior margin is slightly arched (Pl. 52, fig. 12*b*).

The exoskeleton was up to 0·1 mm. thick and was fairly rigid (see under 'Material', above). From the form of the cracks which have affected some specimens, however, it may be inferred that it was not brittle but slightly flexible. Some of the best-preserved external moulds show that the exoskeleton was minutely granulose.

Measurements in mm.

GSM specimen no.	50282	50283	50280	JR 3137	50285	JR 3134	JR 3127	JR 3125–6
Length of cephalic axis	1·5	2·4	2·8[1]	6·4	6·9	8·1	—	—
Width of occipital ring	0·9	1·7	2·5	5·0	5·7	6·7	—	—
Width of glabella at S1	0·9	1·6	2·4	4·3	4·7	6·0	—	—
Width of interocular cheek	0·6	1·1	1·2	2·2	2·4	3·2	—	—
Length of frontal area	0·35[2]	0·3	—	0·6	0·6	—	—	—
Chord of palpebral lobe	1·0	1·7	2·2	3·9	—	5·1	—	—
Length of thorax	—	4·5	5·5	—	—	—	12·5	—
Length of pygidium	—	0·7	1·0	—	—	—	2·3[3]	2·9
Width of pygidium	—	1·5[4]	2·2	—	—	—	—	6·8

[1] Foreshortened by frontal pressure.   [3] Teratological pygidium.
[2] Preglabellar field with anterior border.   [4] Estimated figure.

The axial length of the lectotype (GSM 50280) is 9·3 mm. but before deformation it was probably about 9·6 mm. The largest specimen (SM A57283) has a thoracic axis 12·5 mm. wide, suggesting a total length for the whole trilobite of 40–50 mm.

Remarks. In general, Sharman's description is accurate, but the statement that the glabella bends over the anterior margin applies only to the lectotype, which has been affected by frontal pressure. Sharman also stated that there are 'eleven to thirteen body-rings' and described the eighth as having a long spine. Two of Sharman's specimens (Pl. 52, figs. 6, 8) and one collected by the writer show complete holaspid thoraces with twelve segments and there is none with any other number. Of the fragmentary thoraces, none has more than seven segments anterior to the macropleural one or (with the exception of an abnormal specimen described below) other than four between it and the pygidium; the macropleural segment appears to be the eighth in every case and the thorax may be taken as normally having twelve segments. Sharman's comparison of the pygidium with that of *Olenus micrurus* Salter was apposite at that time; in 1908, how-ever, Lake (p. 56, pl. 5, fig. 12) showed that the pygidium of the latter species has a small pair of marginal spines, whereas that of *I. nuneatonensis* has not.

The somewhat unusual shape of the thorax of *I. nuneatonensis* recalls that of *Lepto-plastus abnormis* Westergård (1944) and to some extent that of *Centropleura* as described by Öpik (1961), who considered it supported his idea that *Centropleura* was a 'pelagic hunter'. *Irvingella* may have had a similar mode of life.

Abnormal development. Palmer (1965, pl. 6, fig. 11) illustrated an asymmetrical pygidium of *Irvingella major*; three examples of asymmetrical development have been noted in *I. nuneatonensis*, in every case affecting the posterior part of the exoskeleton. In the specimen illustrated on Plate 52, fig. 6 (GSM 50283), the axial ring and right-hand pleura of the last (twelfth) thoracic segment are free but the left pleura is fused with the

pygidium. This type of deformity has been illustrated in species of *Paradoxides* by Westergård (1936, pl. 8, fig. 4, and pl. 10). The pygidium of GSM JR3127, shown in Plate 52, fig. 11, and text-fig. 2a, has the second axial ring incompletely developed on one side (compare the occipital ring of *Rossaspis superciliosa* (Ross) illustrated in Harrington *et al.* 1959, fig. 82c, p. O110). It may be that the right-hand pleural part of this segment was not developed at all and that it is for this reason that the right pleural region of the pygidium is smaller than the left.

a

b
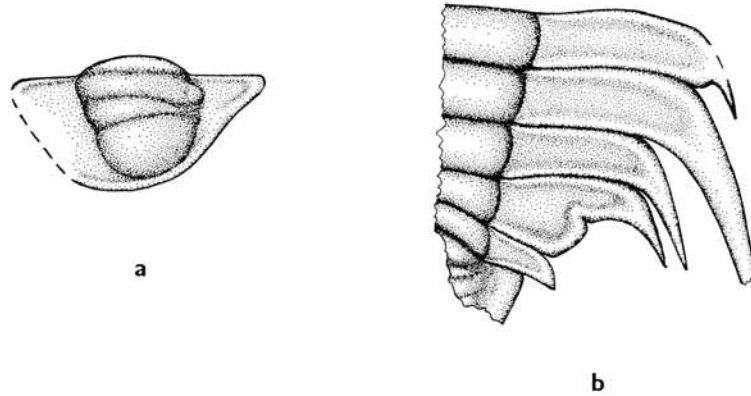
TEXT-FIG. 2. (*a*) Deformed pygidium of the specimen shown in Plate 52, fig. 11, GSM JR3127; (*b*) Deformed pleurae and pygidium, GSM JR3139. Both × 10.

The anterior part of the fragmentary thorax and pygidium (GSM JR3139) shown in text-fig. 2*b* is, so far as can be seen, quite normal, including the macropleural segment and the one posterior to it; the latter two segments are accordingly taken to be the eighth and ninth, as usual. The tenth segment presents the normal appearance along its anterior margin but the posterior margin is oblique to the sagittal line, the pleura being abnormally swollen behind the spine and the ring apparently longer on the right than on the left. The eleventh and final free thoracic segment is also oblique to the sagittal line and has an unusually short pleural spine. The anterior margin of what appears to be the pygidium is oblique and it seems that either the first or second of the four axial rings seen on the fragment preserved is imperfectly developed in a manner somewhat similar to the second axial ring of the pygidium shown in text-fig. 2a.

Although the specimen appears to have had only eleven free thoracic segments it is too large for this to be ascribed to immaturity, and it seems likely that the abnormalities in form and in number of the posterior thoracic segments are connected in some way. The right pleura attached to the tenth axial ring has the appearance of being composed of two ankylosed pleurae, presumably the tenth and eleventh; if so, the eleventh axial ring may also be fused with the tenth, and the segment corresponding to the twelfth in the normal thorax appears as the eleventh here. Alternatively, if the swelling on the tenth pleura is a pathological growth, it may be surmised that this displaced or distorted the eleventh segment somewhat and caused the right-hand pleura of the twelfth segment

to be suppressed altogether; in this case it would appear that the twelfth axial ring is fused with the pygidium.

Comparison with other species. *Irvingella nuneatonensis* is distinguished from the group of species separated by some authors as '*Parairvingella*' [*I. angustilimbata* Kobayashi, *I. convexa* (Kobayashi, not Ivshin), *I. megalops* (Kobayashi), *I. specioza* (Ivshin) and *I. tropica* Öpik] by the absence of a distinct anterior border and border-furrow in cranidia of mature specimens (more than 2·0 or 2·5 mm. long).

In *Irvingella major* Ulrich and Resser (see Palmer 1965, p. 48, pl. 6, figs. 9–15) the glabella is cylindrical and with a rounded front, not tapered and truncate anteriorly as in *I. nuneatonensis*, and it is more convex transversely; the eyes are longer with their anterior ends closer together, and (in large cranidia only) the interocular cheeks are narrower than half the glabellar width, not wider as in *I. nuneatonensis*.

The glabella of *I. flohri* Resser (see Palmer 1965, p. 47, pl. 6, figs. 16, 19, 20, 24) is much like that of *I. nuneatonensis* except that in the former the S2 furrows are obscure and S3 absent; in large cranidia the interocular cheeks are narrower.

Irvingella transversa Palmer (1965, p. 48, pl. 6, figs. 7, 8) has wider interocular cheeks than *I. nuneatonensis*; the glabella is not tapered, the eyes are longer and their anterior ends are further apart.

The glabella of *I. suecica* Westergård (1947, p. 16, pl. 3, figs. 1–3, 5?, 6?, not fig. 4) is less convex longitudinally and has weaker S2 furrows than those of *I. nuneatonensis*, and S3 are absent; the anterior border persists to a later stage of growth and the anterior margin appears not to bend abruptly down as it does in *I. nuneatonensis* and other species of the genus.

I. nuneatonensis differs from *I. convexa* Ivshin (1962, p. 54; not *Komaspis* (*Parairvingella*) *convexa* Kobayashi) by having a tapered glabella with S3 furrows present and wider cheeks. It differs also from *I. kassini* Ivshin (1962, p. 56) in having a tapered glabella with S2 and S3 present. The tapered glabella with S3 impressed likewise serves to separate it from the species *I. platycephala* described by Rusconi (1953).

Horizon and localities. The type-material was collected in 1886 by J. Rhodes from within the upper 250 ft. of the Outwoods Shales in Stockingford Railway Cutting, 1,200 yards N. 54° E. of St. Paul's Church, Stockingford, west of Nuneaton, Warwickshire (NGR SP3429.9207 or thereabouts); precise horizon uncertain. A few specimens of *Irvingella*, provisionally referred to *I. nuneatonensis* but with the diagnostic features not preserved, were collected by the writer in 1963 from a shallow excavation about 110 yards east by south of the Lodge in Parkhill Outwoods and 30 yards north of the Atherstone–Coleshill road (B4116), one mile south-west of Atherstone, Warwickshire (NGR SP2980.9654); the shale fragments were not definitely *in situ* but nevertheless probably came from the top 100 ft. of the Outwoods Shales.

The horizon is high in the *Olenus* Zone, not lower than the subzone of *Olenus dentatus* and quite probably higher.

The evidence both for the stratigraphical and zonal horizon given above is somewhat circumstantial and as the stratigraphical palaeontology of the Outwoods Shales has not been published the main points are stated below.

Illing (1913, p. 453) subdivided the 'Middle Stockingford' or 'Oldbury Shales' of Lapworth (1898, pp. 345–6) as follows:

Oldbury Shales
{
Monks Park Shales
Moor Wood Flags and Shales
Outwoods Shales
Abbey Shales
}

He published a map (Illing 1916, pl. 38) showing that the Outwoods Shales (which are somewhat over 1,000 ft. in thickness) crop out in Stockingford Railway Cutting. However, Mr. K. Taylor and I have noted fragments of the Moor Wood Flags at the extreme west end of this cutting. According to Lapworth (1898, pp. 346, 347) *Irvingella* [*Olenus*?] *nuneatonensis* was found at a somewhat higher horizon in Stockingford Cutting than '*Agnostus pisiformis* var. *sociale*' (= *Homagnostus obesus* Belt sp.); since I have collected the latter species from a few horizons in the cutting up to about 250 ft. stratigraphically below the base of the Moor Wood Flags, *I. nuneatonensis* was probably collected from this 250-ft. interval. As mentioned above, the specimens of *Irvingella* collected by the writer appear to have come from the upper 100 ft. of the Outwoods Shales.

The zonal arrangement applied to the early Upper Cambrian of north-west Europe is as follows (Westergård 1947, pp. 20, 21):

Zones	*Subzones*
Parabolina spinulosa with *Orusia lenticularis*	{ *P. spinulosa* *P. brevispina*
Olenus with *Homagnostus obesus*	{ *O. scanicus* with '*Polyphyma*' *angelini* *O. dentatus* *O. attenuatus* *O. wahlenbergi* *O. truncatus* } with *Glyptagnostus reticulatus* *O. gibbosus* } *reticulatus*
Agnostus pisiformis	——

I have detected the Subzones of *O. gibbosus*, *O. truncatus* and *O. wahlenbergi* in the Outwoods Shales and have found that the last of these is overlain at a horizon some 400 ft. below the base of the Moor Wood Flags by *Olenus cataractes* Salter accompanied by *Proceratopyge tullbergi* Westergård; the latter species is recorded by Westergård from the upper part of the Subzone of *O. dentatus* and by Tullberg from the Subzone of *Protopeltura aciculata* (= *Parabolina brevispina*; see Westergård 1947, p. 12). *I. nuneato-nensis* occurs at a substantially higher horizon than that with *P. tullbergi* and *O. cataractes*, and is accordingly thought to be either above the Subzone of *O. dentatus* or possibly within its upper part.

The Moor Wood Flags have yielded no fossils, but in the Geological Survey Merevale No. 1 Borehole the lower beds of the overlying Monks Park Shales were found to contain *Parabolina* cf. *brevispina* Westergård, with *P. spinulosa* (Wahlenberg) at a somewhat higher horizon, both species being associated with abundant specimens of *Orusia lenti-cularis* (Wahlenberg). *I. nuneatonensis* thus appears to occur below the Subzone of *P. brevispina*. This conclusion is not in conflict with the situation in Sweden for although Westergård (1947, p. 17) originally considered that *I. suecica* possibly came from a

horizon near the base of the *Peltura* Zones he was later able to show that a subzone below that of *Parabolina spinulosa* was more probable (Westergård 1949, p. 606).

Correlation. In North America, assemblages of trilobite genera are used to define the standard Cambrian zones, each of which is named after one of the included genera. The zones of the Upper Cambrian are as follows:

Zones	*Stages*
Saukia	Trempaleauan
Ptychaspis and Prosaukia ⎫	
Conaspis ⎬	Franconian
Elvinia ⎭	
Dunderbergia ⎫	
Aphelaspis ⎪	
Crepicephalus ⎬	Dresbachian
Cedaria ⎭	

Generally speaking there are so few genera of trilobites known from both Europe and the mid-continent regions of North America that correlation between the respective series of standard zones is quite uncertain. Palmer, however, has used the subspecies *Glyptagnostus reticulatus reticulatus* to correlate the lower part of the *Aphelaspis* Zone with the lower subzones of the *Olenus* Zone (Palmer 1962, text-fig. 9, p. 10). In his research on the trilobites from the Great Basin Region in the United States, Palmer (1965, text-fig. 15) showed that *Irvingella* first appears slightly above the base of the *Elvinia* Zone, having evolved from *Elviniella laevis* Palmer. He also showed that the successive species of *Irvingella* lose the distinct anterior border at successively earlier stages in ontogeny; thus *I. angustilimbata*, the only species to retain the anterior border in fully grown individuals, is confined to the lower part of the *Elvinia* Zone, and the other species (*I. major*, *I. flohri*, and *I. transversa*) appear only in the upper part. *I. nuneatonensis* is most similar to the species *I. major* and *I. flohri*, and probably developed directly or indirectly from *I. angustilimbata*; if so, it is certainly no older than *I. angustilimbata* and is probably of the same age as the species in the upper part of the *Elvinia* Zone, or a little younger. This suggests that the top of the *Elvinia* Zone is no higher than the top of the *Olenus* Zone, that is, somewhat lower than the position tentatively suggested by Palmer in his correlation table (1962, text-fig. 9, p. 10).

REFERENCES

HARRINGTON, H. J. *et al.* 1959. *Treatise on invertebrate paleontology, Part O.* Univ. Kansas Press, and Geol. Soc. Am.

ILLING, V. C. 1913. Recent discoveries in the Stockingford Shales near Nuneaton. *Geol. Mag.* **10**, 452–3.

ILLING, V. C. 1916. The Paradoxidian fauna of a part of the Stockingford Shales. *Q. Jl geol. Soc. Lond.* **71** [for 1915], 386–448, pl. 28–38.

IVSHIN, N. K. 1962. Upper Cambrian trilobites of Kazakhstan. Part II. *Inst. geol. Nauk, Akad. nauk Kazakhskoĭ SSR. Alma-Ata.* [In Russian.]

KOBAYASHI, T. 1954. On the Komaspidae. *Jap. J. Geol. Geogr.* **24**, 23–44, pl. 6.

LAKE, P. 1908. A monograph of the British Cambrian trilobites, Part 3. *Palaeontogr. Soc.* [*Monogr.*], 49–64, pl. 5, 6.

LAPWORTH, C. 1898. A sketch of the geology of the Birmingham District. *Proc. Geol. Ass.* **15**, 313–416, pl. 10–12.

LOCHMAN, C. 1953. Analysis and discussion of nine Cambrian trilobite families. *J. Paleont.* **27**, 889–96.

ÖPIK, A. A. 1961. The geology and palaeontology of the headwaters of the Burke River, Queensland. *Bull. Bur. Miner. Resour. Geol. Geophys. Aust.* **53**, 1–249, pl. 1–24.

—— 1963. Early Upper Cambrian fossils from Queensland. Ibid. **64**, 1–133, pl. 1–9.

PALMER, A. R. 1960. Trilobites from the Upper Cambrian Dunderberg Shale, Eureka District, Nevada. *Prof. Pap. U.S. geol. Surv.* **334-C**, 53–109, pl. 4–11.

—— 1962. *Glyptagnostus* and associated trilobites in the United States. Ibid. **374-F**, 1–49, pl. 1–6.

—— 1965. Trilobites of the Late Cambrian Pterocephaliid biomere in the Great Basin, United States. Ibid. **493**, 1–105, pl. 1–23.

RUSCONI, C. 1953. Siete especies de trilobitas del Cambrico de la Quebradita Oblicua sud del Cesso Aspero. *Boln Paleont. B. Aires*, **28**, 1–4.

RUSHTON, A. W. A. 1966. A monograph of the Cambrian Trilobites from the Purley Shales of Warwickshire. *Palaeontogr. Soc.* [*Monogr.*], 1–55, pl. 1–6.

SHARMAN, G. A. 1886. On the new species *Olenus Nuneatonensis* and *Obolella granulata*, from the Lower Silurian ('Cambrian', Lapworth), near Nuneaton. *Geol. Mag.* (3) **3**, 565–6.

STRAHAN, A. 1886. On the rocks surrounding the Warwickshire Coal-field, and on the base of the Coal-measures. Ibid. (3) **3**, 540–57.

STUBBLEFIELD, C. J. 1932. In *Mem. geol. Surv. Summ. Prog.* for 1931, 65.

WALCOTT, C. D. 1924. Cambrian geology and palaeontology V, No. 2, Cambrian and Lower Ozarkian trilobites. *Smithson. misc. Collns* **75** (2), 53–60, pl. 9–14.

WESTERGÅRD, A. H. 1936. *Paradoxides oelandicus* beds of Öland. *Sver. geol. Unders. Afh.*, Ser. C, **394**, 1–66, pl. 1–12.

—— 1944. Borrningar genom Skånes alunskiffer 1941–42. Ibid. **459**, 1–45, pl. 1–6.

—— 1947. Supplementary notes on the Upper Cambrian trilobites of Sweden. Ibid. **489**, 1–34, pl. 1–3.

—— 1949. On the geological age of *Irvingella suecica* Westergård. *Geol. För. Stockh. Förh.* **71**, 606.

A. W. A. RUSHTON
Institute of Geological Sciences,
Exhibition Road,
London, S.W. 7

Typescript received 18 June 1966
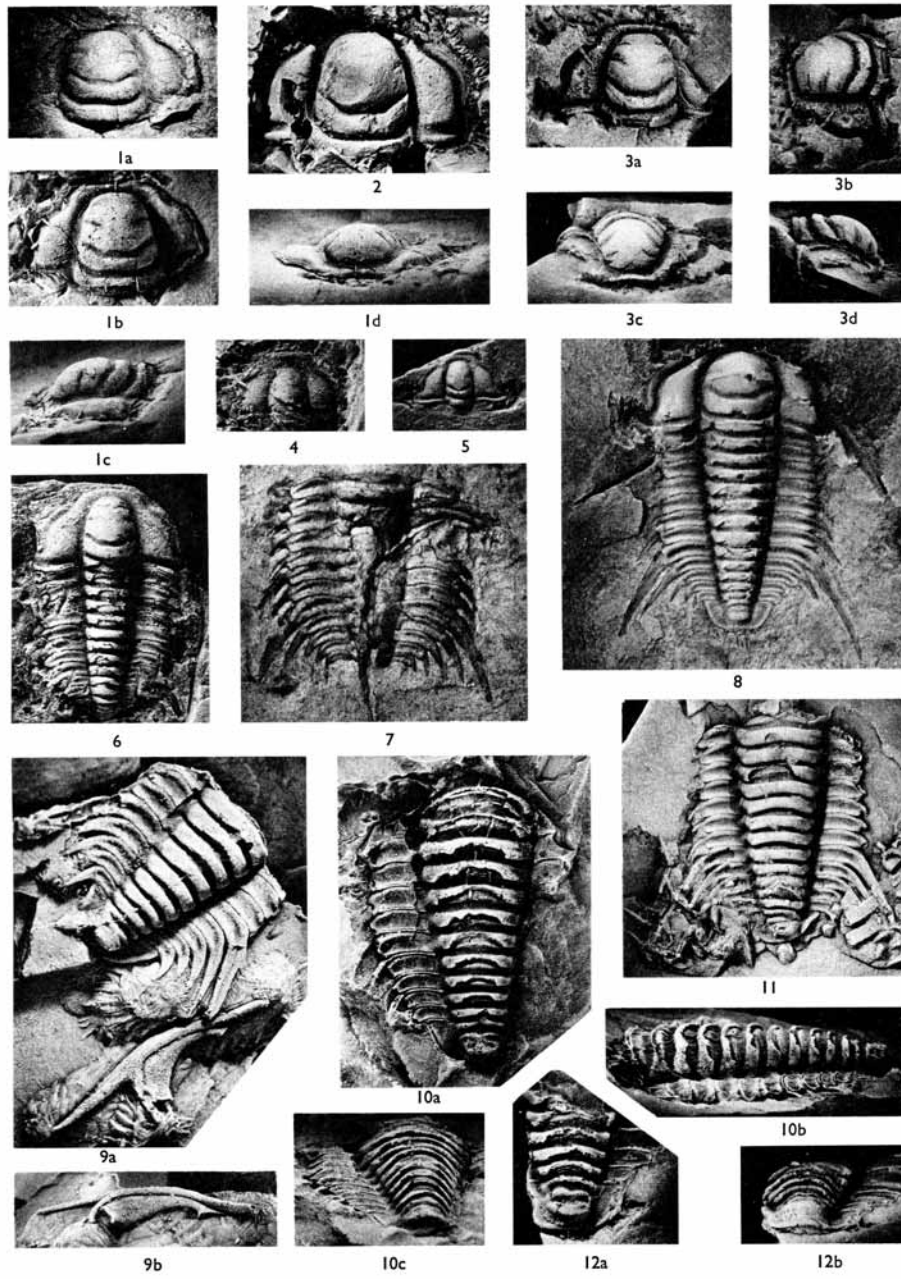
RUSHTON, Upper Cambrian trilobite *Irvingella nuneatonensis*