PHACOPID TRILOBITES FROM THE SILURIAN OF ARCTIC CANADA

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DIVERSE SILICIFIED trilobite faunas from the lower Wenlock to lower Ludlow of the Cape Phillips Formation, central Canadian Arctic, have been the subject of works by Perry and Chatterton (1977), Chatterton and Perry (1979), Adrain (1994), and Adrain and Edgecombe (1995, and in press). The present work describes a very minor component of these faunas, the family Phacopidae, which is nevertheless of considerable biogeographic interest.

Phacopids are exceedingly rare in the Silurian of northern Laurentia, and this work is the first record of their occurrence. While a mere two specimens are described, the material is of interest in that it reinforces an overall biogeographic contrast with the faunas of southern Laurentia, and includes a representative of what is possibly a new phacopid genus. Both of the specimens are from Wenlock-Ludlow sections on the south shore of Baillie-Hamilton Island (Figure 1). Comprehensive locality information has been given at length by Adrain and Edgecombe (in press), and will not be repeated herein. Details of occurrence are given with each species below. The graptolite zonation referred to is that established for the Wenlock of the Cape Phillips Basin by Lenz and Melchin (1990, 1991).

PALEOBIOGEOGRAPHY

As outlined by Adrain and Edgecombe (in press; see also Rigby and Chatterton, 1989, for sponges), the Silurian trilobite faunas of northern Laurentia differ markedly in generic and familial diversity from those of that portion of the paleocontinent south of the transcontinental arch. For example, dalmantids, acastines, homalonotids, and staurocephalids are all present, and sometimes common, in southern Laurentia, but have not been reported from northern Laurentia. In contrast, aulacopleurines, pyrgometopids, koneprusines, and coronoccephalines are known from the northern Laurentian Silurian, but have yet to be documented from southern Laurentia. The situation is even more pronounced at the generic level, whereby families or subfamilies that occur in either region are often represented by entirely different and mutually exclusive occurrences of genera.

The Phacopidae represent a third pattern, in which genera are shared between the regions, but are overwhelmingly more common in one or the other. Phacopids are widespread, common, and diverse in southern Laurentia, but the present work is the first record of the family from northern Laurentia, beyond an undocumented Llandover occurrence of Acernaspis from the Mackenzie Mountains, Northwest Territories (B. D. E. Chatterton, personal commun. in Ramsköld and Werdelin, 1991, p. 63). Further, although the genus to which one of the species belongs, Eophacops, is represented in southern Laurentia, the species has its closest comparison with a taxon from Baltica.

Other groups that have established relative occurrences similar to the phacopids include, for example, Encrinurus sensu strictu, which is very common in southern Laurentia (e.g., Gass et al., 1992; Edgecombe and Chatterton, 1993), but known from only two species in northern Laurentia (Edgecombe and Chatterton, 1993). Similarly, the otarionine Maurotarion (sensu Adrain and Chatterton, 1995) is the most common aulacopleurid in the southern Laurentian Silurian, but is represented by a single species, M. messieri Adrain and Chatterton, 1995, in northern Laurentia.

![Figure 1 — Map of central Canadian Arctic showing geographic position of sections BH 1 and BH 2 ("BH") on the south shore of Baillie-Hamilton Island. Dashed line indicates position of facies change from platform carbonates to the southeast to basinl graptolitic shales to the northwest. For comprehensive locality details, including detailed locality maps, stratigraphic columns, and graptolite zonation, see Adrain and Edgecombe (in press).](image-url)
SYSTEMATIC PALEONTOLOGY

Repository.—Figured specimens are housed in the collections of the Department of Invertebrate Paleontology, Royal Ontario Museum, Toronto, with prefix ROM.

Order PHACOPIDA Salter, 1864
Suborder PHACOPINA Salter, 1864
Family PHACOPIDAE Hawle and Corda, 1847
Subfamily PHACOPODEA Hawle and Corda, 1847

Discussion.—The phylogenetic history of the subfamily has been construed (Campbell, 1967, text-fig. 6; 1975, 1977, text-fig. 4) as a gradation along a main line of descent, within which the genera recognized were considered inevitably paraphyletic or even polyphyletic (Campbell, 1977, p. 27). Ramsköld and Werdelin (1991) have made the first concerted effort at cladistic analysis of the group. Their study included all known Silurian species traditionally assigned to Phacopinae, in an attempt to find phylogenetic structure based upon synapomorphy. While much more information about Silurian, and particularly Wenlock, members of the group is required, we follow Ramsköld and Werdelin's (1991) hypotheses as an important step in assessing ingroup phacopine structure.

Following Delo (1935), many workers have recognized a subfamily Phacopidellinae, generally considered to include only Eophacops, Phacopidea, and sometimes Denckmannites (see Ramsköld and Werdelin, 1991). Analysis of the subfamilial structure of Phacopidae is beyond the scope of this work, but given Campbell's (1967, 1977) suggested origin of Eophacops and Phacopidea within an expressly paraphyletic Aecernaspis together with the small morphological differences between the groups, the Phacopidellinae is not recognized herein.

Genus EOPHACOPS Delo, 1935

Type species.—Phacops handwerki Weller, 1907, Niagaran dolomites, Wenlock, Chicago Drainage Canal, Lemont, Illinois.

Discussion.—Eophacops has yet to be adequately characterized in terms of its synapomorphies, although Ramsköld and Werdelin (1991, p. 61, point 2) have asserted that the taxon is "... monophyletic, defined by a large number of characters at the basal node." This assessment is accepted herein. Support for the "large number of characters" alluded to by Ramsköld and Werdelin has not been published, but Ramsköld (personal commun.) has indicated some potential apomorphies of Eophacops, and these are given under discussion of the species below.
Eophacops sp.
Figure 2.1, 2.4, 2.6

Description.—Cephalon with very finely tuberculate sculpture, densest on glabella; anterior border furrow expressed as very shallow groove abaxially, completely effaced medially; anterior of glabella with gentle anterior slope in sagittal profile; glabella relatively low and only moderately vaulted in transverse profile; vaulting and slope lessen across and anterior to area of maximum glabellar width; distal part of S3 defines subtriangular anterolateral corners of glabella; axial furrows wide (tr.), moderately deep, diverging anteriorly at 19 degrees from sagittal line; distal part of S3 declined 52 degrees from sagittal line, wide (obliquely) and deep, posteriorly does not reach exaxial line defined by abaxial end of proximal part, merges anteriorly with axial furrow at anterior edge of palpebral lobe; proximal part of S3 considerably shallower than distal part; short (exsag.) and incised, adaxial even end (exsag.) with adaxial end of S2, and with moderate anterior convexity; S2 about 80 percent width (tr.) of S3, similar in depth, and with weaker anterior convexity; both S2 and proximal part of S3 set off from glabella by weak anterior rims; palpebral furrow deep, defining kidney-shaped palpebral lobe; posterior border furrow deeper, longer (exsag.), than distal part of S3, running laterally into much shallower lateral border furrow; genal angle subangular in plan view, rounded in lateral view; posterior fixigena very short (exsag.); behind eye; posterior branch of facial suture with strong anterior convexity, contacting lateral margin of lateral border directly opposite posterior border furrow; librigenal field relatively broad, with sculpture of very fine caecal pits; lateral border furrow wider (tr.) on librigena than on posteroventral part of cranidium; eye with height approximately half length (exsag.); lenses (right eye) arranged in 17 files, minimum number in each file one, maximum five, total lenses 56, lens formula: 334 454 444 433 332 21; vinctural furrow obscured postventrally by debris, present as shallow groove on anterolateral margin, shallowing to short (sag.; exsag.) line, complete medially.

Discussion.—The specimen is assigned to Eophacops on the basis of the deeply incised distal part of S3, the confluence of S3 with the axial furrow, the indentation of the lateral glabellar margin at this confluence, the significant adaxial extent of the forward part of the palpebral lobe (protruding across the axial furrow and interrupting the glabellar margin), and finally the fan-shaped aspect of the frontal glabellar lobe in plan view. The morphology of the vinctural furrow is incompletely known, as this feature is almost entirely obscured postventrally by silicified debris. From what little is visible, however (Figure 2.4), it appears that vinctural notches are absent, in agreement with almost all species of Eophacops.

The Arctic species is most similar to the Baltic Ludlow Eophacops lauensis Ramsköld, 1985, from the Eke and Hamra Beds of Gotland, Sweden. The species are united particularly by the similar width, depth, and spacing of S2 and S3. They differ in the narrower glabellar frontal lobe of the Canadian species, its less anteriorly divergent axial furrows, its smaller eyes and concomitantly larger librigenal field, and its less laterally convex palpebral lobe. Eophacops sp. also resembles the southern Laurentian Wenlock E. fontana Holloway, 1980, from the St. Clair Limestone of Arkansas. This species is known mainly from exfoliated material, but again the glabellar furrows are similarly expressed. Eophacops fontana differs from the Canadian species in its shallower S2, less prominently incised distal part of S3, slightly larger eyes, and particularly in its vinctural furrow, which is anteriorly broader and deeper, as opposed to the reduction of this feature to a narrow lineation sagittally.

Material.—Cephalon, ROM 51305, from section BH 1 204 m, Cape Phillips Formation, Wenlock (upper Sheinwoodian; Cyrtograptus perner-Monograptus opimus Zone), southern Baillie-Hamilton Island, central Canadian Arctic.

Phacopid genus indet.
Figure 2.2, 2.3, 2.5, 2.7, 2.8

Description.—Glabella with maximum width 82 percent sagittal length excluding L0; anterior of glabella even with anterior cephalic margin; anterior and anterolateral margins of glabella vaulted, slope gentler (sag.; exsag.) between highest glabellar level in vicinity of S3 and margins; axial furrow wide (tr.) and relatively shallow, diverging at 17 degrees from exsagittal line, merging anterior with distinct but extremely shallow lateral border furrow; distal part of S3 deep, declined 34 degrees from exastral line, adaxial even (tr.) with anterior extent of palpebral furrow; proximal part of S3 wholly effaced; S2 shallow, incised, and anteriorly convex; S1 transverse, long (exsag.), and deep; L1 lower than L2, nearly confluent with intercalating ring, abaxial margin rounded; S0 transversely straight, very short (sag.; exsag.), moderately deep, yielding to deeper portion behind L1; L0 highest sagittally at posterior (height subequal to maximum glabellar height), slopes anteriorly with gentle dorsal convexity to S0, with more rounded dorsal convexity exaxially; L0 forms semicircular arch (tr.) medially, more gently sloped behind L1, longest (sag.; exsag.) medially, tapering to two thirds length laterally; posterior border furrow long (exsag.), straight (tr.), merges with very broad, shallow lateral border furrow; genal angle rounded; posterior branch of facial suture with prominent posterior embayment behind eye, posterior of eye set far behind anterolateral extent of suture; palpebral furrow very shallow; palpebral lobe wider (tr.) posteriorly, describing half-teardrop shape, with very faint secondary furrow running dorsally subparallel with lateral margin; lateral border wide and flattened; lateral border furrow extremely shallow; librigenal field very narrow, developed only on opposite posterior part of eye; eye with maximum height 63 percent of length (exsag.); lenses with 20 files, 114 lenses in total, lens formula: 345 676 777 767 665 655 5; doublure long (exsag.) anteriorly; vinctural furrow without notches, wide (tr.) and deep, shallowing slightly posteriorly and anteriorly becoming very shallow and short (exsag.) line along margin; posterior branch of facial suture posteriorly convex on doublure, with apex posterior of posterior border furrow.

Discussion.—The morphology of this fragmentary cephalon is so unusual that its relationship to established Silurian phacopid clades is ambiguous. The closest comparison is perhaps with Eophacops. The Arctic taxon lacks notches in its vinctural furrow, similar to the majority of species of Eophacops, and also shares with that genus a deeply incised distal part of S3 that is confluent with the axial furrow (Figure 2.2). However, the lack of definition of the intercalating ring, which is essentially laterally confluent with L1, is a very unusual feature in a phacopid. Further, the frontal glabellar lobe is not fan-shaped as in most Eophacops; it also bears faint but large tubercules, completely unknown in Eophacops, and the anterior edge of the palpebral lobe does not intrude on the lateral glabellar margin as it does in Eophacops. In addition, several species of Eophacops show effacement of the glabellar furrows, but typically S2 and the proximal part of S3 are of similar depth, whether effaced or not. In the Arctic species, the proximal part of S3 is completely effaced, whereas S2 is retained as a fairly deep furrow. The only species of Eophacops that shows differential effacement of these furrows is the contemporaneous E. trapeziceps (Barrande, 1846), from the upper Wenlock of the Czech Republic, but that species is otherwise a typical member of the genus and differs from the Canadian taxon in the features listed above. It seems likely that the Arctic species represents a new phacopid.
genus, naming of which must await the discovery of adequate material.

Material.—Fragmentary cephalon, ROM 51306, section BH 2 3 m, Cape Phillips Formation, Wenlock (Homerian; 
Cyrtograpthus undgreni-Monograptus tests Zone), southern Baillie-
Hamilton Island, central Canadian Arctic.

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