Furongian Series (Cambrian) biostratigraphy of Scandinavia – a revision

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The Furongian Series (Cambrian) biostratigraphy of Scandinavia is revised. We propose a two-fold trilobite zonation based on agnostoids and polymerids respectively. The agnostoid zonation includes four zones, in ascending order: the *Glyptagnostus reticulatus, Pseudagnostus cyclopyge, Lotagnostus americanus,* and the *Trilobagnostus holmi* Zone. The polymerid zonation includes 28 zones, in ascending order: the *Olenus gibbosus, O. truncatus, O. wahlenbergi, O. attenuatus, O. dentatus, O. scanicus, Parabolina brevispina, P. spinulosa, Leptoplastus paucisegmentatus, L. raphidophorus, L. crassicornis, L. ovatus, L. stenotus, L. neglectus, Ctenopyge postcurrens, C. flagellifera, C. similis, C. spectabilis, C. tumida, C. affinis, C. bisulcata, C. linnarssoni, Parabolina lobata, Peltura paradoxa, P. transiens, P. costata, Westergaardia scanica,* and the *Acerocare ecorne* Zone. Traditional subzones are elevated to zonal status and modified by definition to become interval-zones. The traditional 'superzones' are abandoned. Each of the biozones, as now defined, is delimited at the base by the first appearance of the eponymous species, and delimited at the top by the base of the overlying zone.

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Introduction

The Cambrian System is currently undergoing substantial revisions with regards to its biostratigraphy and chronostratigraphy. This is evident in the recent ratification of the Cambrian Furongian Series, the Paibian Stage (Peng et al. 2004), the Drumian Stage (Babcock et al. 2004, 2007), and international agreement on a chronostratigraphic framework comprising four series and ten stages, as opposed to the traditional tripartite subdivision (Fig. 1; Babcock et al. 2005; Peng et al. 2006; Zhu et al. 2006). The overall program of the International Subcommission on Cambrian stratigraphy is to develop a global stage-level chronostratigraphic framework for the whole Cambrian System. This is welcome but obviously requires that regional stratigraphic schemes (Babcock et al. 2007) be revised.

The traditional upper Cambrian biostratigraphy of Scandinavia suffers from the lack of designated reference sections, properly defined boundaries, consistent terminology, together with a mixture of taxon-range zones and local abundance (acme) zones. For these reasons, we aim to revise the Furongian biostratigraphy of Scandinavia and tie it to the global chronostratigraphic subdivision scheme as closely as possible. Ideally, we would like to establish a system that can be used for correlation anywhere, not just in the region where it was developed, as is the case now. To achieve this, simplicity is one goal and internal consistency another. Improvements to the biostratigraphic zonation scheme, which will enhance ties to global chronostratigraphic correlation schemes, include separation of agnostoid zones from polymerid zones, designation of biozones based on species rather than genera, and the designation of zonal bases using the first appearance datum (FAD) points of species, the top of each zone being automatically defined by the base of the overlying zone.

Geology and stratigraphy

The Cambrian of Scandinavia is exposed in several regions from northern Norway to the island of Bornholm, Denmark, in the south (for general reviews, see Martinsson 1974 and Bergström & Gee 1985). The lower part of the Cambrian (Terreneuvian Series through provisional Series 2) consists predominantly of shallow marine sandstones, whereas Series 3 ("middle Cambrian") and Furongian strata are largely represented by the Alum Shale Formation, a succession of dark grey to black shales and limestones. The Cambrian Series 3 through lower Tremadocian Alum Shale Formation (see Gee 1972; Buchardt et al. 1997; Nielsen & Schovsbo 2006) of Scandinavia is condensed and the net rate of sedimentation low, of the order of 1–10 mm/1000 years (e.g. Thickpenny 1984, 1987). Parallel laminations and lack of sedimentary structures typical of tidal and shallow marine environments suggest that most deposition took place below the storm-wave base. Locally, however, deposition was affected by currents (e.g. Dworatzek 1987; Eklöf et al. 1999; Terfelt 2003), suggesting the pres-

SYSTEMS	SERIES	STAGES	BOUNDARY HORIZONS (GSSPs) or provisional stratigraphic tie points
Ordovician	Lower	Tremadocian	FAD of *Iapetognathus fluctivagus* (GSSP)
CAMBRIAN	Furongian Series	Cambrian Stage 10 (Undefined)	FAD of *Lotagnostus americanus*
		Cambrian Stage 9 (Undefined)	FAD of *Agnostotes orientalis*
		Paibian Stage	FAD of *Glyptagnostus reticulatus* (GSSP)
	Cambrian Series 3 (Undefined)	Cambrian Stage 7 (Undefined)	FAD of *Lejopyge laevigata*
		Drumian Stage	FAD of *Ptychagnostus atavus* (GSSP)
		Cambrian Stage 5 (Undefined)	?FAD of *Oryctocephalus indicus*
	Cambrian Series 2 (Undefined)	Cambrian Stage 4 (Undefined)	?FAD of *Olenellus* or *Redlichia*
		Cambrian Stage 3 (Undefined)	FAD of trilobites
	Terreneuvian Series	Cambrian Stage 2 (Undefined)	?FAD of SSF or archaeocyathan species
		Fortunian Stage	FAD of *Trichophycus pedum* (GSSP)
Ediacaran			

Fig. 1. Stratigraphic chart showing the working model for global chronostratigraphic subdivision of the Cambrian System with the Furongian Series, being of primary interest in this study, shaded gray (modified from Babcock et al. 2007). SSF = small shelly fossils. FAD = first appearance datum.

ence of intrabasinal highs. The lithological homogeneity and large aerial extent of the alum shale facies indicate a fairly uniform depositional environment in a broad, sediment-starved epicontinental sea that covered much of the present western part of Baltica (e.g. Thickpenny 1987). The last decades have witnessed major efforts to increase knowledge about the biostratigraphy of the Cambrian part of the Alum Shale Formation (e.g. Bergström & Gee 1985; Ahlberg 2003; Terfelt 2003; Terfelt et al. 2005; Lauridsen & Nielsen 2005; Ahlberg et al. 2006; Axheimer et al. 2006).

The thickest and stratigraphically most complete successions of the Alum Shale Formation are found in Scania (Skåne), in southernmost Sweden, and in the Oslo region of Norway (Fig. 2A; Buchardt et al. 1997, fig. 2). In these areas alum shales were largely deposited in outer shelf settings, and are up to c. 100 m thick. In other parts of southern Scandinavia, the Alum Shale Formation is considerably thinner and several stratigraphical gaps of various magnitudes occur within the succession (e.g. Martinsson 1974).

Traditional upper Cambrian biozonation of Scandinavia

The traditional upper Cambrian (from the base of the *Agnostus pisiformis* Zone to the top of the *Acerocare* Zone) biozonation of Scandinavia was based largely on successions of agnostoid and polymerid trilobites at Andrarum (Westergård 1922, 1944, 1947). This biozonation included six trilobite-based zones and 24 subzones (Fig. 3; Westergård 1947). Subsequently, Henningsmoen (1957) revised the zonation, adding data from the Oslo

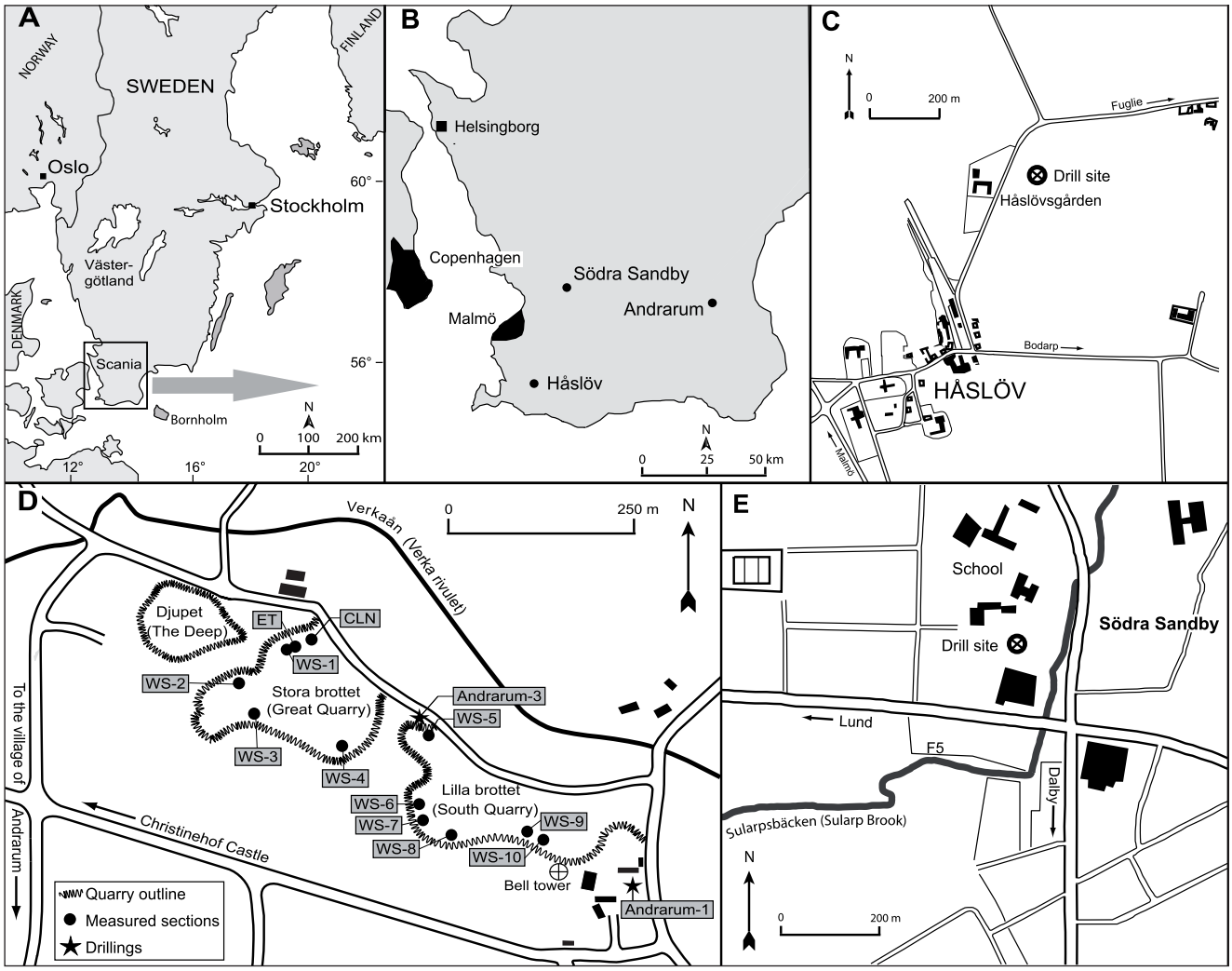

Fig. 2. A, Orientation map of southern Scandinavia. B, Map of Skåne (Scania), the southernmost province of Sweden, showing the location of Södra Sandby, Håslöv, and Andrarum. C, Detailed map showing the location of the drill site of the Håslöv-1 core (Terfelt et al. 2005). D, Detailed map showing the Andrarum quarries and the location of the reference sections; Westergård's (1922) sections 1-10 (abbreviated WS-1 to 10), additional sampled sections, and drill core locations. The Andrarum-1 core was described by Westergård (1944), and the Andrarum-3 core was described by Eriksson & Terfelt (2007) and Ahlberg et al. (in press). The ET section (Fig. 2D) was described by Eriksson & Terfelt (2007), and the CLN section was described by Clarkson et al. (1998a) and Lauridsen & Nielsen (2005). The section of Ahlberg et al. (2006) is the same as section 6 of Westergård (1922); WS-6. Note that the Andrarum-2 borehole, ca 500 m SE of Christinehof Castle (Westergård 1944), is outside the map area. E, Detailed map showing the Södra Sandby area and the location of locality F5 of Moberg (1896) and the location of the drill site of Westergård (1944).

region, Norway, and subdivided the traditional upper Cambrian of Scandinavia into eight zones and 32 subzones (Fig. 3). Nielsen & Schovsbo (1999) rejected three of Henningsmoen's subzones, the *Leptoplastus crassicornis, Protopeltura broeggeri*, and *P. holtedahli* zones (see also Bergström and Gee 1985, p. 254). Nielsen and Schovsbo (1999) did not recognize the presence of the *L. crassicornis* Subzone in the Oslo region. This subzone was, however, recorded by Ahlberg et al. (2006) at Andrarum and therefore reintroduced into the biozonation scheme of Scandinavia. *Protopeltura broeggeri* was shown to be restricted to the *Leptoplastus* Zone and *P. holtedahli* was shown to be a possible junior synonym of *P. aciculata* (Nielsen & Schovsbo 1999). After these amendments, the traditional upper Cambrian biozonation included eight zones and 29 subzones (Fig. 3; Ahlberg 2003). However, with the establishment of the Furongian Series, the base of which coincides with the FAD of *Glyptagnostus reticulatus* Angelin, 1851 (Peng & Babcock 2003; Peng et al. 2004), the *A. pisiformis* Zone became the uppermost zone in the Scandinavian middle Cambrian instead of the lowermost zone of the upper Cambrian. Hence, the Furongian biozonation of Scandinavia, following ratification of the Furongian Series (and Paibian Stage) GSSP (Peng et al., 2004), includes seven zones and 28 subzones (Ahlberg et al. 2006).

In Scandinavia, the base of the Furongian Series coincides with a major change in trilobite faunas (Eriksson & Terfelt 2007). Cambrian Series 3 faunas are replaced by faunas dominated by species of the family Olenidae. Species turnover rate was high. There are never more than

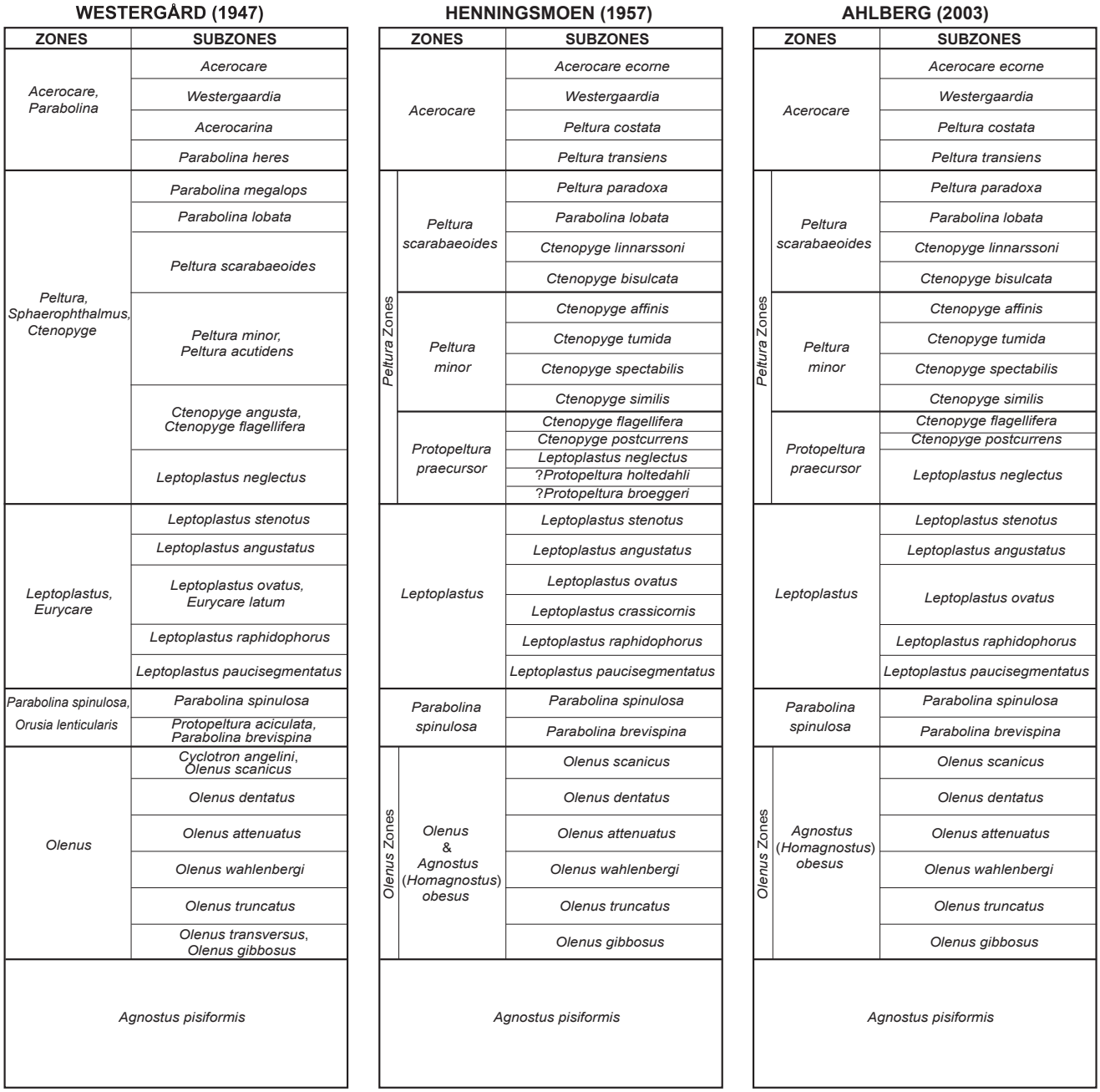

Fig. 3. Different views of the upper Cambrian biozonation of Scandinavia listed for comparison.

three co-occurring trilobite genera and the assemblages are often monospecific (e.g. Clarkson & Taylor 1995a). In addition to the abundance of trilobites at many levels, brachiopods [in particular the benthic orthide *Orusia lenticularis* (Wahlenberg, 1818)], conodonts (including protoconodonts and paraconodonts), and non-trilobite arthropods, such as phosphatocopines and minute phosphatised crustaceans, are also common at certain intervals, particularly in the stinkstone concretions (e.g. Müller & Walossek 1985; Müller & Hinz 1991; Szaniawski & Bengtson 1998; Maas et al. 2003; Eriksson & Terfelt 2007).

The Andrarum succession

The Forsemölla-Andrarum district of south-eastern Scania, southern Sweden, is a classic lower Paleozoic outcrop area in Baltoscandia. The undeformed and continuous Cambrian Series 3 through the Furongian succession is best exposed in the old quarries at Andrarum (Figs. 2D, 4). The three main alum shale workings extend from NW to SE, and because the strata dip gently towards the SE, virtually the whole provisional Stage 7 through the Furongian Series succession is present within the quarry area (cf. Moberg 1910). Except for a few intervals, the strata are richly fossiliferous with a trilobite-dominated

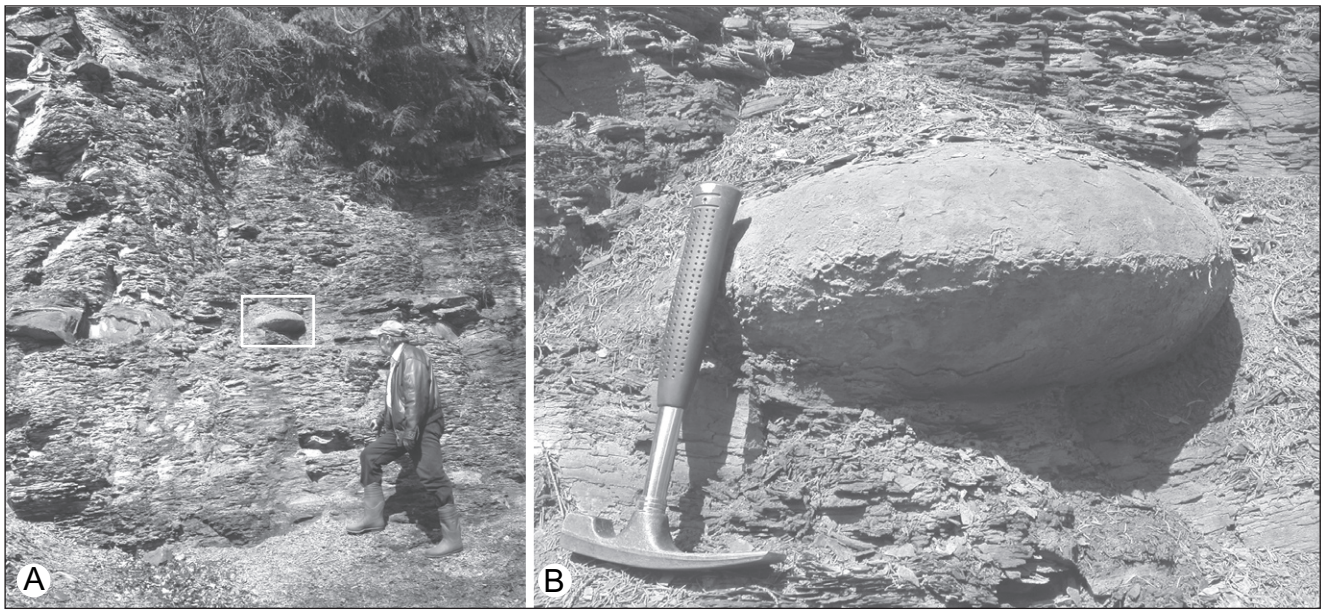

Fig. 4. Photographs showing the Alum Shale Formation in the Great Quarry at Andrarum, Scania, southern Sweden. A. Overview of a section through the upper Cambrian Provisional Series 3–lower Furongian alum shales in the northeastern part of the quarry. B. Close-up of the stinkstone (orsten) lens framed in A.

fauna (e.g. Moberg 1910; Westergård 1922, 1944). Fossils are generally abundant both in the shale and the stinkstone, although they are considerably better preserved in the latter. Stratigraphically, the exposed Andrarum succession spans the middle Cambrian *Lejopyge laevigata* Zone through the middle part of the Furongian *Peltura scarabaeoides* Zone. The best exposure is in the north-central part of the Great Quarry (Figs. 2D, 4).

In addition to the exposed strata, three core drillings have been made in the area (Fig. 2D); Andrarum-1 and Andrarum-2 were drilled in 1941–1942 (Westergård 1942, 1944) and Andrarum-3 was drilled in 2004 (Eriksson & Terfelt 2007; Ahlberg et al. in press). These cores have shown that the Alum Shale Formation in the Andrarum area has a thickness of at least 76 m. Of this succession, approximately 24 m belong to Cambrian Series 3, 44 m belong to the Furongian, and more than 8 m belong to the Lower Ordovician (Tremadocian Stage) *Dictyonema* Shale. The Andrarum-1 and 2 cores of Westergård (1944) are unfortunately no longer available. The Andrarum-3 core was taken at the South Quarry (Fig. 2D). It is 32.35 m long (2.40–34.75 m below ground level) and has a diameter of 70 mm. It comprises a succession from the Furongian (*Parabolina brevispina* Zone as recognized here) down into the Drumian Stage *Ptychagnostus atavus* Zone (Ahlberg et al. in press).

Pioneer Cambrian investigations in the Forsemölla-Andrarum district were carried out by, among others, Nathorst (1869, 1877), Tullberg (1880), and Linnarsson (1880, 1883), followed by more detailed studies by others including Persson (1904) and Westergård (1922, 1942, 1944). More recent investigations include those of Bergström & Ahlberg (1981), Clarkson & Taylor (1995b), Clarkson et al. (1998a, b), Lauridsen & Nielsen (2005), Terfelt (2006), Ahlberg et al. (2006), Eriksson & Terfelt (2007), and Ahlberg et al. (in press).

Proposed Furongian biozonation of Scandinavia

In order to maximize the ability to compare the Furongian biostratigraphy in Scandinavia with that of other areas in the world, and to minimize the ambiguity of the biozonation system, three main changes have been introduced: 1, agnostoid zonation has been separated from polymerid zonation; 2, biozone names have been based on species (rather than genera) and subzones based on polymerids have been elevated from subzonal to zonal status; 3, only the bases of zones (interval-zones) have been defined using the first known appearances of eponymous taxa. This technique of defining only the base of a zone, the top being automatically defined by the base of the overlying zone, follows in principle the boundary-stratotype concept used in chronostratigraphy (Salvador 1994). It also reflects recent practice in other areas of the world where boundary-stratotypes have been defined (e.g., Peng et al., 2004; Babcock et al., 2005, 2007). In the list below all reference sections refer to Andrarum, Scania, unless stated otherwise.

Agnostoid zonation

A separate zonal scheme based on agnostoid trilobites in the Furongian has not previously been applied in Scandinavia. The main reasons for this are that agnostoids

Series	Agnostoid trilobites ZONES	Polymerid trilobites ZONES
FURONGIAN	*Trilobagnostus holmi*	*Acerocare ecorne*
		Westergaardia scanica
		Peltura costata
		Peltura transiens
		Peltura paradoxa
		Parabolina lobata
		Ctenopyge linnarssoni
		Ctenopyge bisulcata
	Lotagnostus americanus	*Ctenopyge affinis*
		Ctenopyge tumida
		Ctenopyge spectabilis
	Pseudagnostus cyclopyge	*Ctenopyge similis*
		Ctenopyge flagellifera
		Ctenopyge postcurrens
		Leptoplastus neglectus
		Leptoplastus stenotus
		Leptoplastus ovatus
		Leptoplastus crassicornis
		Leptoplastus raphidophorus
		Leptoplastus paucisegmentatus
		Parabolina spinulosa
		Parabolina brevispina
	Glyptagnostus reticulatus	*Olenus scanicus*
		Olenus dentatus
		Olenus attenuatus
		Olenus wahlenbergi
		Olenus truncatus
		Olenus gibbosus
CAMBRIAN SERIES 3	*Agnostus pisiformis*	

Fig. 5. The Furongian Series biozonation of Scandinavia as proposed in this paper.

become rare above the lowermost Furongian (Ahlberg, 2003), and also because the development of a global agnostoid zonation for the Furongian has not been a priority until recently. We propose a division of the Furongian into four agnostoid interval-zones. In ascending order these are the *Glyptagnostus reticulatus, Pseudagnostus cyclopyge, Lotagnostus americanus,* and *Trilobagnostus holmi* zones (Fig. 5). Each of the agnostoid biozones is delimited at the base by the first appearance of the eponymous species, and delimited at the top by the base of the succeeding zone.

1. *Glyptagnostus reticulatus Zone*

Boundaries: The base of the Scandinavian *Glyptagnostus reticulatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Pseudagnostus cyclopyge* Tullberg, 1880. The *G. reticulatus* Zone corresponds to the *Olenus gibbosus* through the *O. scanicus* polymerid zones as recognized here. *Glyptagnostus reticulatus* occurs in the lowermost three of these polymerid zones (Fig. 5).

Characteristics: The *G. reticulatus* Zone is characterized by the eponymous species that occurs in low to moderate abundance in the lower part of the zone. Its FAD is approximately coeval to that of *Agnostus (Homagnostus) obesus* (Belt, 1867) and *O. gibbosus* (Wahlenberg, 1818) (Eriksson & Terfelt 2007; see also below). For a record of zonal taxa, see the polymerid zonation below.

Reference section: Section of Clarkson et al. (1998*a*) and Lauridsen & Nielsen (2005); CLN in Fig. 2D.

Remarks: During an investigation by Eriksson & Terfelt (2007) and Ahlberg et al. (in press) it was noted that both *A. (H.) obesus* and *O. gibbosus* appear about 5 cm below the FAD of *G. reticulatus* (see also Lauridsen & Nielsen 2005, text-fig. 8) at Andrarum. This succession of taxa was also observed in Västergötland (Terfelt 2003). However, due to the relatively rare occurrences of *G. reticulatus* and because its FAD is close to the FAD of the abundant *O. gibbosus* and *A. (H.) obesus,* the FAD of these species can be treated as essentially contemporaneous (see also Rushton 1978, 1983). Westergård (1947) recorded large *Glyptagnostus* specimens with exceptionally dense patterns of reticulate furrows in the *O. wahlenbergi* Zone at Andrarum and assigned them to *G. reticulatus nodulosus*. It has, however, been shown that the degree of reticulation varies both with ontogeny and stratigraphy (Peng & Robison 2000, and references therein; Peng et al., 2004). Because of the absence of other morphological characters differentiating *G. r. reticulatus* and *G. r. nodulosus*, we follow Peng & Robison (2000) in not applying the subspecies names. *Glyptagnostus reticulatus* is a species with a nearly cosmopolitan distribution.

2. *Pseudagnostus cyclopyge* Zone

Boundaries: The base of the *Pseudagnostus cyclopyge* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Lotagnostus americanus (*Billings, 1860). The *P. cyclopyge* Zone corresponds to the *Parabolina brevispina* through the *Ctenopyge similis* polymerid zones as recognized here. *Pseudagnostus cyclopyge* occurs in the lowermost of these polymerid zones (Fig. 5).

Characteristics: The *P. cyclopyge* Zone is characterized by the eponymous species, which occurs only in the lowermost part of the zone (Ahlberg 2003). For a record of zonal taxa, see the polymerid zonation (*Parabolina brevispina* to *Ctenopyge similis* zones) below.

Reference sections: Sections 3–10 of Westergård (1922, p. 19–22).

Remarks: Pseudagnostus cyclopyge has been recorded from Scandinavia and the United Kingdom. Moreover, specimens assigned to *P. cyclopyge* were described from the Rabbitkettle Formation (Furongian Series: Paibian Stage) in the southern Mackenzie Mountains, Canada (Pratt 1992).

3. The *Lotagnostus americanus* Zone

Boundaries: The base of the *Lotagnostus americanus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Trilobagnostus holmi* (Westergård, 1922). The *L. americanus* Zone corresponds to the *Ctenopyge spectabilis* through *Ctenopyge linnarssoni* polymerid zones (Fig. 5) as revised here. *Lotagnostus americanus* occurs in all these polymerid zones.

Characteristics: The *L. americanus* Zone is characterized by the eponymous species, which occurs infrequently through the entire zone (Westergård 1922, 1944; Ahlberg 2003). For a record of zonal taxa, see the polymerid zonation (*Ctenopyge spectabilis* to *C. linnarssoni* zones) below.

Reference section: Section 10 of Westergård (1922, p. 21–22).

Remarks: The specimens of *L. americanus* from Sweden were described by Westergård (1922) as belonging to *Agnostus* (=*Lotagnostus*) *trisectus* Salter, 1864. Peng & Babcock (2005) showed, however, that this species name actually is a junior synonym of *L. americanus. Lotagnostus americanus* has a relatively narrow stratigraphic range and a wide (intercontinental) distribution in open-shelf lithofacies (e.g. Peng & Babcock 2005).

4. *Trilobagnostus holmi* Zone

Boundaries: The base of the *Trilobagnostus holmi* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of the graptolite *Rhabdinopora praeparabola* (Erdtmann, 1982). The *T. holmi* Zone corresponds to the *Ctenopyge bisulcata* through *Acerocare ecorne* polymerid zones (Fig. 5) as recognized here. *Trilobagnostus holmi* occurs in the lower three of these polymerid zones and is most abundant in the *Parabolina lobata* Zone (cf. Westergård 1944; Terfelt et al. 2005).

Characteristics: The *T. holmi* Zone is characterized by the eponymous species, which occurs infrequently to abundantly in the lowermost part of the zone (Westergård 1944; Terfelt et al. 2005). For a record of zonal taxa, see the polymerid zonation (*Ctenopyge bisulcata* to *Acerocare ecorne* zones) below.

Reference sections: The Södra Sandby drill core, Scania (Westergård 1944), and the Håslöv-1 drill core from southwestern Scania (Terfelt et al. 2005).

Remarks: Trilobagnostus holmi was originally described as a variety of *T. rudis* (Salter, 1864) by Westergård (1922), but was raised to species level by Ahlberg & Ahlgren (1996). Based on our present knowledge, *T. holmi* is restricted to Scandinavia and the United Kingdom.

Polymerid zonation

To avoid an inconsistent biozonation scheme (mixing taxon-range zones and acme zones, mixing genus- and

species-based zones, and mixing boundary definitions) while continuing to maintain a high degree of biostratigraphic resolution, we propose subdividing the Furongian of Scandinavia by using the same polymerid trilobites as those used traditionally for subzones. The subzones, however, are elevated to zonal status and their definition appropriately modified to become interval-zones. In ascending order the 28 biozones are the *Olenus gibbosus, O. truncatus, O. wahlenbergi, O. attenuatus, O. dentatus, O. scanicus, Parabolina brevispina, P. spinulosa, Leptoplastus paucisegmentatus, L. raphidophorus, L. crassicornis, L. ovatus, L. stenotus, L. neglectus, Ctenopyge postcurrens, C. flagellifera, C. similis, C. spectabilis, C. tumida, C. affinis, C. bisulcata, C. linnarssoni, Parabolina lobata, Peltura paradoxa, P. transiens, P. costata, Westergaardia scanica*, and the *Acerocare ecorne* Zone (Fig. 5). The traditional 'superzones' and zones are abandoned. Each of the polymerid biozones, as now defined, is delimited at the base by the first appearance of the eponymous species, and delimited at the top by the base of the overlying zone.

1. *Olenus gibbosus* Zone

Boundaries: The base of the Scandinavian *Olenus gibbosus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *O. truncatus* (Brünnich, 1781).

Characteristics: The *O. gibbosus* Zone is characterized by the eponymous species, which occurs in abundance through the entire zone. Its FAD nearly coincides with the FADs of *Glyptagnostus reticulatus* and *Agnostus (Homagnostus) obesus* (see Eriksson & Terfelt 2007). In addition to the zonal guide fossil, the following taxa have been recorded in the *O. gibbosus* Zone: *A. (H.) obesus, G. reticulatus, Aspidagnostus lunulosus* (Kryskov in Borovikov & Kryskov, 1963) (not recorded in Scania), *Hypagnostus* aff. *correctus* Öpik, 1967 (not recorded in Scania), *O. transversus* Westergård, 1922, *Acrocephalites stenometopus* Angelin, 1854, *Acrocephalites? rarus* Westergård, 1922 (the latter two species are not recorded in Scania), and possibly *Proceratopyge nathorsti* Westergård, 1922 (Westergård 1922, 1944, 1947).

Reference section: Section of Clarkson et al. (1998*a*) and Lauridsen & Nielsen (2005); CLN in Fig. 2D.

Remarks: Olenus gibbosus has been recorded from Scandinavia and the United Kingdom.

2. *Olenus truncatus* Zone

Boundaries: The base of the Scandinavian *Olenus truncatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *O. wahlenbergi* Westergård, 1922.

Characteristics: The *O. truncatus* Zone is characterized by the eponymous species, which occurs in abundance through the entire zone. In addition to the zonal guide fossil, *A. (H.) obesus* and *G. reticulatus* have also been recorded from this zone (Westergård 1922, 1944).

Reference section: Section of Clarkson et al. (1998*a*) and Lauridsen & Nielsen (2005); CLN in Fig. 2D.

Remarks: Olenus truncatus has been recorded from Scandinavia and the United Kingdom.

3. *Olenus wahlenbergi* Zone

Boundaries: The base of the Scandinavian *Olenus wahlenbergi* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *O. attenuatus* (Boeck, 1838).

Characteristics: The *O. wahlenbergi* Zone is characterized by the eponymous species, which occurs in abundance through the entire zone. In addition to the zonal guide fossil, *A. (H.) obesus, G. reticulatus*, and the phosphatocopine *Cyclotron* sp. have been recorded in this zone (Westergård 1922, 1944; Clarkson et al. 1998*a*).

Reference section: Section of Clarkson et al. (1998a) and Lauridsen & Nielsen (2005); CLN in Fig. 2D.

Remarks: Olenus wahlenbergi has been recorded only from Scandinavia and the United Kingdom. Lauridsen & Nielsen (2005) suggested that *O. transversus, O. truncatus* and *O. wahlenbergi* may represent a single species that underwent gradual morphological changes over time. However, we think that the combination of features of each of these three species listed by Westergård (1922, p. 125–128, 132) and Henningsmoen (1957, p. 108–111) warrants recognition of three separate species. The species, however, may represent an anagenetic evolutionary series.

4. *Olenus attenuatus* Zone

Boundaries: The base of the Scandinavian *Olenus attenuatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *O. dentatus* Westergård 1922.

Characteristics: The *O. attenuatus* Zone is characterized by the eponymous species, which occurs in abundance through the entire zone. In addition to the zonal guide fossil, *A. (H.) obesus* has been recorded from this zone (Westergård 1944).

Reference section: Section 1 of Westergård (1922, p. 18) and section of Clarkson et al. (1998*a*) and Lauridsen & Nielsen (2005); CLN in Fig. 2D.

Remarks: Olenus attenuatus has been recorded only from Scandinavia.

5. *Olenus dentatus* Zone

Boundaries: The base of the Scandinavian *Olenus dentatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *O. scanicus* Westergård, 1922.

Characteristics: The *O. dentatus* Zone is characterized by the eponymous species, which occurs in abundance in the lower part of the zone (Westergård 1922, 1944). In addition to the zonal guide fossil, *A. (H.) obesus* and *Proceratopyge tullbergi* Westergård, 1922 have been recorded (Westergård 1944, 1947).

Reference section: Section 1 of Westergård (1922, p. 18).

Remarks: Olenus dentatus occurs in Scandinavia and questionably (Rushton 1983) in the United Kingdom.

6. *Olenus scanicus* Zone

Boundaries: The base of the Scandinavian *Olenus scanicus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Parabolina brevispina* Westergård, 1922.

Characteristics: The *O. scanicus* Zone is characterized by the eponymous species, which occurs infrequently in the lower part of the zone. In addition to the zonal guide fossil, the *O. scanicus* Zone yields *O. rotundatus* Westergård, 1922, a diverse fauna of phosphatocopines, including *Cyclotron ventrocurvatum* Gründel in Gründel & Buchholz, 1981, *C. angelini* (Linnarsson, 1875) and *Vestrogothia steffenschneideri* Hinz-Schallreuter, 1993 (Westergård, 1922, 1944, 1947; Clarkson et al. 1997; Eriksson & Terfelt 2007; Ahlberg et al. in press).

Reference sections: Section 2 and 3 of Westergård (1922, pp. 18–20).

Remarks: Olenus scanicus has been recorded only from Scandinavia (Scania).

7. *Parabolina brevispina* Zone

Boundaries: The base of the Scandinavian *Parabolina brevispina* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Parabolina spinulosa* (Wahlenberg, 1818).

Characteristics: The *P. brevispina* Zone is characterized by the eponymous species, which occurs infrequently in the entire zone. In addition to the zonal guide fossil, the following taxa have been recorded in the *P. brevispina* Zone; *A. (H.) obesus laevis* Westergård, 1947 (but see Ahlberg & Ahlgren 1996, p. 131), *Pseudagnostus cyclopyge* (Tullberg, 1880), *Proceratopyge tullbergi, Conokephalina olenorum* Westergård, 1922, "*Liostracus*" *pusillus* Westergård, 1922, *Protopeltura? solitaria* (Westergård, 1922), *Protopeltura aciculata aciculata* (Angelin, 1854), *Eoasaphus superstes* (Linnarsson, 1875), and the brachiopod *Orusia lenticularis* (Wahlenberg, 1818) (Westergård 1922, 1944, 1947). *Irvingella suecica* Westergård, 1947 may occur in this subzone (Westergård 1949).

Reference sections: Section 3 and 5 of Westergård (1922, p. 19–20).

Remarks: Parabolina brevispina has been recorded from Scandinavia and the United Kingdom.

8. *Parabolina spinulosa* Zone

Boundaries: The base of the Scandinavian *Parabolina spinulosa* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Leptoplastus paucisegmentatus* Westergård, 1922.

Characteristics: The *P. spinulosa* Zone is characterized by the eponymous species, which occurs moderately to abundantly through the entire zone. In addition to the zonal guide fossil the following taxa have been recorded in the *P. spinulosa* Zone: *Parabolina*? sp., *Protopeltura aciculata aciculata* (Angelin, 1854), *P. aciculata pusilla* Westergård, 1922, *Maladioidella abdita* (Salter, 1866) (see Rushton et al. 2002) and *Peratagnostus falanensis* (Westergård, 1947) from Västergötland, *A. (H.) obesus*, and the brachiopod *Orusia lenticularis*, which occurs in abundance in some levels.

Reference sections: Section 5 and 6 of Westergård (1922, p. 20) and section of Ahlberg et al. (2006, fig. 3).

Remarks: Parabolina spinulosa has been recorded from Scandinavia, the United Kingdom and eastern Canada.

9. *Leptoplastus paucisegmentatus* Zone

Boundaries: The base of the Scandinavian *Leptoplastus paucisegmentatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *L. raphidophorus* Angelin, 1854.

Characteristics: The *L. paucisegmentatus* Zone is characterized by the eponymous species, which occurs infrequently through the entire Zone. In addition to the zonal guide fossil, *Protopeltura intermedia* Westergård, 1922 has been recorded in the *L. paucisegmentatus* Zone (Westergård 1922, 1944).

Reference section: Section of Ahlberg et al. 2006 (fig. 3).

Remarks: Leptoplastus paucisegmentatus occurs in Scandinavia, the United Kingdom, and questionably (Hutchinson 1952) in eastern Canada. Westergård (1944) stated that *P. spinulosa* ranges up into the *L. paucisegmentatus* Zone at Andrarum. This was, however, not confirmed in a meticulous study of the *Leptoplastus*-yielding strata at Andrarum (Ahlberg et al. 2006).

10. *Leptoplastus raphidophorus* Zone

Boundaries: The base of the Scandinavian *Leptoplastus*

raphidophorus Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *L. crassicornis* (Westergård, 1944).
Characteristics: The *L. raphidophorus* Zone is characterized by the eponymous species that occurs infrequently to abundantly in the entire zone. In addition to the zonal guide fossil, *Pseudagnostus leptoplastorum* Westergård, 1944 has been recorded in the *L. raphidophorus* Zone (Westergård 1944).

Reference section: Section of Ahlberg et al. (2006, fig. 3).

Remarks: Leptoplastus raphidophorus has been recorded only from Scandinavia and the United Kingdom.

11. *Leptoplastus crassicornis* Zone

Boundaries: The base of the Scandinavian *Leptoplastus crassicornis* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *L. ovatus*, Angelin 1854.

Characteristics: The *L. crassicornis* Zone is characterized by the eponymous species, which occurs infrequently to abundantly through the entire zone. In addition to the zonal guide fossil, *L. angustatus* (Angelin, 1854), *L. norvegicus* (Holtedahl, 1910) and *Eurycare latum* (Boeck, 1838) have been recorded in the *L. crassicornis* Zone (Westergård 1944; Ahlberg et al. 2006).

Reference section: Section of Ahlberg et al. (2006, fig. 3).

Remarks: The traditional *L. angustatus* Biozone is abandoned. The reason for this is that the FAD of *L. angustatus* is approximately coeval with that of *L. crassicornis. Leptoplastus crassicornis* is a better zonal guide fossil due to its shorter range (see Ahlberg et al. 2006, fig 3.). *Leptoplastus crassicornis* has been recorded from Scandinavia and the United Kingdom.

12. *Leptoplastus ovatus* Zone

Boundaries: The base of the Scandinavian *Leptoplastus ovatus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *L. stenotus*, Angelin 1854.

Characteristics: The *L. ovatus* Zone is characterized by the eponymous species, which occurs abundantly in the lower part of the zone. In addition to the zonal guide fossil, the following taxa have been recorded: *L. angustatus, L. abnormis* Westergård, 1944, *L. intermedius* (Westergård, 1944), *Eurycare latum, E. brevicauda* Angelin, 1854, *E. spinigerum* Westergård, 1922, *Parabolinites? leptoplastorum* (Westergård, 1947), *Protopeltura intermedia* Westergård 1922, an undetermined obolid brachiopod, and possible phosphatocopines (Westergård 1922, 1944, 1947; Ahlberg et al. 2006).

Reference section: Section of Ahlberg et al. (2006, fig. 3).

Remarks: Leptoplastus ovatus occurs in Scandinavia, the United Kingdom, and possibly (Hutchinson 1952) in eastern Canada.

13. *Leptoplastus stenotus* Zone

Boundaries: The base of the Scandinavian *Leptoplastus stenotus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *L. neglectus* (Westergård, 1922).

Characteristics: The *L. stenotus* Zone is characterized by the eponymous species, which occurs abundantly in the entire zone. No other faunal elements have so far been recorded from this zone.

Reference section: Section of Ahlberg et al. (2006, fig. 3).

Remarks: Leptoplastus stenotus occurs in Scandinavia and possibly (Stubblefield 1930) the United Kingdom.

14. *Leptoplastus neglectus* Zone

Boundaries: The base of the Scandinavian *Leptoplastus neglectus* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Ctenopyge (Eoctenopyge) postcurrens* Westergård, 1944.

Characteristics: The *L. neglectus* Zone is characterized by the eponymous species, which occurs infrequently through the entire zone. In addition to the zonal guide fossil, *Protopeltura praecursor* (Westergård, 1909) has been recorded in the *L. neglectus* Zone (Westergård 1909, 1944; Henningsmoen 1957).

Reference section: Section 9 of Westergård (1922, p. 21).

Remarks: Leptoplastus neglectus occurs in Scandinavia and possibly in the United Kingdom.

15. *Ctenopyge postcurrens* Zone

Boundaries: The base of the Scandinavian *C. postcurrens* Zone is defined by the FAD of the eponymous species and the top is delimited by the FAD of *C. (Eoctenopyge) flagellifera* (Angelin, 1854).

Characteristics: The *C. postcurrens* Zone is characterized by the eponymous species, which occurs in moderate numbers through the entire zone. *Protopeltura praecursor* has been recorded in the *C. postcurrens* Zone. Additional olenid trilobites have been recovered from this zone or slightly younger strata in the Kistedal Formation of Finnmark, northern Norway (Nikolaisen & Henningsmoen 1985).

Reference section: Section 9 of Westergård (1922, p. 21).

Remarks: Ctenopyge (E.) postcurrens has been recorded from Scandinavia and the United Kingdom.

16. *Ctenopyge flagellifera* Zone

Boundaries: The base of the Scandinavian *C. flagellifera* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (Mesoctenopyge) similis* Henningsmoen, 1957.

Characteristics: The *C. flagellifera* Zone is characterized by the eponymous species, which occurs infrequently to abundantly through the entire zone. In addition to the zonal guide fossil, *C. (E.) drytonensis* Cobbold, 1934 and *P. praecursor* have been recorded in the *C. flagellifera* Zone of Scandinavia (Henningsmoen 1957).

Reference section: Section 9 of Westergård (1922, p. 21).

Remarks: Ctenopyge (E.) flagellifera has been recorded from Scandinavia, the United Kingdom, and eastern Canada.

17. *Ctenopyge similis* Zone

Boundaries: The base of the Scandinavian *C. similis* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (M.) spectabilis* Brøgger, 1882.

Characteristics: The *C. similis* Zone is characterized by the eponymous species, which occurs infrequently to abundantly in the entire zone. In addition to the zonal guide fossil, *C. (E.) modesta* Henningsmoen, 1957, *Parabolina mobergi* Westergård, 1922, and *Protopeltura bidentata* (Brøgger, 1882) have been recorded in the *C. similis* Zone outside of Scania, and *Protopeltura planicauda* (Brøgger, 1882) in the same zone in Scania (Westergård 1922, 1944; Henningsmoen 1957).

Reference section: Section 9 of Westergård (1922, p. 21).

Remarks: Ctenopyge (M.) similis has been recorded from Scandinavia and the United Kingdom.

18. *Ctenopyge spectabilis* Zone

Boundaries: The base of the Scandinavian *C. spectabilis* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (M.) tumida* Westergård, 1922.

Characteristics: The *C. spectabilis* Zone is characterized by the eponymous species, which occurs infrequently through the entire zone. In addition to the zonal guide fossil, the following taxa have been recorded in the *C. spectabilis* Zone: *Peltura minor, C. angusta, C. tumidoides* Henningsmoen, 1957, and *Lotagnostus americanus* (Westergård 1922, 1944; Henningsmoen 1957). *Macropyge (Promacropyge) scandinavica* Terfelt & Ahlgren, 2007 has also been recorded from the zone but not in Scania (Terfelt & Ahlgren 2007).

Reference section: Section 10 of Westergård (1922, pp. 21–22).

Remarks: Ctenopyge (M.) spectabilis has been recorded from Scandinavia and the United Kingdom.

19. *Ctenopyge tumida* Zone

Boundaries: The base of the Scandinavian *C. tumida* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (M.) affinis affinis* Westergård, 1922.

Characteristics: The *C. tumida* Zone is characterized by the eponymous species, which occurs infrequently throughout the entire zone. In addition to the zonal guide fossil the following taxa have been recorded in the *C. tumida* Zone: *Sphaerophthalmus alatus* (Boeck, 1838), *Protopeltura planicauda* (Brøgger, 1882), *Peltura acutidens* Brøgger, 1882, *Peltura minor, Parabolinites laticaudus* (Westergård, 1922), and *Lotagnostus americanus* (see Westergård 1922, 1944).

Reference section: Section 10 of Westergård (1922, pp. 21–22).

Remarks: Ctenopyge (M.) tumida has been recorded from Scandinavia, the United Kingdom, and Poland.

20. *Ctenopyge affinis* Zone

Boundaries: The base of the Scandinavian *C. affinis* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (C.) bisulcata* (Phillips, 1848).

Characteristics: The *C. affinis* Zone is characterized by the eponymous species, which occurs infrequently through the entire zone. In addition to the zonal guide fossil, the following taxa have been recorded from the *C. affinis* Zone: *Sphaerophthalmus alatus, Ctenopyge affinis gracilis* Henningsmoen, 1957, *Peltura minor*, and *Lotagnostus americanus* (Westergård 1922, 1944; Henningsmoen 1957).

Reference section: Section 10 of Westergård (1922, pp. 21–22).

Remarks: Ctenopyge (C.) affinis has been recorded only from Scandinavia.

21. *Ctenopyge bisulcata* Zone

Boundaries: The base of the Scandinavian *C. bisulcata* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *C. (C.) linnarssoni* Westergård, 1922.

Characteristics: The *C. bisulcata* Zone is characterized by the eponymous species, which occurs infrequently through the entire zone. In addition to the zonal guide fossil, the following taxa have been recorded in the *C. affinis* Zone: *Sphaerophthalmus humilis* (Phillips, 1848), *Sphaerophthalmus majusculus* Linnarsson, 1880, *Peltura*

scarabaeoides scarabaeoides Wahlenberg, 1818, *Elkanaspis kinnekullensis* Terfelt & Ahlgren, in press (not in Scania), *Parabolinella* sp. Terfelt & Ahlgren, in press (not in Scania), *Nericiaspis robusta* (Tjernvik, 1953) (not in Scania), *Lotagnostus americanus,* and *Trilobagnostus holmi* (Westergård 1922, 1944; Terfelt & Ahlgren in press). *Ctenopyge ceciliae* Clarkson & Ahlberg, 2002 was recorded either from the *C. bisuclata* or the *C. linnarssoni* Zone.

Reference section: Section 10 of Westergård (1922, pp. 21–22).

Remarks: Ctenopyge (Ctenopyge) bisulcata has been recorded from Scandinavia, the United Kingdom, and eastern Canada.

22. *Ctenopyge linnarssoni* Zone

Boundaries: The base of the Scandinavian *C. linnarssoni* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Parabolina (Neoparabolina) lobata lobata* (Brøgger, 1882).

Characteristics: The *C. linnarssoni* Zone is characterized by the eponymous species, which occurs infrequently in the entire zone. In addition to the zonal guide fossil, the following taxa have been recorded in the *C. linnarssoni* Zone: *Sphaerophthalmus humilis, Sphaerophthalmus majusculus, Peltura scarabaeoides scarabaeoides, Ctenopyge (C.) pecten* (Salter, 1864), *C. (C.) fletcheri* (Matthew, 1901), *Nericiaspis robusta, Lotagnostus americanus*, and *Trilobagnostus holmi* (see Westergård 1922, 1944).

Reference section: Section 10 of Westergård (1922, pp. 21–22).

Remarks: Ctenopyge (C.) linnarssoni occurs in Scandinavia, the United Kingdom (Cope & Rushton 1992), and questionably in eastern Canada (Henningsmoen 1957, p. 207) and Poland (Żylińska 2001, 2002).

23. *Parabolina lobata* Zone

Boundaries: The base of the Scandinavian *Parabolina lobata* Zone is defined by the FAD of *P. (N.) lobata praecurrens* Westergård, 1944 and the top of the zone is delimited by the FAD of *Peltura paradoxa* Moberg & Möller, 1898.

Characteristics: The *P. lobata* Zone is characterized by the eponymous species, which includes two moderately abundant to abundant subspecies, *P. (N.) lobata praecurrens* and *P. (N.) lobata lobata,* both of which may occur throughout the entire zone. In addition to the zonal guide fossil, *Peltura scarabaeoides westergaardi* Henningsmoen, 1957, *P.* cf. *transiens* (Brøgger, 1882), *P.* cf. *paradoxa* (Moberg & Möller, 1898), *Sphaerophthalmus humilis, S.* cf. *alatus, S.* cf. *majusculus, Niobella aurora* Westergård, 1939, *Lotagnostus subtrisectus* Westergård, 1944, and *Trilobagnostus holmi* have been recorded from this zone (Westergård 1944; Henningsmoen 1957; Terfelt et al. 2005; Ahlberg et al. 2005).

Reference section: The Håslöv-1 drill core from southwestern Scania (Terfelt et al. 2005).

Remarks: Parabolina (N.) lobata lobata and *P. (N.) lobata praecurrens* have been recorded only from Scandinavia.

24. *Peltura paradoxa* Zone

Boundaries: The base of the Scandinavian *Peltura paradoxa* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Peltura transiens* (Brøgger, 1882).

Characteristics: The *P. paradoxa* Zone is characterized by the eponymous species, which occurs infrequently in the lower part of the zone. In addition to the zonal guide fossil, *Parabolina (P.) heres megalops* (Moberg & Möller, 1898) has been recorded from this zone (Westergård 1944).

Reference section: The Håslöv-1 drill core from southwestern Scania (Terfelt et al. 2005).

Remarks: Peltura paradoxa has been recorded only from Scandinavia.

25. *Peltura transiens* Zone

Boundaries: The base of the Scandinavian *Peltura transiens* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Peltura costata* (Brøgger, 1882).

Characteristics: The *P. transiens* Zone is characterized by the eponymous species which occurs infrequently in the zone. In addition to the zonal guide fossil, *Parabolina (P.) heres heres* Brøgger, 1882 and *Acerocarina granulata* (Moberg & Möller, 1898) have been recorded from this zone (Westergård 1944; Terfelt et al. 2005).

Reference section: The Håslöv-1 drill core from southwestern Scania (Terfelt et al. 2005).

Remarks: Peltura transiens occurs in Scandinavia and questionably (Żylińska 2001, 2002) in Poland.

26. *Peltura costata* Zone

Boundaries: The base of the Scandinavian *Peltura costata* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of *Westergaardia scanica* (Westergård, 1909).

Characteristics: The *P. costata* Zone is characterized by the eponymous species, which occurs only infrequently in the zone. In addition to the zonal guide fossil, *Parabolina (P.) heres heres* and *Acerocarina micropyga* (Linnarsson, 1875) have been recorded from this zone (Westergård 1944).

Reference section: Røyken near Oslo, Norway (Henningsmoen 1957).
Remarks: Peltura costata occurs in Scandinavia and questionably (Żylińska 2001, 2002) in Poland.

27. *Westergaardia scanica* Zone

Boundaries: The base of the Scandinavian *Westergaardia scanica* Zone is defined by the FAD of the eponymous species and the top is delimited by the FAD of *Acerocare ecorne* Angelin, 1854.

Characteristics: The *W. scanica* Zone is characterized by the eponymous species, which occurs in moderate abundance in the lower part of the zone. In addition to the zonal guide fossil, the following taxa have been recorded from the *W. scanica* Zone: *W. lata* (Matthew, 1891), *W. intermedia* Westergård, 1944, *Parabolina heres lata* Matthew, 1892 and *Pelturina punctifera* Henningsmoen, 1957 (Westergård 1944; Henningsmoen 1957).

Reference section: The Södra Sandby and Andrarum-2 drill cores, Scania (Westergård 1944).

Remarks: The traditional *Westergaardia* Subzone is here transferred from subzonal to zonal status, modified slightly in definition, and renamed the *Westergaardia scanica* Zone after the earliest occurring *Westergaardia* species (cf. Westergård 1944, pl. 4–6; Henningsmoen 1957, p. 254). *Westergaardia scanica* has been recorded only from Scandinavia.

28. *Acerocare ecorne* Zone

Boundaries: The base of the Scandinavian *A. ecorne* Zone is defined by the FAD of the eponymous species and the top of the zone is delimited by the FAD of the graptolite *Rhabdinopora praeparabola*.

Characteristics: The *A. ecorne* Zone is characterized by the eponymous species, which occurs infrequently to abundantly in the lower part of the zone. In addition to the zonal guide fossil, the following taxa have been recorded from the *A. ecorne* Zone: *A. tullbergi* Moberg & Möller, 1898, *Parabolina (P.) acanthura* Angelin, 1854, *Parabolina (P.) heres heres*, *Parabolina (P.) heres lata, Pelturina punctifera, Parabolina acanthura*, and *Niobella primaeva* (Westergård, 1909) (Westergård 1944, 1947; Henningsmoen 1957, 1958; Bruton et al., 1982, 1988).

Reference sections: Locality F5 at Södra Sandby, Scania (Moberg 1896, p. 22; locality also referred to as 5 by Westergård, 1922) and the Nærsnes type section, Oslo region (Bruton et al. 1988).

Remarks: Acerocare ecorne is known only from Scandinavia.

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