

A new Late Ordovician erratic anthaspidellid sponge (Porifera) originating from Baltica

Freek Rhebergen

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F. Rhebergen, Slenerbrink 178; 7812 HJ Emmen, the Netherlands (freek.rhebergen@planet.nl).

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The new anthaspidellid taxon *Brevaspidella dispersa* is erected for specimens recovered from the Late Ordovician sponge assemblages of the island of Gotland, Sweden and the Dutch-German border region. In the latter area, they are collected from Early Pleistocene fluvial deposits of the Baltic River System, whereas those from Gotland are part of Late Pleistocene glacial or fluvio-glacial deposits. The provenance of both assemblages is uncertain, but they probably originated from an Ordovician basin in the northern Baltic Sea or the Bothnian Gulf, west of Finland. As yet, *Brevaspidella dispersa* gen. et sp. nov. is restricted to the Gotland-German-Dutch sponge association and has not been found in the assemblage of nearly-coeval 'lavender-blue cherts' and 'blue sponges'. The new taxon is closely related to the genus *Anthaspidella*, but differs in the aquiferous system and in having a well developed concentrically wrinkled dermal layer.

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Introduction

Late Ordovician erratic sponges originating from Baltica have been known for almost two centuries. There are several distinct assemblages in northern Europe. From the Island of Gotland (Sweden), Lindström (1885, 1888) listed several taxa which had been collected as erratics found widely over the island. Rauff (1893, 1894, 1895) described and figured several specimens from these collections in the Swedish Museum of Natural History in Stockholm. More recently, Rhebergen & Von Hacht (2000) inventoried these collections and compared them with two other, coeval sponge assemblages from Germany and the Netherlands. One has been collected from the Island of Sylt in the northernmost Germany, and the other from the eastern Netherlands and adjacent westernmost region of Germany. The latter is known as the WWW-area, short for the villages Wilsum, Wielen (both Germany) and Westerhaar (the Netherlands) (Rhebergen *et al.*, 2001). Another, minor sponge assemblage is known from Lausitz, south-east of Berlin (Von Hacht & Rhebergen, 1997).

The four assemblages share an origin in basins and / or shelf areas of the palaeocontinent Baltica, but their exact provenances remain unknown. However, each assemblage

shows distinct diagenetic characteristics, taxonomic composition, and diagenetic and weathering features such as silicification and late-stage erosion (Rhebergen *et al.*, 2001).

The German-Dutch sponge assemblages are found in fluvial deposits from the huge Baltic River System that drained the Baltic area from Early Miocene to Early Pleistocene times. Its drainage area extended from Lapland in the north and the Pre-Neva in the east. Its delta filled successively the present southern Baltic Sea, the Polish-German Basin and, fanning westwards, extended far into the present North Sea, thus forming the largest river delta that Europe has ever known.

The sponge assemblage from Lausitz and from the Island of Sylt were deposited as early as Middle Miocene and Pliocene, respectively. They are part of a characteristic association of bluish-gray to nearly black silicifications, the so-called 'Lavendel Blaue Hornsteine' (LBH) recently described by Van Keulen *et al.* (2012). It is intermixed with a minor component of other material, similar to or identical with the WWW-area material and with a small amount of 'brown' sponges (see below). As yet, no specimens of the new sponge described below have been recognized in this association. Therefore, the 'blue sponge assemblage' from Miocene to Pliocene fluvial deposits is not considered further.

The new material was discovered as part of the 'brown' sponge assemblages from the WWW-area and from Gotland. These assemblages are composed mainly of lithistid demosponges, comprising five families: the Anthaspidellidae Miller, 1889; Streptosolenidae Johns, 1994; Chlastoclonellidae Rauff, 1894; Astylospongiidae von Zittel, 1877; and Hindiidae Rauff, 1893.

Geological setting and material

The geological settings and occurrences of the sponges from the WWW-area (Fig. 1) and from Gotland (Fig. 2) are discussed in turn. The sponges of the assemblage from the WWW-area have been collected from sand- and gravel pits cut into Early Pleistocene fluvial deposits. During the Late Pleistocene Saalian glaciation, glaciers were hampered in their movements as they crossed the older Early Pleistocene fluvial deposits, which resulted in the formation of a complex of ice-pushed ridges. It is emphasized that the sponge assemblage described below was not part of the Late Pleistocene Saalian tills. The sponges are part of an association of silicified limestone and chert pebbles of Late Ordovician (Sandbian and Katian) age, similar to the previously described Backsteinkalk (Sandbian, Haljala stage), Brown Pirgu Chert (*sensu* Van Keulen *et al.*, 2012) and Öjlemyrflint (both Katian, Pirgu stage). Most of the collected material of *Brevaspidella dispersa* gen. et sp. nov. is deposited in some tens of private collections, all of which have been made accessible for study. The same is true of museum collections, which together comprise much less material. Approximately 45 specimens of the new species from the WWW-area have been recognized in this study, twenty of which have been studied more intensively.

Additionally, two further unnumbered specimens have been collected from the Island of Sylt (see above) with the characteristic features of 'brown' sponges similar to those of the WWW-area and are also included in this study. They are housed in the Archiv für Geschiebekunde in the Geologisch-Paläontologisches Institut und Museum of the University of Hamburg (Germany).

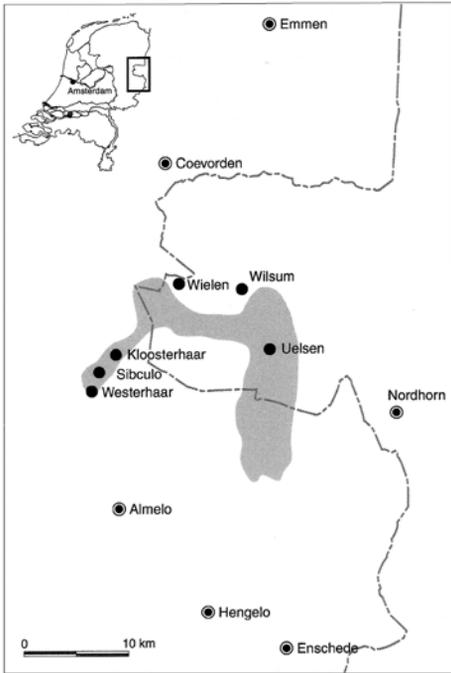


Figure 1. Locality map of the German-Dutch border area.

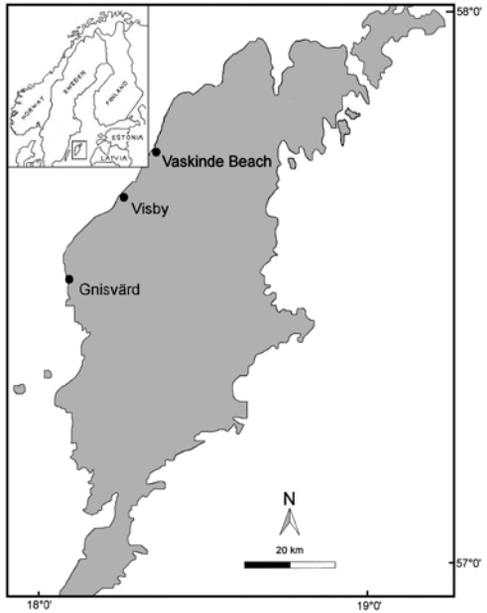


Figure 2. Locality map of Gotland.

The sponge assemblage from the Island of Gotland has been collected since the last decades of the 19th Century. They are distributed widely over the island, and have been recovered from beaches, fields and during the digging of canals in the first decades of the 20th Century. I am not aware of any private collections on Gotland, so investigations were dependent on two museum collections, those of the Museum of Gotland in Visby and the Swedish Museum of Natural History in Stockholm. In the latter institution, fifteen specimens of the new species were recognized during my inventory in 2004 and seven specimens have been examined in detail for this study. The sponge assemblage is part of an association of cherts described by Wiman (1907) from the hamlet Öjle Myr on Gotland. These cherts are of the Late Ordovician (Katian, Pirgu) stage. Representatives of the older 'Backsteinkalk' mentioned above are rare and there are no reports of 'lavenderblue' cherts or sponges of the 'blue' assemblage.

A complicating factor is the co-occurrence of a new sponge assemblage of Early Silurian (Llandovery, Telychian) age (Rhebergen & Botting, 2014). These erratic sponges originate from the 'Red Layers', underlying the Lower Visby Formation. Although the distribution of these sponges is restricted to certain localities along the western coast, the Silurian assemblage is intermixed with the Ordovician one in the accumulations of pebbles at those sites. The Silurian sponges are distinguishable from the Ordovician ones by different taxa, by their usually reddish colour, the frequently occurring monaxons and hexactinellid spicules washed in on surfaces and in cavities, as well as the com-

mon occurrence of the encrusting sponge *Opetionella* sp. nov. (Rhebergen & Botting, 2014). Based on the extent of erosion of the deposit, it is assumed that the Ordovician sponges from Gotland were initially transported by rivers from their original bedrock and deposited on the island during the Weichselian glaciation.

The skeleton has been preserved poorly in nearly all of the studied specimens, both from Gotland and the WWW-area, with loss of information resulting from coarse replacement of the limestone by chalcedony. As a result of this, it was not in this case useful to create polished sections of the sponges, and most of the recognizable features are seen on surfaces. Five specimens showed natural fractures and only one of these convincingly demonstrate a well preserved anthaspidellid skeletal structure (see below). Drawings of relevant sponge spicules (desmas) mentioned in this study are shown in Figure 3.

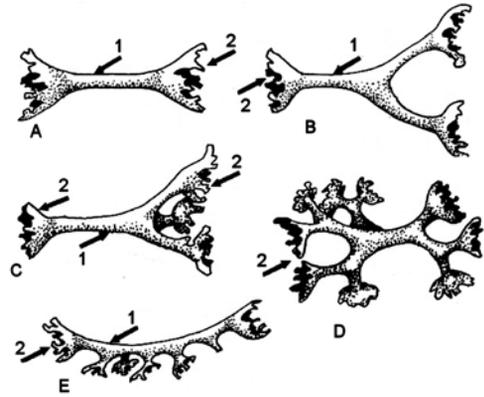


Figure 3. Dendroclones, chiastoclone and rhizoclone (after de Freitas, 1991, fig. 3). (A) I-shaped or amphiarborescent dendroclone. (B) Y-shaped or triclone dendroclone. (C) X-shaped or polyclonid dendroclone. (D) Chiastoclone. (E) Rhizoclone. Key: 1 = shaft; 2 = zygome.

Institutional abbreviations – The following abbreviations are used to denote the repositories of material referred to in the text: GPIH – Archiv für Geschiebekunde in the Geologisch-Paläontologisches Institut und Museum of the University of Hamburg (Germany); NRM – Naturhistoriska Riksmuseet (Swedish Museum of Natural History), Stockholm; and RGM – Naturalis Biodiversity Center, Leiden, the Netherlands.

Systematic palaeontology

Phylum Porifera Grant, 1836
 Class Demospongiae Sollas, 1875
 Order Orchocladina Rauff, 1894
 Family Anthaspidellidae Miller, 1889
 Genus *Brevaspidella* gen.nov.

Etymology – Combination of Latin *brevis* (short), *aspis* (shield) and *ellus* (diminutive), describing its body form: short and cylindrical with a shield-like top. The name also refers to the closely related *Anthaspidella* Ulrich & Everett in Miller, 1889.

Diagnosis – Cylindrical sponge with height roughly equal to diameter. Apex usually slightly concave with a number of osculi scattered over the surface. Flat to slightly conical base with concentrically wrinkled, imperforate dermal layer. Aquiferous system composed of small canals parallelling the skeletal strands and larger radial canals running from the lateral surface to large (sub-)vertical canals that empty into the upper

surface. Skeleton composed predominantly of amphiarborescent dendroclones, forming an anthaspidellid ladder-like skeletal structure. Trabs run from the skeletal radiante at the base and meet the outer surface sub-perpendicularly. Intraserial trabs usually adjacent. Short parietal trabs with some polyclonid dendroclones occur where a new intraserial trab is intercalated.

Remarks – Specimens of *Brevaspidella* gen. nov. from the island of Gotland in the collections of the Swedish Museum of Natural History have until now remained unidentified. Specimens from the Dutch-German border region, known as the WWW-area, and from the island of Sylt (northwestern Germany), were provisionally assigned to *Aulocopium* Oswald, 1847 (Rhebergen *et al.*, 2001, p. 56, pl. 2, figs. 8, 9, 11).

Brevaspidella gen. nov. is assignable to the Anthaspidellidae on account of the regularly parallel arrangement of dendroclones. This is clearly distinct from the skeletal structure of the Streptosolenidae Johns, 1994, including *Aulocopium* Oswald, 1847, the predominant genus on the islands of Gotland and Sylt, as well as in the WWW-area. The same is true of the rather common genera *Aulocopella* Rauff, 1895, and *Hudsonospongia* Raymond & Okulitch, 1940. Dendroclones in the trabs of the Streptosolenidae are irregularly oriented, and consequently the skeletal pattern and canal systems are more irregular, as demonstrated by Johns (1994, fig. 6). In addition, polyclonid (Y- and X-shaped) dendroclones in Streptosolenidae dominate over the monoclonid (I-shaped) ones. Chiastoclones occur frequently in those skeletons, in contrast with the Anthaspidellidae. Johns' erection of the Streptosolenidae is followed in the present study and the skeletal characteristics of the new genus are best accommodated by the Anthaspidellidae.

Most of the genera in the Anthaspidellidae have a canal system in which radial canals empty into a central spongocoel. This might be an open cloacal funnel as in *Calyco-coelia* Bassler, 1927, or a bundle of axial canals as in *Finksella* Rigby & Dixon, 1979, and *Diotricheum* Van Kempen, 1989, or even a combination as in most species of *Archaeoscyphia*. These genera can all be excluded, since in *Brevaspidella* the aquiferous system is decentralized. *Patellispongia* Bassler, 1927, shows numerous rows of radiating pores on its upper surface, but lacks convergent exhalant canals and it differs, therefore, from *Anthaspidella* and *Brevaspidella*. The Permian dome-shaped *Multistella* Finks, 1960, from Texas, USA, shows stellate structures of exhalant canal structures on its upper surface, but differences in body shape and canal system are so conspicuous that this genus can be excluded. The same is true of the wide variety of other genera of Devonian to Permian age.

Anthaspidella Ulrich & Everett in Miller, 1889, has several features in common with *Brevaspidella* and a more detailed comparison of both genera is needed. *Anthaspidella* includes a large number of species found in Lower Ordovician to Devonian rocks and is distributed worldwide. They vary considerably in growth form, but all possess a funnel- or saucer-shaped body form and a short obconical stalk. In some species an ectodermal layer is present. The upper surface shows a variable number of osculi. In some species the osculi are centres of radiating, sub-horizontally arranged canals, whereas in others the osculi are at the centres of small tumuli, which are in turn surrounded by sub-horizontal canals. In *Brevaspidella* the general body form is cylindrical with sub-vertical side and a with conspicuous, usually flat, concentrically wrinkled basal dermal layer, features not seen in any *Anthaspidella* species. It has the numerous osculi scattered

over the slightly concave upper surface, as in *Anthaspidella*, but radiating surface canals to each of the osculi are absent or, if present, are restricted to the distal side of the distally disposed osculi.

The Anthaspidellidae are otherwise represented in the two studied assemblages by a single species, namely *A. florifera* Ulrich, 1890. This taxon is, however, extremely rare in both sponge assemblages; to my knowledge, only ten specimens have been recognized among total of c. 20,000 sponges. In contrast, *Brevaspidella* is considerably more common, with a total of nearly 60 known specimens from both assemblages.

***Brevaspidella dispersa* gen. et sp. nov.**

Pls. 1-3.

Etymology – Latin *disperses*, referring to the dispersed osculi that are scattered over the upper surface.

Type material and repository – Holotype, NRM Sp1410, an erratic block from the beach near Västkinda, Gotland, Sweden, coordinates: N 57°45'; E 18°21'; height 53 mm, diameter 72 mm. Paratypes (four), NRM Sp4533, an erratic block from an unknown locality on Gotland, Sweden; GPIH 4830, from a sandpit near Braderup, Island of Sylt, Germany, Von Hacht collection in the Archiv für Geschiebekunde, reg. nr. AfG 3-118-9-1; RGM 791 224, from a sandpit near Wilsum, Germany, Koops collection; and RGM 791 225, from a sandpit near Wilsum, Germany, De Looze collection, reg. nr. Ja 8-20.

Other material – NRM Sp4531, NRM Sp4535, NRM Sp4536, all from unknown localities on Gotland; RGM 791 226, from a sandpit near Wilsum, Germany, Rhebergen collection, reg.nr. Ue 11479; RGM 791 227, from a sandpit near Wilsum, Germany, Rhebergen collection, reg.nr. Ue 11834; RGM 791 228, from a sandpit near Wilsum, Germany, Anninga collection, reg. nr. D 207; and RGM 791 229, from a sandpit near Sibculo, the Netherlands, Rhebergen collection, reg. nr. S 11134

Diagnosis – As for genus.

Description – A short, cylindrical sponge with height and diameter more or less equal. The base and sometimes part of the lower side are covered with a dense, impermeable, concentrically wrinkled dermal layer (Pl. 1, fig. B; Pl. 2, figs. C, D, H). The top exposes a number of osculi of excurrent canals, scattered over the flat or slightly concave upper surface. The number of canals vary from 52 in NRM Sp4533 (Pl. 1, fig. D) to eight as in NRM Sp4536 and RGM 791 229 (Pl. 2, fig I). The diameter of the excurrent canals varies from 1-3 mm in NRM Sp1410 to 4.5-5 mm in RGM 791 227 (Pl. 1, fig. F). The canals in the centre are vertical, whereas more distal ones are inclined at about 10-15°. In some specimens osculi are closely clustered in the centre (Pl. 2, fig. F), but more typically they are separated from each other by 2-4 mm. The largest specimen, NRM Sp4533, is 97x84 mm in diameter and has 52 osculi, which are scattered randomly over the whole upper surface. There are extremely irregular arrangements of vertical canals in NRM Sp4531, RGM 791 225 and RGM 791 226 (Pl. 2, figs. A, B, E).

The aquiferous system is composed of three kinds of canals. Large vertical canals either run from the base through the entire sponge body to the surface or start sub-horizontal and curve rapidly upwards to continue vertically, as seen in RGM 791 224 (Pl. 2, fig. J; Pl. 3, fig. A). A second system of smaller radial canals run from distal parts, curving upwards to empty at an angle of about 60° into one of the vertical canals, as demonstrated in GPIH 4830 and RGM 791 224 (Pl. 2, figs. H, J). Radial canals could only be measured uncommonly and are around 0.8-1.0 mm in diameter. There are also small radial canals on the upper surface, about 0.6-1.0 mm wide, slightly sinuous and branching distally, observed in NRM Sp1410 (Pl. 1, fig. A), NRM Sp4535 (Pl. 1, fig. C) and NRM Sp4536. Rows of vertically stacked radial canals are usually horizontally adjacent (Pl. 3, fig. A). The third system of canals, parallelling the skeletal strands, are still smaller. Due to the intensive silicification and replacement by chalcedony, measurement of the incurrent canals was not possible.

The skeleton is typically anthaspidellid. Horizontally arranged dendroclones are stacked in vertical ladderlike structures, in which shafts of dendroclones form the rungs and connected zygomes of adjacent dendroclones form the beams. These ladder-like trabs run from the base, curving upwards and outwards, to meet the lateral surface at angles of 80°-90°. As a result, some of the sponges show a pattern of small triangles and knots on the lateral surface, which represent cross-sections of the trabs and the connected zygomes (Pl. 2, fig. D, G; Pl. 3, fig. B). The skeleton of *Brevaspidella dispersa* is composed predominantly of amphiarborescent or I-shaped dendroclones (Pl. 3, fig. A), with generally uniform dimensions. Their length varies from 0.33-0.38 mm, but the vast majority of dendroclones are 0.36 mm long. Shafts are on average 0.05 mm across. Short parietal trabs with polyclonid dendroclones occur where a new intraserial trab is intercalated, as seen in GPIH 4830 and RGM 791 224. The skeleton of the imperforate basal dermal layer could not be studied in the present material due to replacement by chalcedony, but in other studies identical layers appeared to be composed by small dendroclones and even smaller chiastoclones (Van Kempen, 1983; Rhebergen *et al.*, 2001).

Remarks – In most species of the Anthaspidellidae and Streptosolenidae, trabs are pinnately arranged. They bend from the plane of pinnation upwards and outwards to meet the dermal wall, and inwards to meet the gastral wall. Since there is no discrete gastral wall in *Brevaspidella*, a plane of pinnation is absent.

During this study, some sponge bodies of the Streptosolenidae were seen with a cluster of vertical canal osculi on the upper surface, but their body form differed from *Brevaspidella* in the length-width ratio; more importantly, their skeleton was more irregular, with more parietal strands, and with many more Y- and X-shaped dendroclones. These sponges are not assignable to genera such as *Aulocopium*, *Aulocopella* or *Hudsonospongia* that are already known in the assemblage and, possibly, represent a further undescribed taxon.

Co-occurring fossils on the surface of *Brevaspidella dispersa* are rare. Some remains of probably *Corynotrypa* sp. and other unidentified bifoliate and trepostomate bryozoans occur on the dermal basal layer of some specimens, such as on NRM Sp4531. In addition, two holdfasts of a crinoid have been observed in the extended studied material.

Conclusions

Brevaspidella dispersa gen. et sp. nov. is a new representative of the Late Ordovician Gotland-WWW-area sponge association (*sensu* Rhebergen & Von Hacht, 2000). Its presence emphasizes the distinctive faunal composition of the assemblage, as the genus is unknown in the Lausitz-Sylt-association (*sensu* Rhebergen & Von Hacht, 2000) or in contemporaneous strata in Estonia and Laurentia. Although its exact provenance is uncertain, its source may be from eroded strata in the Bothnian Sea, west of Finland.

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Plate 1

Brevaspidella dispersa gen. et sp. nov., from Late Ordovician erratics of northern and western Europe.

Figs. A, B. NRM Sp1410, holotype, from beach near Västlanda, Gotland, Sweden. (A) View on upper side with dispersed osculi and radial surface canals. (B) Lateral view with concentrically wrinkled dermal layer in the lower part.

Fig. C. NRM Sp4535, from unknown locality on Gotland, Sweden. Flat to slightly concave upper surface with cluster of osculi and some converging lateral canals.

Figs. D, E. NRM Sp4533, paratype, from unknown locality on Gotland, Sweden. (D) The top shows more than 50 osculi, scattered over the flat surface. (E) Side view. Dermal layer poorly developed and restricted to the base.

Fig. F. RGM 791 227 from sand- and gravel pit near Wilsum, western Germany. Coll. Rhebergen, reg. nr. Ue 11834. Large osculi of canals, extending to the basal area.

Scale bars represent 10 mm.

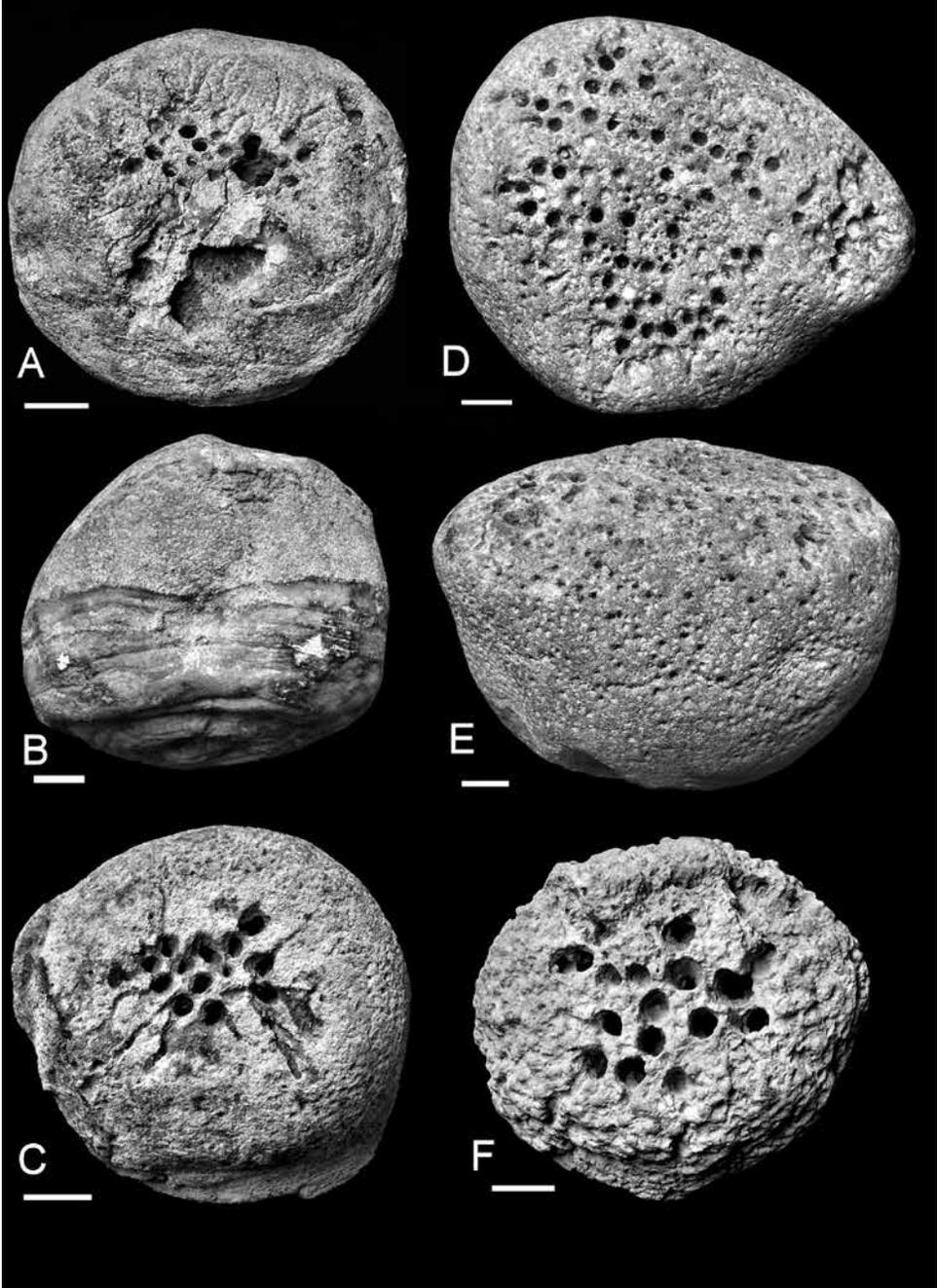


Plate 2

Brevaspidella dispersa gen. et sp. nov., from Late Ordovician erratics of northern and western Europe.

Fig. A. NRM Sp4531 from unknown locality on Gotland, Sweden; oblique view of upper surface and part of the lateral surface. Numerous osculi are scattered randomly over the concave upper surface. Centrally-disposed canals are vertical, laterally disposed canals meet the surface at angles between 75 and 80°.

Figs. B, C. RGM 791 225, paratype, from Jansen sandpit, Wilsum, Germany. Coll. De Looze, reg. nr. Ja 8.20. (B) Top view with extremely irregularly dispersed osculi of vertical canals. (C) Oblique view of lateral surface and base with well-developed wrinkled dermal layer.

Figs. D, G. NRM Sp4536, from unknown locality on Gotland, Sweden. (D) Lateral surface and basal dermal layer. (G) Detail of lateral surface shown in (D) with a pattern of triangles that represent natural cross sections of skeletal trabs.

Fig. E. RGM 791 226, from Schröder sandpit, Wilsum, Germany. Coll. Rhebergen, reg. nr. Ue 11479. Top view showing irregularly scattered vertical canals. See also (Pl. 3, fig. B).

Fig. F. RGM 791 228 from Schröder sandpit, Wilsum, Germany. Coll. Anninga, coll. nr. D 207. It shows closely closely packed osculi of vertical canals, extending to the base.

Fig. H. GPIH 4830, paratype, from a sand- and gravel pit near Braderup, the island of Sylt, northern Germany. Coll. Von Hacht; AfG. Lateral view, showing a natural fracture, revealing the internal structure of the canal system. In the centre, a natural longitudinal section of one of the vertical canals is exposed, extending to the base. Radial canals flare upwards and inwards to empty into one of the vertical canals.

Fig. I. RGM 791 229, from Bolks / Beuving sandpit, Sibculo, the Netherlands. Coll. Rhebergen, reg. nr. S 11134. Oblique view of upper surface, with a small number of irregularly disposed vertical canals.

Figs. J, K. RGM 791 224, paratype, from Jansen sandpit, Wilsum, Germany. Coll. Koops. The specimen has recently been broken longitudinally. (J) View showing both vertical and radial canals. In the lower right, one of the canals starts horizontally and bends about 90° upwards to continue as a vertical canal. (K) Detail of anthaspidellid skeleton, composed of trabs, flaring upward and outward. Stacked dendroclones are arranged perpendicularly to the direction of the trabs. See also (Pl. 3, fig. A).

Scale bars represent 10 mm except in G.

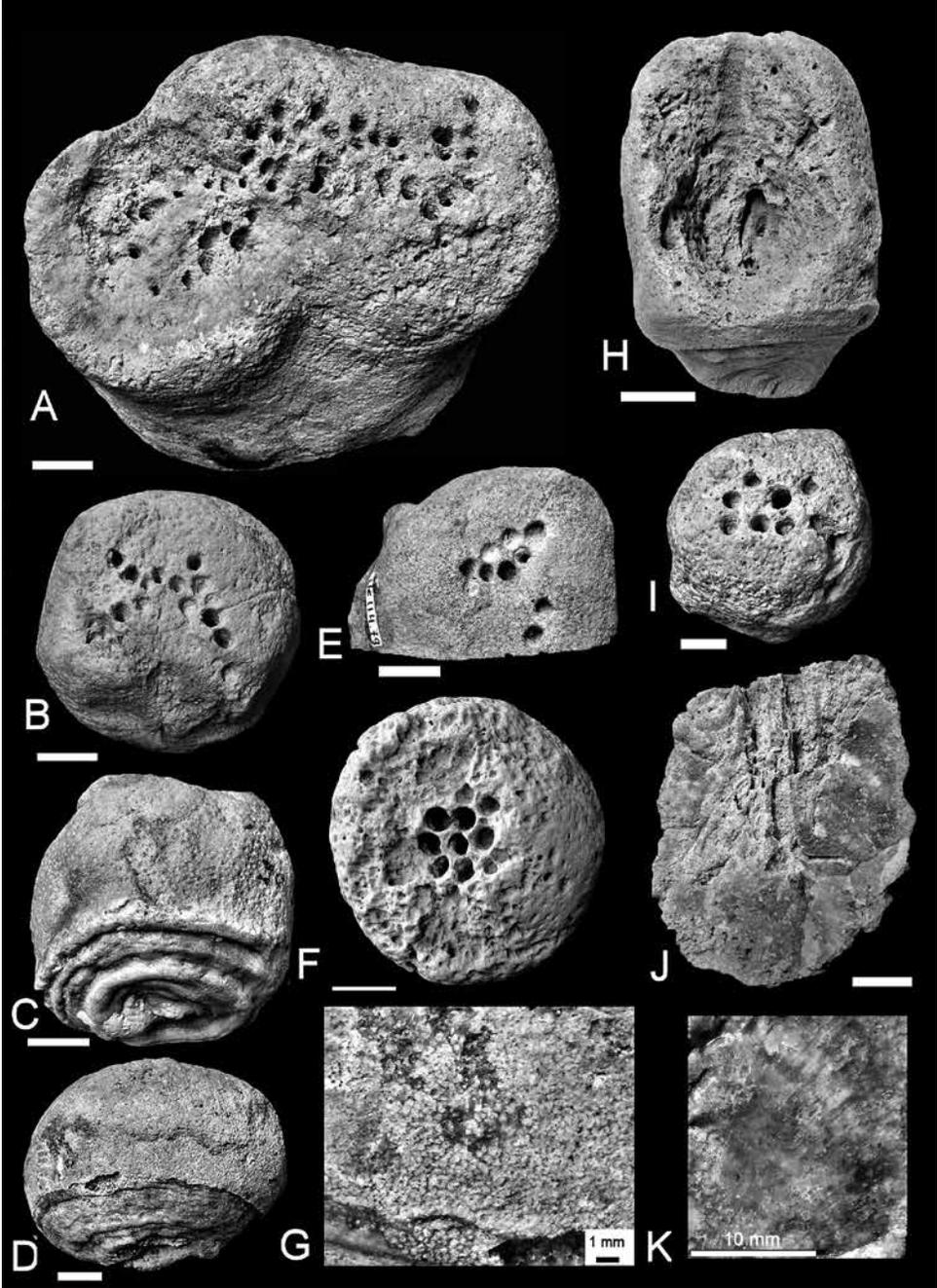


Plate 3

Brevaspidella dispersa gen. et sp. nov., from Late Ordovician erratics of northern and western Europe.

Fig. A. RGM 791 224, paratype. The same specimen as in (Pl. 2, figs. J, K). Detail of (Pl. 2, fig. K) to show the skeletal structure of predominantly intraserial trabs, which are adjacent and usually without intercalated parietal trabs. Coll Kooops. Scale bar represents 1 mm.

Fig. B. RGM 791 226 is a detail of the lateral side of the specimen in (Pl. 2, fig. E), showing the triangles of connected amphiarborescent or I-shaped dendroclones. This pattern is the result of skeletal strands that meet the distal surface perpendicularly. Coll. Rhebergen, reg. nr. Ue 11479. Scale bar represents 10 mm.

