

Notes on some trace fossils and other parataxa from the Maastrichtian type area, southeast Netherlands and northeast Belgium*

S.K. Donovan^{1,*}, J.W.M. Jagt² & D.N. Lewis³

¹ Department of Geology, Nederlands Centrum voor Biodiversiteit (Naturalis), Postbus 9517, NL-2300 RA Leiden, the Netherlands.

² Natuurhistorisch Museum Maastricht, de Bosquetplein 6-7, NL-6211 KJ Maastricht, the Netherlands.

³ The Natural History Museum, Department of Palaeontology, Cromwell Road, London SW7 5BD, United Kingdom.

* Corresponding author. Email: Steve.Donovan@ncbnaturalis.nl

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Abstract

New specimens described herein add to our knowledge of uncommon parataxa (embedment structures, borings and a certain type of burrow) from the type area of the Maastrichtian Stage, the material originating from the ENCI-HeidelbergCement Group (Maastricht), Ankerpoort-t Rooth (Bemelen) and former Blom (Berg en Terblijt) quarries in southern Limburg (the Netherlands), and from the CBR-Romontbos (Eben Emael) and CPL SA (Haccourt) chalk pits in the province of Liège (northeast Belgium). Although *Centrichnus eccentricus* Bromley & Martinell has previously been recorded from this area, it has not received formal description; the specimen documented herein shares a test of the echinoid *Echinocorys gr. conoidea* with numerous other episkeletozoans. *Podichnus* cf. *centrifugalis* Bromley & Surlyk occurs both on echinocorythid echinoid tests and guards of belemnite coleoids; two out of seven specimens display radial discontinuous channels, indicative of the extreme penetration of filaments from the attached brachiopod's pedicle. *Renichnus arcuatus* Mayoral shows a range of morphologies, from the embedment structure sensu stricto through to specimens retaining internal moulds of the producing, embedded vermetid gastropod to free shells of *Vermetus binkhorsti* Cossmann. Burrows packed with bioclastic debris, particularly primary spines and a few test plates of phymosomatid echinoids, present a systematic conundrum, although appearing comparable to the ichnogenera *Nummipera* Hölder and *Baronichnus* Breton in several respects.

Keywords: Ichnology, systematics, *Centrichnus*, *Podichnus*, *Renichnus*, burrows, Maastrichtian

Introduction

The ichnology of the extended type area of the Maastrichtian Stage (uppermost Cretaceous, 70.6–65.5 Ma) in the southeast Netherlands and northeast Belgium, has been described over a period of many years in a plethora of short papers by a host of authors. A brief review of the diversity of this ichnofauna was published by Dortangs (1998), while Jagt (2003, p. 181, appendix) provided a tabulation of the ichnotaxa known at that time from the Vaals, Gulpen and Maastricht formations, of early Campanian to latest Maastrichtian age, in this area, but no monographic study exists.

Herein, we add new specimens to three embedments, and provide new observations on morphology and substrate

preference. We also illustrate and discuss a distinctive burrow morphology that remains in open nomenclature, but which does show some resemblance to, for example, the ichnogenera *Nummipera* Hölder, 1989, and *Baronichnus* Breton, 2002.

Terminology of trace fossil morphology follows Häntzschel (1975; see also De Gibert et al., 2004; Bromley & Heinberg, 2006). Our approach to ichnotaxonomy conforms to that of Pickerill (1994) and Bertling et al. (2006), while the philosophy of open nomenclature outlined by Bengtson (1988) is adopted here. All specimens are deposited in the collections of the Natuurhistorisch Museum Maastricht (abbreviation: NHMM, with subsets indicated by letters, as follows: JJ – J.W.M. Jagt Collection; MD – M.J.M. Deckers Collection; RZ – S. Renkens/H. Zijlstra Collection; WR – W. van Rijsselt Collection).

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Localities and horizons

In the extended type area of the Maastrichtian Stage (Fig. 1), a number of key localities have been selected which, in combination, represent the entire stratigraphic sequence from the middle/upper Santonian to the lowermost Paleocene (middle Danian). The present parataxa originate principally from the former CPL SA-Haccourt (Haccourt, Liège), ENCI-Heidelberg Cement Group (south of Maastricht) and CBR-Romontbos (Eben Emael, Liège) quarries. The stratigraphic levels from which the material stems all relate to the Maastrichtian, and comprise the Vijlen, Lixhe 1 and Lanaye members (Gulpen Formation), as well as the Gronsvelt and Meerssen members (Maastricht Formation; see Jagt, 2010 for details).

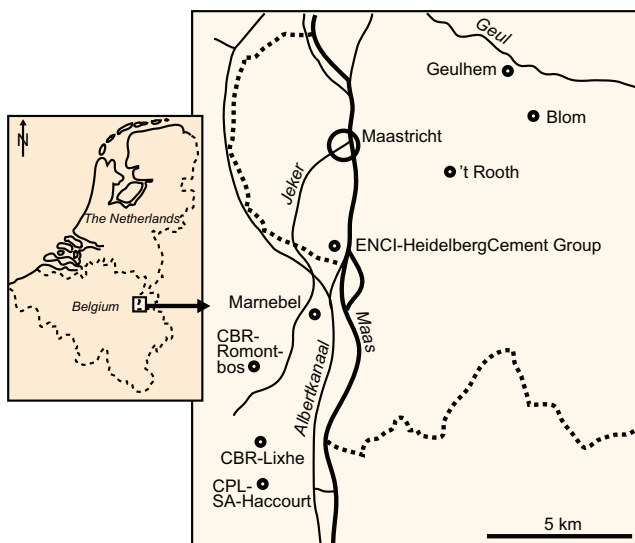


Fig. 1. Map of southern Limburg (the Netherlands) and contiguous Belgian territory, showing a selection of key localities (CPL SA-Haccourt; CBR-Lixhe; CBR-Romontbos; ENCI-Heidelberg Cement Group; Blom; Geulhem (Curfs); Marnebel; 't Rooth-Bemelen), inclusive of the ones which yielded the present material.

Systematic ichnology

Ichnogenus *Centrichnus* Bromley & Martinell, 1991

Type ichnospecies

Centrichnus eccentricus Bromley & Martinell, 1991, pp. 247-249, figs 5, 6, by original designation.

Other ichnospecies

Centrichnus concentricus Bromley & Martinell, 1991.

Diagnosis

Shallow biogenic etching traces on carbonate lithic or skeletal substrates comprising centrally arranged arcuate or ring-shaped grooves (based on Bromley & Martinell, 1991, p. 247).

Remarks

The teardrop-shaped *C. eccentricus*, considered to be produced by the byssal plug of anomiid bivalves (Bromley, 1994, p. 145, fig. 5.1B; Taddei Ruggiero & Annunziata, 2002, p. 48, pl. 2; Bromley & Heinberg, 2006, table 1), ranges from the lower Campanian to the present day, thus markedly post-dating the first appearance of the Anomiidae in the Middle Jurassic (Bromley, 2004, p. 462). The other ichnospecies, *Centrichnus concentricus*, is produced by verrucid barnacles; although the Verrucidae have a fairly extended Late Cretaceous record (see Buckeridge et al., 2008), we know of no examples of this ichnotaxon of that age. It should also be noted here that De Gibert et al. (2007, p. 792, fig. 9A, B) recorded small-sized (1.0-1.5 mm in length) traces from the Pliocene of southern France which they listed as *C. cf. eccentricus* and interpreted as etching (fixation) traces of cibicidid foraminifera.

Centrichnus eccentricus Bromley & Martinell, 1991

Fig. 2B.

Material

One incomplete specimen (Fig. 2B) at about mid-height and to the right of the anterior ambulacrum on a test of *Echinocorys* gr. *conoidea* (NHMM WR 1791), just out of view to the right in Fig. 2A.

Locality and horizon

CPL SA-Haccourt quarry, Haccourt (Oupeye, Liège, northeast Belgium); Gulpen Formation, top 5 m of Lixhe 1 Member, directly below the Hallembaye 1 Horizon.

Diagnosis

Tear- or drop-shaped *Centrichnus* comprising a series of bundled or crowded, bow-shaped grooves concave toward the pointed end (based on Bromley & Martinell, 1991, p. 247).

Description

Kidney-shaped depression in the test of an echinoid, the long axis being oriented perpendicular to the oral surface; closely-packed, gently curved, parallel grooves in the base of the depression, parallel to the two long sides of the trace.

Remarks

Previous reports of *C. eccentricus* from the Maastrichtian type area include Jagt & Dortangs (2000, figs 2-4) and Jagt (2003, fig. 1). These papers illustrated specimens that were more complete than the one described herein, which lacks a 'pointed end' (see diagnosis above), but *C. eccentricus* from this area has not hitherto received a formal systematic treatment.

The substrate is particularly densely infested by diverse epi- and endoskeletozoans, including numerous craniid brachiopods of two species, *Crania antiqua* Defrance, 1818, and *Ancistrocrania* aff. *parisiensis* Defrance, 1818 (see Krutzler, 1969, p. 12, fig. 2;

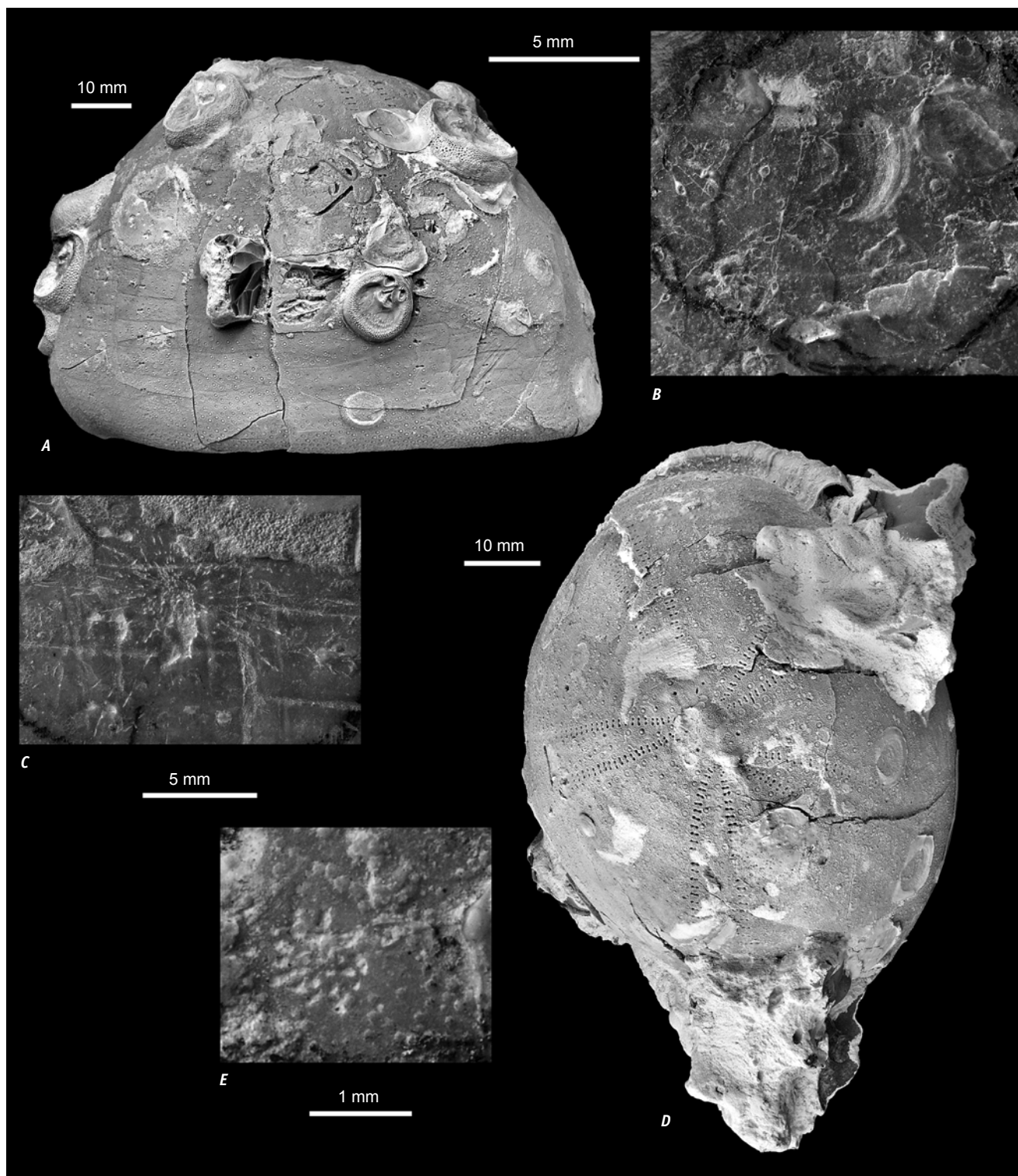


Fig. 2A-C, E. *Echinocorys* gr. *conoidea* (Goldfuss, 1829), NHMM WR 1791. A – test in lateral view (anterior towards the right), showing encrusting organisms [mainly the craniid brachiopods *Ancistrocrania* aff. *parisiensis* (Defrance, 1818) and *Crania antiqua* (Defrance, 1818)], although trace fossils are less easily discerned; B – *Centrichnus eccentricus* Bromley & Martinell, 1991, incomplete specimen; C – *Podichnus* cf. *centrifugalis* Bromley & Surlyk, 1973, specimen showing discontinuous radial grooves (see also Fig. 3A, B); E – *Podichnus* cf. *centrifugalis* Bromley & Surlyk, 1973; D – *Echinocorys* gr. *conoidea* (Goldfuss, 1829), NHMM 2010 129 (leg. N. Debrun, deceased), test bored in left-hand side, anterior half, by *Podichnus* cf. *centrifugalis* Bromley & Surlyk, 1973 (see Fig. 3A). Specimens coated with ammonium chloride prior to photography.

and p. 19, fig. 5, respectively), cyclostome and cheilostome bryozoans, *Podichnus cf. centrifugalis* Bromley & Surlyk, 1973 (see below), *Oichnus paraboloides?* Bromley, 1981, *Trypanites?* isp. and *C. eccentricus*. The last-named ichnotaxon is closely associated with bryozoans (Fig. 2B); it is positioned just beneath and anterior of the large craniid seen in the upper right of Figure 2A. This test was undoubtedly infested post-mortem, after the loss of all spines, with encrusters covering pore pairs and tubercles without any sign of an adverse reaction by the echinoid (as would be expected in a live individual). Although dead *Echinocorys* tests were common hard substrates utilised by encrusters and borers in the Late Cretaceous, the two specimens illustrated herein (Fig. 2A, D) seem to have been particularly popular and are typical of at least a quarter (i.e., 25 per cent) of the population of echinocorythid echinoids in the Lixhe 1 Member of the Haccourt-Lixhe-Boirs area (northeast Belgium; JWMJ, pers. obs.). *Centrichnus eccentricus* is also known from pycnodonteine oyster substrates in the study area (see Jagt, 2003, fig. 1) as well as from another echinoid species, *Echinocorys gr. limburgica* from the underlying Vijlen Member (interval 6; see Jagt & Dortangs, 2000, figs 2-4).

Ichnogenus Podichnus Bromley & Surlyk, 1973

Type ichnospecies

Podichnus centrifugalis Bromley & Surlyk, 1973, p. 364, fig. 13, by original designation.

Other ichnospecies

Podichnus obliquus Robinson & Lee, 2008; *Podichnus perpendicularis* Robinson & Lee, 2008.

Diagnosis

More or less compact group or cluster of short pits, holes, elongate cylindrical shafts and/or furrows, mutually parallel or diverging. Surface expression is a c. 1-4 millimetre-sized cluster of holes each up to c. 200 µm in diameter (modified after Robinson & Lee 2008, p. 223).

Remarks

Robinson & Lee (2008) included, '... within carbonate substrates' as part of their emended ichnogenetic diagnosis of *Podichnus*. Substrate is not an ichnotaxobase per se (Pickerill, 1994; Donovan & Pickerill, 2002), although we do recognise its importance (Andrew et al., 2010, p. 92), but we prefer that it should not form part of the diagnosis. Although not recorded hitherto, a *Podichnus* in a non-carbonate substrate would still be *Podichnus*; for example, it might conceivably occur in a lithic or phosphatic clast.

A further ichnospecies of *Podichnus* is currently being described by Gérard Breton (pers. comm. to SKD, September 2010). Examination of a photograph of the same shows it is not similar to specimens described herein.

Podichnus cf. centrifugalis Bromley & Surlyk, 1973

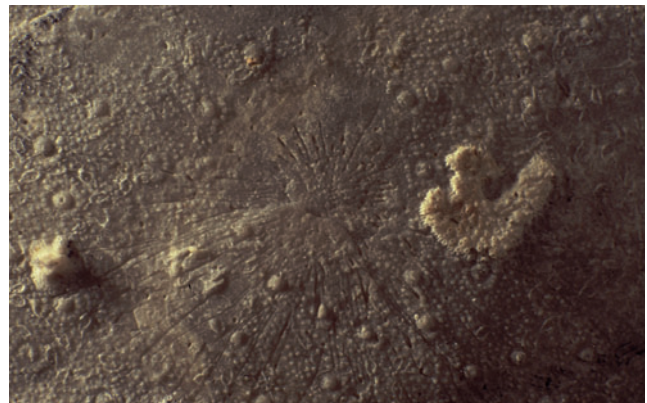
Figs 2C, E, 3A, B, 4B-D.

Material

Two specimens (Fig. 2C, E) below mid-height in right posterior interambulacrum and one above mid-height in right posterior ambulacrum on *Echinocorys gr. conoidea* (NHMM WR 1791), respectively; one in left posterior interambulacrum of *Echinocorys gr. conoidea* (NHMM 2010 129) (Fig. 3A); three specimens (Fig. 4A-D) on a belemnite guard, *Belemnitella gr. junior* Nowak, 1913 (NHMM WR 565); one on a belemnite guard, *Belemnella* sp. (NHMM WR 936) (not figured); plus one further specimen (Fig. 3B) on a belemnite guard, *Belemnitella* sp. (NHMM 2010 130, leg. W. van Rijsselt).

Locality and horizon

NHMM WR 1791 is from the upper part of the Lixhe 1 Member (Gulpen Formation) at the former CPL SA quarry (Haccourt), NHMM 2010 129 originates from the same member at the adjoining CBR-Lixhe quarry, while NHMM WR 565, NHMM WR



A.



B.

Fig. 3. *Podichnus cf. centrifugalis* Bromley & Surlyk, 1973; A – NHMM 2010 129 (leg. N. Debrun, deceased), in a test of *Echinocorys gr. conoidea* (see Fig. 2D); greatest diameter of trace is 13 mm; B – NHMM 2010 130 (leg. W. van Rijsselt), in a belemnite guard, *Belemnitella* sp.; greatest diameter of trace is 4.5 mm.

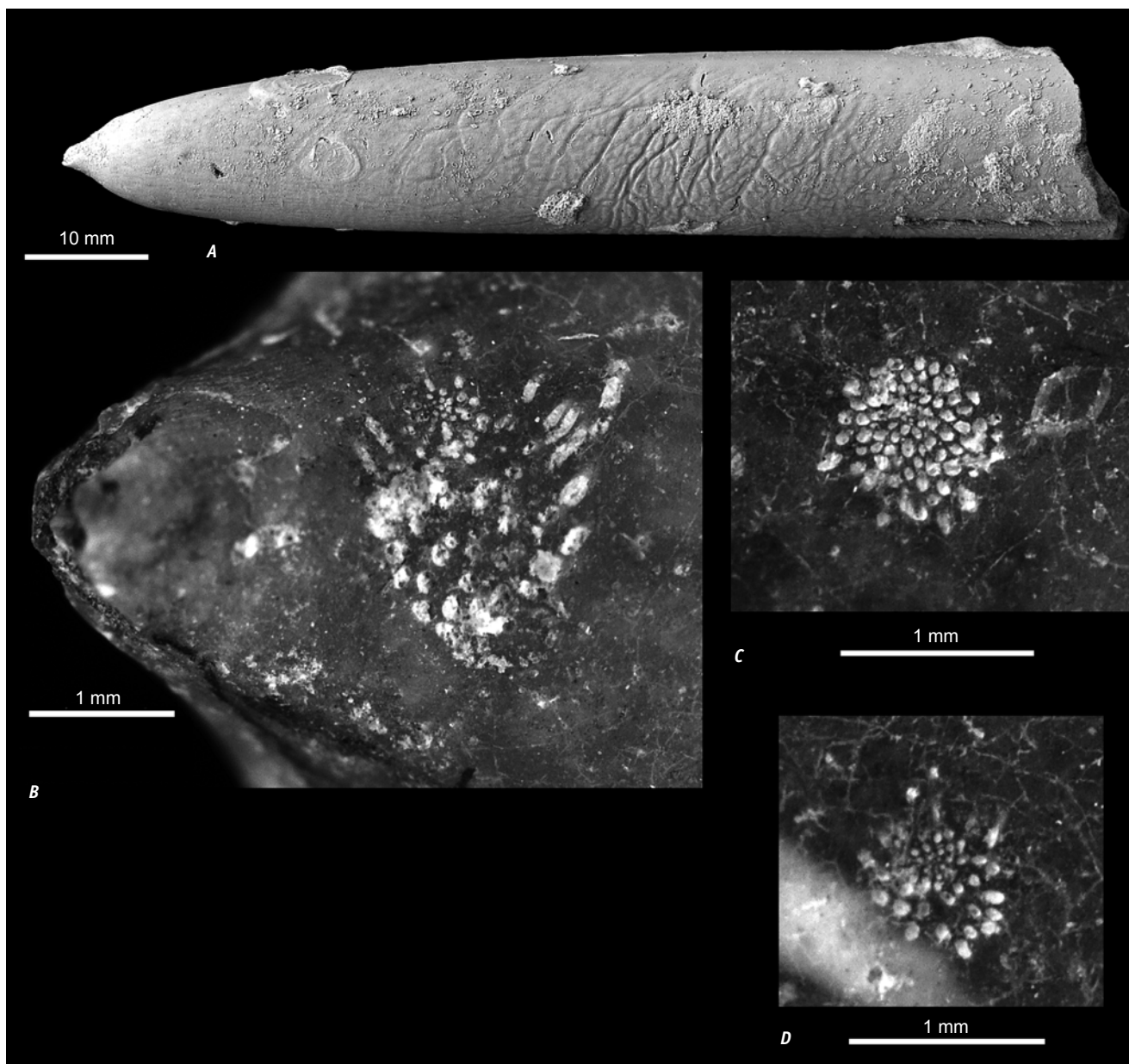


Fig. 4. *Belemnitella gr. junior* Nowak, 1913, NHMM WR 565. A – guard in oblique lateral view; B–D – *Podichnus cf. centrifugalis* Bromley & Surlyk, 1973, all infesting the figured guard – in B two traces can be seen to overlap partially. Specimen coated with ammonium chloride for photography.

936 and NHMM 2010 130 are all from the Vijlen Member (near the Zonneberg Horizon; Gulpen Formation) at the ENCI-HeidelbergCement Group quarry, Maastricht.

Description

Small- to medium-sized, rounded clusters of numerous, minute circular to elliptical or, where more closely spaced, roughly polygonal pits in the surface of echinoid tests (Figs 2C, 3A) and belemnite guards (Figs 2E, 3B, 4B–D). One specimen (Fig. 4B) appears to consist of two partially overlapping traces, as is suggested by the strong differentiation between rounded and more elongate pits as well as their size. Three specimens (that is, Figs 2C, 3A, B), two of which (Figs 2C, 3A) are of comparatively large size (that is, greatest diameters of 13 and 11 mm,

respectively, the latter partially overgrown by a pycnodonteine oyster), have a strong radial development of discontinuous grooves in addition to a cluster of circular and elliptical pits in the centre.

Remarks

The only previous report of *Podichnus* from the type area of the Maastrichtian Stage was that by Jagt et al. (2007), who described two specimens of *P. centrifugalis* on a test of *Echinocorys gr. conoidea* from the Lixhe 1 Member at the CPL SA quarry (Haccourt, Liège) and discussed possible agents amongst the brachiopod assemblages known from this level.

Here we opt to leave our *Podichnus* specimens in open nomenclature. When this ichnogenus comprised only one

ichnospecies, identification of *P. centrifugalis* was possible from external morphology alone. Now that there are four ichnospecies, at least one carefully oriented section cut through the substrate or the production of an epoxy cast would be required of each specimen to determine its precise morphology. For now, we refrain from such destructive preparation. However, the external morphology of all specimens described herein is closest to the type ichnospecies, with the exception of those illustrated in Figures 2C and 3A, B, which are atypical in showing a strong radial component of discontinuous grooves; they may represent another, perhaps new ichnospecies. These provide unusual evidence of the extreme degree of insertion of filaments of the brachiopod pedicle into the echinoid test. Although functionally different, the rootlets of the extant abyssal soft-sediment dweller *Chilonophora* Thomson, 1927, provide an indication of the fine branching possible in such a structure (Rudwick, 1970, fig. 36). It is interesting to note that, unlike occurrences elsewhere (see, for example, Małkowski, 1975; Taddei Ruggiero & Annunziata, 2002; Žitt et al., 2006), we know of no *Podichnus* traces on any brachiopod shells from the study area.

Ichnogenus Renichnus Mayoral, 1987

Type ichnospecies

Renichnus arcuatus Mayoral, 1987, pp. 56-57, fig. 3; pl. 2, fig. 13, by original designation.

Other ichnospecies

None.

Diagnosis

Kidney-shaped depressions in the form of a half moon, disposed in a crude row or coarsely coiled (after Mayoral, 1987, p. 56; translated from Spanish).

Remarks

This monospecific ichnogenus is easily differentiated from the superficially similar *Centrichnus eccentricus* by being composed of relatively few adjacent, concentric depressions that are less gracile (compare with Jagt, 2003, fig. 1).

Renichnus arcuatus Mayoral, 1987

Figs 5-7.

Material

Renichnus arcuatus (sensu stricto): NHMM RZ 00887 (ex 98A; see Fig. 5A) and NHMM WR 1845 (Fig. 7); miscellaneous vermetid moulds and shells, including NHMM JJ 7443 (Fig. 5E), JJ 8456 (Fig. 5I), JJ 11485a, b (Fig. 6A, B), JJ 12389 (Fig. 5H), JJ 13559 (Fig. 5B, C), JJ 13560 (Fig. 5G), JJ 14249 (Fig. 5J), JJ 14257 (Fig. 5F) and NHMM RZ 02108 (ex 319) (Fig. 5D). These mainly

infest colonial scleractinian corals of various types, with the exception of NHMM WR 1845, which occurs in a calcareous serpulid tube.

Locality and horizon

All material originates from subunit IVf-4 of the Meerssen Member (Maastricht Formation), of late Maastrichtian age, at the ENCI-HeidelbergCement Group (Maastricht; NHMM JJ 7443, JJ 8456, JJ 11485a, b, JJ 12389, JJ 13559a, JJ 13560, JJ 14249 and JJ 14257) and former Blom (Berg en Terblijt; NHMM RZ 02108) quarries, except for NHMM RZ 00887, which is from the base of subunit IVf-3 at the former Blom quarry and NHMM WR 1845, which stems from the basal Meerssen Member at the Ankerpoort – 't Rooth quarry.

Diagnosis

As for the ichnogenus.

Description

Reference is made to Jagt (2003, p. 177) and Jagt et al. (2009, p. 159) for descriptions of *R. arcuatus* from the type Maastrichtian. Other records of this ichnospecies include Radwański (1977, pp. 246-247), Mayoral (1987, pp. 56-57), Donovan (2004, p. 139) and Taddei Ruggiero & Raia (2010, p. 163, as *Renichnus arcuatus*).

Remarks

To demonstrate the range of morphologies possible, we here illustrate *R. arcuatus* (sensu stricto), along with external and internal moulds of vermetid gastropods, and their shells (Figs 5, 6). These serve to demonstrate the problem of determining where preservation of embedment structures stops and body fossil preservation starts. Many specimens are part body fossil and part embedment structure. Perhaps most confusing is NHMM JJ 13559 (Fig. 5B, C), best described as an external mould of *Vermetus binkhorsti* Cossmann, 1902 (= *V. clathratus* Binkhorst van den Binkhorst, 1861, p. 35, pl. 5a2, fig. 3, non Deshayes 1861, p. 286, pl. 9, figs. 9, 10, as *Serpulorbis clathratus*); if not for the infill of the hollow columella this would have been better regarded as *R. arcuatus*. *Renichnus arcuatus* is also known from shells of exogyrine oysters and calcareous serpulid worm tubes in the study area (Fig. 7; see also Jagt 2003, pl. 2, fig. 3; Jagt et al. 2009, fig. 1).

Burrows packed with bioclastic debris

Fig. 8.

Material

Two large pieces, NHMM JJ 11983a, b (part of the same specimen) (Fig. 8A, B, D, F) and two smaller pieces, also of the same burrow, NHMM MD 4952/24 (Fig. 8C, E, G).

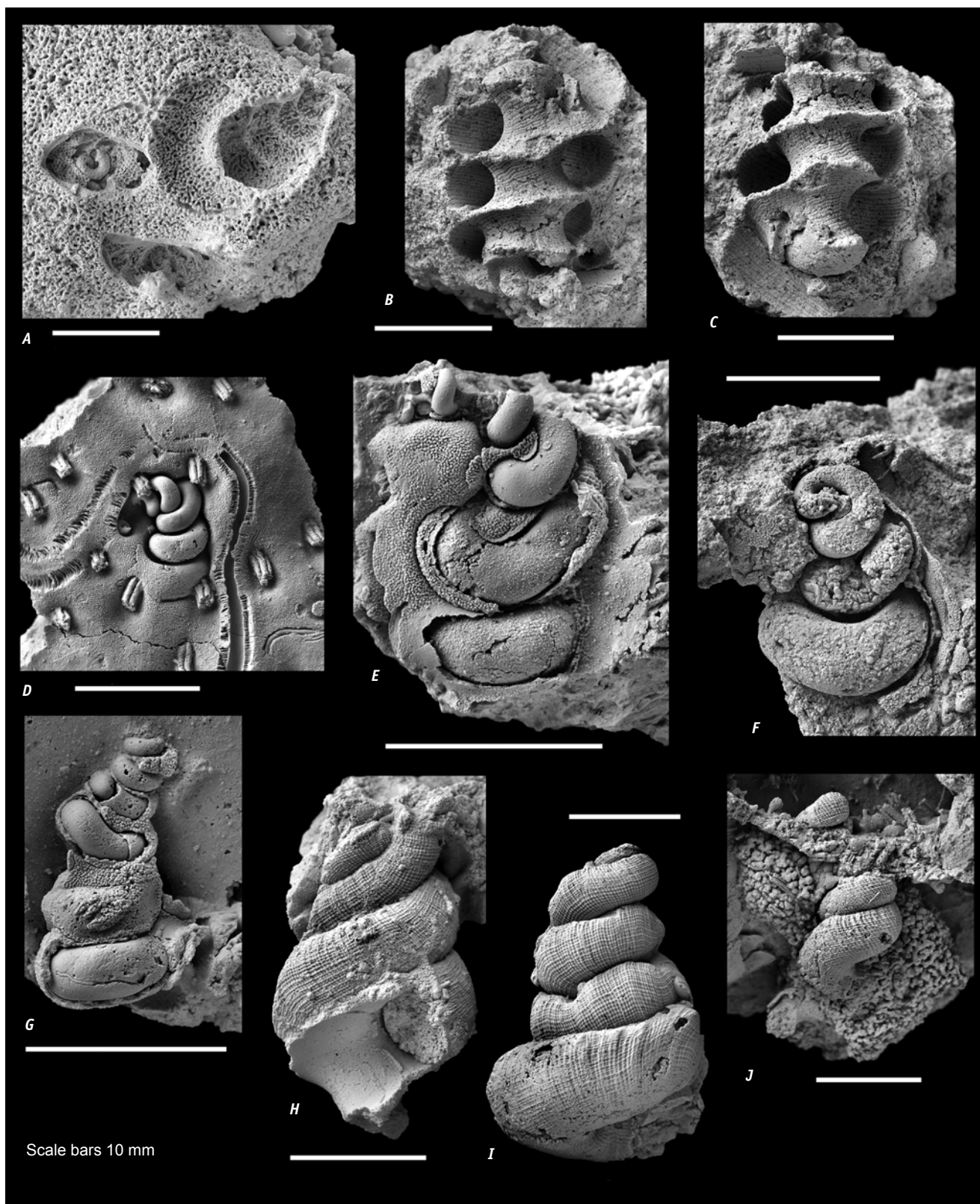


Fig. 5. Vermetid gastropods and their embedment structures. A – *Renichnus arcuatus* Mayoral, 1987, NHMM RZ 00887 (ex 98A); B, C – *Vermetus binkhorsti* Cossmann, 1902, NHMM JJ 13559a, external mould, two views of same specimen, inverted in relation to each other; D – vermetid internal mould, NHMM RZ 02108 (ex 319), in *R. arcuatus*; E – vermetid internal mould, NHMM JJ 7443; F – vermetid internal mould, NHMM JJ 14257; G – *V. binkhorsti*, NHMM JJ 13560, internal mould retaining some part of cast of shell; H – *V. binkhorsti*, NHMM JJ 12389; I – *V. binkhorsti*, NHMM JJ 8456, previously illustrated by Jagt (2003, pl. 2, fig. 4); J – *V. binkhorsti*, NHMM JJ 14249. Specimens coated with ammonium chloride prior to photography.

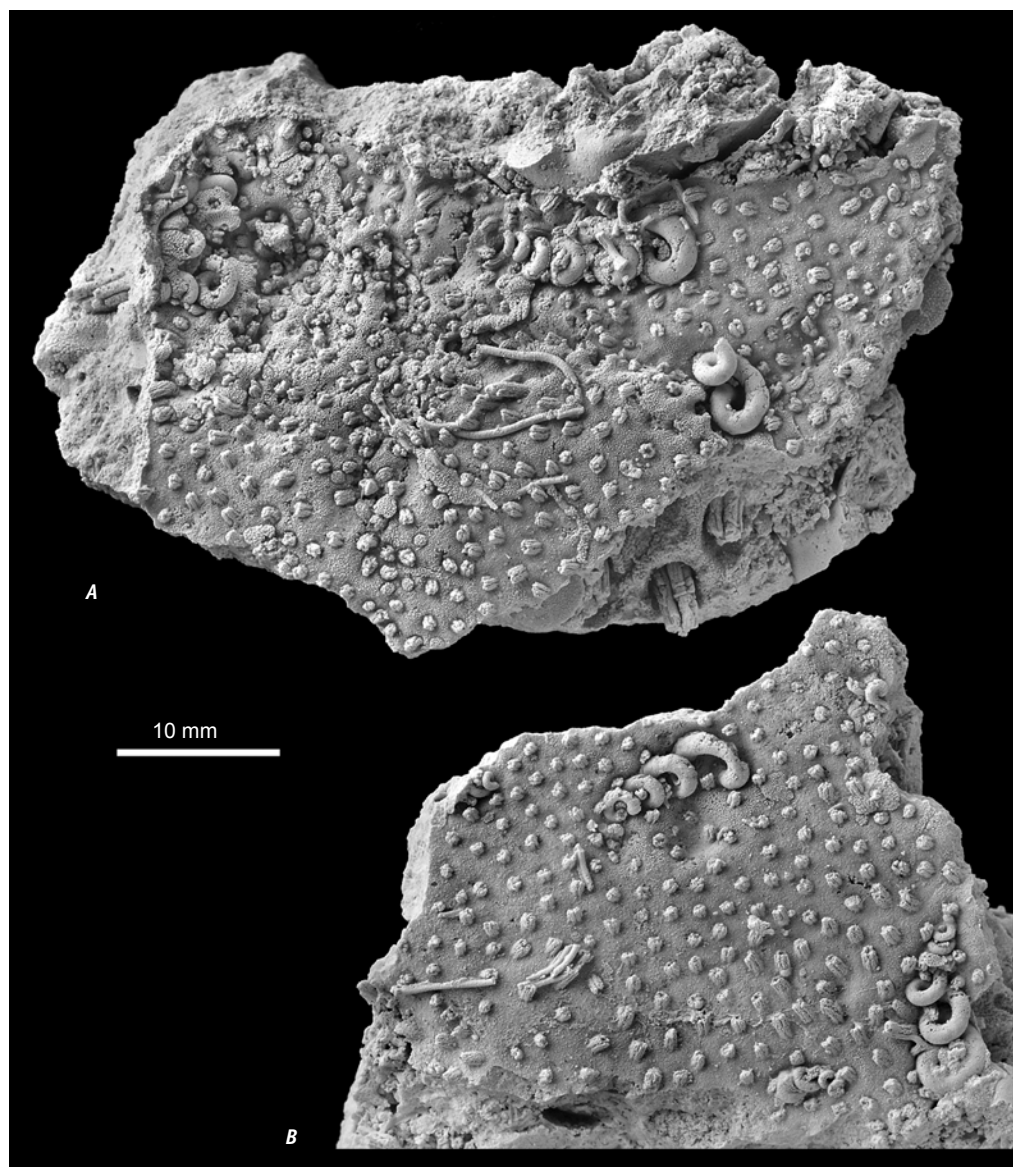


Fig. 6. Vermetid internal moulds embedded in a coral substrate, NHMM JJ 11485a, b (A and B, respectively). Specimens coated with ammonium chloride prior to photography.



Fig. 7. *Renichnus arcuatus* on a serpulid tube (NHMM WR 1845) from the basal Meerssen Member at the 't Rooth (Ankerpoort) quarry (Bemelen); greatest length of trace is 9.5 mm.

Locality and horizon

NHMM JJ 11983a, b is from the basal Gronsvelde Member (Maastricht Formation; ENCI Horizon +0.2 m) at the ENCI-HeidelbergCement Group quarry, while NHMM MD 4952/24 stems from between flint levels 16 and 17 of the Lanaye Member (Gulpen Formation) at the CBR-Romontbos quarry.

Remarks

NHMM JJ11983a, b appears to be a massive fill of an unlined burrow (cf. *Planolites* isp.); it was collected in situ in a vertical position, the widest part up. In contrast, NHMM MD 4952/24 is lined with echinoid debris (a skeletal debris wall sensu Keighley & Pickerill, 1994, text-fig. 1) with a fill which is more coarsely grained and more obviously laminated than the enclosing lithology; the fill is not meniscate. Unfortunately, the original position in the sediment has not been noted during collection. Stated bluntly, an unbranched burrow with a fill of different morphology to the surrounding sedimentary rock is not

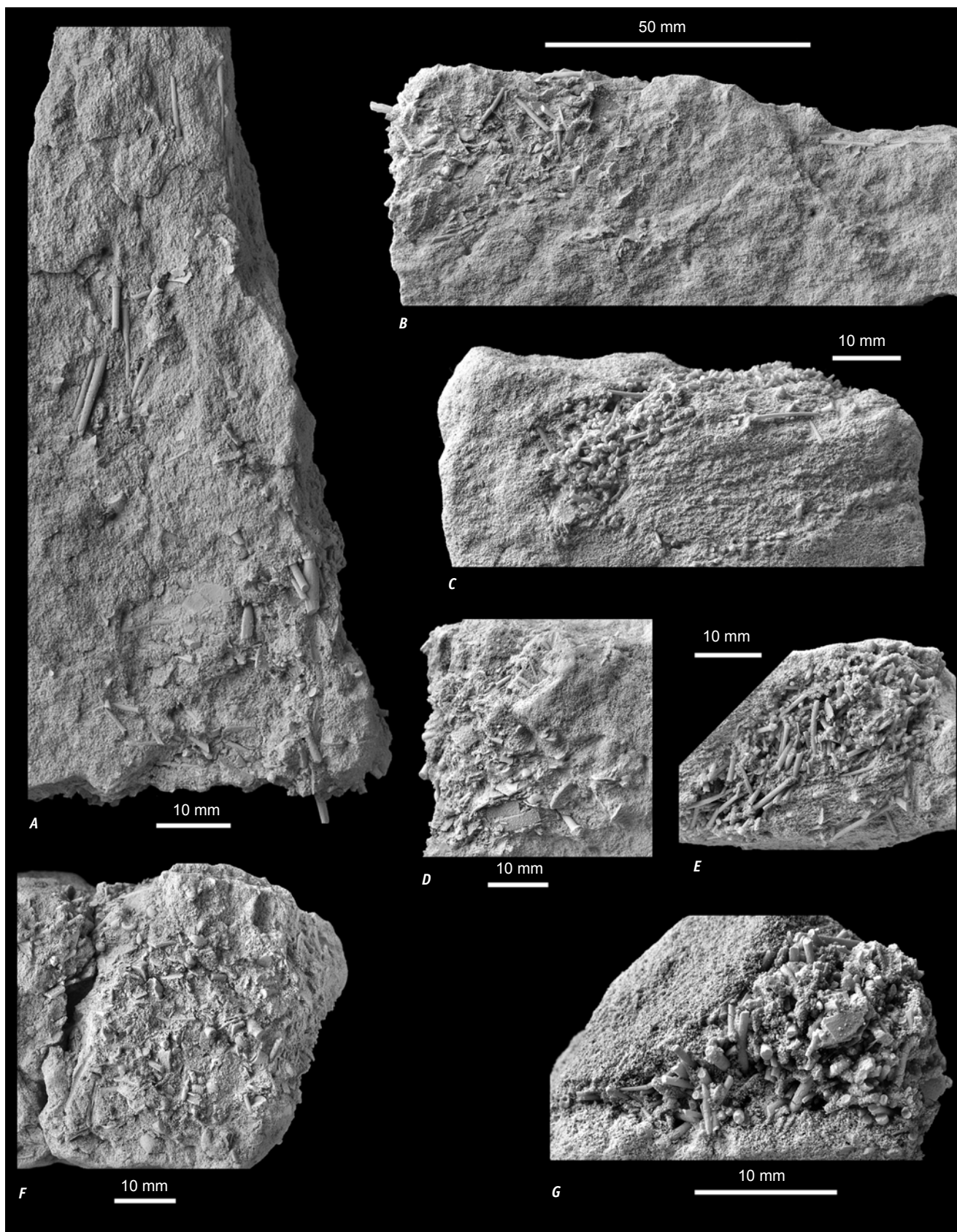


Fig. 8. Burrows packed with bioclastic debris. A, B - two views of a large specimen, NHMM JJ 11983a; C, E, G - three views of two pieces of the same, small specimen, NHMM MD 4952/24; D, F - two views of clasts, NHMM JJ 11983b. Specimens coated with ammonium chloride prior to photography.

particularly unusual, but, despite obvious similarities between these specimens (Fig. 8), the lined burrow is rather different to *Planolites* isp. and these specimens represent different ichnogenera, although both are left in open nomenclature. They are here included together for the single purpose of drawing attention to them.

These burrows are remarkable for their fill which is dominated by echinoid fragments, mainly primary spines of the small- to medium-sized phymosomatid *Gauthieria pseudoradiata* auctt. (?non Schlüter, 1883; see Jagt, 2000, pp. 233-236, for discussion), but also fragments of the test. In addition, isolated spines of *Trochalosoma corneti* (Cotteau, 1875) (*inops* morphotype; see Jagt, 2000, pl. 13, figs 3-7) and fragments of pectinoid bivalves, scalpellid cirripedes, micrasterid echinoids, astropectinid asteroids, cheilostome and cyclostomes bryozoans, bourgueticrinid columnals and brachials, fish scales and ophiolpid brittlestars, plus a single ?nautiloid conchorhynch (*Conchorhynchus limburgicus* Van der Tuuk, 1982) have been recognised. These are unlikely to be selective hydrodynamic accumulations and most probably represent the result of selective scavenging or predation by burrowing organism(s) unknown. Their interest is thus mainly palaeobiological. In certain respects (that is, overall (near)cylindrical shape and consistency of material selected to reinforce the burrow wall), there is a resemblance to *Nummipera* Hölder, 1989, and *Baronichnus* Breton, 2002. *Nummipera eocenica* Hölder, 1989 (p. 25, fig. 9), which constitutes a burrow (of domichnion type) whose wall consists of larger benthic foraminifera, mainly nummulitids, was first described from the Eocene of Split (Croatia). However, Breton (2004) subsequently demonstrated that this ichnotaxon was not validly introduced and should be treated as a nomen dubium. In contrast, *Baronichnus armatus* Breton, 2002 (p. 32, figs 2-9), from the lower/middle Turonian interval of Touraine (France), is a valid ichnotaxon, erected to accommodate subvertical and tubular burrows, whose wall is reinforced with bryozoan zoaria horizontally placed within that wall.

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