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AN EXCEPTIONAL ASSEMBLAGE OF *MACCOYA SPHAERICA* (ECHINOIDEA) FROM THE MISSISSIPPIAN OF HOOK HEAD, CO. WEXFORD, IRELAND

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Abstract

Echinoids are seldom prominent or conspicuous elements of Paleozoic marine communities. This could be a taphonomic artefact due to their flexible tests deflating and rapidly disarticulating after death—a fact that has undeniably hampered greater understanding of the group. Here, an extremely well-preserved cluster of echinoids is described from Tournaisian marine strata at Hook Head in southeast Ireland. All were collected in close proximity to each other and from essentially the same horizon towards the top of the Hook Head Formation, and all can be assigned to *Maccoya sphaerica* (M'Coy, 1844) based on their interambulacral plating. Preservation of features on some specimens is so exceptional that they reveal hitherto unknown details about the peristome and adoral plating in the broader palaeochinid group. The sedimentological setting of the fossil-bearing site at Hook Head is in deep water and well below wave base towards the distal end of a mixed siliciclastic-carbonate ramp. Conditions on the seafloor appear to have been very calm and quiet, with minimal post-mortem disturbance of the echinoids promoting their excellent preservation. It remains unclear why these specimens of *M. sphaerica* congregated in this particular location on the seafloor, or what ultimately led to their sudden demise.

Preamble

Throughout his academic life a consistent theme of George Sevastopulo's research was the investigation of Mississippian echinoderms, their systematics, palaeobiology and stratigraphical distribution—a journey that essentially began with his doctoral research (Sevastopulo 1969). Although he ventured into many other research topics (Wyse Jackson and Murray 2024) his love of—and fascination for—echinoderms and especially crinoids remained unwavering (e.g. Sevastopulo 2002). The echinoids described here are from the Mississippian of Hook Head, County Wexford, a location that George studied extensively (e.g. Ausich and Sevastopulo 1994, 2001). They were given to him to work up but,

unfortunately, this was not to be. In tribute to his role as friend, mentor and exceptional scholar, we are humbled to publish a short note recording this material here.

Mississippian echinoid studies in Ireland

The fossil record of Mississippian echinoderms in Ireland is diverse, with crinoids receiving the most attention. The earliest studies were those by Austin and Austin in the 1840s (see Ausich *et al.* 1999) and many others have followed, including the monographic description and taphonomic considerations of the Hook Head crinoid fauna in County Wexford (Ausich and Sevastopulo 1994, 2001). A more recent review of their stratigraphical distribution is given by



Ausich *et al.* (2024), based on work in which George played a significant role in seeding and encouraging. Two other Classes in the Echinodermata, the Blastoidea and Echinoidea, have been less frequently documented from Irish Mississippian successions. For the former, Waters and Sevastopulo (1984, 1985) provided compilations of their diversity and distribution.

Echinoids were first documented in the Irish Mississippian by Scouler (in M'Coy 1844), who named the distinctive *Palaechinus sphaericus* as well as *P. ellipticus* M'Coy (1844) in his seminal synoptic monograph. This was based on material collected by, and for, Sir Richard Griffith (Wyse Jackson and Monaghan 1994) and described in two genera several species of echinoid of which four were considered to be new. Five years later he erected the taxon *Perischodomus biserialis* on material collected at Hook Head (M'Coy 1849), while a further fifteen years later Wright (1864) described a new species of *Palaechinus* and Baily (1864a,b) considered in some detail the morphology of a number of the taxa erected by M'Coy. While most of these early studies concerned echinoids preserved in Mississippian limestones, Harte (1864) illustrated and described a new, but unnamed, echinoid from the overlying sandstones at Lough Esk, County Donegal, subsequently named *Archaeocidaris harteiana* by Baily (1874) and assigned to the genus *Perischocidaris* by Jackson (1912, p. 408). Austin (1860) erected the new genus and species *Protoechinus anceps* from Hook Peninsula. In a comprehensive study, Jackson (1912) documented eight echinoid species from Hook Head, and later Kier (1956) reassessed Hook Head material of *P. biserialis* and determined it to be a new genus and species *Eupholidocidaris brightoni*. Most recently, a limestone slab from Slade, Hook Head containing a large and exceptional suite of intact archaeocidarids was recovered and documented by Álvarez-Armada *et al.* (2022).

Geological setting

The succession on Hook Peninsula in southeast Ireland consists of a transgressive sequence of siliciclastics and overlying argillaceous limestones and shales (Fig. 1; see Clayton and Higgs 1979; Graham and Sevastopulo 2020). The Famennian-Tournaisian boundary is located towards the top of the Harrylock Formation (Fig. 1C; Sleeman *et al.* 1983; Higgs *et al.* 1988), a red-bed fluvial succession comprising gravelly braided

river channel fill and silty floodplain deposits. The overlying Oldtown Bay Formation represents a sand-dominated braided river deposit, while marine conditions become apparent in the succeeding Porter's Gate Formation (Sleeman *et al.* 1974, 1983; Sleeman 1977).

The Porter's Gate Formation is followed by a largely carbonate-dominant sequence termed the Hook Head Formation (Sleeman *et al.* 1974, 1983; Ausich and Sevastopulo 1994, 2001), which is approximately 335m in thickness on the Hook Peninsula and contains a rich and well-preserved marine invertebrate fauna. The Hook Head Formation is equivalent to the more regionally recognised and mapped Ballymartin Limestone and Ballysteen Limestone formations (Fig. 1C; e.g. see Philcox 1984; Somerville and Jones 1985; Tietzsch-Tyler *et al.* 1994; Sevastopulo and Wyse Jackson 2009).

Smyth (1930) originally divided the carbonate-dominated part of the sequence on Hook Peninsula into several informal units on the basis of lithology and macrofossil content. These were, in ascending stratigraphic order: *Michelina* Beds (c.124m; further subdivided into *M. antiqua* and overlying *M. favosa* Beds), Dolomite (c.25m; formally redefined as the Bullockpark Bay Dolomite Member by Sleeman *et al.* 1974), Supradolomite Beds (c.91m), *Linoproductus* Beds (c.38m) and the *Chonetes* Beds (c.50m). Despite their informal status, Smyth's (1930) divisions do have some local utility and they have been retained in subsequent studies of the Tournaisian fauna (e.g. Ausich and Sevastopulo 1994, 2001; Mottequin 2010; Hageman *et al.* 2011; Wyse Jackson *et al.* 2017) and are retained in this study (Fig. 1C).

The informal units of Smyth (1930) reflect deposition on a mixed siliciclastic-carbonate shelf-ramp, under gradually deepening marine conditions (Ausich and Sevastopulo 1994). The Bullockpark Bay Dolomite Member represents a minor regressive episode within an overall transgressive sequence. It comprises cross-bedded crinoidal and oolitic grainstones and was the only part of the Hook Head Formation deposited above fair-weather wave base. In the other units, deposited below fair-weather wave base, episodic tempestite deposition resulted in the rapid burial of marine communities and played a prominent role in promoting excellent fossil preservation, particularly of the multi-element skeletons of echinoderms (Ausich and Sevastopulo 1994).

The echinoids reported on herein were collected from close to the top of the Hook Head Formation,

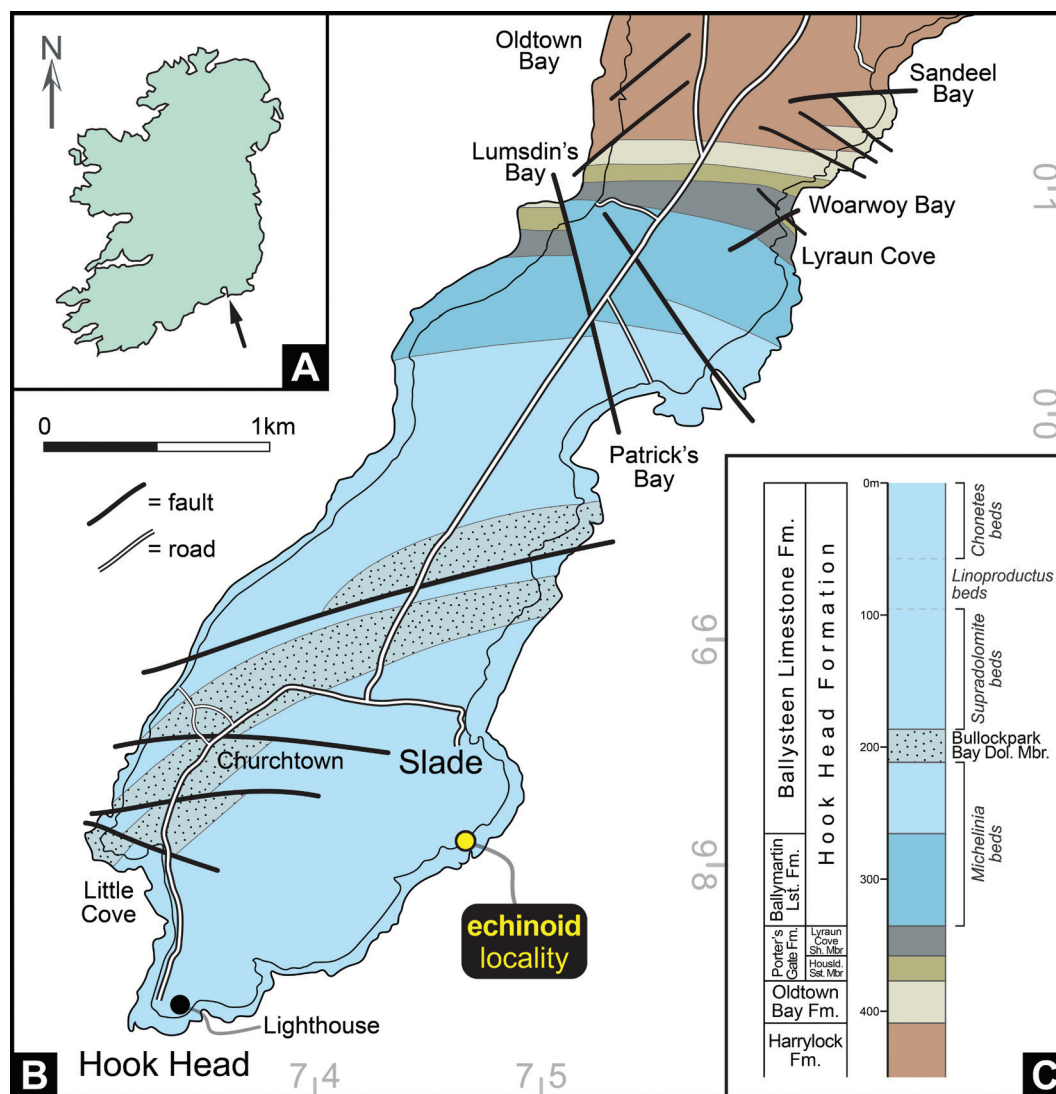


Fig. 1—Location and stratigraphic context of Slade echinoid fossil assemblage in County Wexford. **A.** General map showing location of Hook Head in southeast Ireland (arrowed). **B.** Geological sketch map of Hook Peninsula showing the location of the echinoid fossil locality (yellow filled circle), south from Slade. Geological map adapted from MacCarthy and Higgs (2013) and also Geological Survey Ireland data. The succession generally youngs in a southerly direction on the peninsula - see C for lithostratigraphic key. **C.** Comparative lithostratigraphic scheme for Hook Peninsula, based on the schemes proposed by various authors, including Smyth (1930) - shown on right of the column. Dol. = dolomite, Fm. = formation, Mbr. = member, Sh. = shale, Sst. = sandstone.

in the *Chonetes* Beds at locality 13b of Smyth (1930) (Figs 1B-C, 2; Grid Reference: X 74679811). At this location the formation comprises interbedded argillaceous dark grey limestones (calclutites and calcisiltites) and calcareous shales. Bedding is generally medium to thickly developed, tabular and laterally persistent. The *Chonetes* Beds represent the deepest part of the Hook Head Formation and are conspicuously more uniformly fine-grained than the underlying units (Ausich and Sevastopulo 1994; see also Ausich *et al.* 2024, fig. 6). Fossils are concentrated in thin horizons, typically on the top surfaces

of the limestones. A rich and diverse invertebrate fauna dominated by the brachiopod *Chonetes* with eomphalid gastropods and less conspicuous cryptostome and fenestrate bryozoans (Fig. 2) has been recorded. Mottequin (2010) described the brachiopods *Antiquatonia teres*, *Buxtonia?* sp., *Rhipidomella michelini*, *Cleiothyridina glabristria* and *Tylothyris laminosa* from the Slade location.

Crinoids are comparatively rare in the *Chonetes* Beds and are concentrated in thin lags. Ausich and Sevastopulo (2001) noted seven crinoid taxa present in this facies. Those encountered are typically small

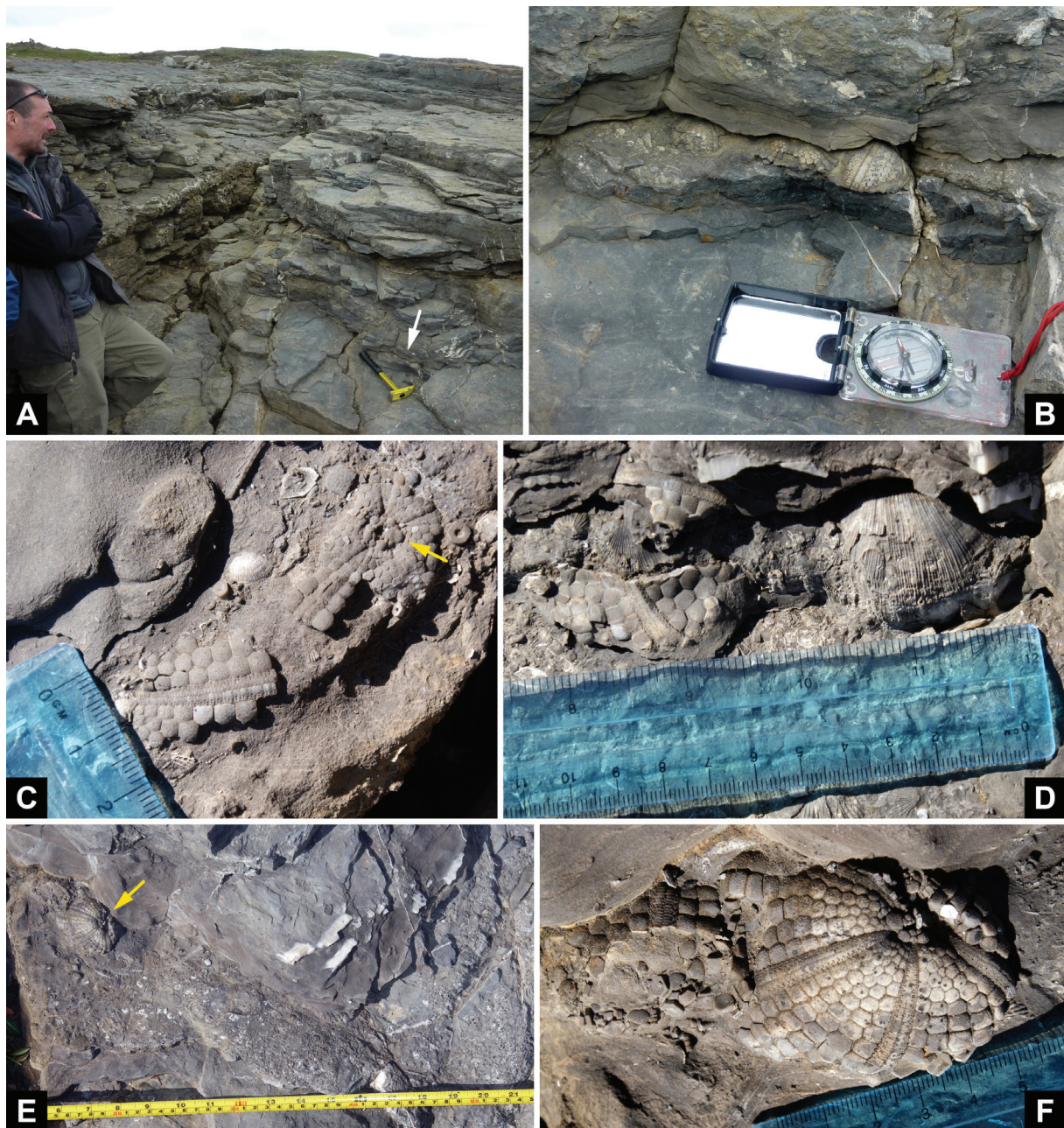


Fig. 2—Field photographs of Hook Head *Maccoya sphaerica* specimens. A. General view of the sample locality in the *Chonetes* Beds, south from Slade. Note well-bedded and fine-grained nature of the strata. Hammer for scale, white arrow points to specimens shown in detail in B. B. Small cluster of at least three *M. sphaerica* specimens in close association. These appear to have deflated after death. C-D. *M. sphaerica* specimens in various stages of disarticulation, in association with brachiopod and crinoid debris. Yellow arrow in C points to an apical disc with possible madreporite. E. Overhead view of a bedding plane with prominent and well-preserved *M. sphaerica* to left (yellow arrow) and numerous *Chonetes* brachiopods, fenestrate bryozoans and crinoidal debris. F. Detailed view of *M. sphaerica* specimens arrowed in E.

euclidids preserved with their arms (brachials) and stems attached. The muddier intercalations in this unit tend to be heavily bioturbated. Echinoids are generally well-preserved and represent *in-vivo* preservation on the seabed (Fig. 2B-F). Johnston and

Higgins (1981) determined that the upper part of the Hook Head Formation (including the *Chonetes* Beds) contained the *Polygnathus mehli* conodont biozone, indicating an upper Tournaisian (Ivorian) age for this part of the sequence.

Material

Fifteen echinoid specimens have been deposited in the Trinity College Dublin Geological Museum; catalogue numbers TCD.60440-60454. All are from the *Chonetes* Beds, Hook Head Formation, Tournaisian, Mississippian; Locality 13b of Smyth (1930), *c.* 500m south of the village of Slade, Hook Peninsula, County Wexford (Fig. 1).

Systematic Palaeontology

Class ECHINOIDEA Leske, 1778
Family PALAEOCHINIDAE M'Coy, 1849
Genus *MACCOYA* Pomel, 1869

Type species. *M. gigas* (M'Coy, 1844).

Other species. *M. sphaerica* (M'Coy, 1844), *M. intermedia*. (Keeping, 1876), *M. burlingtonensis*

(Meek and Worthen, 1860), *M. gracilis* (Meek and Worthen, 1869).

Diagnosis. Palaechinid with two columns of ambulacral plates in each area. Ambulacral plates many times wider than high, chisel shaped. A single pore-pair on each ambulacral plate. Pore-pairs located near to abradial suture. Area between perradial suture and pore-pair wide, bearing numerous closest-packed, small perforate, areole-bearing secondary tubercles. Pore-pairs within each half-ambulacrum biserial, with every other plate bearing enlarged adambulacral end at ambitus and adapical, and with other plates slightly reduced in size to demi-plates. Demi-plates occasionally occluded from abradial suture. Interambulacral plates arranged into a maximum of four to nine columns, depending upon the species and ontogenetic stage. Interradial interambulacral plates hexagonal, adambulacral plates pentagonal. All test plates covered with small, areole-bearing secondary tubercles.

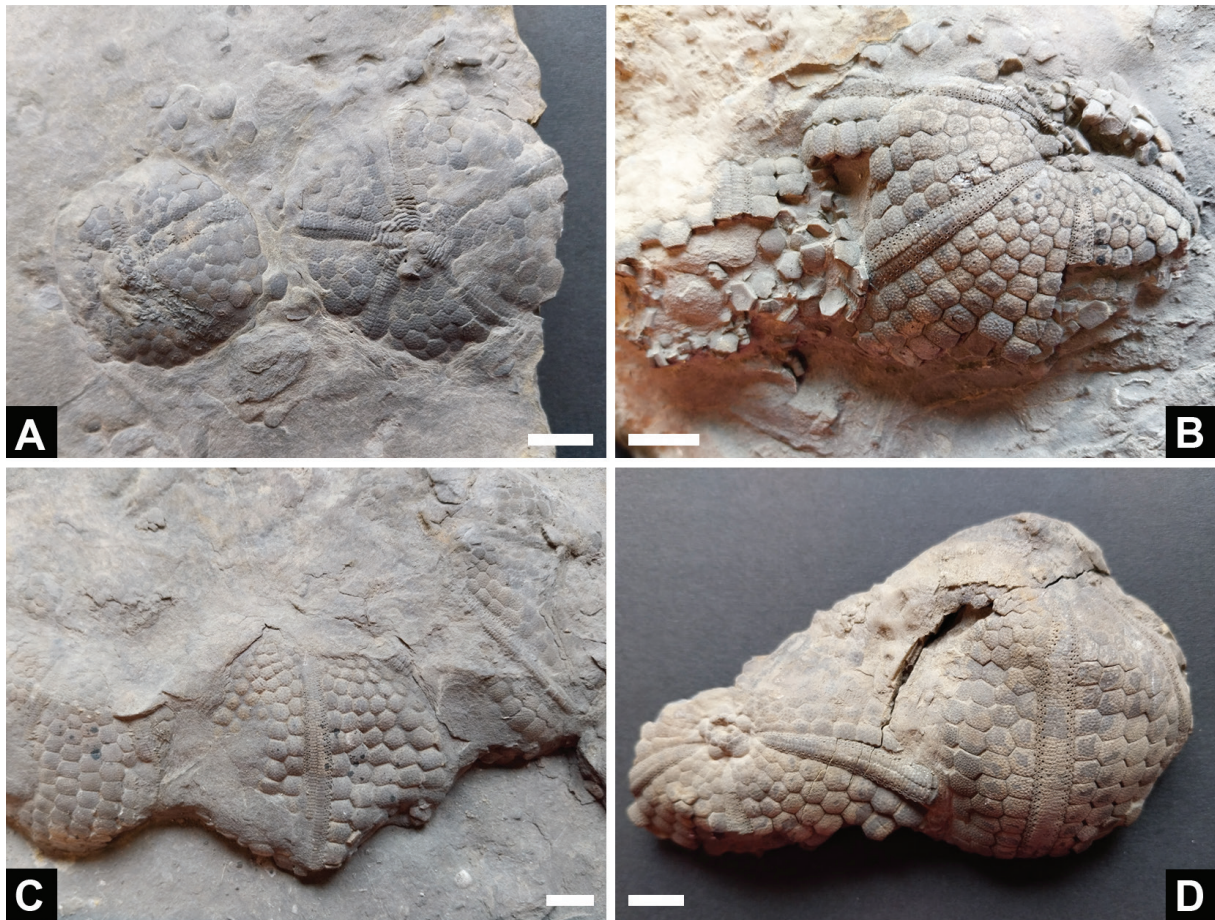


Fig. 3—Cleaned and prepared specimens of *Maccoya sphaerica* from Hook Head. A. TCD.60440 on right and TCD.60441 on left. B. TCD.60442 on right and TCD.60443 on left. This is the same specimen as shown in the field photograph in Fig. 2E-F. C. TCD.60446 on right, TCD.60445 in middle and TCD.60444 on left. D. TCD.60453 on right and TCD.60452 on left. White scalebars in all images = 10mm.

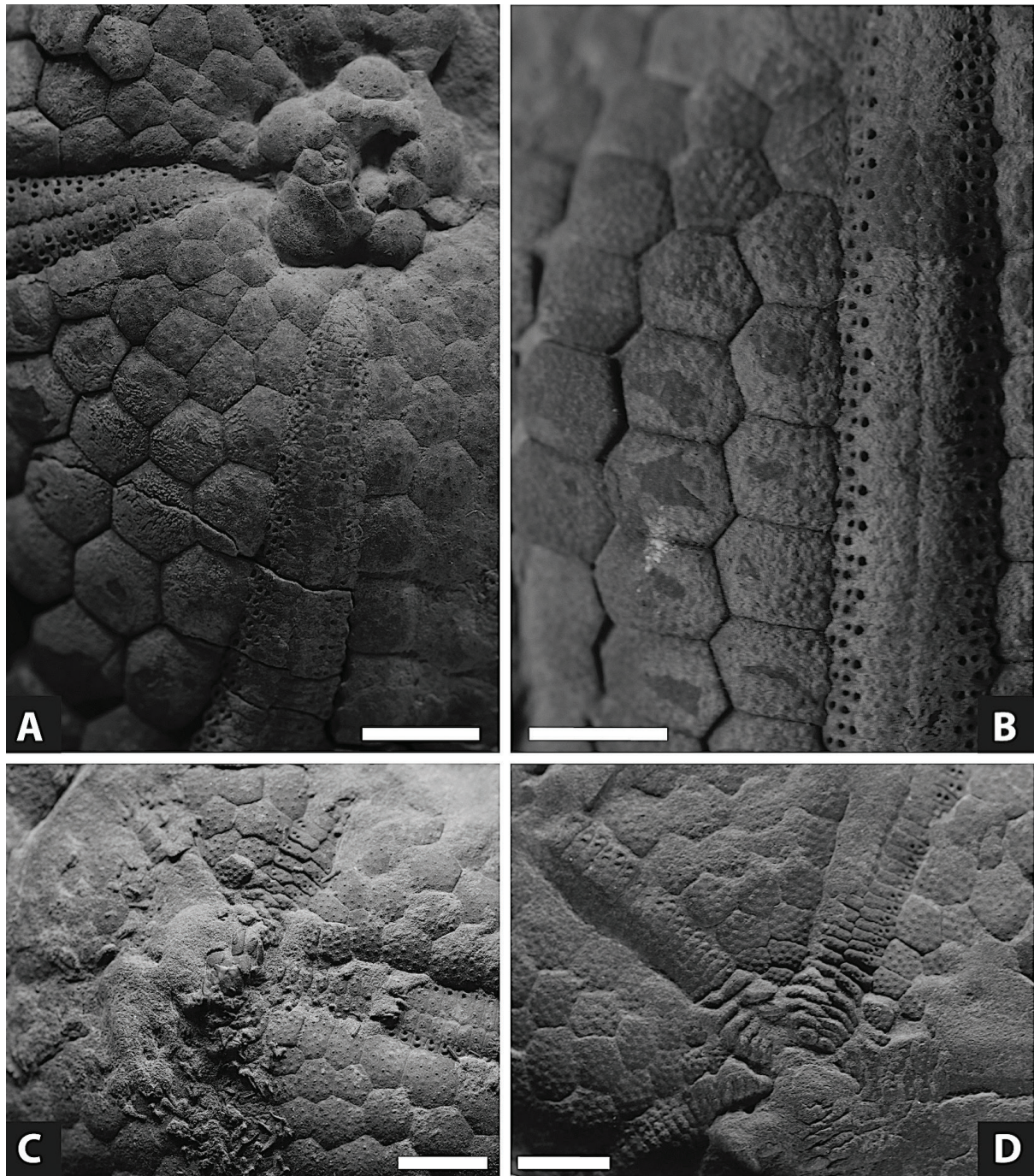


Fig. 4—Detailed views of morphological characteristics of *Maccoya sphaerica* from Hook Head. **A.** Close-up of the adapical region, including genital, ocular, and peristomial plates of TCD.60452. **B.** Details of the interambulacral and ambulacral plating of TCD.60453. Note the biserial arrangement of pores in half-ambulacrum. **C.** Adoral surface, including details of peristomial region, of TCD.60441. **D.** Details of peristomial plating in TCD.60440. A single basicoronral plate is present in the most adoral interambulacral. White scale-bars in all images = 5mm.

Spines small, needle-like. Peristomial plating consisting only of ambulacral plates.

Maccoya sphaerica (M'Coy, 1844)
Figs 2B–F, 3A–D, 4A–D

Diagnosis. *Maccoya* with five to seven columns of interambulacral plates in each interambulacrum. Test plates thick, interambulacral plates about as high as wide to wider than high.

Description. Most of the Slade specimens are well-preserved (Table 1). Some are heavily disarticulated, with only scattered ambulacral plating evident. However, several specimens—particularly TCD.60440 (Fig. 3A) and TCD.60452 (Fig. 3C)—are very well-preserved, whereby the majority of the specimen, including the periproct, is intact (Fig. 4D).

These specimens comprise a test that is circular in outline and raised or convex in profile. The diameter of the test ranges from 36mm to 52mm, with the average measurement being 45mm. The apical disc is small and monocyclic, but composed of plates that are thick and blocky, and covered with numerous secondary tubercles (Fig. 4A). Genital plates are large, subcircular to hexagonal, and mostly are not in contact with one another. One genital plate is densely perforated by hydropores and is thus recognisable as the madreporitic plate. The ocular plates are much smaller than the genital plates (Fig. 4A). There are at least thirteen periproctal plates, which are angular and irregular in shape.

Ambulacra are biserial, straight, and narrow. Each zone is approximately 4mm in width. Ambulacra bear melon-like ribs, making the perradial suture the furthest point on the ambulacra adaxially. Ambulacral plates are simple, tessellate and chisel shaped. Every other plate has a slightly enlarged and expanded abradial end, and the intervening plates are reduced slightly to demi-plates (Fig. 4B), which have pore-pairs located more adradially. Uncommonly, smaller plates are occluded from abradial suture. Pore pairs are non-conjugate and located towards the adradial suture. Within each half-ambulacrum, pore pairs are biserial at the ambitus and adapically (Fig. 4B). On the oral surface, ambulacral plates are enlarged, in particular being much taller (Fig. 4C). There is no obvious difference in plate size between those at the ambitus and those more adapically. Pore-pairs are enlarged on each plate and arranged more-or-less uniserially within each half-ambulacrum. Ambulacral plates bearing numerous areole-bearing secondary tubercles are arranged on plate in a closest-packed arrangement.

Interambulacral zones are many times wider than the ambulacra and bear five columns of regular plates (Fig. 3). Plates in the adambulacral columns are pentagonal, with scalloped margins that tessellate with ambulacral plates (Fig. 4B). Plates in the three interradial columns are hexagonal. All plates are more irregularly shaped, and taller, adapically. Interradial plates are slightly wider than high, while adambulacral plates are about as high as wide. Small, areole-bearing secondary tubercles are present on interambulacral plates. They are arranged in a closest-packed arrangement on plates (Fig. 4B). A single basicoronal plate is present in each interambulacral area, as is visible on specimen TCD.60440 (Figs 3A, 4D). The plate pattern in the first four row adoral-most rows is 1-2-2-3.

The details of the Aristotle's lantern cannot be seen in any of the Slade echinoids, but specimen TCD.60440 has a relatively well-preserved peristomial region (Fig. 4D). Peristomial plating consists only of ambulacral plates, without any non-ambulacral plates, and these plates are enlarged relative to the adoral ambulacral plates of the corona. Peristomial ambulacral plates are in continuity with those of corona, and heavily imbricate across the perradial suture.

Specimens TCD.60446 and TCD.60444 bear very small, needle-like spines sparsely covering the ambulacra (Fig. 4C). These spines are absent from interambulacral plates in these specimens, which we interpret to be taphonomic.

Remarks. *Maccoya sphaerica* is differentiated from other species of *Maccoya* largely on the number of plates in each interambulacral area, which is the primary criterion used for differentiating all species of *Maccoya*. *M. sphaerica* displays from five to seven plates in each interambulacral area; *M. intermedia* (Keeping, 1876) and *M. burlingtonensis* (Meek and Worthen, 1860) have four; *M. gigas* has six columns of very large, wide, interambulacral plates; and seven to nine are found in *M. gracilis* (Meek and Worthen, 1869). Jackson (1912) listed five plates as present in the adambulacra of *M. phillipsiae* (Forbes, 1848), but this taxon is now considered to be a lepidocentrid based upon the presence of an enclosed radial water vessel, and thus it has little to do with any other palaechinids (Thompson *et al.* 2022).

The Slade specimens described here provide novel insight into the oral region of *Maccoya*, and palaechinids more generally. Specimen TCD.60440 is remarkable amongst Paleozoic echinoids in that it clearly displays a relatively well-preserved and undisturbed peristome and surrounding adoral

Table 1—Notes on the preservation of the Slade echinoid specimens TCD.60440–60454

<i>Accession Number</i>	<i>Preservation</i>
TCD.60440	This is the most well-preserved specimen in the Slade collection. The ambulacral and interambulacral zones from a dorsal view can be seen, with the periproct in view. Figs 3A, 4D.
TCD.60441	This specimen is well preserved; however, the ambulacra are slightly eroded. A dorsal view is evident. Figs 3A, 4C.
TCD.60442	The margin of this specimen is disarticulated and eroded; however, a portion of the dorsal side of the echinoid is relatively well preserved. Fig. 3B.
TCD.60443	This specimen is very disarticulated. Only remnants of the ambulacral plating are exposed. It may potentially be a portion of specimen TCD.60442, rather than being a separate specimen. Fig. 3B.
TCD.60444-6	The surfaces of these three specimens are greatly eroded; however, a portion of the interambulacral and ambulacra is preserved. Fig. 3C.
TCD.60447	This specimen is highly disarticulated. Remnants of the interambulacral and ambulacral plates are evident. However, it may be a portion of specimen TCD.60446, rather than a completely separate specimen.
TCD.60448	This specimen is relatively disarticulated. Parts of the interambulacral and ambulacral zones are evident.
TCD.60449	This specimen is relatively disarticulated. Portions of the interambulacral and ambulacral zones are evident. Zones and plates are smoother in appearance, likely due to erosion.
TCD.60450	This specimen is relatively disarticulated. Remnants of interambulacral and ambulacral zones are evident.
TCD.60451	This specimen is very disarticulated. Remnants of scattered interambulacral plates are evident only.
TCD.60452	This is well preserved; however, the entire specimen is not intact. The periproct is present and clear and hosts the most well-preserved periproctal structure out of all collected specimens. Figs 3D, 4A.
TCD.60453	The remnants are very well preserved; however, the entire specimen is not intact. Some ambulacral and interambulacral zones can be seen. Figs 3D, 4B.
TCD.60454	This specimen is very disarticulated. Remnants of what appears to be a large specimen are evident, whereby two interambulacral, and one ambulacral zone can be visualised. The width of the preserved portion is approximately 50mm.

plating (Fig. 4D). Peristomial regions and peristomial plating are rare in Paleozoic echinoids and are unknown in most taxa. Amongst the palaechinidae, the only figured peristomial region is from a specimen of *Melonechinus multiporus* (Norwood and Owen, 1846) drawn by Jackson (1912). This specimen shows a single basicoronal plate in the most adoral row of interambulacral plates, a feature also observed in specimen TCD.60440. This new Slade specimen provides confirmatory evidence that the resorption of plates around the peristomial membrane, a feature seen in archaeocidarids and crown group echinoids (Smith 1984), was definitively not present in palaechinids. Furthermore, the construction of the peristomial membrane seen here indicates that non-ambulacral plates, as seen in some cidaroids and archaeocidarids (Smith 1984), are

not present in palaechinids. Instead, the peristomial plating of palaechinids is more similar to that seen in proterocidarids such as *Hyattechinus* Jackson, 1912.

Discussion

Paleozoic echinoid fossils are usually found in various states of disarticulation (Thompson and Ausich 2016; Thompson and Denayer 2017), with well-preserved and articulated or semi-articulated individuals being exceptionally rare. The preservation of these echinoids at Hook Head is thus noteworthy, with several preserved largely in their original, albeit flattened, shape and with the small plates of the periproct intact (Fig. 3A–C). The preservation of the peristomial plating on specimen TCD.60440 is particularly significant

since it sheds novel light on the details of peristomial plating in the palaechinidae, and Paleozoic echinoids more broadly (Fig. 4D). Additionally, a number of taphonomic modes are present, with specimens showing various degrees of disarticulation, from slight separation of the plates (TCD.60453) to greater disarticulation (TCD.60443) (Fig. 3B).

One Slade specimen bears evidence of possible predation in the form of a small subcircular opening on the external surface of the test. The identity of the organism responsible for this borehole is unclear; it could have been produced by a predatory platyceratid gastropod or an unknown soft-bodied animal (see Mottequin and Sevastopulo 2009 for further discussion on boreholes produced by predation on Tournaisian brachiopods). Although traces of predation (praedichnia) can be found on many fossil echinoids, identifying the specific trace makers remains contentious. Farrar *et al.* (2020) examined a multitude of traces to improve the ability to identify and quantify biotic interactions associated with echinoids. Given that there is a lack of predation scars present on these Hook Head echinoids, this suggests that this interaction was not common. An alternative to this boring being evidence of predation is that it may be the post-mortem excavation of a domicile (domichnia; see Donovan 2024).

The relatively close association of these echinoids in essentially the same horizon of the *Chonetes* Beds at Hook Head (Fig. 2) perhaps represents an example of aggregation behaviour that is common in many modern echinoids (Nebelsick and Kroh 2002). This typically occurs when specimens are either close to a food source, being harassed by predators or are spawning (Schneider 2008). Evidence of Paleozoic echinoid aggregations is sparse, although several instances have been recorded. At Brownwood, Texas, thousands of well-preserved Pennsylvanian archaeocidarid echinoids were found in the 1970s (Schneider *et al.* 2005) and at Hook Head a large number of small archaeocidarids were recovered from a single bedding plane a short distance north of Slade (Álvarez-Armada *et al.* 2022). These archaeocidarids are from a stratigraphically lower unit in the Hook Head Formation, occurring in a gradational boundary interval between the Supradolomite and overlying *Linoproductus* beds (Fig. 1C). Although the *Maccoya* specimens in this study were not found in the hundreds, and are clearly not archaeocidarids, their abundance here is still exceptional. The collected material, comprised of just over a dozen specimens clustered together over a relatively short lateral (strike-section) distance of several metres,

bears similarities to the very high densities in which the palaechinid *Melonechinus* occurs in the Viséan of North America (Jackson 1896, 1912). This suggests that during the Mississippian, at least two families of echinoids, the palaechinids and the archaeocidarids, displayed aggregational behaviour. It is noteworthy that despite the otherwise excellent preservation of these taxa, there are no secondary spines known from the interambulacral. This is not atypical for palaechinids, as specimens with secondary spines preserved on the interambulacral are particularly rare (Jackson 1896, 1912). The rarity of these structures would suggest that secondary spines are amongst the most taphonomically fragile elements of the test and would be amongst the first morphological features to be lost to post-mortem disarticulation.

Even though many individual Slade specimens were found clustered together, only one species of *Maccoya* is evident, which is not atypical for other mass occurrences of echinoids in fossil and extant ecosystems (Nebelsick and Kroh 2002). It may be the case that other taxa were present within the deep-water ecosystem represented by the *Chonetes* Beds, but not recovered herein, as numerous other echinoids have been recorded from Hook Head in the past (e.g. Jackson 1912; Kier 1956). However, the presence of a multitude of a singular species may also indicate the lack of coexistence or resource partitioning between echinoid communities within this particular palaeoenvironment (Schneider 2008).

Overall, the geological setting in which these *Maccoya sphaerica* echinoids existed at Hook Head in late Tournaisian times was in relatively deep and quiet marine waters, well below wave-base and at a depth where storm wave energy was only very infrequently felt (Ausich and Sevastopulo 1994). Generally speaking, macrofossils in the *Chonetes* Beds tend to be smaller (crinoids are a good example) and more dispersed in comparison to the underlying *Michelinia*, Supradolomite and *Linoproductus* beds, which might indicate low nutrient availability. On the other hand, some horizons in the *Chonetes* Beds display appreciable bioturbation (burrowing), some of it penetrating vertically and horizontally through the substrate, suggesting perhaps higher than anticipated nutrient levels. It is also possible that fluctuating bottom-water oxygen levels may have influenced the distribution of the benthic fauna in the *Chonetes* Beds more generally. Whatever the truth of the situation, it was evidently a palaeoenvironment in which a small community of *M. sphaerica* could cluster and apparently thrive, albeit for only a short amount of time.

Conclusions

Fifteen relatively intact Tournaisian echinoid specimens were recovered and are described from the *Chonetes* Beds, close to the top of the Hook Head Formation at Slade in County Wexford, southeast Ireland. This uppermost part of the Hook Head succession represents very quiet still-water deposition (largely from suspension-fallout) on the deepest part of a mixed siliciclastic carbonate ramp. The echinoid specimens were located in close proximity to each other, essentially along the top of a single bedding plane.

Based on detailed investigation of their morphology, the Slade echinoids are all assigned to a single species: *Maccoya sphaerica* (M'Coy, 1844), in particular due to the nature of their interambulacral plating. The preservation of these specimens of *M. sphaerica* is quite remarkable (Figs 2–4) and it serves to shed novel light on the morphologies found in palaechinid echinoids. In particular, specimen TCD.60440 displays a relatively well-preserved and undisturbed peristome and surrounding adoral plating. Preservation of these features is extremely rare in Paleozoic echinoids, and it affords an opportunity to better understand how the peristome was constructed (and ultimately functioned) in Paleozoic echinoids.

It remains unclear why these specimens of *M. sphaerica* clustered and congregated at this particular location on the seafloor during the late Tournaisian. It could have been entirely opportunistic, perhaps the sudden appearance of a rich localised food source, or they may have aggregated for either defence or reproductive purposes. Alternatively, they might have been passively swept together during a storm/obtrusion event that would have simultaneously helped to bury them to varying degrees, this perhaps being reflected in their differing states of preservation. Whatever the reason, the ambient palaeoenvironment evidently allowed them to thrive, albeit for a short time. Finally, the Hook Head echinoid specimens appear to have died together and experienced little or no post-mortem disturbance. It is also unclear why this happened, however, the conditions on the seafloor again appear to have played a prominent role in facilitating this.

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