Swiss J Palaeontol (2016) 135:343–348
DOI 10.1007/s13358-015-0099-5

Reworked crinoidal cherts and screwstones (Mississippian, Tournaisian/Visean) in the bedload of the River Maas, south-east Netherlands

Stephen K. Donovan[1] · John W. M. Jagt[2] · Mart J. M. Deckers[3]

Received: 20 May 2015 / Accepted: 11 August 2015 / Published online: 25 September 2015

Abstract Rare Palaeozoic chert clasts collected from gravels in the bedload of the River Maas in the province of Limburg, south-east Netherlands, are rich in crinoid debris. These were transported during the Late Pliocene–Pleistocene by fluvial action from the southern Ardennes Massif (Namur-Dinant area, southern Belgium) and are of Early Carboniferous (Mississippian) age. Clasts are either completely chertified or may preserve macrofossils as natural moulds in a chert matrix; the latter are screwstones, a well-known lithology from rocks of this age. One screwstone preserves its fossiliferous debris, mainly crinoid columnals and pluricolumnals, in exquisite detail, including an archetypal 'screw', the mould of the axial canal. But the delicate 'screw' is not always preserved after fluvial transport. Further, the best-preserved specimen retains a mould of a pit in the latus, *Oichnus simplex* Bromley, probably a domicile excavated by an unmineralized invertebrate after the death of the crinoid.

Keywords Reworking · Taphonomy · Silicification · Ichnology · *Oichnus simplex*

✉ Stephen K. Donovan
Steve.Donovan@naturalis.nl

John W. M. Jagt
john.jagt@maastricht.nl

Mart J. M. Deckers
martdeckers@planet.nl

[1] Department of Geology, Naturalis Biodiversity Center, Postbus 9517, 2300 RA Leiden, The Netherlands

[2] Natuurhistorisch Museum Maastricht, de Bosquetplein 6-7, 6211 KJ Maastricht, The Netherlands

[3] Industriestraat 21, 5931 PG Tegelen, The Netherlands

Introduction

> ""Screwstones", the country folk call some of them—that name being given in reality to those siliceous casts of encrinital stems which occur abundantly in the chert-bands, where the original limy matter of the *ossicles* (or individual joints of the stem) has been dissolved away" (Taylor 1885, p. 119).

Screwstones are fossiliferous cherts, commonly associated with Mississippian (Lower Carboniferous) limestones and best known from northern Europe, such as in the White Peak area of the southern Pennines in England (=Derbyshire screws). Their name reflects the inclusion of crinoid columnals and, particularly, pluricolumnals preserved as natural moulds in chert, the latter preserving infills of the axial canal which are screw-like in appearance.

The quotation by Taylor (above) has been used by S.K.D. before to emphasise that screwstones have long been noted by both geologists and laymen. They are recognised for their unusual appearance more than for their palaeontology, which has only rarely been investigated in detail. Because of the common occurrence of the included echinoderms, particularly crinoids, as disarticulated remains, screwstones have yet to be adequately exploited as a source of systematic information, although some progress has been made on the Mississippian of the English White Peak (Donovan 2006, 2013; Donovan et al. 2014; Bouman and Donovan 2015).

Herein, we describe and interpret three specimens collected from gravels derived from the bedload of the River Maas in southern and central Limburg, the Netherlands (Information and Documentation Centre for the Geography of the Netherlands 1985, p. 30). Although reworked fossils

from Palaeozoic rocks are well known from the Netherlands, transported both by Pleistocene precursors of the rivers Maas and Rhine in the south of the country, by Pleistocene glaciers in the north-central and east parts, and the Eridanos River in the north and east (see, for example, Oostingh 1911; Schuijf and Boelens 1949; van der Lijn 1974; Eggink 1991; Bosch 1992; Jagt 2001, 2002; Akkerman 2012; Burger 2012; Hoedemaeker 2012; Hoedemaeker and Jagt 2012; Blankers and Nelissen 2013; Rhebergen 2014; Russcher et al. 2014). Erratics from Maas and Rhine gravels originate from the Ardennes Massif (Belgium), and the Eifel and Hunsrück mountains in Germany; the Eridanos River brought material from Scandinavia and the Baltic area.

As amply demonstrated by van der Lijn (1974) and Bosch (1992, 1998), fluvially transported cobbles in the province of Limburg originated from areas in northern France, and the southern (Namur-Dinant Basin) and northern Ardennes Massif (Liège Basin) in Belgium. They represent a rock type previously recorded as 'ftaniet/silexiet' or 'schroevensteen' (=screwstone) (see van der Lijn 1974; Bosch 1992). Although there is no macrofossil evidence to date these erratics precisely, they are certainly related to the chert-bearing lithostratigraphic units of Tournaisian and Visean age in the Belgian Ardennes as outlined by Poty et al. (2002). The present lot includes a specimen preserving evidence of an ancient organism–organism interaction. Taken together, we consider these factors to be of some general interest.

Terminology of the crinoid endoskeleton follows Moore et al. (1968, 1978), Ubaghs (1978) and Webster (1974). Our philosophy of open nomenclature follows Bengtson (1988). Specimens are deposited in the collections of the Natuurhistorisch Museum Maastricht, the Netherlands (NHMM).

Material, localities and horizons

The three specimens described herein were all collected from the bedload of the River Maas, province of Limburg, the Netherlands (Fig. 1), and, as stated above, are all most probably derived from the Mississippian (Tournaisian/Visean) of the Ardennes Massif in Belgium (Oncken et al. 1999; Poty et al. 2002). The label with specimen NHMM 724 states, "Silexiet met Crinoide. Maasgrind. Vindplaats: Amstenrade. Formatie: Ardennen Componenten" (=Chert with crinoid. River Maas gravels. Locality: Amstenrade. Formation: Ardennes 'components', that is, derived from the Ardennes). Amstenrade is a village some 3.5 km east of Nagelbeek. NHMM 2014 061b (ex Paul Baggen Collection) came from a gravel pit in River Maas deposits near Nagelbeek, that is, close to the locality for NHMM 724, while NHMM MD 8154 was picked from bedload dredged from the River Maas in the Roermond-Wessem area and subsequently dumped on the easterly river bank near Tegelen (municipality of Venlo, northern Limburg).

Descriptions

NHMM 2014 061b (Fig. 2a). This is a dark grey, silicified chert pebble (*c*. 63 × 42 × 30 mm), angular with rounded angles and packed with silicified crinoid pluricolumnals. For example, the pluricolumnal in Fig. 2a (bottom right) is heteromorphic, N3231323, circular in section and with gently convex latera. Articulation is symplectial, the axial canal is central and jugula are produced by symmetrically sloping claustra. A pluricolumnal immediately above this specimen may be conspecific, but there is a range of columnal and pluricolumnal morphologies. Pluricolumnals appear swollen medially due to the cut effect.

NHMM 724 (Fig. 2b, c). A fist-sized cobble of chert (*c*. 90 × 66 × 46 mm) with fossils (mainly crinoid columnals and pluricolumnals) preserved as natural moulds. The most prominent pluricolumnal is 28 mm long and consists of 13 columnals (Fig. 2b, c). Column circular in section, heteromorphic with planar latera. Articulation radial symplectial comprised of numerous fine crenulae including some that are bifurcating. No areola. Axial canal central, circular in section, with dish-like jugula sloping down from articular facet. What was originally misidentified as a rounded radice scar occurs at mid-height (best seen in Fig. 2c, to the left of the axial canal), but corresponds to a suture between columnals, rather than being situated at mid-height on a columnal latus, and with no apparent connection to the axial canal. More probably, this is a domicile constructed by a pit-forming invertebrate, assigned to the ichnotaxon *Oichnus simplex* Bromley 1981. Other crinoid debris represents a range of taxa, including a hexagonal thecal plate.

NHMM MD 8154 (Figs. 2d, 3). A cobble (*c*. 76 × 46 × 38 mm) of screwstone chert, similar in colour and appearance to NHMM 724, but more rounded and polished, and broken at one end. It is rich in mouldic crinoid stem debris, but, with one notable exception, contains fewer well-preserved specimens than NHMM 724. The exception is a long, broad pluricolumnal (Figs. 2d, 3), circular in section, about 30 mm in length (but incomplete due to breakage) and composed of about 22 columnals. The axial canal ('screw') is not preserved and was presumably lost in river transport. The articulation is radial symplectial with fine crenulae, the lumen and jugulum broad and circular, and no areola. The column is homeomorphic (?) or weakly heteromorphic, perhaps N1.

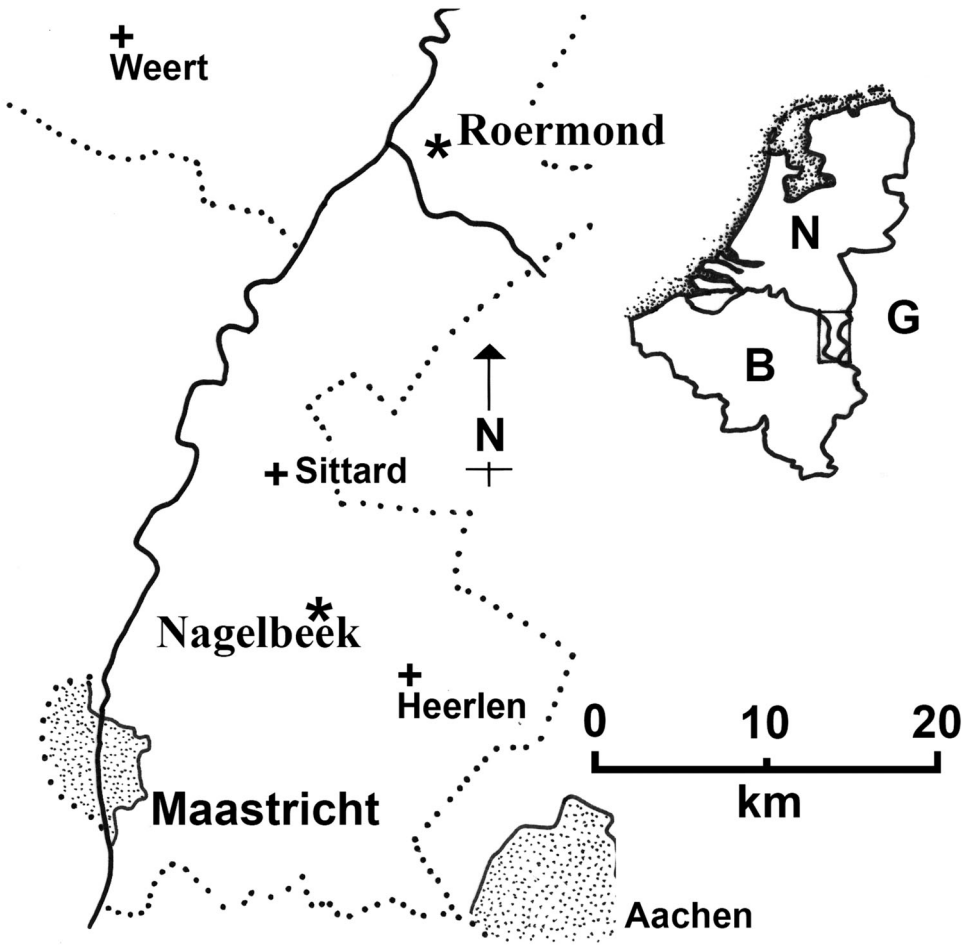

Fig. 1 Outline locality map of the study area. *Asterisk* fossil locality (in a different font from rest of map for easy identification); *cross* large town or city; *stippling* major city; *solid line* river; *dotted line* political boundary (in part coinciding with river). *Inset map* (*right*) shows the area of the main map (oblong box) in northern Europe. *B* Belgium; *G* Germany; *N* The Netherlands

Discussion

These specimens display two contrasting modes of silicification of chertified crinoidal limestones and two specimens might be related as a taphonomic series determined by bedload transport. In screwstones sensu stricto, the matrix is silicified, but many or all fossils are preserved as natural moulds. That is, the fine-grained matrix, composed of minute carbonate grains, was silicified, but the larger crystals in fossils (particularly echinoderm ossicles) were not (Carson 1991). Subsequently, the unsilicified fossils were dissolved by acidic groundwater (Fig. 2b–d). In contrast, NHMM 2014 061b (Fig. 2a) is completely silicified, including all fossils. Fossils in this specimen are more complete, but are only available for study in two dimensions.

One of the true screwstones, NHMM 724, is better preserved than the other, NHMM MD 8154 (compare Fig. 2b, c with Fig. 2d). The former specimen is a particularly illustrative example of a screwstone, whose name is easily understandable—the so-called screw is prominent—and comparable with, for example, the description of Taylor (1885, p. 119), given above, and the precise definition of Humble (1860, p. 396), "The name of a fossil resembling, at first sight, a screw; if, however, the marks be carefully examined they will be found to be circular, and not spiral." That NHMM MD 8154 is not immediately recognisable as a screwstone is because it has been broken during the late stages of its transport (broken surface top in Fig. 2d) and the screw lost, although the external mould of the pluricolumnal is prominent. Further transport and abrasion would probably reduce the evidence of the large pluricolumnals completely, leaving an indeterminate pebble of vuggy chert (compare with Donovan 2010).

Despite the interesting preservation of these fossil crinoids, their identification is problematic. The robust nature of the more prominent crinoid pluricolumnals argues against them belonging to the disparids, the 'weedy' crinoids (Donovan and Lewis 2008). Thus, they most likely represent a mixture of debris from the other two major crinoid groups of this age, the cladids and the camerates. Taking this determination further is unlikely as crinoid systematics almost invariably relies on the features of the crown, not preserved in any of the present material.

Fig. 2 Chertified limestone (**a**) and screwstones from the bedload of the River Maas, the Netherlands; all presumed Tournaisian/Visean in age (see text). **a** NHMM 2014 061b, a crinoidal limestone ('ftaniet/silexiet') completely replaced with silica apart from rare vugs. **b, c** NHMM 724. **b** One surface of the clast with numerous mouldic crinoid columnals and pluricolumnals. **c** Detail of the most prominent 'screw'. *Scale bar* represents 10 mm. **d** NHMM MD 8154 (compare with Fig. 3). The prominent external mould has lost its axial canal ('screw') due to breakage during transport. Specimens uncoated. *Scale bars* represent 20 mm, except where stated otherwise

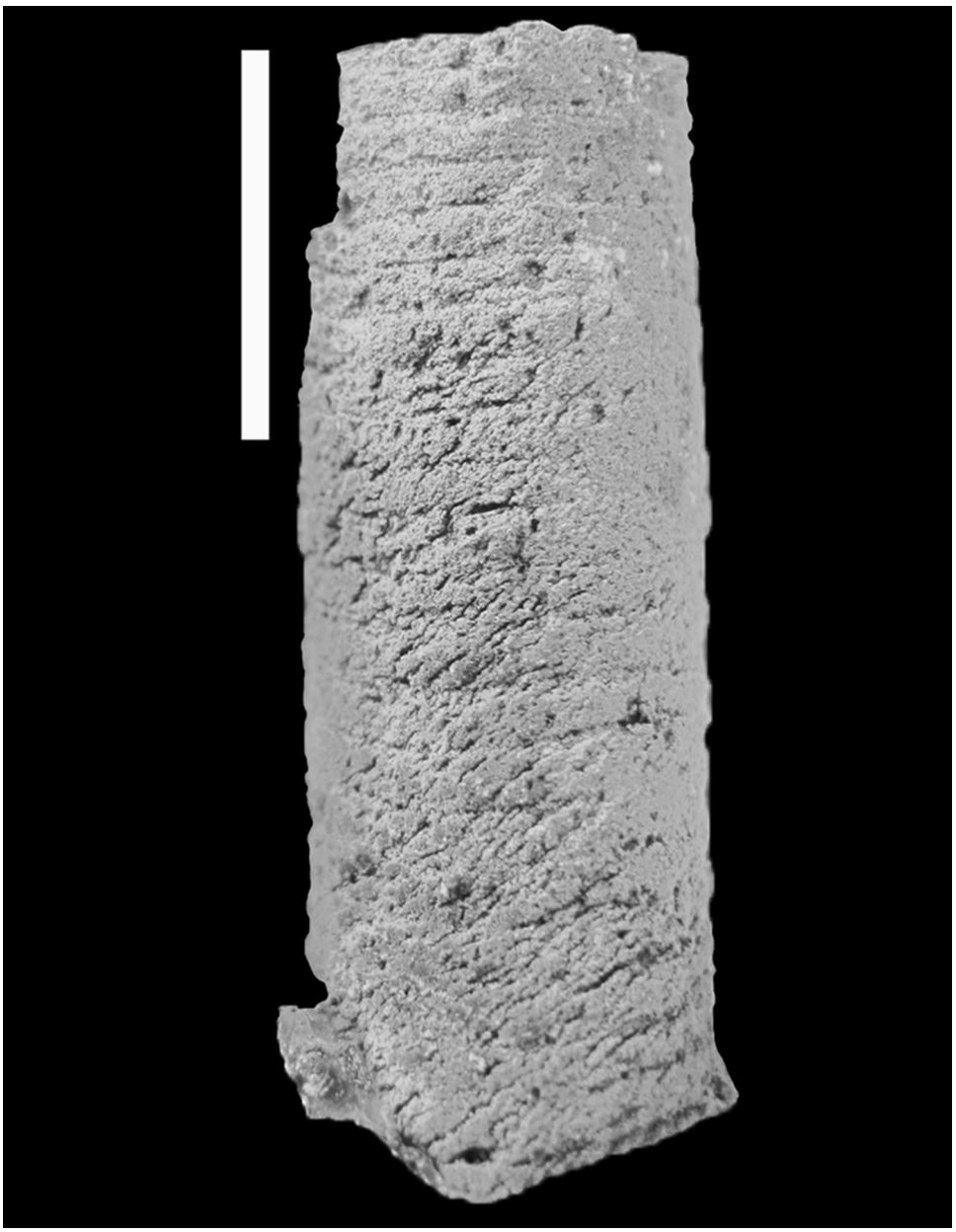

Fig. 3 Latex cast of a Mississippian (Tournaisian/Visean) screwstone, NHMM MD 8154 (compare with Fig. 2d), from the bedload of the River Maas, the Netherlands. Note that the columnals are of similar height; it is difficult to judge if these are identical (homeomorphic) or show slight regular alternations of height (heteromorphic N1). Specimen coated with ammonium chloride. *Scale bar* represents 10 mm

The pit, *Oichnus simplex*, is of some note. If it had been a radice scar, this would have been situated on a latus, not a suture. Further, if it was a radice evidence of a connection to the axial canal via a canalicula (Moore et al. 1978, p. T233) would be expected; there is none. For similar reasons, neither is it a radiating intracolumnal canal sensu Franzén-Bengtson (1983). Rather, this is a pit formed by an unmineralized invertebrate which constructed a domicile on the crinoid stem. There is no obvious growth reaction to this invasion, which most likely occurred after the death of the crinoid (see discussion in Donovan and Tenny 2015, in press). The choice of the plate suture for this structure presumably facilitated construction of the pit (compare with Donovan 1991), although only rarely have similar infestations been described.

In conclusion, rare Palaeozoic cherts in the bedload of the River Maas in the Netherlands are rich in crinoid debris and probably derived from the Mississippian (Tournaisian/Visean) of the Ardennes Massif. Clasts are either completely chertified or may preserve macrofossils as natural

moulds in a siliceous matrix, that is, screwstones. Screwstones may preserve crinoid debris in excellent detail, but the relatively delicate 'screw', that is, the mould of the axial canal, does not always survive. The best-preserved specimen retains a mould of a pit in the latus, *Oichnus simplex*, probably a domicile excavated after the death of the crinoid.

Acknowledgments We thank Annalet Willems (Schimmert) for donating her late husband's (Paul Baggen) collection to the Natuurhistorisch Museum Maastricht (compare Baggen 2015; Jagt et al. 2015). Constructive reviews by Dr Fiona E. Fearnhead (Natural History Museum, London) and a second, anonymous referee are gratefully acknowledged.

References

Akkerman, H. (2012). Zwerfstenen en verzamelaars. *Staringia*, *13*, 26–33.

Baggen, P. (2015). Stenen. *Sprekende Bodem*, *59*(3), 72–82.

Bengtson, P. (1988). Open nomenclature. *Palaeontology, 31*, 223–227.

Blankers, P., & Nelissen, L. (2013). *Het Limburgse Heuvelland. Landschap en gesteenten in Zuid-Limburg*. Dagblad 'De Limburger', Maastricht/IVN Spau-Beek, Beek/Spaubeek, 1–88.

Bosch, P. W. (1992). De herkomstgebieden van de Maasgesteenten. *Grondboor & Hamer, 46*, 57–64.

Bosch, P. W. (1998). De grindafzettingen van de Maas op de St. Pietersberg. *Grondboor & Hamer, 52 (Limburgnummer 9A: Geologie van de St. Pietersberg)*, pp. 86–90.

Bouman, R. W., & Donovan, S. K. (2015). Biodiversity of Mississippian (Lower Carboniferous) crinoids from Bradford Dale, Derbyshire. *Proceedings of the Yorkshire Geological Society*.

Bromley, R. G. (1981). Concepts in ichnotaxonomy illustrated by small round holes in shells. *Acta Geològica Hispànica, 16*, 55–64.

Burger, A. W. (2012). Goniatitidae in het grind van Nederland. *Staringia, 13*, 46–59.

Carson, G. A. (1991). Silicification of fossils. In P. A. Allison & D. E. G. Briggs (Eds.), *Taphonomy: releasing the data locked in the fossil record* (pp. 455–499). New York: Plenum.

Donovan, S. K. (1991). Site selectivity of a Lower Carboniferous boring organism infesting a crinoid. *Geological Journal, 26*, 1–5.

Donovan, S. K. (2006). 'Screwstones' from the Lower Carboniferous (Mississippian; Visean, Brigantian) at Bradford Dale, Youlgrave, Derbyshire, and a new species of Gilbertsocrinus Phillips (Echinodermata, Crinoidea). *Proceedings of the Yorkshire Geological Society, 56*, 87–90.

Donovan, S. K. (2010). A Derbyshire screwstone (Mississippian) from the beach at Overstrand, Norfolk, eastern England. In Donovan, S. K., & Hoek Ostende, L. W. van den (Eds), Palaeontological papers in honour of Dr. Cor F. Winkler Prins. *Scripta Geologica Special Issue, 7*, pp. 43–52.

Donovan, S. K. (2013). Where are all the crinoids? An enigma of the Lower Carboniferous (Mississippian) White Peak of midland England. *Geology Today, 29*, 108–112.

Donovan, S. K., & Lewis, D. N. (2008). The disparids: weird and weedy crinoids of the Palaeozoic. *Deposits, 16*, 12–17.

Donovan, S. K., Lewis, D. N., & Bouman, R. A. (2014). Echinoid remains preserved in a Derbyshire screwstone (Mississippian: Viséan, Brigantian), UK. *Proceedings of the Yorkshire Geological Society, 60*, 135–139.

Donovan SK, Tenny A (2015, in press) A peculiar bored crinoid from Salthill Quarry, Clitheroe, Lancashire (Mississippian; Tournaisian), UK. *Proceedings of the Yorkshire Geological Society*.

Eggink, R. G. (1991). Vondstmelding van een Bothriocidaris [sic] te Westerhaar. *Grondboor & Hamer, 45*, 7–9.

Franzén-Bengtson, C. (1983). Radial perforations in crinoid stems from the Silurian of Gotland. *Lethaia, 16*, 291–302.

Hoedemaeker, P. J. (2012). Endoceratoidea, Actinoceratoidea en Nautiloidea. *Staringia, 13*, 34–45.

Hoedemaeker, P. J., & Jagt, J. W. M. (2012). Nautiloïden en ammonieten uit Maas- en Rijngrind in Limburg en zuidelijk Gelderland. *Staringia, 13*, 188–197.

Humble, W. (1860). *Dictionary of geology and mineralogy: comprising such terms in natural history as are connected with the study of geology*. Griffin and Co., London, viii + 470 pp.

Information and Documentation Centre for the Geography of the Netherlands (1985). *Compact geography of the Netherlands*. Fifth impression. Ministry of Foreign Affairs, The Hague, p. 43.

Jagt, J. W. M. (2001). Limburgse trilobieten. *Gea, 34*, 31–35.

Jagt, J. W. M. (2002). Nog meer Limburgse trilobieten. *Gea, 35*, 26–28.

Jagt, J. W. M., Kisters, P. J. M. & Stroucken, J. W. (2015). Enkele gesteenten en fossielen uit de collectie Baggen. *Sprekende Bodem, 59*(3), 83–88.

Moore, R. C., Jeffords, R. M., & Miller, T. H. (1968). Morphological features of crinoid columns. *University of Kansas Paleontological Contributions, Echinodermata Article, 8*, 1–30.

Moore, R. C., with additions by Ubaghs, G., Rasmussen, H. W., Breimer, A. & Lane, N. G. (1978). Glossary of crinoid morphological terms. In Moore, R. C. & Teichert, C. (Eds), *Treatise on Invertebrate Paleontology, Part T, Echinodermata 2*(1). Geological Society of America and University of Kansas Press, Boulder and Lawrence, T229, T231, T233-T242.

Oncken, O., von Winterfield, C., & Dittmar, U. (1999). Accretion of a rifted passive margin: the Late Paleozoic Rhenohercynian fold and thrust belt (Middle European Variscides). *Tectonics, 18*, 75–91.

Oostingh, C. H. (1911). Eerste bijdrage tot de kennis van het verspreidingsgebied onzer zwerfsteenen van zuidelijken oorsprong. *Mededeelingen van de Rijks Hoogere Land-, Tuin- en Boschbouwschool, 4*, 1–23.

Poty, E., Hance, L., Lees, A. & Hennebert, M. (2002). Dinantian lithostratigraphic units (Belgium). In Bultynck, P. & Dejonghe, L. (Eds), Guide to a revised lithostratigraphic scale of Belgium. *Geologica Belgica, 4 (for 2001)*, pp. 69–94.

Rhebergen, F. (2014). A new Late Ordovician erratic anthaspidellid sponge (Porifera) originating from Baltica. *Scripta Geologica, 146*, 1–15.

Russcher, J., De Kruijk, H., & Lambert, J. (2014). Zwerven door zwerfstenen. Werkgroep Zwerfstenen, Nederlandse Geologische Vereniging. *Afdeling Utrecht en't Gooi. Staringia, 14*, 1–113.

Schuijf, P., & Boelens, B. (1949). *Fossielen uit noordelijke zwerfstenen*. Leiden: Nederlandsche Uitgeversmaatschappij N.V., 140 pp.

Taylor, J. E. (1885). *Our common British fossils and where to find them: a handbook for students*. Chatto and Windus, Piccadilly, xii + 331 pp.

Ubaghs, G. (1978). Skeletal morphology of fossil crinoids. In R. C. Moore & C. Teichert (Eds.), *Treatise on Invertebrate Paleontology, Part T, Echinodermata 2(1)* (pp. T58–T216). Boulder and Lawrence: Geological Society of America and University of Kansas Press.

van der Lijn, P. (1974). *Het Keienboek. Mineralen, gesteenten en fossielen in Nederland*. Zutphen: W.J. Thieme & Cie, 361 pp.

Webster, G. D. (1974). Crinoid pluricolumnal noditaxis patterns. *Journal of Paleontology, 48*, 1283–1288.