A larger agglutinated foraminifer originally described as a marine plant: the case of Arthrodendron Ulrich, 1904 (Foraminifera), its synonyms and homonyms

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ABSTRACT – The large, agglutinated foraminiferal genus Aschemocella Vialov, 1966 (type species Aschemonella carpathica Neagu, 1964) and the body fossil Halysium Swidzinski, 1934 (type species Halysium problematicum Ulrich, 1904) are herein synonymized with the genus Arthrodendron Ulrich, 1904 (type species A. diffusum Ulrich, 1904), a form originally described as a marine alga from Upper Cretaceous (Maastrichtian) flysch sediments of the Kodiak Formation of the Yakutat Group (formerly Yakutat Formation) on Pogibshi Island, Alaska. The species Aschemonella carpathica Neagu is regarded as a subjective junior synonym of Arthrodendron diffusum Ulrich, which is herein lectotypified and transferred to the Foraminifera. J. Micropalaeontol. 27(2): 103–110, November 2008.

KEYWORDS: Foraminifera, algae, systematics, Arthrodendron, Upper Cretaceous

INTRODUCTION

During the 1899 Harriman Geological Expedition to the coast of Alaska, a curious segmented body fossil was distinguished as a new genus and species Arthrodendron diffusum (Ulrich, 1904). It was described from flysch sediments of the Kodiak Formation (formerly Yakutat Formation, now Yakutat Group), near the town of Kodiak and was originally regarded as a fossil alga of unknown affinity (Ulrich, 1904). Similar fossils have been found in the Alpine and Carpathian Cretaceous and Palaeogene flysch deposits, where they have been given different names. Since the 1960s, they have been considered to be large agglutinated foraminifera (Geroch, 1960; Neagu, 1964), commonly under the genus Aschemonella Brady, 1879 or Aschemocella Vialov, 1966.

The genus Arthrodendron Ulrich, 1904 is now regarded as an agglutinated foraminifera and the senior objective synonym for these foraminifera described from Alpine-Carpathian flysch deposits.

Such fossils have been reported often in the palaeontological literature as algae. As late as 1990, specimens of Arthrodendron, tentatively identified as ‘fossil sea green alga’, were described from the Upper Cretaceous Lupkov Beds in eastern Slovakia (Plicka & Thomka, 1990, pl. 49, figs 1–2).

The purpose of this paper is to clarify the generic affiliation of these large deep-sea agglutinated foraminifera based on restudy of the type specimens.

BACKGROUND

The genus Arthrodendron

The genus name Arthrodendron has had a troubled history and has been applied variously to a Carboniferous plant, marine algae and trace fossils. The first use of Arthrodendron was by Scott (in Seward, 1898) with reference to a specimen of calamitean plant stem from a North American coal field. Seward (1898) recognized three structural types of calamite stems that were regarded as subgenera belonging to the genus Calamopitus Williamson, 1871 – Calamodendron, Arthropytus and Arthrodendron. In his textbook Studies in Fossil Botany, Scott (1900) elevated Arthrodendron to generic rank. Henceforth, the name ‘Arthrodendron’ became entrenched in the botanical literature as a type of a Carboniferous plant, and the name can still be found in the Encyclopaedia Britannica used in this sense. Unfortunately, neither Seward (1898) nor Scott (1900) designated a type species for ‘Arthrodendron’ and, therefore, the name in its original sense must be regarded as nomen nudum.

One year after Seward applied this name to a fossil plant, an enigmatic fossil was discovered by G. K. Gilbert during the 1899 Harriman Geological Expedition to Alaska and described by Ulrich (1904) in the expedition reports, which were reprinted by the Smithsonian Institution in 1910 (hence the publication date is sometimes erroneously cited as 1910). Found in sedimentary rocks of ‘older than Cenozoic’ age on Pogibshi Island opposite the town of Kodiak Alaska (referred to as ‘Kadiak’ in the expedition reports), the fossil was originally regarded as a fossil alga of uncertain affinity. Apparently unaware of Stewart’s description of Carboniferous calamite stems, Ulrich (1904) described and illustrated the fossil as Arthrodendron diffusum n. gen. n. sp.’ (Fig. 1). The species was described as follows:

“Branches moniliform,springing from a central point and spreading outwardly and upwardly so as the form a loose bush-like mass as much as 15 cm in diameter; divisions dichotomous, at intervals varying from 6 mm to over 20 mm. Joints subelliptical, the lower half usually a little narrower than the upper half, 4 mm to 6 mm in length and from 2.2 mm to 2.28 mm in width; surface usually glossy and smooth, but where preservation is more favourable is covered by minute granules and punctae.”

Based on this specimen (Ulrich, 1904; pl. 14, fig. 1) reproduced herein in Fig. 1), the genus Arthrodendron was thus defined: ‘Plant ramose, bushy, the branches constricted at irregular intervals, and probably consisting each of a series of rounded or ovate, flattened (probably inflated) joints; surface of joints minutely granopunctate’.

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As pointed out by Reed (1952) this is undoubtedly the earliest valid use of the genus name *Arthrodendron*, and the name must be applied only with reference to Ulrich’s Alaskan fossil. The calamite wood specimens from the Carboniferous were consequently renamed ‘*Arthroxyton*’ by Reed (1952). Nevertheless, the name *Arthrodendron* still persists in the popular literature in its original sense.

The homonymy of the name *Arthrodendron Seward* with *Arthrodendron Ulrich* was also pointed out by Dayal (1964). Unaware that Seward’s *Arthrodendron* was, in fact, a *nomen nudum*, Dayal regarded Ulrich’s form to be the junior homonym and renamed it *Palaeoarthrodendron*, a rather unfortunate choice of a name because Ulrich’s genus was described from much younger strata. Because Ulrich’s description of *Arthrodendron* is valid, the replacement name *Palaeoarthrodendron* must be rejected as a superfluous name under the rules of the ICZN (1999). Consequently, *Arthrodendron Ulrich*, 1904 is available in the sense of ICZN rules. Because the first valid use of the genus name *Arthrodendron Ulrich* is from the twentieth century and the name was used subsequently by Andrews (1955, 1970) and by Seilacher (1959), it is too young to be regarded as *nomen oblitum* under Paragraph 23.9.1 of the ICZN (1999).

Fortunately, many of the palaeontological specimens collected during the Harriman Alaskan Expedition have found their way to the Smithsonian Institution, where they are preserved in the collections of the Department of Paleobiology, including the specimens illustrated by Ulrich (1904; pl. 14, figs 1–3) (Fig. 1, Pl. 1). Without doubt, these specimens are not plants, but are large, agglutinated foraminifera, with a mineralized wall.

### Nineteenth century descriptions

*Arthrodendron* or *Arthrodendron*-like fossils have been reported in the macrofossil literature as either algae, trace fossils, or as body fossils of uncertain affinity. There are several examples of presumed *Arthrodendron* in the nineteenth century literature, variously described as species of *Corallinates Unger*, 1841, *Hormosira* Endlicher, 1836 or *Halimeda* Lamouroux, 1812. The earliest report is that of Unger (1841), who described the species *Corallinates halimeda* from the ‘Jurassic’ of Austria. This specimen (Fig. 2a) shows strong similarity to *Arthrodendron diffusum* Ulrich. Massalongo (1856) described four additional species of *Corallinates* from the Tertiary marly limestones of the Vicento Province of Italy; Heer (1877) described the species *Hormosira moniliformis* from flysch sediments of Freiberg Canton, Switzerland; and Fuchs (1894) described the species *Halimeda saportae* from the Eocene Greifenstein Sandstone of Kritzendorf, Austria (Fig. 2b). All of these reports require further investigation to establish the possibility of synonymy with the type species of *Arthrodendron*. However, in each case the generic names applied were for green algae (*Corallinates, Hormosira, Halimeda*). Some of the species names described under these genera may be regarded as valid.

### The genus *Halysium Świdziński*, 1934

A potential subjective junior synonym of *Arthrodendron* is the genus *Halysium Świdziński*, 1934 (Fig. 2c) [non *Halysium Corda*, 1837; type species *H. atrum* Corda, 1837] described from the Late Cretaceous Inoceramian Beds at Przegonina near Gorlice, Carpathian flysch in Poland. This genus was included under ‘Body Fossils’ in the *Treatise of Invertebrate Paleontology, Part W*, by Häftschel (1975), who listed *Arthrodendron Ulrich* as a junior synonym on the grounds of its supposedly being *nomen nudem*. However, now that status of the type specimens of *Arthrodendron* housed in the collections of the Smithsonian Institution has been clarified, this can no longer be the case. *Halysium* was described in the *Treatise...* (p. W151) as follows: ‘Ovate capsules, commonly flattened, smooth or minutely granulated, consistency differing from matrix; some specimens with carbonaceous lining; capsules forming branching rows’ [*?Alga*].

The only described species, *Halysium problematicum* Świdziński, 1934 displays chambers that vary in size and are elongated, as in *A. carpathica* Neagu, 1964. However, the individual figured by Seilacher (1962) as *H. problematicum* (and reproduced in the *Treatise...*) displays uniformly oval chambers.
and more frequent branching than *A. moniliformis*, branching after only 2–5 chambers. The whereabouts of Świdziński's specimen is unknown.

The name *Halysium Świdziński* is a junior homonym of the fungal genus *Halysium* Corda, 1837 (Index Fungorum, 2004) and, as a result, it is unavailable. To the authors’ knowledge there is no replacement name for *Halysium Świdziński*. If it were a valid name, *Halysium Świdziński* would be placed into the synonymy of *Arthrodendron* Ulrich, based on descriptions and the similarity of the published illustrations. Additionally, the genus *Halysium Świdziński* was reported by Kern (1977) from the Upper Cretaceous Sieveringer Schichten of the Wienerwald flysch in Austria.

*Aschemonella carpathica* Neagu, 1964

Neagu (1964) described large-sized agglutinated foraminifera *Aschemonella carpathica, A. moniliformis* and *Dendrophyra dichotomicus* from the upper part of the Cretaceous Valea Mare Beds in the Teleajen Nappe of the Eastern Carpathians. The type specimens were found in reddish sediments of late Campanian age that are overlain by lower Maastrichtian grey marls in the Ulves Valley, near the Valea Mare, Romania (Neagu, 1968, 1970). The type description of *Aschemonella carpathica* Neagu, 1964 is as follows:

“Test free, moniliform, with an articulate aspect, dichotomically branched, consisting of numerous chambers with an oval-truncated-glandular contour. Parts connected with both the precedent and subsequent chamber nearly identical. Dimensions of chambers gradually but irregularly increasing. Test wall formed of quartz grains, mica flakes, sponge spicules, etc., of varying size, bound by an abundant siliceous cement. Wall thickness ca. 0.12 mm. Chambers filled with a dark greenish argillaceous material. Apertures circular, situated on small necks either at the end of terminal chambers or on the sides of the chambers. The size of the specimens varies between 2–7 cm, thickness 1–3 mm.”

The holotype specimen (Fig. 3) possesses chambers of varying length. Chambers on the central ‘stem’ are elongated, but chambers on lateral branches are smaller and more oval. Additional paratypes from the collection of the Laboratory of Palaeontology, University of Bucharest, are illustrated in
Plate 2. One of the specimens illustrated by Neagu (1964, pl. 26, fig. 5) was supplied by Stanisław Geroch. This specimen was collected from the Upper Cretaceous Inoceramian Beds of the Magura Nappe at Grybów, Poland. The Grybów locality is described in greater detail by Suliński & Kaminski (1998).

The genus *Aschemocella* Vialov, 1966 and the family *Aschemocellidae* Vialov, 1966

In the mid-1960s a series of papers was written by Soviet micropalaeontologists on the supposed Silicinifera, a group of foraminifera that were purported to have primary siliceous tests. A number of new genera were proposed by researchers such as E. V. Miatliuk (1966) and O. S. Vialov (1966) to separate the supposed ‘siliceous’ genera from their agglutinated homoeomorphs. Unfortunately, for these authors, silification of agglutinated foraminiferal tests turned out to be a purely diagenetic feature. As a result, whether or not an agglutinated test is silicified has no taxonomic significance, and most of the alleged ‘siliceous’ genera have been regarded subsequently as junior subjective synonyms.

One exception was the genus *Aschemocella* Vialov, 1966 (type species *Aschemonella carpathica* Neagu, 1964), which was considered by Loeblich & Tappan (1987) to be a valid name for fossil foraminifera formerly placed in the genus *Aschemonella*. Moreover, Vialov (1966) established the family *Aschemocellidae* for his new genus *Aschemocella*. The type species of *Aschemo- nella* (*A. scabra* Brady, 1879) was discovered by Gooday & Nott (1982) to synthesize barite crystals identical to those found in xenophyophoreans, and was transferred from the Foraminifera into the Xenophyophorea. A generic name was therefore required for the fossil foraminifera described as *Aschemonella* by Neagu (1964) from the Carpathian flysch. Vialov’s genus *Aschemocella* served this purpose (see discussion by Berggren & Kaminski, 1990). Since 1990, the genus name *Aschemocella* has been applied consistently to large, mostly fragmentary chambers of multilocular foraminifera recovered from deep-water turbidites (Kaminski & Gradstein, 2005). However, the separation between the Xenophyophorea and the Foraminifera was brought into question by the discovery of Pawłowski *et al.*
Paratype specimens of *Aschemonella carpathica* Neagu, 1964, from the upper Campanian Valea Mare Beds, Brașov County, Eastern Carpathians, Romania, from the collections of the Laboratory of Paleontology, University of Bucharest, photographs by Cristian Foceanu. fig. 1. Specimen LPB 5002/F. fig. 2. Specimen LPB 5002/B. figs 3–4. Details of figure 2.
(2003) that the xenophyophoran *Syringammina corbulica* is a foraminifer based on ribosomal DNA analysis. More molecular studies are needed to determine whether the taxonomic separation between Xenophyophorea and the Foraminifera should be maintained.

**SYSTEMATIC PALEONTOLOGY**

**Family Aschemocellidae** Vialov, 1966

1966 Aschemocellidae Vialov: 31. Subsequent designation: 1987 Loeblich & Tappan: 55; 2004 Kaminski: 246; 2004 Mikhalevich: 339.

1974 Aschemocellinae Loeblich & Tappan: 43, nom. transl. ex family Aschemocellidae.

**Type genus.** *Arthrodendron* Ulrich, 1904.

**Description.** Test free, dichotomously branched, of ovoid to tubular or irregular uniserial chambers; wall imperforate, agglutinated, firmly cemented; apertures at ends of necks.

**Remarks.** The family name Aschemocellidae is here maintained as valid according to recommendations of Article 40.1 of the ICZN. Irrespective of the validity of the generic name, the family name Aschemocellidae Vialov is conserved.

In the most recently published suprageneric classifications (Kaminski, 2004; Mikhalevich, 2004) the Aschemocellidae was placed within the Superfamily Hormosinacea (or Hormosinoidea). Because of its large dimensions and catenate branching morphology, *Arthrodendron* bears superficial resemblance to the komokiacean genus *Catena* Schroeder, Medioli & Scott, 1989. This brings into question the systematic affiliation of the Family Aschemocellidae. The Superfamily Komokiacea encompass typically large, branching forms that are either unchambered or pseudochambered, and differ from other foraminifera in accumulating stercomata (faecal pellets) inside their tests. Because of their weakly cemented wall, the komokiaceans are not known to leave a fossil record. If it turned out that *Arthrodendron* accumulated stercomata, based on external morphology the Family Aschemocellidae would fit better within the Komokiacea. Until this matter is resolved, the Aschemocellidae are tentatively retained within the Hormosinoidea.

**Genus Arthrodendron** Ulrich, 1904

1904 *Arthrodendron* Ulrich: 138, pl. 14, figs 1–3 [type species: *Arthrodendron diffusum* Ulrich, 1904].

1934 *Halysium* Świdszinski: 146 [type species: *Halysium problematicum* Świdszinski, 1934; non *Halysium* Corda, 1837].

1964 *Palaeoarthrodendron* Dayal: 727 [nom. subst. pro *Arthrodendron* Ulrich, 1904].

1966 *Aschemocella* Vialov: 31 [type species: *Aschemonella carpatica* Neagu, 1964].

**Type species.** *Arthrodendron diffusum* Ulrich, 1904, p. 138, by original designation. [Subjective junior synonym: *Aschemonella carpatica* Neagu, 1964, p. 582].

**Type specimens.** The two specimens illustrated by Ulrich (1904, pl. 14, figs 1, 2) are housed in the Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington D.C. The specimen illustrated by Ulrich in his fig. 1 (USNM 30787) is designated here as the lectotype (Pl. 1, figs 1–2). The paralectotype (Ulrich’s fig. 2) is registered as USNM 30788 (Pl. 1, figs 3–4).

**Type locality.** The holotype of *A. diffusum* was collected by G. K. Gilbert during the 1899 Harriman Alaskan Expedition from the 'Yakutat Formation' (now the Kodiak Formation within the Yakutat Group) on Pogibshi Island separated by a narrow strait from the Kodiak Island opposite the town of ‘Kadiak’ [now Kodiak, Alaska]. The accompanying trace fossil assemblage found at the locality included *Chondrites* and graphoglyptids, indicating a deep-sea environment. Sedimentological (Nielsen & Moore, 1979) and ichnological studies (McCann & Pickerill, 1988) indicate that the Kodiak Formation was deposited in a distal deep-sea fan turbidite setting.

**Type level.** The Kodiak Formation is now regarded to be of Late Cretaceous (Early Maastrichtian) age on the basis of inoceramid bivalves (Jones & Clark, 1973).

**Diagnosis.** Branched chains of large, often irregular chambers with a simple, imperforate, agglutinated wall.

**Description.** Test free, with large (commonly 1–3 mm wide) irregularly ovoid, flask-shaped, or tubular chambers in a linear or dichotomously branching series, increasing very slowly in size. Chambers are compressed with a raised outer rim and may have irregular shape at the point of branching. Wall imperforate, simple, of agglutinated quartz, mica, and sponge spicules in abundant cement, probably with an inner organic lining. May have more than one rounded aperture, which may be produced on a neck, terminal, or may be at the side of the chamber, probably just before a new branch arises.

**Occurrence.** Upper Cretaceous (Campanian–Maastrichtian) in Alaska, Austria, Italy, Poland, Romania, Slovakia, Switzerland, Ukraine; Palaeogene in Austria, Italy, Poland, Switzerland, Trinidad and the North Sea.

**Remarks.** The similarity between the type species *A. diffusum* Ulrich, 1904 and the species *Aschemonella carpatica* Neagu, 1964 is striking. Both species are reported from rocks of similar age and palaeoenvironment. Ulrich reported the thickened rims around the individual chambers of *A. diffusum*, a feature that is also typical of the type specimens of *A. carpatica*.

At least four valid species of *Arthrodendron* have been reported from Late Cretaceous to Palaeogene aged deep-sea sediments under various generic names. In addition to the type species *A. diffusum* (= *A. carpatica* Neagu, 1964), the species *A. moniliformis* (= *Aschemonella moniliformis* Neagu, 1964), *A. grandis* (= *Reophax grandis* Grzybowski, 1898) and *A. subnodosiformis* (= *Hyperammina subnodosiformis* Grzybowski, 1898) are commonly reported from deep-sea turbiditic deposits, mostly in the Carpathians. The latter two species were transferred to the genus *Aschemocella* by Kaminski & Geroch (1993). However, the validity of the nineteenth century species originally described as fossil algae needs to be evaluated. It is possible that some of
Palaeoarthrodendron

1934, Ulrich, 1904 (with the genera trace fossils. The valid generic name for such fossils is Arthro-

Carpathian literature also belong in Vialov, 1966 included as junior synonyms), which is transferred Cretaceous and Palaeogene flysch deposits world-wide. Some of Larger agglutinated foraminifera commonly occur in Upper ACKNOWLEDGEMENTS names in current usage.

may be senior synonyms of some of the foraminiferal species described by Unger (1841), Heer (1877) and by Fuchs (1894) needs to be evaluated, as it is possible that some of the species nineteenth century species originally described as fossil algae (Grzybowski, 1898). The validity of the A. subnodosiformis (Grzybowski, 1898) and A. grandis (Grzybowski, 1898) and A. subnodosiformis (Grzybowski, 1898) and A. grandis (Grzybowski, 1898). The validity of the nineteenth century species originally described as fossil algae needs to be evaluated, as it is possible that some of the species described by Unger (1841), Heer (1877) and by Fuchs (1894) may be senior synonyms of some of the foraminiferal species names in current usage.

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