

<i>Bollettino della Società Paleontologica Italiana</i>	39 (3), 2000	ISSN 0375-7633	311-317	—	Modena, Dicembre 2000
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Taxonomic review of the acritarch genera *Acanthodiacrodium* Timofeev, 1958 and *Diornatosphaera* Downie, 1958

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This publication is dedicated to Prof. Dr. Dieter Mai, Berlin, on his 65th birthday

KEY WORDS – *Acritarcha, Taxonomy, Late Cambrian, Early Ordovician.*

ABSTRACT – Following a previous suggestion, the acritarch genus *Acanthodiacrodium* Timofeev, 1958 is restricted to its type species *A. dentiferum* Timofeev, 1958; also, an emendation of the genus *Diornatosphaera* Downie, 1958 is proposed. About 152 species of *Acanthodiacrodium* are validly published; four of them are formally transferred herein to *Diornatosphaera*; viz., *D. angusta* (Downie, 1958), the type species; *D. comptula* (Rasul, 1979); *D. echinata* (Timofeev, 1959) and *D. golubii* (Fensome et al., 1990).

RIASSUNTO – [Revisione tassonomica dei generi di acritarchi *Acanthodiacrodium* Timofeev, 1958 e *Diornatosphaera* Downie, 1958] – Seguendo un precedente suggerimento, il genere di acritarchi *Acanthodiacrodium* Timofeev, 1958 è ristretto alla specie-tipo *A. dentiferum* Timofeev, 1958 e viene anche proposto un emendamento del genere *Diornatosphaera* Downie, 1958. Attualmente, circa 152 specie di *Acanthodiacrodium* sono pubblicate validamente. Quattro di queste sono trasferite in *Diornatosphaera*: *D. angusta* (Downie, 1958), la specie-tipo; *D. comptula* (Rasul, 1979); *D. echinata* (Timofeev, 1959); *D. golubii* (Fensome et al., 1990).

INTRODUCTION

In 1957, greywackes from the Elbe zone, south-east of Dresden, and from Lusatia (Germany) were sampled for palynological investigations by Serge v. Bubnoff and colleagues from the former Academy of Science (East Berlin) and the Humboldt University (Berlin) to resolve the stratigraphic positions of the strata which were then controversial. The samples were treated according to standard procedures in Timofeev's palynological laboratory in Leningrad (now St. Petersburg) and the results were published the following year (Timofeev, 1958). The palynomorphs were reportedly indicative of an Early or Middle Cambrian age.

The fossiliferous sample yielding the type species of the genus *Acanthodiacrodium*, *A. dentiferum* Timofeev, 1958, originated from a location in the Müglitz valley, ca. 10 km southeast of Dresden, between the villages of Weesenstein and Dohna. Here, at the Köttewitz weir, the Cadomian Dohna granodiorite intrudes the Weesenstein greywacke and thermally affects the surrounding rocks. The granodiorite was dated from a single zircon age of ca. 538 ± 4 Ma (Gehmlich et al., 1997).

SYSTEMATIC PALAEONTOLOGY

Assemblages of acritarchs and chitinozoans have recently been obtained from Cambro-Ordovician boundary beds encountered in Danilov-7 well,

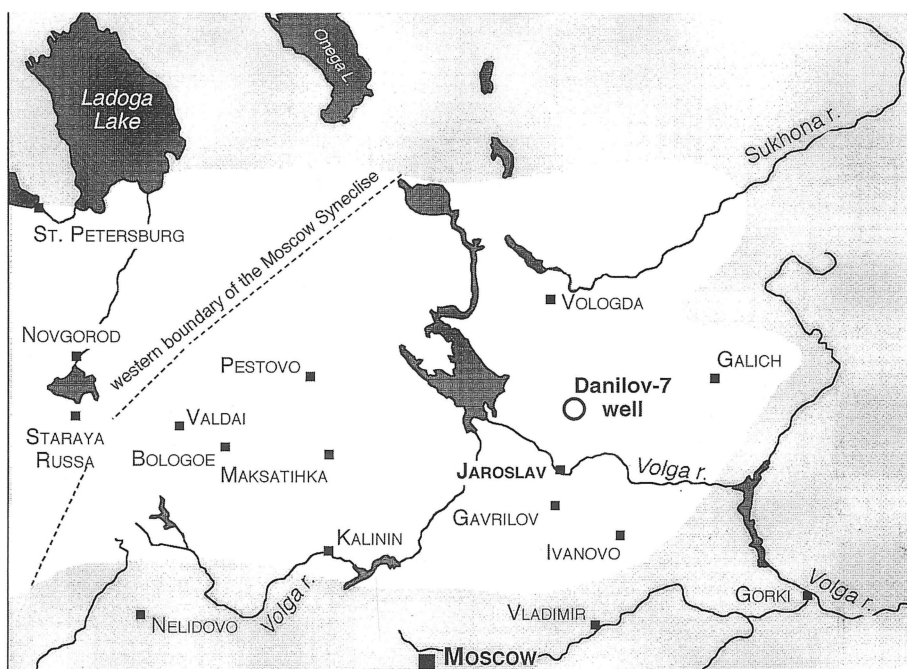
Moscow Syncline, East European Platform (EEP, Text-fig. 1) by Paalits & Heuse (1998), including many well-preserved specimens assignable to *Acanthodiacrodium*. This provided the impetus for the taxonomic discussion herein.

Used abbreviations – LV = vesicle length; Wv = vesicle width; Lp = process length; Wp = process width; Dp = distance between the processes; Lez = length of the equatorial zone.

Incertae sedis “group” ACRITARCHA Evitt, 1963
Genus ACANTHODIACRODIUM Timofeev, 1958
emend. Deflandre & Deflandre-Rigaud, 1962 here restricted

Type species (by monotypy) – *Acanthodiacrodium dentiferum* Timofeev, 1958.

Remarks – The first illustrations and descriptions of obvious Late Cambrian and/or Tremadoc bipolar acritarchs were those of Naumova (1950, pp. 181-187, pls. 2-4). They were erroneously interpreted as miospores of the genus *Azonomonoletes* Luber & Valts, 1938 ex Naumova, 1939 (Fensome et al., 1990, pp. 618-619). Almost simultaneously but independently, two papers were published that contained descriptions and illustrations of acritarchs with a bipolar vesicle (Timofeev, July 1958; Downie, December 1958). Timofeev (1956) had initially but invalidly established the genus *Acanthodiacrodium*



Text-fig. 1 - Location of Danilov-7 well, Moscow Syncline, East European Platform.

without diagnosis, illustration, typification, or locality information. Two years later, he published palynological results from samples of the Weesenstein and Lusatian greywackes of Germany, including descriptions and photomicrographs of three new acritarch species featuring a bipolar vesicle: *Acanthodiacrodium dentiferum*, *Lophodiacrodium obtusum*, and *Lophorytidodiacrodium bubnoffi*. No type species for *Acanthodiacrodium* was designated and neither was a holotype specified for *A. dentiferum*.

Downie (1958) reviewed organic-walled microfossils from the Shineton Shales of England and described several new taxa including the genus *Diornatosphaera* (type species, *D. angusta* Downie, 1958) for homopolar diacrodian acritarchs.

From the Baltic region, Timofeev (1959) described 51 new species of *Acanthodiacrodium*, three new species of *Lophodiacrodium*, and 23 new species of *Lophorytidodiacrodium*. Additionally, six new homodiacrodian genera were established by Timofeev (1959): *Acanthorytidodiacrodium* (32 species), *Acanthozonodiacrodium* (two species), *Trachydiacrodium* (four species), *Trachyrytidodiacrodium* (monospecific), *Trachyzonodiacrodium* (monospecific), and *Lophozonodiacrodium* (four species). Deflandre & Deflandre-Rigaud (1962) partly revised these diacrodian taxa, emending the diagnosis of *Acanthodiacrodium* and proposing *A. dentiferum* Timofeev, 1958 (p. 831; pl. 1, fig. 2; pl. 3, fig. 2) as type species. With regard to the cited Timofeev illustrations, the former is line-drawn from a photograph of an incomplete half test (Pl. 3, fig. 2) and only assumes homopolarity. The drawing (Pl. 1, fig. 2) was later chosen as holotype by Fensome *et al.* (1990, p. 26).

Acanthodiacrodium and its taxonomic applications have been discussed by Eisenack, Cramer & Díez (1976), Loeblich & Tappan (1978), Tongiorgi *in* Bagnoli *et al.* (1988), Martin *in* Martin & Dean (1988), Fensome *et al.* (1990), Servais (1993) and Servais & Molyneux (1997). Some 152 species of *Acanthodiacrodium* are validly established (Fensome *et al.*, 1990).

The microfossils reported by Timofeev (1958) from thermally metamorphosed greywackes of East Germany consisted mainly of unidentifiable organic matter, aside from three photomicrographs of whole or fragmentary acritarchs. Obviously, there was a striking contrast between preservational modes of *Acanthodiacrodium dentiferum*, *Lophodiacrodium obtusum*, and *Lophorytidodiacrodium bubnoffi* on the one hand and the remaining organic material on the other (see Timofeev, 1958, pls. 1-3).

Burmam (1966, 1969) regarded laboratory contamination as probably responsible for the illustrated well-preserved acritarchs of Timofeev (1958). Timofeev himself did not exclude the possibility of contamination (1961 verbal communication from Timofeev to Burmann: see Burmann, 1966, p. 220). It is suspected that the acritarch contaminants could have originated from younger strata of the EEP (Loeblich & Tappan, 1978, p. 1237).

No acanthomorphic acritarchs or diacrodians have so far been published from the Lusatian greywackes. Subsequent investigations on the material originally studied by Timofeev led to a Precambrian (probably Vendian) age-determination (Burmam, 1966, 1969, 1972; Weber, Kemnitz & Paech, 1990).

Discussion – According to ICBN article 42 (Greuter *et al.*, 1994, pp. 52–53), *Acanthodiacrodium* is validly published in spite of the following:

1. The bipolar acritarchs originally described by Timofeev (1958) from the Lusatian greywackes are almost certainly contaminants (Burmman, 1966, 1969).
2. Accordingly, *A. dentiferum*, the type species proposed by Deflandre & Deflandre-Rigaud (1962), does not have a *bona fide* or reproducible type locality or stratum.
3. The originally illustrated specimen of *A. dentiferum* (see Timofeev, 1958, pl. 3, fig. 2) is only a half specimen. Its line-drawn reconstruction (Timofeev, 1958, pl. 1, fig. 2), later proposed as holotype by Fensome *et al.* (1990, p. 26), was executed on the assumption of homopolarity. Consequently, the possibility cannot be excluded that Timofeev's (1958) original specimen of *A. dentiferum* is a heteropolar acritarch belonging to another genus; e.g., *Dasydiacrodium* Timofeev ex Deflandre & Deflandre-Rigaud, 1962, *Ladogella* Golub & Volkova emend. Di Milia, Ribecai & Tongiorgi, 1989, *Nellia* Golub & Volkova in Volkova & Golub, 1985, etc., which are common in Upper Cambrian-Tremadoc deposits.
4. Since its institution, no further specimens of the type species have been reported. Timofeev's original material has disappeared according to M. Burzin of the Palaeontological Institute of the Russian Academy of Sciences, Moscow (pers. comm.). Thus, taxonomic revision is not feasible at this time.

The confused taxonomic situation requires a pragmatic solution like the one offered by Martin (*in* Martin & Dean, 1988). In discussing *Actinotodissus achrasii* (Martin), Martin (*in* Martin & Dean, 1988, p. 35) advocated monospecific usage of the problematic but valid generic name *Acanthodiacrodium* Timofeev 1958 (i.e., restriction to type species *A. dentiferum*). Accordingly, all other homopolar diacrodian acritarchs with short solid processes should be assigned to the well characterized genus *Diornatosphaera* Downie 1958. Similarly, *Lophodiacrodium* should be applied only to its type species *L. obtusum* and to *L. bubnoffi*. The remaining species with short solid processes should be attributed to *Diornatosphaera*.

Genus DIORNATOSPHERA Downie, 1958 emend.

Type species (by original monotypic designation) – *Diornatosphaera angusta* Downie, 1958.

Emended diagnosis – Homopolar vesicle, ellipsoidal or nearly spherical, single-walled. The two poles separated by equatorial zone and covered with densely and somewhat irregularly distributed processes of variable number. Processes short, apparently

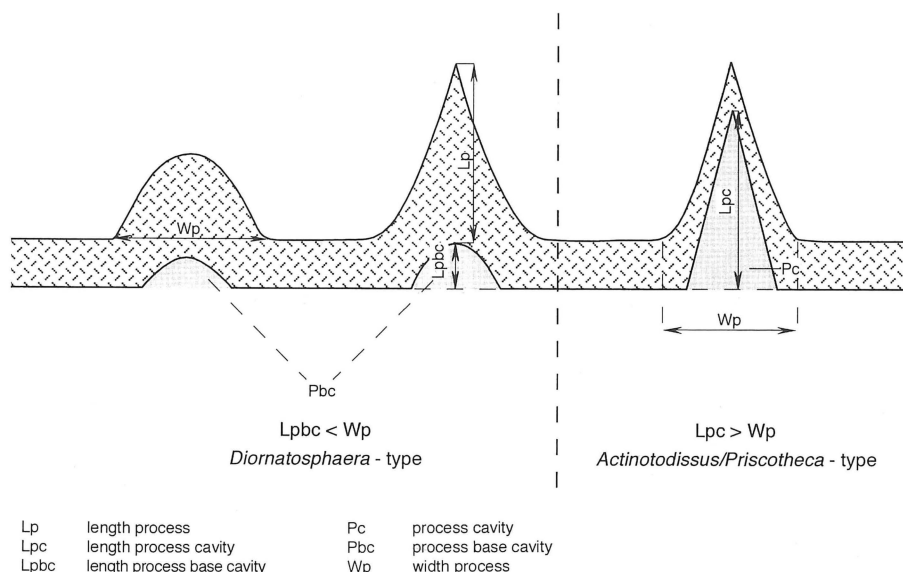
solid with small basal cavity; distal termini simple; process surfaces smooth or bearing grana or small spinae. Equatorial zone smooth, striated or spinose. Excystment opening absent, or represented by irregularly distributed split.

Discussion – The genus *Diornatosphaera* was originally described as "Hystrichospheres with a test constricted in the middle. The ornament on the narrow part differs from that on the swollen ends", Downie (1958, p. 345). In an emendation of the original diagnosis, it was recommended to include those diagnostic features of the former species of *Acanthodiacrodium*, combined herein, and to review the remaining species still attributed to *Acanthodiacrodium* or *Lophodiacrodium*. After reexamination of the holotype of *Diornatosphaera*, housed in the palynological collection at the University of Sheffield, K. Dörning was convinced that it has hollow processes though the distal part may be solid (K. Dörning, pers. comm.). The present authors believe that only in case of short processes observed under the light microscope the basal cavity could be described as hollow. Paalits (*in* Mens *et al.*, 1996, pl. 2, figs. 4, 5) figured SEM photographs showing a broken vesicle of *Acanthodiacrodium* sp. (now *Diornatosphaera* sp.) from the Kallavere Formation of Estonia with apparently solid processes and small basal cavities. In the original diagnoses of *Diornatosphaera* and *D. angusta*, no excystment mode was defined, beside the remark concerning *D. angusta* having "a more or less circular opening...", recognized in only two specimens (Downie, 1958, p. 346). This excystment mode has never been observed again in specimens now assigned to *Diornatosphaera*.

Comparison – The type species of *Actinotodissus* Loeblich and Tappan, 1978 and *Priscotheca* Deunff, 1961 possess hollow processes freely communicating with the vesicle cavity whereas the processes of *Diornatosphaera* are solid or have small cavities basally. *Trachydiacrodium* Timofeev emend. Deflandre and Deflandre-Rigaud, 1962 features a bipolar vesicle without processes. Other genera like *Dasydiacrodium*, *Arbusculidium*, *Ladogella*, and *Nellia* are heteropolar.

Remarks and comparison – Cramer & Díez (1979, p. 98) considered *Priscotheca* to be a junior synonym of *Acanthodiacrodium*. Tongiorgi (*in* Bagnoli, Stouge & Tongiorgi, 1988, p. 180) noted that the diagnoses of *Priscotheca* and *Actinotodissus* are similar, and considered both genera as junior synonyms of *Acanthodiacrodium*. In the final analysis, the morphological difference between *Diornatosphaera* and *Actinotodissus*/*Priscotheca* centres upon: solid processes with a process basal cavity vs hollow processes (Text-fig. 2). In the case of very small processes, this criterion may be difficult to apply conclusively.

Some 152 species of *Acanthodiacrodium* have hith-



Text-fig. 2 - Schematic reconstruction of *Diornatosphaera*- and *Actinotodissus/Priscotheca*-type processes. Lp = length of process; Lpc = length of process cavity; Lpbc = length of process base cavity; Pc = process cavity; Pbc = process base cavity.

erto been instituted either originally as new species or as recombinations (see, e.g., Fensome *et al.*, 1990). In addition to the type species, three of these species, here considered as belonging to *Diornatosphaera*, have been observed in the present study materials, and are formally combined (below) with *Diornatosphaera*. A revision of all remaining species of the genus *Acanthodiacrodium* which is needed before they can be newly combined is beyond the scope of the present paper.

DIORNATOSPHERA ANGUSTA Downie, 1958

Text-fig. 3 a, b

1958 *Diornatosphaera angusta* DOWNIE, pp. 345-346; pl. 17, figs. 7-8, text-fig. 3e (holotype, pl. 17, fig. 8)

Description – Homopolar vesicle, elongated and single-walled. Poles densely covered by small, non-furcated and solid processes. Distance between processes does not exceed their length. Poles separated by an equatorial zone usually without processes. Equatorial zone narrow, striated or smooth with straight or dimpled sides. Opening absent or represented by 3-5 μm long split of equatorial zone, detected in approximately 20 % of measured specimens.

Dimensions – 37 specimens from samples D-2159, D-2149 and D-2148; Lv: 18-37 μm ; Wv: 16,5-30 μm ; Lp: 0,5-2,5 μm ; Wp: 0,3-1,7 μm ; Lez: 2,5-8,5 μm .

Variability – Equatorial zone usually well-developed but, seldom specimens without clearly visible zone occur. Striation of the equatorial zone not very common; absent in sample D-2159 and varies

between 15-20 % of specimens in samples D-2149 and D-2148.

Comparison – *D. echinata* differs by hair-like very densely located processes.

Remarks – *D. angusta* and *D. echinata* are closely related species.

DIORNATOSPHERA COMPTULA (Rasul) comb. nov.

Text-fig. 3 c, d

1979 *Acanthodiacrodium comptulum* RASUL, p. 65; pl. 2, fig. 8 (holotype).

Description – Homopolar vesicle, single-walled, covered by rare, randomly distributed solid, conical processes. Processes simple non-furcated or seldom furcated, distally acuminate or rarely rounded. Process base cavity not longer than process width. Equatorial zone usually well developed, without processes and non-striated; in approximately 10-15% of specimens equatorial zone unsharp due to few processes. Sides of equatorial zone straight (about 30 %), concave (10 %) or convex (about 60 %). Vesicle surface even and densely granulated or sometimes with small spines (approximately 0,5 μm long). Processes smooth or rarely covered by single granulae. Opening absent or represented by split of equatorial zone (about 30 %).

Dimensions – 20 specimens from sample D-2148; Lv: 21,0-34,7 μm ; Wv: 20,5-30,0 μm ; Lp: 0,5-1,6 μm ; Wp: 0,3-1,2 μm ; Dp: 3,5-4,0 μm ; Lez: 0-9,5 μm .

Variability – Number of processes is difficult to observe and might vary between 25 to 40 per pole.

DIORNATOSPHAERA ECHINATA (Timofeev) comb. nov.
Text-fig. 3 e

1959 *Acanthorytidodiacrodiium echinatum* TIMOFEEV, p. 87; pl. 7, fig. 31 (holotype).

For further synonymy and discussion see Fensome *et al.* (1990, pp. 27, 37).

Description – Vesicle bipolar, more or less elongated and single-walled. Poles densely covered by small hair-like, non-furcated and solid processes. Equatorial zone usually well-developed, narrow with smooth or rarely slightly striated surface. Beside that, specimens with a “disguised” type of equatorial zone occur bearing less processes than the poles. Opening absent or rarely represented by split.

Dimensions – 18 specimens from sample D-2148; Lv: 25,5-39,0 µm; Wv: 18,5-28,0 µm; Lp: 1,5-3,0 µm; Wp: 0,3-0,8 µm; Lez: 4,5-8,5 µm.

Variability – Distal process furcation is recognizable using SEM; not visible under the light microscope. Obviously, arc-like structure originally described by Timofeev (1959) and frequently detectable not

only in *D. echinata* specimens is caused by diagenetic compression and possibly more common in specimens with concave equatorial zone.

DIORNATOSPHAERA GOLUBII (Fensome *et al.*) comb. nov.
Text-fig. 3 f

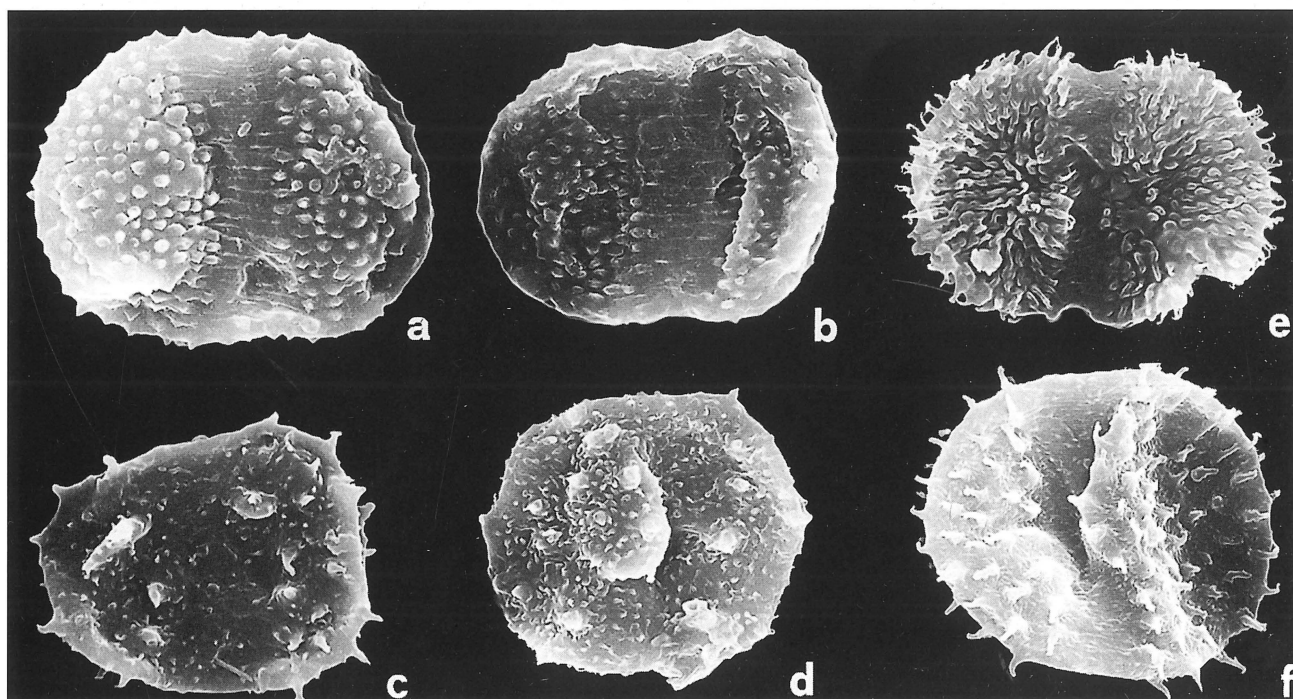
1990 *Acanthodiacrodiium golubii* FENSOME *et al.*, p. 28.

For further synonymy and discussion see Fensome *et al.* (1990, p. 28).

Description – Homopolar vesicle, more ore less elongated and single-walled. Poles with small non-furcated and solid processes. Distance between processes exceeds the process length. Equatorial zone narrow, striated and without processes. Opening absent or represented by a small split.

Dimensions – 15 specimens from samples D-2159, D-2149 and D-2148; Lv: 25,5-39,0 µm; Wv: 20,5-33,0 µm; Lp: 2,5-5,0 µm; Wp: 0,5-1,5 µm; Lez: 4,5-9,5 µm.

Comparison – *D. golubii* differs from *D. angusta* and *D. echinata* by longer processes and longer distance between the processes.



Text-fig. 3 a, f - All specimens are from sample D-2148, slide SCAN/D-2148; magnification x 1600 (a) and x 1250 (b-f).

a, b - *Diornatosphaera angusta* Downie, 1958

c, d - *Diornatosphaera comptula* (Rasul, 1979) comb. nov.

e - *Diornatosphaera echinata* (Timofeev, 1959) comb. nov.

f - *Diornatosphaera golubii* (Fensome *et al.*, 1990) comb. nov.

Remarks – Vesicle size and process length of *D. golubii* are comparable to *Schizodiacrodium armatum* Volkova, 1990, but *D. golubii* is distinguished from the latter by non-ornamented processes. Volkova (1999, p. 49) synonymized *S. armatum* with *Acanthodiacrodium digermulense* Welsch, 1986 (now *S. digermulense*).

SUMMARY

Following Martin (*in* Martin & Dean, 1988), a monospecific usage of the acritarch genus *Acanthodiacrodium* is advocated by effectively restricting it to type species *A. dentiferum*. Similarly, *Lophodiacrodium* applies to type species *L. obtusum* and also to *L. bubnoffi*. An emended diagnosis of *Diornatosphaera*, as typified by *D. angusta*, is proposed; three other species are transferred herein to *Diornatosphaera*. Future revision and morphological clarification of other species attributed to *Acanthodiacrodium* and *Lophodiacrodium* is recommended.

Diornatosphaera, *Actinotodissus*, and *Priscotheca* are distinguishable only by internal detail of processes. Accordingly, this acritarch group also appears susceptible to restudy and clarification.

ACKNOWLEDGEMENTS

We are grateful to Werner Greuter (Berlin) and Volker Wilde (Frankfurt am Main) for detailed taxonomic discussions of the *Acanthodiacrodium-Diornatosphaera* complex; Marco Tongiorgi (Pisa) and Geoffrey Playford (Brisbane) for critical review of the manuscript, for the "Riassunto" and checking the English text. We are greatly indebted to Ken Dörning (Sheffield) for valuable remarks on the holotype of *Diornatosphaera*. Ivo Paalits has been supported by grants no. 3237 and 3498 of the Estonian Science Foundation and a German DFG-Project ER 96/16. Thomas Heuse's research was facilitated by a grant from the Geological Survey of Saxony. The publication is a contribution to the IGCP 410.

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*(manuscript received April 14, 2000
accepted June 22, 2000)*

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