



Acritarchs

Case study from the Eocene of Egypt

By

Mohammed shawky Ahmed shaban

(4th year, Special Geology)

Supervised by

Dr. Ali Soliman

Geology Department

Faculty of Science

Tanta University

2013



Acritachs

Case study from the Eocene of Egypt

"An article submitted to the Department of Geology-Faculty of Science- Tanta University"

"To complete the requirements for obtaining a bachelor's degree in geology"

By

Mohammed shawky Ahmed shaban

(4th year, Special Geology)

Supervised by

Dr. Ali Soliman

Geology Department

Faculty of Science

Tanta University

2013



الاكريتاش

دراسة لعينات من رواسب الأيوسين - مصر

إعداد

محمد شوقي أحمد شعبان

(الفرقة الرابعة علوم جيولوجيا)

تحت إشراف

د/ على سليمان

قسم الجيولوجيا

كلية العلوم

جامعة طنطا

2013

الاكريتاش



دراسة لعينات من رواسب الأيوسين - مصر

"مقال مقدم إلى قسم الجيولوجيا- كلية العلوم – جامعة طنطا"

"لإستكمال متطلبات الحصول على درجة البكالوريوس فى الجيولوجيا"

إعداد

محمد شوقى أحمد شعبان

(الفرقة الرابعة علوم جيولوجيا)

تحت اشراف

د/ على سليمان

قسم الجيولوجيا

كلية العلوم

جامعة طنطا

2013



قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا

إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ

صَدَقَ اللَّهُ الْعَظِيمُ

سورة البقرة الآية: 32



ACKNOWLEDGEMENTS



Acknowledgement

All my thanks to "Allah" who give me help and ability to finish this work.

Then, I wish to express my deepest gratitude to Dr. Ali Soliman, lecturer of stratigraphy and paleontology, Geology Department, Faculty of Science, Tanta University for suggesting the present point of study, Great efforts and guidance, providing me with reference related to the subject and also for her continuous encouragement during the preparation of this work.





CONTENTS



| CONTENTS | Pages No. |
|--|-----------|
| ACKNOWLEDGMENTS | |
| LIST OF FIGURES | |
| LIST OF TABLES | |
| ABSTRACT | |
| CHAPTER ONE: INTRODUCTION | |
| 1.1 Introduction | |
| CHAPTER TWO: HISTORY OF ACRIARCH STUDY | |
| 2.1 HISTORY OF ACRIARCH STUDY | |
| 2.2 MORPHOLOGY | |
| 2.3 Vesicle size and shape | |
| CHAPTER THREE: CLASSIFICATION | |
| 3.1 Wall structure | |
| 3.2 Processes | |
| 3.3 TAXONOMY | |
| 3.4 CLASSIFICATION | |
| 3.4.1 Phenetic classifications | |
| 3.4.2 Phylogenetic classifications | |
| Chapter FOUR: BIOSTRATIGRAPHY | |
| 4.1 BIOSTRATIGRAPHY | |
| 4.2 Diversity trends | |
| 4.3 PALEOECOLOGY AND PALEOGEOGRAPHY | |
| Chapter Five: Case study from the Eocene of Egypt | |
| Summery | |
| References | |
| Arabic summery | |



LIST OF FIGURES

LIST OF TABLES



List of Figures

| Fig. No. | Fig. Caption | Page No. |
|----------|---|----------|
| Fig. 1 | Figure 1: Size frequency diagram for a species of <i>Leiosphaeridia</i> (data from Colbath 1983). | |
| Fig. 2 | Figure2: Acritarch morphology. | |
| Fig. 3 | Figure3: Acritarch morphology. | |
| Fig. 4 | Figure4: Process variation within individual specimens. | |
| Fig. 5 | Figure5: Some Acritarchs photos | |
| Fig. 6 | Figure6: Some Acritarchs photos | |
| Fig. 7 | Figure 7: Distribution of acritarch genera over time. | |
| Fig. 8 | Figure 8: Acritarch species diversity over time | |
| Fig. 9 | Figure 9: Number of acritarch species vs. time, | |
| Fig. 10 | Figure10: A photograph of the Mudawara Mt. Fayoum Depression, Egypt. | |
| Fig. 11 | Figure11: Basics of palynological sample processing (Soliman, 2006). | |

List of Tables

| Table No. | Text | Page No. |
|-----------|---|----------|
| Table 1 | A comparison of phenetic acritarchs classifications, including some groups now considered to be prasinophytes | 24 |



ABSTRACT



Abstract

Acritarchs are fossilized, organic-walled cysts of unicellular protists that cannot be assigned to known groups of organisms. The group Acritarcha (**akrit-os**) (uncertain, mixed, and confused) and (**arche**) (beginning, origin) was proposed by Evitt (1963 a, b) as an informal taxon to accommodate forms left over after many of the hystrichospheres were transferred to the Dinophyceae. Most acritarchs are probably the resting cysts of marine phytoplankton.

The early history of acritarch studies has been well documented by many Palynologists (e.g. the latter giving a brief review of acritarch studies in North America. A detailed history of research on *Tasmanites* can be found in Muir & Sarjeant (1971); Mendelson (1992) and Martin (1993). Tappan (1980) also discussed the history of acritarch and prasinophyte studies.

Beginning in the 1930s, many fundamental systematic studies on acritarchs were carried out in Europe. Eisenack (e.g. 1938, 1958) described many common genera such as *Baltisphaeridium*, *Leiofusa* and *Leiosphaeridia*. His systematic studies are continued in the "Katalog der fossilen Dinoflagellaten, Hystrichosphiren and verwandten Mikrofossilien" (Eisenack *et al.* 1973, 1976, 1979a, 1979b), a valuable resource for taxonomists. Deflandre was also influential in early systematic work, establishing the ubiquitous *Michrystidium* in 1937.

Acritarchs are found in large numbers, and the taxonomic diversity of individual assemblages can be quite high. Perhaps a reasonable conclusion is that different taxa will become useful for the contrasting functions of paleoecological, biostratigraphic and paleogeographic analyses. The application of acritarch distributions to more generalized analyses of global and regional studies of the Paleozoic oceans will undoubtedly become more important in future work.



Chapter I

Introduction



Chapter I

Introduction

1. Introduction

Acritarchs are fossilized, organic-walled cysts of unicellular protists that cannot be assigned to known groups of organisms. The group Acritarcha (**akrit-os**) (uncertain, mixed, and confused) and (**arche**) (beginning, origin) was proposed by Evitt (1963 a, b) as an informal taxon to accommodate forms left over after many of the hystrichospheres were transferred to the Dinophyceae. Most acritarchs are probably the resting cysts of marine phytoplankton (Evitt 1963 a, b).

Acritarchs can be found throughout the geological column, but are most common in the Lower Paleozoic. The group is probably polyphyletic, including ancestors of both chromophytes and chlorophytes.

The morphology of the acritarchs is diverse, presumably reflecting their heterogeneous origins. Most individuals consist of a single, hollow vesicle (or theca) that may be ornamented with processes (most often spines or muri) and surficial sculpturing elements. Vesicle symmetry varies from spherical or radial to bipolar to irregular.

The gross morphology of acritarchs as single organic sacs (vesicles) suggests a derivation from unicellular organisms. Many show simple Excystment structures, which strengthens the suggestion that they are algal cysts. Acritarchs vary from <10 μm to >1 mm in size, but most species range from 15 to 80 μm .

Acritarchs have great value in biostratigraphic applications, particularly for the Paleozoic. However, their potential is currently under-recognized, to some extent owing to the prior establishment of better known organisms for



biostratigraphic zonation. They will become more useful for Lower and Middle Paleozoic biostratigraphy as more well-dated stratigraphic sections are described.

Acritarchs are the obvious choice for Proterozoic biostratigraphy, but their utility has been limited by the imprecise dating of Precambrian sequences and by the imprecise taxonomy of the sphaeromorph acritarchs that dominate Precambrian assemblages.

Acritarchs also have great potential in paleogeographic and paleo environmental studies, but our lack of understanding of systematic relationships between acritarchs and the algae make critical paleoecological inferences difficult.

Many non-acanthomorphic acritarchs could be cysts of freshwater Chlorophyta, given that several studies have demonstrated sporopollenin in recent representatives of these algae (Atkinson *et al.* 1972; see Johnson 1985 for a list of sporopollenin-containing freshwater chlorophytes). The recovery of cyano bacterial sheaths from macerations of Proterozoic shales (Butterfield *et al.* 1988; Strother 1994) opens up the possibility that these prokaryotes may have produced resistant, organic-walled structures capable of being preserved as palynomorphs *sensu* Traverse (1988).

Acritarchs are an important source of paleobiological information. The sheer numbers of acritarchs preserved in the rock record make them attractive for quantitative biostratigraphic and paleobiological studies. They represent the fossil record of the base of the global food chain during the Proterozoic and Paleozoic. Together with the cyanobacteria, they record the history of oxygen-producing autotrophes, organisms which have had a profound effect upon the composition of the atmosphere and the subsequent evolution of life on Earth.



Chapter II

HISTORY OF ACRITARCH STUDY



Chapter II

HISTORY OF ACRITARCH STUDY

2.1. HISTORY OF ACRITARCH STUDY

The early history of acritarchs studies has been well documented by many Palynologists (e.g., the latter giving a brief review of acritarch studies in North America. A detailed history of research on *Tasmanites* can be found in Muir & Sarjeant (1971); Mendelson (1992) and Martin (1993). Tappan (1980) also discussed the history of acritarch and prasinophyte studies (Martin, 1993).

In 1963, Evitt suggested removing from the Hystrichosphaerida those microfossils clearly related to the dinoflagellates. The remaining problematic taxa were labelled acritarchs. Evitt's suggestion was widely accepted and has proved useful. But inherent in his definition is the caveat that, "When ever the biological affinities of individual acritarch genera can be established with sufficient précision, those genera should forth with cease to be referred to as acritarchs and should be assigned to their proper places in the taxonomic hierarchy under the appropri-ate nomenclatural code." (Evitt 1963 b).

Mantell (1845) clearly demonstrated that the "Xanthidia" were organic-walled, but throughout the remainder of the nineteenth century, confusion about their cheffilcal composition added to the difficulties in their classification. Henry Deane (cited by Mantell 1845), was apparently the first person to free "Xanthidia" from the cherty matrix by acid maceration, making him and Mantell the first to observe acritarchs as dispersed palynomorphs.

White (1862) is credited with the first description of Paleozoic acritarchs. He described microfossils from cherts, referring them to Xanthidia, and like Ehrenberg, he seems to have had difficulty in distinguishing between primary organic preservation and primary/secondary mineralization of the fossils. Dana (1895, p. 582) illustrated some of White's specimens featuring a "diatom" and "*Xanthidia*, spore cases of Desmids." Dana's "diatom" appears to be a



Pterospermella, and some of the specimens labeled "spicules of sponges" are possibly *Veryhachium*.

The description of organic-walled microfossils from both cherts (in petrographic sections) and siliciclastic rocks (where they are first removed by chemical maceration) has continued to the present time (see discussions in Diver & Peat 1979; Mendelson 1992). Evitt (1963b, p. 301) considered some of the 2 Ga Gunflint Chert microfossils to be acritarchs, although this implies the existence of euk-aryotes in an assemblage that is thought to be entirely prokaryotic.

Beginning in the 1930s, many fundamental systematic studies on acritarchs were carried out in Europe. Eisenack (e.g. 1938, 1958) described many common genera such as *Baltisphaeridium*, *Leiofusa* and *Leiosphaeridia*. His systematic studies are continued in the "Katalog der fossilen Dinoflagellaten, Hystrichosphiiren and verwandten Mikrofossilien" (Eisenack *et al.* 1973, 1976, 1979a, 1979b), a valuable resource for taxonomists. Deflandre was also influential in early systematic work, establishing the ubiquitous *Michrhystridium* in 1937.

During the 1960s and early 1970s systematic work on the acritarchs expanded in Belgium (Martin), England (Downie and his students), North America (Loeblich Jr.) and Spain (Cramer). Staplin (1961) proposed the genus *Multiplicisphaeridium* for forms with discrete, branched processes with closed tips. Staplin *et al.* (1965) clarified the concept of *Baltisphaeridium*. The work of Loeblich (1969) and Tappan (1980) and their students have advanced acritarch studies in the United States.

Most research on acritarchs has been primarily concerned with taxonomic description and biostratigraphy. Consequently, acritarchs research is not yet oriented toward the synthesis of evolutionary trends or other broader problems. While the need for good taxonomy remains, practical and theoretical applications will prove valuable in the future.



2.2. MORPHOLOGY

The accurate description of morphology is critical in the study of acritarchs. Morphology forms the basis for a consistent and objective taxonomy upon which more general paleo-ecological, paleogeographic, stratigraphic and evolutionary models can be built. Cramer (in Eisenack et al. 1979a) presented an impassioned argument for the primacy of morphology over typology in classification and taxonomy (Cramer in Eisenack *et al.* 1979a)

Most acritarchs consist of an organic-walled sac (also called the vesicle or central body), which may be modified by outgrowths of linear elements (processes) and / or by planar membranes forming septa, muri, wings or a velum. Processes and vesicle walls may be further modified by surficial sculpture such as grana, knobs or small spines, rugulae, or striae.

Many of these terms are defined in general works on palynology because most acritarchs represent the cysts of phytoplankton, Excystment structures (slits and holes in the vesicle walls) may also be prominent in their morphology (Cramer & Diez, 1979).

Differences in vesicle wall ultrastructure could possibly reflect underlying, fundamental taxonomic differences. Determination of wall ultrastructure generally requires the use of transmission electron microscopy (TEM), but this technique is impractical for general descriptive work.

An essential aspect of acritarch morphology concerns the topology, or geometric arrangement, of its various components. The position of processes and sculpture on the vesicle can form patterns that become important descriptive characters. Multiple, distinct wall layers, internal bodies and membranous envelopes are all aspects of acritarch topology.

Accurate description of multiple wall layers may demonstrate the relations between vegetative and sexual phases in the original organism. Have advocated topology as a character of fundamental importance in the study of acritarchs morphology. (Le Herisse, 1989).



2.3. Vesicle size and shape

Acritarchs exhibit a wide range in size. Spherical spiny forms range from 5 to 240 μm . Within simple Precambrian spherical forms (Sphaeromorphitae), species can range in diameter from a few microns (Pl. 1, Fig. 1) to *Chuarina* which has a size range of 0.5 to 5 μm . This corresponds to a volumetric range from $1.4 \times 10^{-11} \text{ cm}^3$ to 0.07 cm^3 a volumetric doubling ratio of 232. Size as expressed in vesicle diameter, process length and overall diameter, can be an important character, but size has often been used arbitrarily and many taxa with size-based boundaries appear to overlap or intergrade.

In taxonomic descriptions, size is usually expressed in terms of a mean value (such as vesicle diameter or process length). These descriptive statistics may also be expressed as a Size-frequency diagram. Such an empirical diagram can be useful in delineating taxa and in ecological interpretations. **For example: Figure 1** shows a positively skewed size-frequency plot of *Leiosphaeridia* sp described. Positively skewed distributions are typical of many fossilized populations of algae, and may indicate derivation from a single, actively growing population (Downie & Sarjeant, 1963).

Shape is described in terms of the symmetry of the vesicle, the shape of the vesicle outline, and the relative placement of processes and other extensions of the vesicle wall. In addition, the topological relations of discrete multiple walls may be important in shape description. Vesicle symmetry is described with reference to axes of rotation and mirror planes. Most acritarchs are viewed as the flattened remains of three-dimensional objects, and descriptions of symmetry may reflect their reconstructed shape, as recommended by Mendelson (1992).

Some acritarchs, however, were originally flat or discoidal prior to depositionally induced flattening. For example, *Duvernaysphaera* was clearly discoidal in its original form. Some species of *Veryhachium* and *Neoverhachium* were also originally planar. (Le Herisse, 1989).

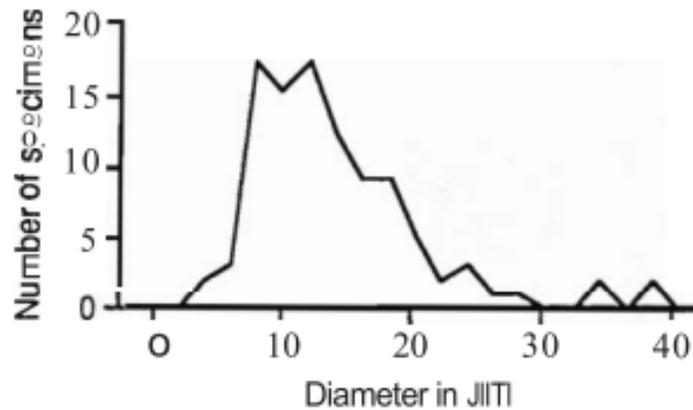


Figure 1: Size frequency diagram for a species of *Leiosphaeridia*

(from Colbath 1983).

The distribution of processes or other extensions of the vesicle wall may determine symmetry. Eisenack *et al.* (1973) used process distribution to define three symmetry classes:

1. **Hemimorphic symmetry**: bipolar symmetry in the distribution of processes and/ or sculptural elements in an acritarchs where one pole has a process and/or sculpture cover clearly and systematically different from the other.
2. **Holomorphic symmetry**: bipolar symmetry in the distribution of processes and/ or sculptural elements in an acritarch, where both poles have an essentially identical cover of processes and/or sculptural elements.
3. **Regular symmetry**: symmetry in the distribution of processes and/ or sculpture on an acritarchs where there is no apparent topical preference for anyone place of the central body. I.e., the processes or sculptures notch early concentrated at the poles, equator, **etc.**

Bipolar symmetry refers to a single **rotational** axis of symmetry. In holomorphic forms, such as *Eupoikilofiisa*. There is an additional mirror plane normal to the bipolar axis. Some specimens of *Veryhachium* preserve varying degrees of rotational symmetry around an **axis perpendicular** to the plane of the flattened vesicle. Thus, *V. tnsposum* possesses a three-fold axis of rotation in addition to its mirror plane in the plane of flattening. In general, an excystment



feature, e.g. the presence of an epityche in *V. trispinosum*, will destroy the preservation of rotational symmetry .

Most acritarchs possess a form of what referred to as radial symmetry (a term preferred to Eisenack's "**regular**" symmetry). Radially symmetric organisms can be rotated about all three orthogonal axes through their center without showing any preferred orientation. **For example:** is radially symmetrical except for a membranous tail or velum that imparts polarity, making it hemimorphic. An excystment feature may break radial symmetry to produce a bipolar axis of rotation, as in *Axisphaeridium* (Tappan 1980) and *Priscogalea*. Acritarchs **with** an equatorial flange (ala), such as *Pterospermella* have radial symmetry only in the equatorial plane, rather than three-fold radial symmetry Tappan (1980, p. 149).

Even though vesicle shape appears to be a useful taxonomic character, it is not always useful in practice. Shape is one of the fundamental characters used in Downie's (1963) supra-generic classification, but there are many acritarchs whose shapes fall between these taxonomic classes. Text-Figure 2 illustrates some common shapes Downie's (1963).



Chapter III

CLASSIFICATION



Chapter III

CLASSIFICATION

3.1. Wall structure

Wall structure concerns both the inner components (ultrastructure) and chemical composition of the acritarch wall. Eukaryotic phytoplankton produces two kinds of wall-forming polymers, cellulose and sporopollenin. Cellulose is ubiquitous in plant cell walls, but its macro-molecular structure generally does not survive diagenesis. Sporopollenin, a class of ester-linked carotenoid derivatives, is the principal chemical component of acritarchs that survives diagenesis (Brooks *et al.* 1971).

It is preserved as a primary organic compound, and is not a replacement or petrification. Sporopollenin production may represent an adaptive response for preserving a live protoplast over periods of adverse environmental conditions. For terrestrial plants, this adaptation permits water retention in a spore or pollen grain; for fully aquatic organisms

Jux (1968, 1971) examined *Baltisphaeridium longispinosum*, *P. trifurcatum*, *Goniosphaeridium balticum* and *Acanthodiacrodium divisum*, using the TEM, and claimed to have found in all of them radial pores that he compared to *Tasmanites* and its modern counterpart, *Halosphaera*. Citing this work (Jux, 1968,1971).

Downie (1973) reasoned that *Baltisphaeridium* has a tasmanitid type of wall structure, relating it to the Prasinophyceae, using light microscopy, described the vesicle wall of *Baltisphaeridium* as "sometimes finely porate or with canals", whereas the "spine wall is usually hyaline". Their observations may support a tasmanitid wall structure for *Baltisphaeridium*. He described *Micrhystridium*, *diacrodian*, and *visbysphaerid* as the other three basic structural types seen in the acritarchs. *Micrhystridium* walls are thin and homogeneous. *Diacrodian*

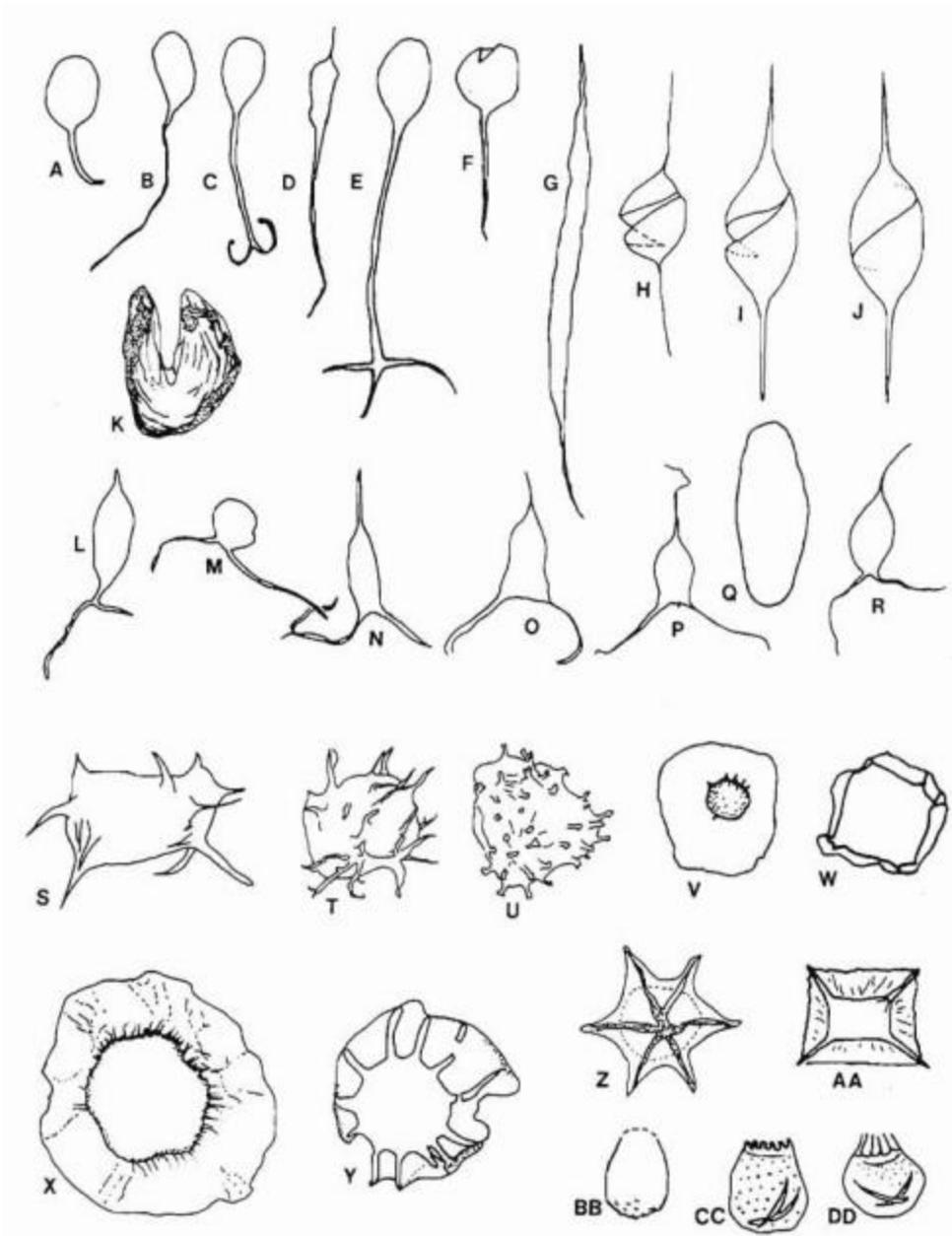


Figure2: Acritarch morphology:

(A-R) Netromorphitae,

(S) Diacromorphitae,

(T, U) Coryphomorphitae,

V, Sphaeromorphitae,

W-Y, Pteromorphitae,

Z, AA, Prismatomorphitae,

(BB-DD) Oomorphitae,

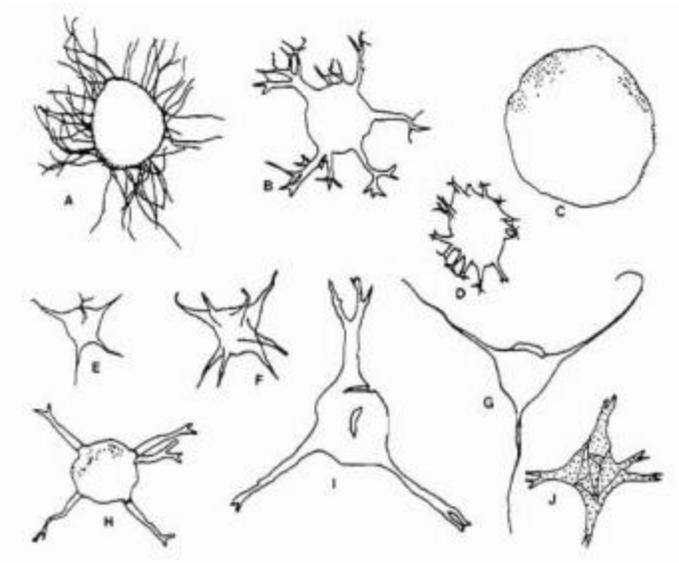


Figure3: Acritarch morphology:

(A, D, H) Acanthomorphae. & (E, G, I, J) Polygonomorphae.

Contain radially aligned pores comparable to those of *Tasmanites* as demonstrated by Kjellstrom (1968). Most of the photomicrographs show homogeneous electron-dense walls with spongy or alveolar electron-clear regions toward the exterior (Jux 1971).

There is no compelling reason to assume even this amount of structure is primary; such textures could be degradational in origin. For example, he demonstrated this for *Gloeocapsomorpha prisca*. In cross section, the vesicle walls of *Baltisphaeridium longispinosum* and *Peteinosphaeridium trifurcatum* appear to be composed of concentric laminations, quite the opposite of a radial arrangement of pores Foster *et al.* (1989)

TEM studies of *Tasmanites wall* ultrastructure showed the radial canals quite clearly, confirming the observations known from light microscopy. In a brief paper on comparative microscopy, reported sectioning a Precambrian sphaeromorph acritarch whose wall was homogeneous in TEM view (Peat, 1981).



Because the original vesicle lumen was not evident, surmised that the walls had fused during diagenesis. Future TEM studies will need to address such taphonomic considerations if they are to become useful in acritarch systematics. With the exception of *Tasmanites*, the few acritarchs that have been examined have not shown any informative wall ultra-structure Guy-Ohlson (1988)

3.2. Processes

Processes are linear elements that protrude radially from the vesicle. Process morphology, number and distribution can be critical to the taxonomy of acritarchs. Processes are described in terms of their attachment to the vesicle wall, whether they are solid or hollow, their shape or primary form, the nature of the tip (distal end), and whether or not they are ornamented. Illustrates many of the basic types of processes found in the Acritarchs.

Processes can be hollow, solid, or hollow with a basal plug. Far from being trivial, these distinctions have been used to delineate genera that are, in all other respects, quite similar. Moczydlowska (1991) assigned Cambrian *Micrhystridium* species to two new genera, *Asteridium* and *Heliosphaeridium*, based on the presence of solid vs. hollow processes respectively. Following the recommendations of a basal plug in *Baltisphaeridium* is used to help distinguish it from taxa like *Solisphaeridium* and *Micrhystridium* Staplin *etal.* (1965).

Intraspecific morphological variation in acritarchs processes is well documented. Lister (1970) and Le Herisse (1989) described species of *Visbysphaera*, illustrating the range in morphological variation found on a single specimen. Many acanthomorph acritarch species exhibit a similarly wide range of morphological variation in branching patterns on individual specimens. Text-Figures 6B and 6C demonstrate this in *Diexallophasis denticulata* and *Multiplicisphaeridium* sp., which contain both branched and unbranched processes on a single individual.



3.3. TAXONOMY

Acritarchs taxonomy is plagued by a classic problem in systematics what are the natural limits of morphological variation in biological species, and how can we construct species taxa that correspond as closely as possible to biological species? A taxon as constructed by the paleontologist is inherently an abstraction of perceived natural groups. Thus, there is a distinction between a *biological* species, which occurs as a real entity in nature, and a species *taxon* which is a human construction intended only to correspond as closely as possible to the biological species.

Acritarchs represent only the encystment phase of an unknown algal life cycle. Cyst morphology may not always be map able one-to-one onto vegetative morphology. Thus, morphologically identical cysts could derive from separate algal species, and morphologically different cysts may have been produced by the same biological species. Similar conditions were demonstrated to have occurred in the higher plants in studies on sporangia and their in situ spores (Fanning *et al.* 1991).

Small differences in vesicle shape, along with variations in spine number, shape and length, form a plexus of homeomorphs (in the sense of point set topology). Even if number of spines is taken as a character for distinguishing these genera, the occurrence of small, adventitious spines makes absolute spine number difficult to use. Wall & Downie (1963) pointed out that collapsing the *Veryhachium irregulare* complex into one species would create confusion and require a completely new interpretation of *Veryhachium* and *Micrhystridium* Downie (1963)

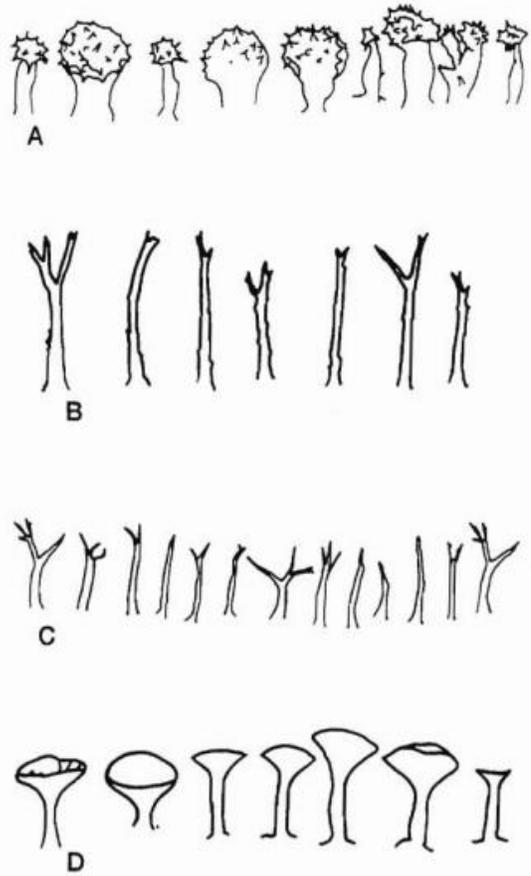


Figure4: Process variation within individual specimens.

A, *Visbysphaera pirifera* (from Le Herisse 1989, pi. 29, fig. 3)

B, *Diexallophasis denticulata* (from Le Herisse 1989, pi. 11, fig. 10)

C, *Multiplicisphaeridium* sp

D, *Umbellasphaeridium* sp (after Wood 1984).

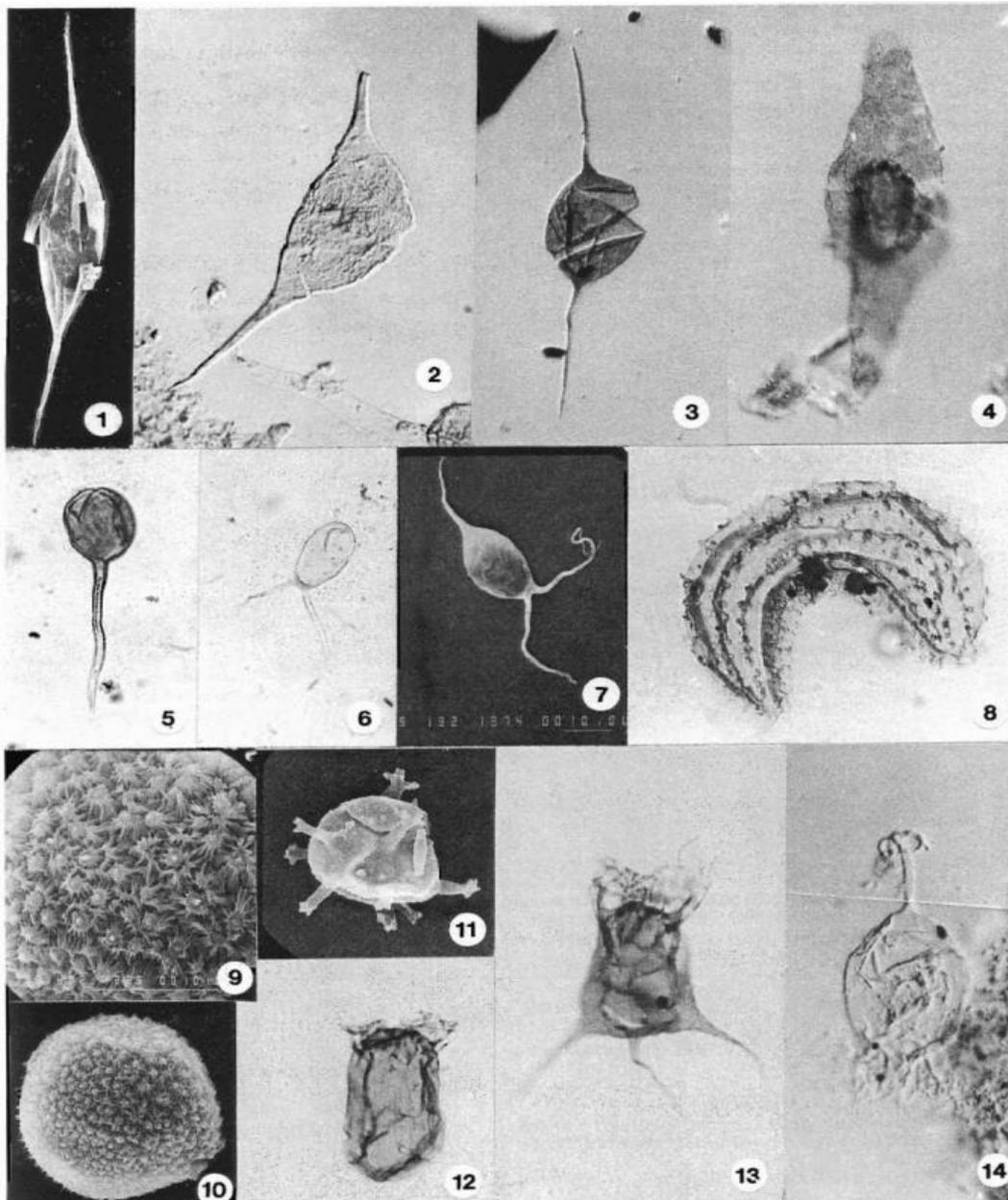


Figure5: Some Acritarchs taxa.

1. *Eupoikilofusa striatifera* var. *typical* Silurian;
2. *Eupoikilofusa cantabrica*,
3. *Leiofusa tumida*
4. Unnamed acritarch possibly belonging to the Dinetro-morphitae
5. *Deunffia monospinosa* var. *robusta*; Silurian; Gotland, Sweden; 750x.
6. *Domasia bispinosa*; Silurian; Gotland, Sweden; 600x.
7. *Domasia trispinosa*; Silurian; Gotland, Sweden; 750x.
8. *Dactylofusa maranhensis*; Silurian; Saudi Arabia; 1000x.
9. *Lophosphaeridium galeatum*, detail showing complex ornament; Visby Formation, Lower Silurian; Gotland, Sweden; 2000x.



10. Lophosphaeridium galeatum; Visby Formation, Lower Silurian; Gotland, Sweden; 750x.
11. Cymbosphaeridium pilaris var. typicum, showing a macropylome; Eke Formation, Ludlow (Upper Silurians-Gotland, Sweden; 750x.
12. Ellipsoidal acritarch with polar ornamentation of fine reticulate processes; Klabava Formation, Ordovician; Bohemia; 750x.
13. Arbusadidium filamentosum; Klabava Formation, Ordovician; Bohemia; 750x.
14. Dicrodiacrodium normale; Ordovician; Saudi Arabia; 750x

3.4. CLASSIFICATION

The grouping of taxa into an ordered scheme forms the basis of biological classification. The purpose of biological classification is twofold: the demonstration of natural order and facilitation of communication. Phylogenetic ("natural" of some authors, e.g. Mendelson 1992) classifications purport to show evolutionary relationships by grouping natural taxa (sensu Wiley 1981, p. 71) using historical relation by descent, i.e. phylogeny. When phylogeny is unknown, as it is with the acritarchs, a phenetic (artificial) classification based on overall similarity in morphology may be constructed.

Phenetic classifications do not necessarily reveal evolutionary relationships among taxa although, to the extent that morphology reflects underlying genetic similarity, acritarchs groupings based on non-overlapping (disjunct) morphological features, may represent natural groups.

3.4.1. Phenetic classifications

Comparison of four published phenetic classifications presented in Table 1. The fundamental structure presented by Downie *et al.* (1963) has been retained throughout subsequent modifications. Even Cramer & Diez (1979), whose views on taxonomic usage differs from those of most authors, agreed that Downie *et al.* were correct to use outline and symmetry to define their basic groups. Cramer & Diez proposed a simplified version of the Downie *et al.* schema, dividing the **acritarchs into three major units:**

- 1) Sphaeromorphitae,
- 2) non-acanthomorphitic acritarchs

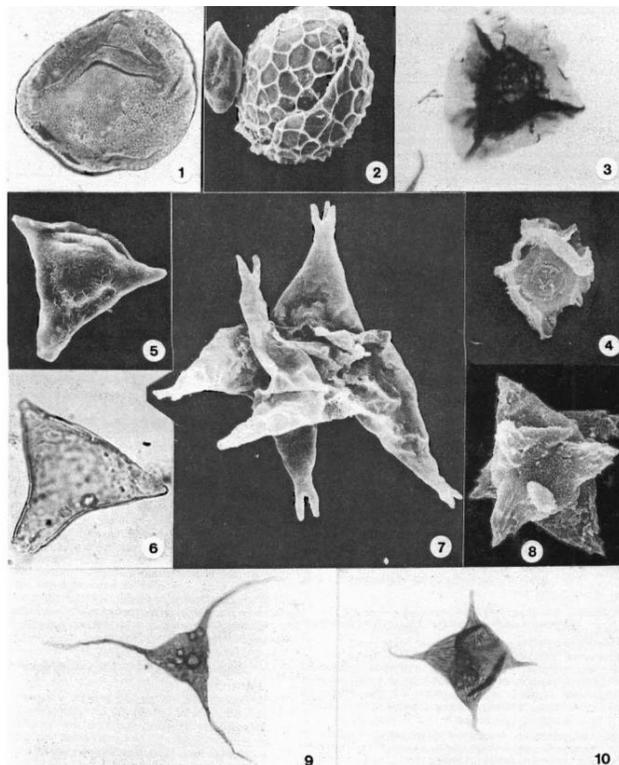
3) acanthomorphic: acritarchs.

The acanthomorphs were further subdivided in: Netromorphitae, Diacromorphitae and Acanthomorphitae Their recommendations only lump previously defined groups and, consequently, do not represent a fundamental change in the classification.

Diver & Peat (1979) erected the group Cryptarcha, into which they placed the sphaeromorphs, cell cluster (Synapломorphitae) and filamentous cyanobacter: (Nematomorphitae). This recommendation came out of concern that separate taxonomies are used for Precambrian and Paleozoic systematics. Using their classification, all simple spherical cells would be grouped together into the sphaeromorphs.

The following is an annotated summary of acritarch subgroups based on the Downie et al. schema. Certain subgroups; such as the Netromorphitae seem to be precisely characterized by simple descriptions of symmetry and outline. Others; contain genera that straddle the boundaries between subgroups, for example, between the Acanthomorphitae and the Polygonomorphitae Diver & Peat (1979).

Figure 6:





| | |
|--|--|
| 1. <i>Dictyotidium faviforme</i> ; Lower Silurian; Gotland, Sweden; 750x. | 2. <i>Dictyotidium dictyotum</i> ; Visby Formation, Lower Silurian; Gotland, Sweden; 750x. |
| 3. <i>Cymatiosphaera</i> sp. cf. <i>C. pauciplana</i> ; Ross Brook Formation, Llandoverly (Lower Silurian); Nova Scotia, Canada; 750x. | 4. <i>Cymatiosphaera mariae</i> ; Silurian; Gotland, Sweden; 750x. |
| 5. <i>Onondagella asymmetrica</i> ; Slite Formation, Wenlock (Silurian); Gotland, Sweden; 750x | 6. <i>Onondagella asymmetrica</i> ; Slite Formation, Wenlock (Silurian); Gotland, Sweden; 750x. |
| 7. <i>Hoegklingia visbyensis</i> ; Visby Formation, Lower Silurian; Gotland, Sweden; 750x. | 8. <i>Estiastra barbata</i> ; Silurian; Gotland, Sweden; 750x. |
| 9. <i>Veryhachium trispinosum</i> ; Klabava Formation, upper Arenig (Ordovician); Bohemia; 500x. | 10. <i>Striatotheca principalis</i> var. <i>parva</i> ; Klabava Formation. Upper Arenig (Ordovician); Bohemia; 750x. |

TABLE 1: A comparison of phenetic acritarchs classifications, including some groups now considered to be prasinophytes

| Downlee <i>et al.</i> (1963) | Evitt (1969) | Dilver & Peat (1979) | Tappan (1980) |
|------------------------------|-------------------|----------------------|---------------------------------------|
| | | Group Acritarcha | |
| Acanthomorphytae | Acanthomorphytae | Acanthomorphs | Acanthomorphytae |
| Polygonomorphytae | Polygonomorphytae | Polygonomorphs | Polygonomorphytae |
| Prismatomorphytae | Prismatomorphytae | Prismatomorph | Prismatomorphytae |
| Diacromorphytae | Diacromorphytae | Diacromorph | Diacromorphytae |
| Oomorphytae | | Oomorph | Oomorphytae |
| Netromorphytae | Netromorphytae | Netromorph | Netromorphytae |
| Dinetromorphytae | | | Dinetromorphytae |
| Stephanomorphytae | | | Stephanomorphytae |
| | | | Tasmanititae (Staplin <i>et al.</i>) |
| Pteromorphytae | Pteromorphytae | Pteromorph | Pteromorphytae |
| Herkomorphytae | Herkomorphytae | Herkomorph | Herkomorphytae |



| | | | |
|--------------------|----------------------------|------------------|-----------------------------------|
| Platymorphitae | Platymorphitae | Platymorph | Platymorphitae |
| | | Group Cryptarcha | |
| Sphaeromorphitae | Sphaeromorphitae | Sphaeromorphitae | Sphaeromorphitae |
| | | | Megasphaeromorphida (Timofeev) |
| | | Synapjomorphitae | |
| Disphaeromorphitae | acritarchs with inner body | | Disphaeromorphitae |
| | | Nematomorphitae | |
| | | | Retractomorphitae (Brito) |
| | | | Scutellomorphitae (Brito) |
| | | | Coryphomorphitae (Vavrdova) |
| | | | Porata (Naumova & Umnova) |

3.4.2. Phylogenetic classifications

The relatively simple morphologies of many acritarchs make the problems of convergence particularly acute. Such problems need to be resolved if better natural classifications are to be constructed. Based on the research of Wall (1962) and Parke *et al.* (1978), among others, it became clear that some cysts previously characterized as acritarchs represent fossil phycomata belonging to the chlorophyte algal family Prasinophyceae. **Four morphological groups of acritarchs correspond to prasinophytes:**

1. *Tasrumites* and related genera with their characteristic thick wall and radial pores (related to the Recent *Pachysphaera*, of which it is a senior synonym).
2. reticulate-murinate genera such as *Dictyotidium*, *Melikeriopalla*, *Cymatiosphaera*, *Daillydium*, *Duvernay-sphaera*, *Muraticavea* and *Polyedryxium*;
3. *Pterospermella*, characterized by a spherical central body with a single, large equatorial flange (ala), and considered to be ancestral to *Pterosperma*;



4. Simple, smooth-walled spheres (*Leiosphaeridia*) corresponding to the extant *Halosphaera*. Parke *et al.* (1978).

The confidence with which these and related genera can be placed in the Prasinophyceae is reflected in classifications and discussions in Wicander (1974), Tappan (1980), Colbath (1983), Wicander & Wright (1983) and Le Herisse (1989). Tappan (1980) even constructed a Linnean classification for the Prasinophyceae that includes numerous fossil forms (Le Herisse (1989).

The history of attempts at a phylogenetic classification of acritarchs was reviewed by Downie (1973), and later by Tappan (1980). Removing the prasinophyte groups listed above, Downie's attempt at an unofficial natural (phylogenetic) **classification can be condensed as follows:**

1. *Baitisphaeridium* group - acanthomorph acritarchs with large spines.
2. *Navifusa* group - only two genera, *Navifusa* and *Leiovalia* elongate, without spines.
3. Sphaeromorph acritarchs - a heterogeneous group characterized by simple ornamentation and simple wall structure. In the sphaeromorphs, I include spherical cysts enclosed within a vesicle (e.g. *Nucellosphaeridium*) and clusters of attached spheres (*Synsphaeridium* sensu Timofeev.
4. *Micrhystridium*-*Veryhachium* groups small vesicles with many (*Micrhystridium*) to few (*Veryhachium*) usually simple spines open to the body cavity. This is a very common and long-ranging group.
5. *Leiofusa* group - based on the genus *Leiofusa* and its morphological relative, *Deunffia*. These forms are elongate with various tapering ends forming spines.
6. *Acanthodiacrodium* group - the remnant of Timofeev's, Diacrodiaaceae, erected for ellipsoidal acritarchs with polar ornamentation.
7. *Visbysphaera* group - according to Downie, characterized by epityche excystment and a tendency to form an inner cyst. He included three



Subgroups: a *Visbysphaera* type, a *Triangulina* type, and a *Diexallophosis* type.

8. "Other acritarchs" - Downie placed the remaining 10% of acritarchs genera in this leftover category of unrelated forms.

A classification of the acritarchs based on inferred ancestor descendant relationship (phylogeny) is desirable. However, before this can be accomplished, much further analysis and comparison between related morphological groups must be attempted.

Chapter IV

BIOSTRATIGRAPHY



Chapter IV

BIOSTRATIGRAPHY

4.1. BIOSTRATIGRAPHY

Acritarchs have a history of speciation and extinction during their wide spread distribution in time and space, with a resultant potential for bio stratigraphic zonation. However, they have been only moderately useful as index fossils. Many i acritarchs have long stratigraphic ranges. These include some common types such as *Veryhachium*, *Leiosphaeridia* and *Michrhystridium*. Such genera have large numbers of species that can be difficult to distinguish. Because morphological variants grade into one another (e.g. the *Veryhachium valiente V. lairdii* complex), it is difficult to establish a consistent concept of the amount of phenotypic variation in natural species.



Without a comprehensive understanding of the extent to which individual acritarchs are restricted to particular environments, it is difficult to use them as zonal index fossils. Even the simple comparison of distributions of taxa preserved in carbonates vs. those in siliciclastics has not been accomplished. Fortey & Mellish (1992) asserted that early Ordovician acritarchs should be useful for intercontinental correlation because they do not show clear differentiation into paleogeographic provinces.

Acritarchs are presently useful for correlation in those instances where conventional index fossils are lacking. Most acritarchs assemblages can be used to infer age to the level of epoch, even when populated by moderately long-ranging taxa. Where they occur with spores and cryptospores, acritarchs have great potential throughout the lower and middle Paleozoic for correlation between marine and non-marine strata.

4.2. Diversity trends

Long term taxonomic trends in acritarchs evolution are expressed in two ways: changes in diversity and changes in taxonomic composition over time. All analyses of acritarchs diversity reveal a similar basic trend: acritarchs show a singular peak in ataxic diversity in the mid Paleozoic that terminates at the Devonian-Carboniferous boundary. They persist throughout the remainder of the Phanerozoic with fewer taxa, and perhaps in much reduced numbers. This scenario is supported by both species and genus curves in Tappan (1980).

Figure 7: shows acritarchs generic diversity tabulated for each geological period, normalized for period length (which yields genera per Ma), and plotted on a scale of absolute time. It reveals a dramatic drop in diversity from almost 4 genera per Ma at the end of the Devonian to less than 0.5 genera per Ma during the Carboniferous-Triassic interval. There is essentially no subsequent recovery



from this drop. The gradual increase in the Tertiary to almost 2 genera per Ma is probably due to the sampling bias of more recent strata, and does not represent an evolutionary return of the acritarchs.

Species level diversity trends were examined by plotting mono specific genera from the compilation of Fen some *et al.* (1990). The resultant species diversity curve (Text-Fig. 8) parallels the generic diversity curves in Text-Figure 7. Another look at species fluctuations was derived from the regional range charts of acritarchs species published by Downie (1984).

This Single evolutionary pulse in the phytoplankton was over by the Mississippian. Wicander (1975) also documented this drop in a section from Ohio in which both absolute phytoplankton abundance and number of species per sample decline close to the boundary. More such studies are needed to remove possible lithofacies biases that affect occurrence and preservation, but the notion of a dramatic decline of the acritarchs at the end of the Devonian is consistently supported by all data examined thus far Wicander (1975).

4.3. Stratophenetic trends

Le Herisse (1989), as discussed earlier ("Taxonomy"), *recognized Hapsidopalla and Naevisphaeridium as possible evolutionary offshoots of Ammonidium.* These genera share the same vesicle shape and process type, but they differ in the surficial expression of wall structure Le Herisse (1989).

Lister (1970) figured a stratophenetic trend in *Filisphaeridium brevispinosum* in which process length and density increased in two punctuated steps within an Upper Silurian sequence. Significantly, he did not feel that this "trend" was sufficient to establish separate species for the differing morph types Lister (1970).

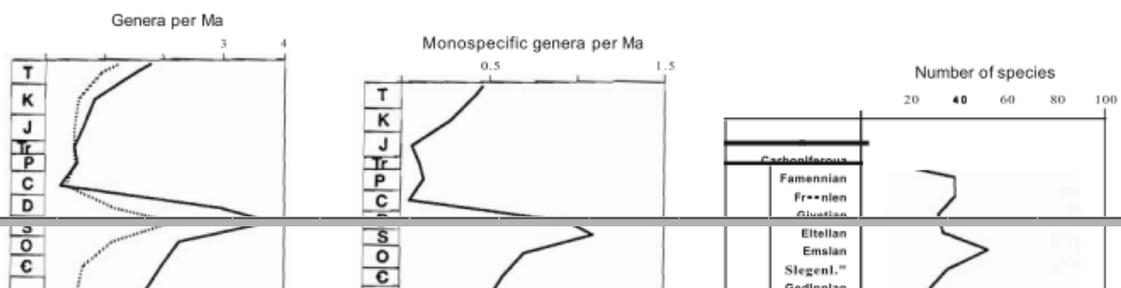




Figure 7: Distribution of acritarch genera over time. *Values* normalized to genera per Ma using the time scale of Harland *et al.* (1990) and plotted per geological period. The Precambrian value was determined using 1400 Ma as the time of the origin of the acritarchs.

Figure 8: Acritarchs species diversity over time. Monospecific generic diversity normalized per period using *time* scale of Harland *et al.* (1990). The curve expresses species per Ma plotted per period. Data derived from Fensome *et al.* (1990).

Figure 9: Number of acritarch species vs. time, from the data of Downie (1984), derived largely from the United Kingdom. Data are plotted per stratigraphic units in Downie (1984) and are not normalized (each interval represents a different time span).

4.4. PALEOECOLOGY AND PALEOGEOGRAPHY

Williams & Sarjeant (1967) concluded that acritarchs are not good depth indicators, which makes sense for a group whose physiological requirement for photosynthesis limits it to the photic zone. However, in combination with known terrestrially-derived palynomorphs acritarchs have been shown to indicate proximity to shoreline. His samples indicated that sphaeromorph abundance



increased distally, gracile acanthomorphs were rare within 2 km of the reefs, and robust acanthomorphs and polyhedral (prasinophyte) forms occurred more than 7 km from reef complexes Williams & Sarjeant (1967).

In a study of Jurassic micro plankton, Wall (1965) reinforced the notion that open marine conditions produced the most diverse acritarch assemblages. He found that "...populations dominated strongly by single species were derived from algae inhabiting inshore waters, whereas the species-rich, heterogeneous assemblages were accumulated in an offshore environment." Shallow depths "increase the likelihood that mono-specific blooms will be preserved in bottom sediments, since in deeper waters more mixing occurs during cyst fallout (Strother 1994).

Smith & Saunders (1970) examined acritarchs from several sedimentologically defined depositional settings in the Tuscarora and Rose Hill Formations of central Pennsylvania. They claimed that preservation improved in more open marine settings, that acritarch distribution was in part controlled by prevailing current direction and that acritarchs did not occur in fluvial deposits. However, they did not identify taxa, reconstruct assemblages or propose any acritarch-based model. The Tuscarora Formation, which they claimed to be devoid of acritarchs (Smith & Saunders 1970, p. 330), is now known to contain a rich palynoflora (Strother & Traverse 1979; Johnson 1985).

Doming (1981) presented a schematic model of diversity and morpho type variation over proximal/distal gradients in the Welsh Basin. **He described three assemblage types:**

1. a low diversity, near shore assemblage of 5-15 species per sample dominated by *Protoleiosphaeridium* (leiospheres), but also including *Veryhachium*, *Micrhystridium* and *Evittia*.
2. an off shore assemblage with 10 to 90 species per sample, but without a single dominant taxon.



3. A deep water assemblage of low diversity (2-15 species) and similar composition to the near shore assemblage Doming (1981).

Richardson & Rasul (1990) attempted to relate assemblage composition of acritarchs and other palynomorphs to depositional setting. They formulated an inshore index based on the ratio between sphaeromorphs + tasmanites + micrhystridia, and sphaeromorphs + tasmanites + micrhystridia + netromorphs + acanthomorphs + polygonomorphs. In combination with a marine influence index that included non-acritarch palynomorphs, they were able to trace transgressive/regressive shifts in depositional settings during Ludlow and Pridoli time in the Welsh Basin Richardson *and et al.* 1990)

Acritarchs are found in large numbers, and the taxonomic diversity of individual assemblages can be quite high. Perhaps a reasonable conclusion is that different taxa will become useful for the contrasting functions of paleoecological, biostratigraphic and paleogeographic analyses. The application of acritarch distributions to more generalized analyses of global and regional studies of the Paleozoic oceans will undoubtedly become more important in future work.



Chapter V

Case study from the Eocene of Egypt

Chapter V

Case study from the Eocene sediments, Fayoum Area, Egypt.

(1) Palynology processing:

Four samples have been selected from the Eocene sediments in the Fayoum area, Egypt in purpose to test their palynofloral content. The standard palynological techniques have been applied for all samples. The two marly samples from Gebel Mudarawa are being productive in terms of dinoflagellates cysts and other palynomorphs. In contrast, the three samples from Gebel Na'alon are being barren from palynomorphs but contain some palynodebris and amorphous organic matters (AOM) (Fig. 1).



Figure10: A photograph of the Mudawara Mt. Fayoum Depression, Egypt.

❖ **Methods**

A. Initial processes: The palynological preparation of the samples began with taken suitable amount of each sample, if available 5-10g were taken.

B. Demineralisation:

- 1. Removal of carbonates:** Up to 50 ml of 35 % HCl was added to dissolve any carbonates. Care must be taken to ensure that all carbonates have been dissolved to avoid calcium fluoride precipitation. The acid was siphoned off and the samples were washed several times with distilled water until neutral, calibrated litmus paper was used to test neutrality of the sample before further treatment.



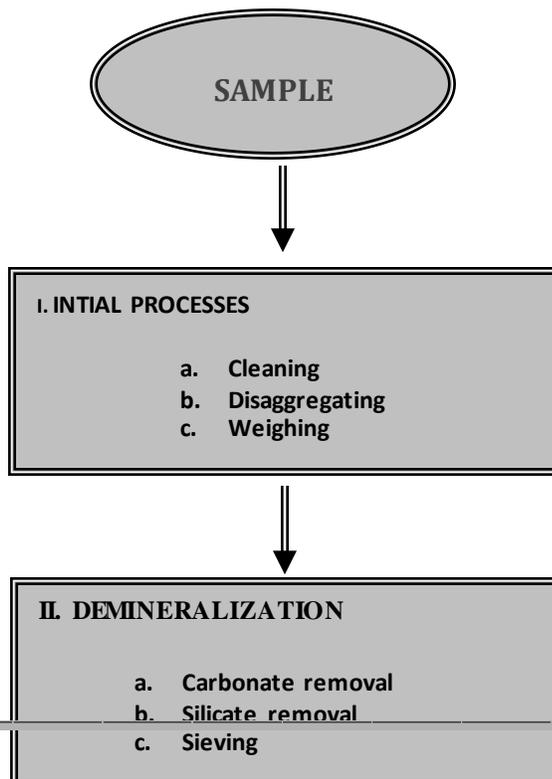
2. Removal of silicates: This procedure requires care because HF has extremely corrosive and toxic nature. So, it should be carried out in a well-ventilated laboratory with an efficient fume cupboard and wearing protective clothes, respiratory filter, clear plastic eyeglasses and rubber gloves. In polypropylene cups, the samples were macerated in 30 to 50 ml of cold concentrated 48 % HF for 48 hrs. to 72 hrs. to dissolve all silicates. The samples were occasionally agitated and stirred with a polypropylene stirring rod. If the sample is highly siliceous excess of HF can be added. The residue was washed several times with distilled water until neutrality. The residue was treated, if necessary, with 10 % HCl to remove any fluorides (CaF_2) which might have formed in the residue. It can be heated and then washed as stated before.

3. Sieving: Before sieving, residues were treated for a few seconds in an ultrasonic bath and for removing any UN dissolved heavy minerals by decantation. Material coarser than 125 μm was removed by brass sieving. The fine fractions ($< 125 \mu\text{m}$) were sieved and washed through a 10 μm nylon sieve.

C. Oxidation: The organic residue contains in addition to the desired microfossils, plant and animal tissues fragment, fine material of uncertain origin and wood fragments. Unless coarse enough to be removed by sieving, the wood fragments, being resistant to oxidation than other organic matter and may be concentrated by a combined process of oxidation and filtration. Schulz's solution (mixture of HNO_3 + KClO_3 in a proportion of 50% to 50%) was used to remove amorphous organic material at least partly from the residue.

D. Removal of oxidation products: Adding NaOH solution (7.5 %) for few a seconds and washing two times at least with distilled water. This was carried out by using MRS (Modified Reissinger System) in fume cupboard (Traverse, 1988).

- E. Staining:** Since most palynomorphs are colourless to pale yellowish brown, it is advantageous to artificially stain them. The residues were stained with red Safranin "O" (1 g. of Safranin "O" + 100 ml of 2 % NaOH), using an ultrasonic bath for a few seconds. Safranin "O" stain does not mask the brown pigment of the protoperidinacean cysts but does enhance the details in pale cysts (de Verteuil & Norris, 1992). Then residues were sieved using a 10 and 20µm mesh.
- F. Slide preparation:** 2 slides of each sample were made using glycerine jelly as mounting media. Using glass slides (26 x 76 mm) and glass cover slips (24 x 50 mm). Ethyl alcohol and soapy solution were used for cleaning slides.
- G. Examination:** The prepared slides examined by traversing each slide at magnification 200 using microscope. Further detailed taxonomic work was carried out at higher magnifications utilising light microscopical and digital photographic facilities. Preservation varies from good to poor.
- H. Photography:** Well preserved specimens were photographed using a Carl-Zeiss (Axioplan 2) microscope fitted with a Sony digital photo camera DKC-5000. Interference contrast photos were taken by a Leica DMR Microscope fitted with a Leica DC300 digital camera, housed in the Department of Geography, Cambridge University. An England Finder reference follows the sample and slide number for each specimen illustrated in plates to indicate its position.



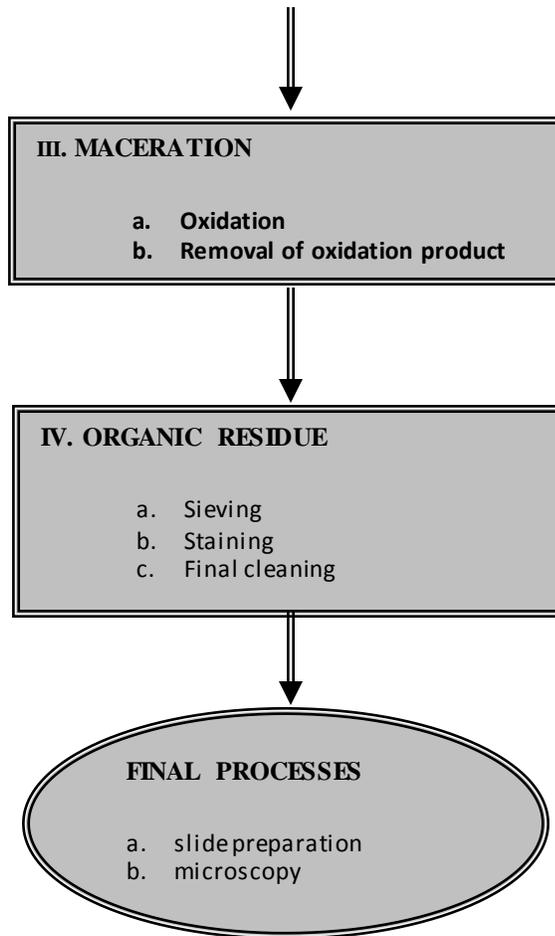


Fig. 11: Basics of palynological sample processing (Soliman, 2006).

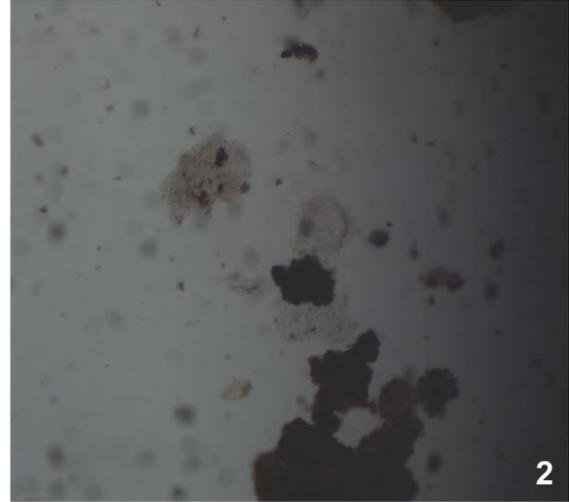
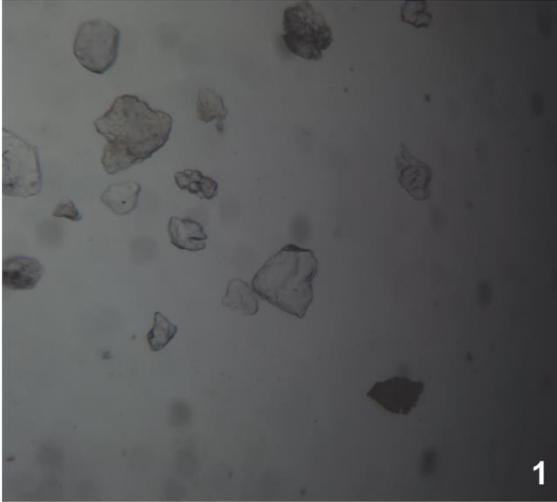
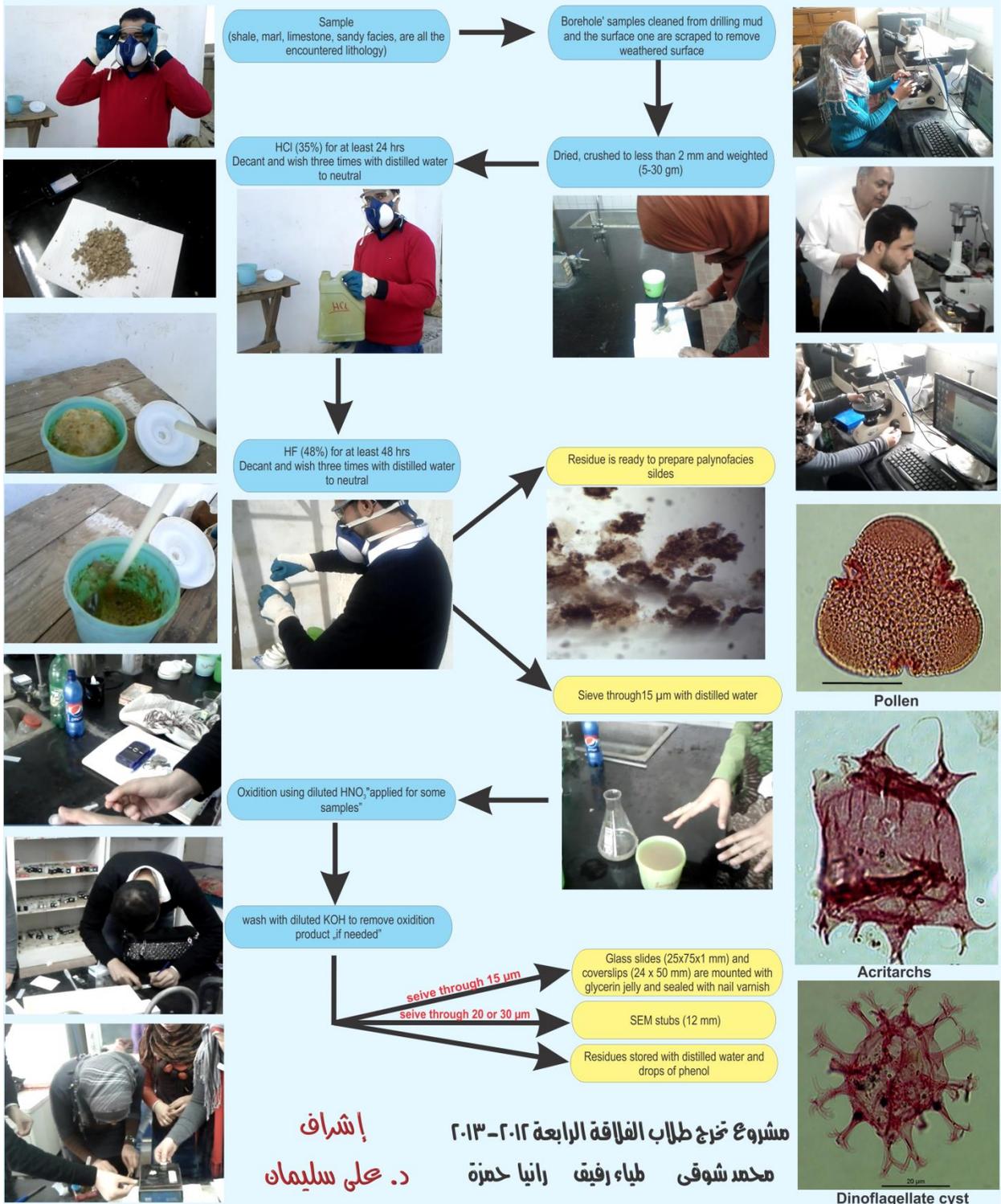


Plate of the recovered acritarchs from the studied samples.

- 1- A barren slide from Naaloon area rich with quartz crystals.
- 2- A slide from Mudawara rich amorphous organic material and palynomorphs.
- 3-4 *Micrhystridium* sp.



Flow chart for processing palynological samples



إشراف
د. علي سليمان

مشروع تخرج طلاب الفلاحة الرابعة ٢٠١٢-٢٠١٣
محمد شوقي طياء ريفيق رانيا حمزة

Dinoflagellate cyst



(2) Calcareous Nannoplankton processing:

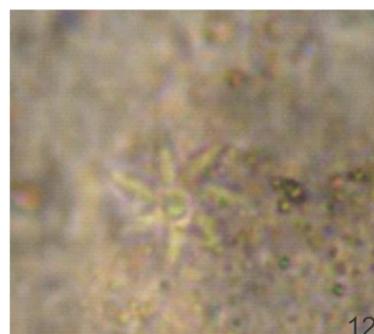
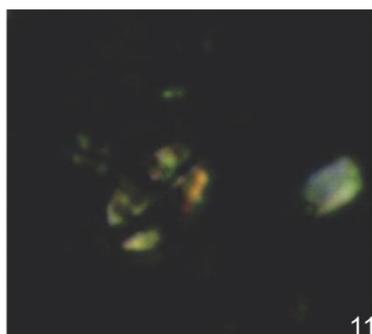
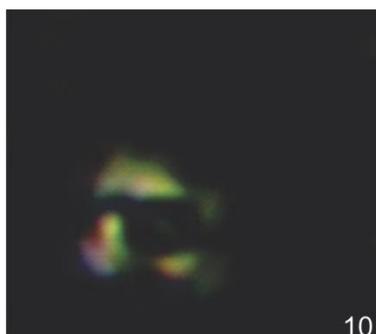
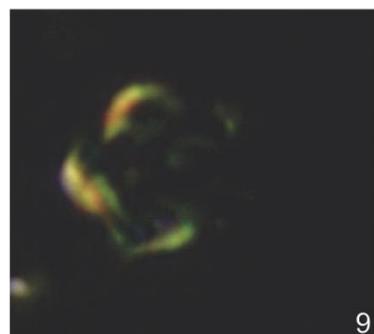
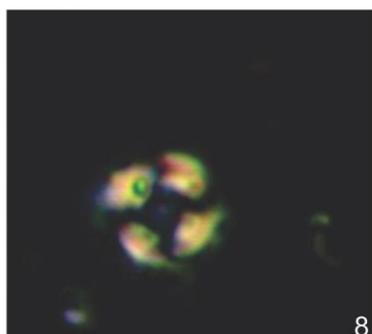
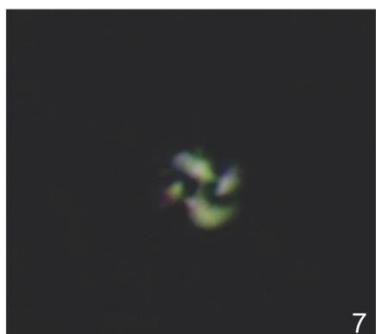
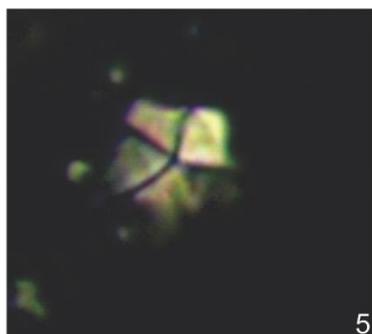
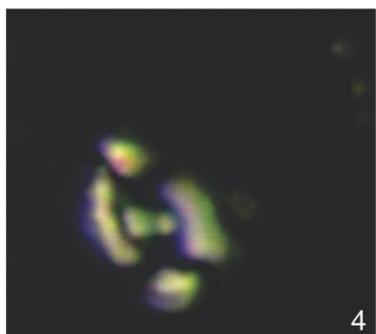
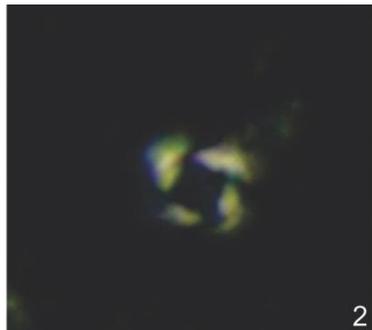
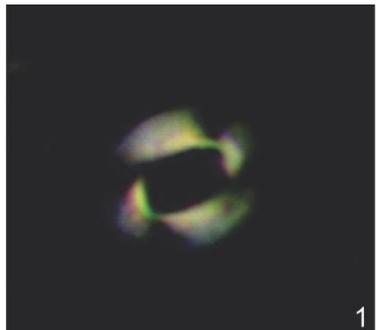
For the calcareous nannofossil study, the same samples were processed by smear slide preparation from raw sediments samples. Smear slides were examined by using polarized microscope with 1250 x magnification. Due to the small size of nannofossils, special care is taken for cleaning laboratory ware in order to prevent the chances of contamination.

Samples were processed by using the standard preparation technique in Bowen and Young (1998) **with the following minor modification:**

- 1) A small sample, approximately thumbnail size, was scraped from the surface and gently crushed in a mortar.
- 2) The powdered sediments was placed into a bottle and soaked in distilled water.
- 3) The sample was agitated and left to settle.
- 4) By using a plastic pipette, a few drops of the suspended particulate matter are put on a glass slide and dried on a hot plate.
- 5) When the sediments were dry, the mounting medium such as Canada balsam was added to the cover slip. The latter was pressed down onto the sample to remove air bubbles.
- 6) The slide was later cooked on a hot plate at about 120 °C for 1-2 minutes, the slides were labeled and left to cure the adhesive and to make the slide more durable and easier to store.
- 7) High quality smear slide was prepared from each sample, for nannofossil viewing and photographing.



Plate of calcareous nannofossil





1. *Reticulofenestra umbilica* (Levin, 1965)
2. *Reticulofenestra hampdenensis* Edwards (1973a)
3. *Cribocentrum reticulatum* (Gartner & Smith, 1967)
4. *Helicosphaera lophota* Bramlette & Sullivan (1961)
5. *Braarudosphaera bigelowii* (Gran & Braarud, 1935)
6. *Coccolithus peligus* (Wallich, 1877)
7. *Reticulofenestra hampdenensis* Edwards (1973a)
8. *Ericsonia formosa* (Kamptner, 1963)
9. *Varolia cistula* Bown (2005)
10. *Pontosphaera multipora* (Kamptner, 1948)
11. *Discoaster saipanensis* Bramlette & Riedel (1954)

Proposal for calcareous nannofossil

Introduction:

1. Definition-Nomenclature-Origin-Size.
2. Biology of calcareous nannofossils.
3. Geologic evolution of calcareous nannofossils.
4. Sample preparation for calcareous nannofossils and requirements.
5. Importance and applications of calcareous nannofossils

Different morphologies of calcareous nannofossils:

(Characteristic Features of different families).

Calcareous nannofossil taxa through Geologic Time:

1. Jurassic calcareous nannofossils.
2. Cretaceous calcareous nannofossils.
3. Calcareous nannofossil changes across the K/P boundary.
4. Paleocene calcareous nannofossils.



5. Changes of calcareous nannofossils across the P/E boundary.
6. Eocene calcareous nannofossils.
7. Calcareous nannofossil remarks at the Eocene /Oligocene boundary.
8. Calcareous nannofossils of the Oligocene.
9. Calcareous nannofossil remarks at the Oligocene/Miocene boundary
10. Miocene calcareous nannofossils.
11. Calcareous nannofossil remarks around the Miocene/Pliocene boundary.
12. Pliocene calcareous nannofossils
13. Quaternary calcareous nannofossils.

Paleoecology, paleoclimatology and paleobiogeography of calcareous nannofossils:

Calcareous nannofossil evolutionary trends:

References

1. **Oceanic Micropaleontology.** (A.T.Ramsy (1977)
2. **Introduction to marine Micropaleontology.** (B.U.Haq &A.Boersma (1979).
3. **Microfossils.** (M.D.Brasier (1980).
4. **Plankton Stratigraphy.** (H.M.Bolli et al.(1985).
5. **Element of Micropaleontology** (G.Bignot (1985).



Summary



Summary

The morphology of the acritarchs is diverse, presumably reflecting their heterogeneous origins. Most individuals consist of a single, hollow vesicle (or theca) that may be ornamented with processes (most often spines or muri) and surficial sculpturing elements. Vesicle symmetry varies from spherical or radial to bipolar to irregular.

In 1963, Evitt suggested removing from the Hystrichosphaerida those microfossils clearly related to the dinoflagellates. The remaining problematic taxa were labelled acritarchs. Evitt's suggestion was widely accepted and has proved useful.

Most acritarchs consist of an organic-walled sac (also called the vesicle or central body), which may be modified by outgrowths of linear elements (processes) and / or by planar membranes forming septa, muri, wings or a velum. Processes and vesicle walls may be further modified by surficial sculpture such as grana, knobs or small spines, rugulae, or striae. Sculptural elements in the acritarchs are similar to those of pollen grains, spores and dinoflagellates consequently.

Acritarchs are found in large numbers, and the taxonomic diversity of individual assemblages can be quite high. Perhaps a reasonable conclusion is that different taxa will become useful for the contrasting functions of paleoecological, biostratigraphic and paleogeographic analyses. The application of acritarch distributions to more generalized analyses of global and regional studies of the Paleozoic oceans will undoubtedly become more important in future work. Acritarchs also have great potential in paleogeographic and paleoenvironmental studies, but our lack of understanding of systematic relationships between acritarchs and the algae make critical paleoecological inferences difficult.



REFERENCES



References

- AL-AMER! T.K (1992):** Diatoms; *in: LIPPS,}H. (ed.), Fossil prokaryotes and protists*; Blackwell Scientific Publishers, Boston, p. 155-167. BOLD, H.C. & WYNNE, M.J.
- CRAMER, F.H. (1990):** Acritarchs of the *Monograptus sedgwickii* zone (Lelkovice Formation, Llandovery) from Hyskov, Barrandian, Bohemian Massif; *Acta Universitatis Carolinae - Geologica*, 1: 75-104, pl. 1-8. EHRENBERG, c.G.
- EISENACK, A (1979 b):** Katalog der jossilen Dinoflagellaten, Hystrichosphiiren and verwandten Mikrofossilien .
- ERDTMAN, G A (1993):** The great Paleozoic crisis: life and death in the Permian; Columbia University Press, New York, 327 p. EVITT, W.R
- FOSTER, CB. REED J D & WICANDER, E.R(1989):** *Gloeocapsomorpha prisca* Zalesky, 1917: a new study part taxonomy, geochemistry, and paleoecology; *Geobios*, 22:735-759, pl. 1-3.
- GENSEL, P.G. (1980):** Devonian in situ spores: a survey and discussion; *Review Palaeobotany and Palynology*, 30: 101-132, pl. 1-4.
- GRAY, J. & BOUCOT, AI. (1990):** A geologic time scale 1989; Cambridge University Press, Cambridge, 263 p.
- JACOBSON, S.R (1992):** Paleobiology of Silurian-Early Devonian acritarchs; 8th International Palynological Congress, Aix-en-Provence, Program and Abstracts, p. 83. LINDGREN, S. and Prokaryotes and protists; Blackwell Scientific Publishers, Boston, 342 p.
- LISTER, T.R (1970):** The acritarchs and Chitinozoa from the Wenlock and Ludlow Series of the Ludlow and Millichope areas, Shropshire. Part 1;



Palaeontographical Society, Monographs, 124 (Publication 528): 1-100, pl. 1-13.

LOEBLICH, AR, JR & TAPPAN, H. (1992): Acritarchs and prasinophytes; in :LIPPS, J. H. (ed.), Fossil prokaryotes and protists; Blackwell Scientific Publishers, Boston, p. 77-104. MILLER, MA.

PARKE, M., BOALCH, G.T., JOWETT, R & HARBOUR, O.S. (1978): The genus *Pterosperma* (Prasinophyceae): species with a single equatorial. Journal of the Marine Biological Association of the United Kingdom, 58: 239-276.

PEAT, C (1981): Comparative light microscopy, scanning electron microscopy and transmission electron microscopy of selected organic walled microfossils; Journal of Microscopy, 122: 287-294, 1 pl.

PLAYFORD, G. (1977): Lower to Middle Devonian acritarchs of the Moose River Basin, Ontario; Geological Survey of Canada, Bulletin, 279: 1-87, pl. 1-20.

REAUGH, A.B. (1978): A new excystment mechanism in the Silurian acritarch *Diexallophosis* of Virginia; Palaeontology, 21: 869-872, pl.100.

RICHARDSON, J.B. & RASUL, S.M. (1990): Palynofacies in a Late Silurian regressive sequence in the Welsh Borderland and Wales; Journal of the Geological Society, London, 147: 675-686, 2 pl.

SARJEANT WAS. (1992): The Proterozoic biosphere; Cambridge University Press, Cambridge, 1348 p.

SOLIMAN, A. (2006): Lower and Middle Miocene dinoflagellate cysts, Gulf of Suez. Egypt. PhD thesis, university of Graz.

STAPLIN, F.L (1994): Sedimentation of palynomorphs in rocks of pre- Devonian age; in: TRAVERSE, A (ed.), Sedimentation of organic particles; Cambridge University Press, Cambridge, p. 489-502. STROTHER, P.K. & TRAVERSE, A



TAPPAN, H. & LOEBLICH, AR., JR (1972): Fluctuating rates of protistan evolution, diversification and extinction; 24th International Geological Congress, Montreal, Section 7, Paleontology, p. 205-213
Evolution of the oceanic plankton; Earth-Science Reviews, 9:207-240.

WICANDER, E.R (1984): Middle Devonian acritarch biostratigraphy of North America; Journal of Micropalaeontology, 3(2): 19-24, pl. 1. WICANDER, R & WRIGHT, RP.

WILEY, E.O. (1984): A stratigraphic, paleoecologic, and paleobiogeographic review of the acritarchs *Umbellasperidium dejlandrei* and *Umbellasperidium saharicum*; in: SUTHERLAND, P.K. & MANGER, W.L. (ed.), Compte Rendu, Neuvieme Congres International de Stratigraphie et de Geologie du Carbonifere, 2 Biostratigraphy; Southern Illinois University Press [Carbondale and Edwardsville, p. 191-211, pl. 1, 2



Arabic summery

Arabic summery



الأكريتايش عبارة عن حويصلة ذات جدار عضوي أجوف مجهرى وهى مصطلح يأتي من كلمتين اليونانية: "acritos" (غير معروف) و "بدائي" (الأصل). تم العثور على الأكريتايش في الرواسب البحرية من معظم الزمنى الجيولوجي، من Archean حتى الوقت الحاضر، ولكن كانت أكثر وفرة وتنوعا في البروتروزويك وحقب الحياة القديمة. انخفض تنوعها في الدهر الوسيط.

وتتكون من حويصله واحده حيث تختلف تماثل الحويصلة من كروية او شعاعيه الى ثنائيه القطب او تكون غير منتظمة الشكل ويختلف حجم الأكريتايش حيث تختلف من <10 ميكرون إلى> 1 مم في الحجم، ولكن معظم الأنواع تتراوح 15-80 ميكرومتر. والأكريتايش هي مصدر هام للمعلومات البيولوجيه القديمه والأعداد الهائلة منها تعمل على الحفاظ على سجل الصخور وجعلها مفيدة للدراسات البيوستراتجرافية و البيولوجية القديمة.

التاريخ المبكر الأكريتايش تم توثيقه جيدا من قبل العديد من الباحثين وعلى سبيل المثال دراسه الأكريتايش فى امريكا الشماليه حيث اعطت الكثير من البحوث التى استخدمها (مارتن، 1993) فى دراساته على الأكريتايش. و فى عام 1963، اقترح Evitt إزالة Hystrichosphaerida من تلك الأحافير الدقيقة المتعلقة و كان اقتراح Evitt مقبول.

وتصنيف الأكريتايش ينقسم الى نوعين :

1. التصنيفات Phenetic : فى هذا التصنيف كما قال داوونى وآخرون. (1963) هناك اربعة تصنيفات Phenetic وهذا كان فى البدايه حتى جاء ي كريمير ودييز (1979) وقسم الأكريتايش الى ثلاث وحدات رئيسية:

- Sphaeromorphae,
- Non-acanthomorphitic acritarchs
- Acanthomorphic acritarchs.

2. التصنيفات Phylogenetic : والأشكال التضاريسية بسيطة نسبيا من العديد من الأكريتايش جعل التقارب حادة بشكل خاص. بحاجة إلى مثل هذه المشاكل التي يتعين حلها إذا التصنيفات الطبيعية الافضل هي التي يتم بناؤها. واستنادا إلى البحوث من ول (1962) وبارك وآخرون. (1978)، أصبح من بين أمور أخرى من الواضح أن من بعض هذه البحوث يتميز سابقا باسم الأكريتايش وتنقسم الى أربع مجموعات المورفولوجية للاكريتايش :

- 1) Tasrumites وأجناس ذات صلة بهم مع جدار سميك مميزة والمسام شعاعي
- 2) جنسا شبكي-murinate مثل Dictyotidium، Melikeriopalla، Cymatiosphaera، Dailyidium، Duvernay-sphaera، Muraticavea و Polyedryxium؛
- 3) Pterospermella، من خلال هيئة مركزية كروية تتميز مع ذلك، شفة واحدة كبيرة الاستواء (ALA)، ؛
- 4) اجناس بسيطة، الكرات على نحو سلس الجدران (Leiosphaeridia) corre sponding إلى Halosphaera موجودة. بارك وآخرون. (1978).

و الأكريتايش لديهم تاريخ من النشأة والانقراض خلال توزيعها كانت على انتشار واسع في الزمان والمكان، مع احتمال الناتجة عن تقسيم المناطق الطبقيه الحيوية. ومع ذلك، فقد كانت معتدلة فقط مفيدة للحفريات المرشدة. العديد من الأكريتايش لديهم نطاقات طبقية طويلة. وتشمل هذه بعض الأنواع الشائعة مثل Veryhachium، Leiosphaeridia، Michrhystridium. هذه الأجناس لديها أعداد كبيرة من الأنواع التي يمكن أن يكون من الصعب تمييزها. لأن المتغيرات المورفولوجية تختلف من واحده الى اخرى (مثل Veryhachium) فإنه من الصعب تحديد مفهوم ثابت من كمية التباين المظهري في الأنواع الطبيعية.

