

Zeitschrift: Archives des sciences [1948-1980]
Herausgeber: Société de Physique et d'Histoire Naturelle de Genève
Band: 28 (1975)
Heft: 2

Artikel: Addendum : evolutionary trends in the Arkhangelskiellaceae (calcareous nannoplankton) of the Upper Cretaceous of Central Oman, SE Arabia
Autor: Lauer, G.
DOI: <https://doi.org/10.5169/seals-739803>

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ADDENDUM

EVOLUTIONARY TRENDS IN THE ARKHANGELSKIELLACEAE
(CALCAREOUS NANNOPLANKTON) OF THE UPPER CRETACEOUS
OF CENTRAL OMAN, SE ARABIAG. LAUER¹

The study was initiated at the request of the oil company P.D. (Oman) Ltd. to arrive at a detailed chronostratigraphic subdivision of the Late Cretaceous Fiqa Formation in the Oman, SE Arabia. This Formation covers the upper part of the *Globotruncana carinata* to the lower part of the *Globotruncana calcarata* planktonic foraminiferal zones and is therefore of Late Santonian to Late Campanian age. The dark calcareous shales of the Fiqa Formation which can be up to 5000' thick were studied in 25 cored well-intervals distributed over an area of approximately 90.000 km².

1. SYSTEMATICS

In the evolution of the family Arkhangelskiellaceae four separate lineages are recognised:

1. *Aspidolithus* NOËL 1969

According to the type species *Aspidolithus angustus* NOËL 1969 this organ genus applies to types of Arkhangelskiellaceae with two major distal cycles of elements and three layers in side view. The central area is occupied by a plate. The evolution shows the following morphological trends in the investigated interval:

- a) increase of size
- b) increasing difference in diameter of the three layers (the early types show three layers of the same size; in the later types the distal layer is larger).
- c) reduction in size of central area
- d) reduction in number of perforations

¹ P.D. (Oman) Ltd., present address: Koninklijke/Shell Exploratie en Productie Laboratorium, Volmerlaan 6, Rijswijk (ZH), The Netherlands.

2. *Broinsonia* BUKRY 1969

The organ genus is defined by a cross structure in the central area, as indicated by the type species *Broinsonia dentata* BUKRY 1969. The studied time interval does not allow the definition of evolutionary trends. However, a variety of types is recognised, which are combined under the preliminary term of *Broinsonia dentata* group.

3. *Arkhangelskiella* VEKSHINA 1959

A large number of morphological variations are condensed in two groups of species. The *Arkhangelskiella* group 1 includes types with four perforations along the short axis of the central area. Six or more perforations are present along the short axis in the central area in the *Arkhangelskiella* group 2. Besides a variety of evolutionary trends, mainly concerning the distribution of the central perforations a clear development of the marginal area is recognisable in both lineages. The early stages have three layers in side view and two cycles on the distal side which indicates an evolutionary connection with *Aspidolithus*. The later stages show four layers in side view and only one cycle at the distal side. The outer cycle has become superimposed by the inner cycle, which finally forms a fourth layer.

4. *Gartnerago* BUKRY 1969

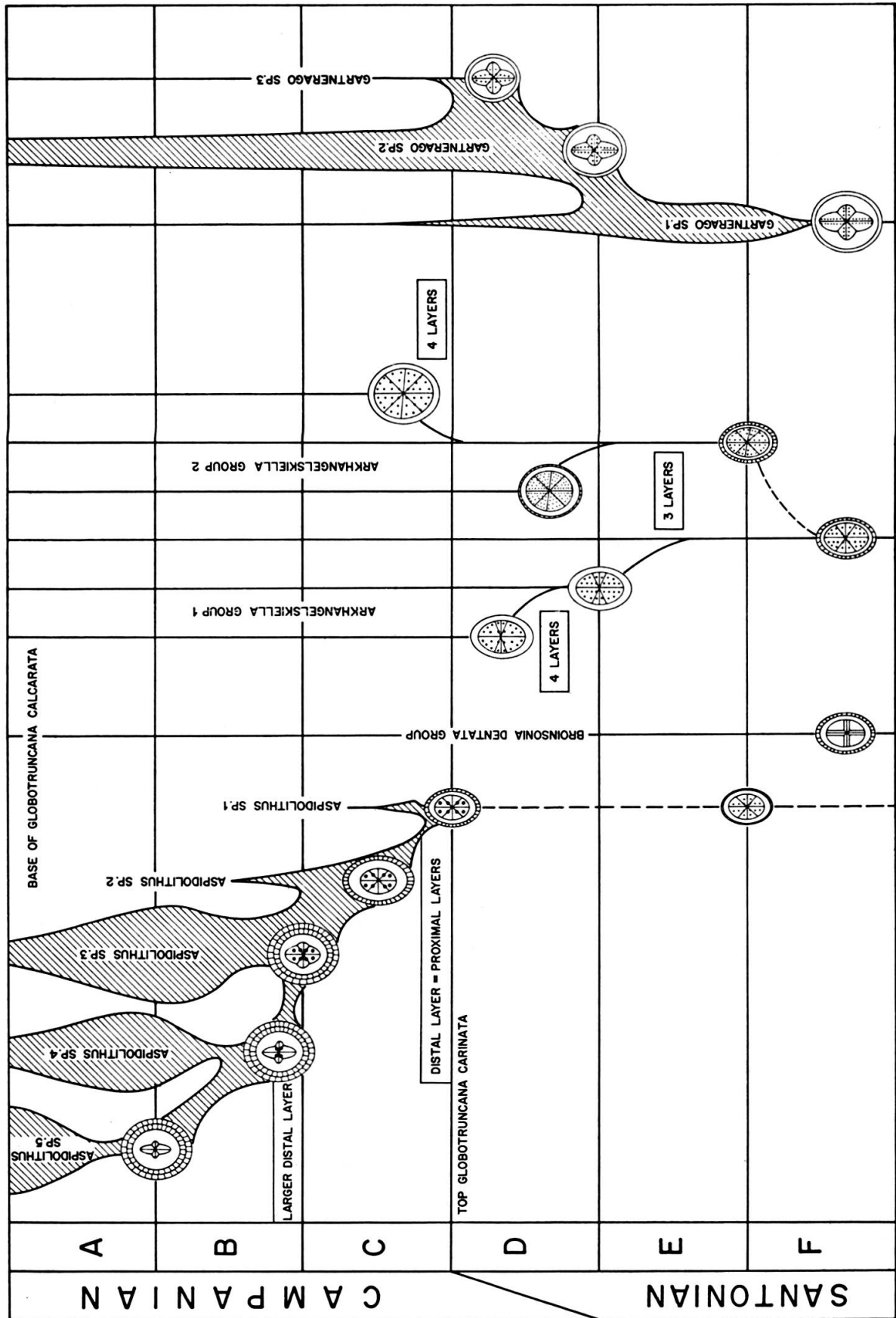
The morphology of this organ genus suggests major differences from the three closely related organ genera mentioned before. Within the Santonian-Campanian interval two evolutionary trends are observed:

- a) decrease in size
- b) decrease in number of central perforations. The three types are distinguished by the number of perforations along the short axis of the central area;
 - Gartnerago* sp. 1: 8 perforations
 - Gartnerago* sp. 2: 6 perforations
 - Gartnerago* sp. 3: 4 perforations

II. STRATIGRAPHY

With these evolutionary lineages a sixfold subdivision has been achieved in the Fiq Formation of Central Oman. The zonation is defined by morphological criteria which are recognisable under the optical microscope.

On the graph the following evolutionary events are indicated from bottom to top:



- Zone F. No lower limit has been defined.
- Zone E. First occurrence of the *Arkhangelskiella* group 2. Furthermore only types of Arkhangelskiellaceae showing two major cycles at the distal side are present.
- Zone D. First occurrence of *Gartnerago* sp. 2. As a second aspect the first representatives with four layers appear in the *Arkhangelskiella* group 1. Also in this case the absence of a differentiation in the marginal area is indicative.
- Zone C. First occurrence of *Aspidolithus* sp. 1, showing three layers of the same size. In addition the first types with four layers appear in the *Arkhangelskiella* group 2. Consequently an undifferentiated marginal area is visible in distal and proximal views.
- Zone B. First occurrence of large *Aspidolithus*, showing different diameters of the three layers in side view (*Aspidolithus* sp. 3). In case of proximal or distal views the morphology can be determined by focussing to the appropriate level.
- Zone A. First occurrence of large *Aspidolithus* without central perforations, and a very small elongated area (*Aspidolithus* sp. 5).

The frequency of the morphological types and their intermediates is shown in the graph by the lateral extent of the shaded areas. The recognition of the submicroscopical morphology is based on the study of 150 SEM photographs supplied by Prof. Dr. F. R. Allemann and Dr. W. Grün (now at Ö.M.V.A.G., Vienna) from the Geological Institute in Bern (Switzerland). Permission by P.D. (Oman) Ltd., to publish this paper is gratefully acknowledged.

Authors' addresses :

Laboratoire de Géologie du Muséum
61, rue de Buffon
75005 Paris (France)

Eidg. Technische Hochschule Zürich
Geologisches Institut
Sonneggstrasse 5
CH-8006 Zürich (Switzerland)