For 28th Annual Meeting on Electron
Microscopy Society of America,
Houston, Texas, October 5-9, 1970

UCRL-19627
Preprint

c. 2

RECEIVED
LAWRENCE
RADIATION LABORATORY

JUL 21 1970

LIBRARY AND
DOCUMENTS SECTION

HIGH VOLTAGE MICROSCOPY IN PALEONTOLOGICAL STUDIES - GRAPTOLITES

W. B. N. Berry, R. S. Takagi, G. Thomas, and D. J. Jurica

May 1970

AEC Contract No. W-7405-eng-48

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

UCRL-19627
cy 2

2

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

HIGH VOLTAGE MICROSCOPY IN PALEONTOLOGICAL STUDIES - GRAPTOLITES

W. B. N. Berry, R. S. Takagi,[1] G. Thomas and D. J. Jurica[2]

[1]Department of Paleontology and [2]Department of Materials Science and Engineering, and Lawrence Radiation Laboratory, University of California Berkeley 94720

Transmission electron microscopy has seldom been used in studies of fossils, and to date, no electron diffraction work has been reported. Because of the limited transmission power of the 100 kV electron microscopes (<1μ), the techniques which have been used to prepare specimens have followed standard biological methods, including ultra-thin sectioning and staining.(1) High voltage electron microscopy on the other hand allows examination of considerably thicker specimens (up to 5μ at 500 kV) and is particularly useful in studying fossils e.g. it is often not necessary to section pieces of the fossil. Minimal preparation is advantageous because materials that have been interred in rocks of the earth's crust for millions of years are commonly brittle and distort or break while being sectioned with the microtome. The present paper describes one of the first in which fossil specimens have been examined directly without following standard biological preparation techniques. All the work was done on the 650 kV Hitachi at Berkeley.

The fossils studied are in a group called the graptolites (see fig. 1a). These have previously been examined at low voltages.(1) The graptolites are an extinct group of colonial organisms that lived from approximately 525 to 375 million years ago. The actual specimens studied are approximately 475 million years old. During their lifetime, they were widely dispersed in large numbers in open seas. Despite an extensive knowledge of the graptolites in the fossil record, nothing is known of the animal that secreted the skeletal parts of the colonies now seen as fossil and little is known of the fine structure of the colony. It is hoped that study of the fine skeletal structures may provide some information on their life activities and biological affinities.

The graptolite colony includes an elongated, bell-shaped shell (the sicula) as the initial part of the colony which is shown in the scanning electron microscope images of fig. 1. The sicula probably housed an individual produced by sexual reproduction. The sicula has upper and lower halves (see figs. 1a,b) which exhibit differences in structure (figs. 2,3). The high voltage electron microscope study to date has shown that the three distinct structural elements of the prosicula are: 1) a thin tissue formed of fibers interwoven to comprise an open mesh (figs. 2a,c); 2) sets of long fibers closely bundled together to form longitudinally-oriented rod-like structures (fig. 2a at A); and 3) a set of fibers joined together to form a band (in weak contrast) that spirals down the length of the prosicula (fig. 2a at B). The diffraction pattern and dark field image (figs. 2b,c) indicate that all three regions are of the same material. The lower half of the sicula (metasicula) is composed of a meshwork of fibers that is similar to but more randomly oriented than that forming the tissue-like structure of the prosicula (see fig. 2a,3a). Superimposed on these fibers is a regularly-layered mesh-work with four-fold symmetry that has a fabric-like aspect (fig. 3a). The faint diffraction spots in fig. 3b indicate that this layer is single crystalline.

Chemical data and microscopic study of the fibers suggest that they are probably formed from large proteinaceous molecules. The diffraction patterns of the fibers in figs. 2b,3b are consistent with this viewpoint. The intensity differences in these patterns reflect possible differences in degree of mineralization due to aging.

(1) W.B.N. Berry and R.S. Takagi J. Paleontology, 44, 117-124 (1970).

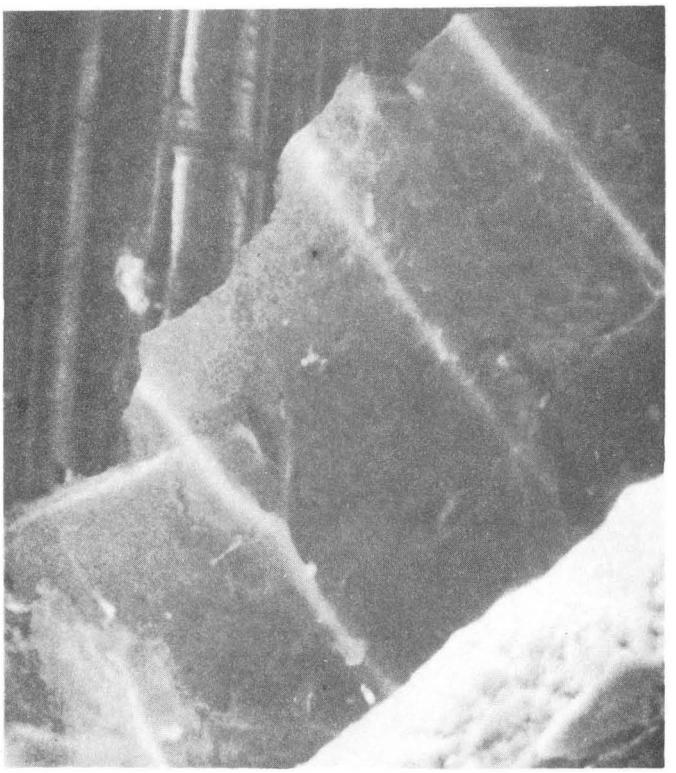
We thank the U.S. Atomic Energy Commission for financial support.

Fig. 1(a) Scanning micrograph of Orthograptus
(b) Scanning micrograph of fragment of metasicula shown in (a) at A.

Fig. 2(a) 650kV transmission bright field image of prosicula shown in 1(a), B.
(b) Diffraction pattern showing rings due to fibres.
(c) Dark field image of region indicated by the aperture in 2(b) of rings reverses contrast of all the fibres.

Fig. 3(a) 650kV transmission bright field image of metasicula.
(b) Diffraction pattern; rings due to fibres, fault spots due to layered structure.

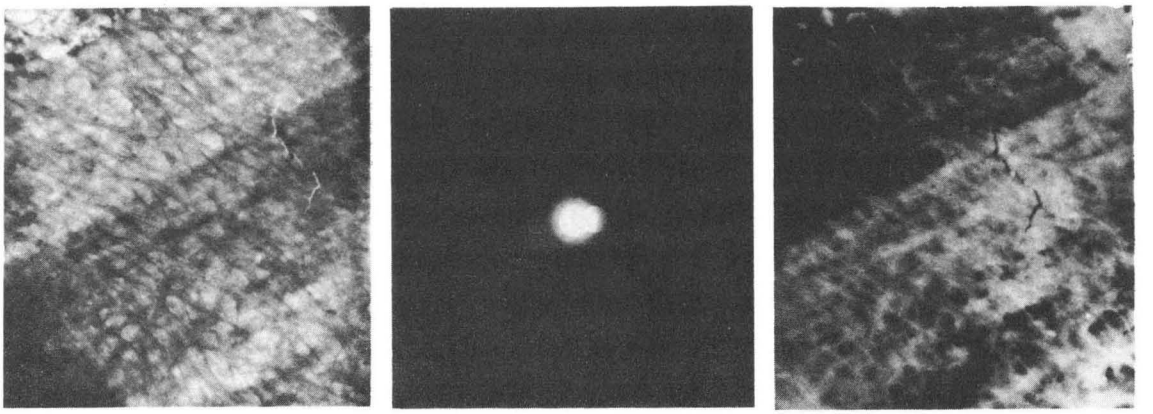
(a) mag = 65X



(b) mag = 1000X

XBB 705-2396

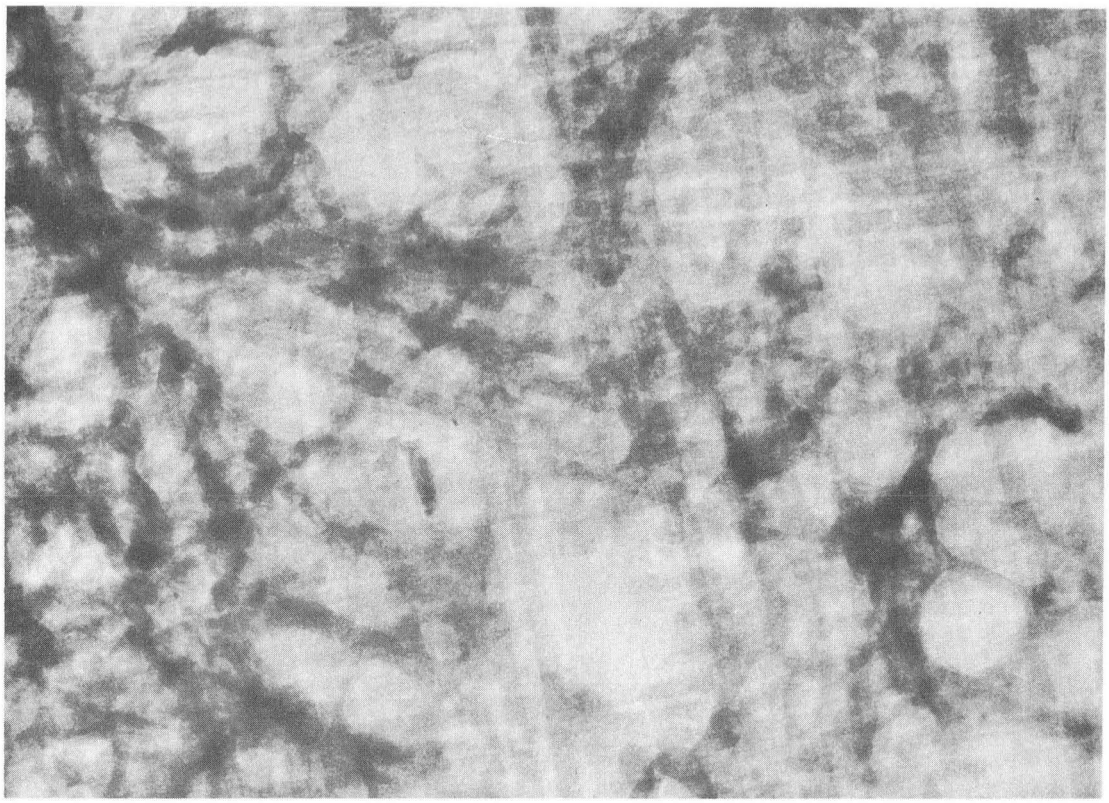
Fig. 1



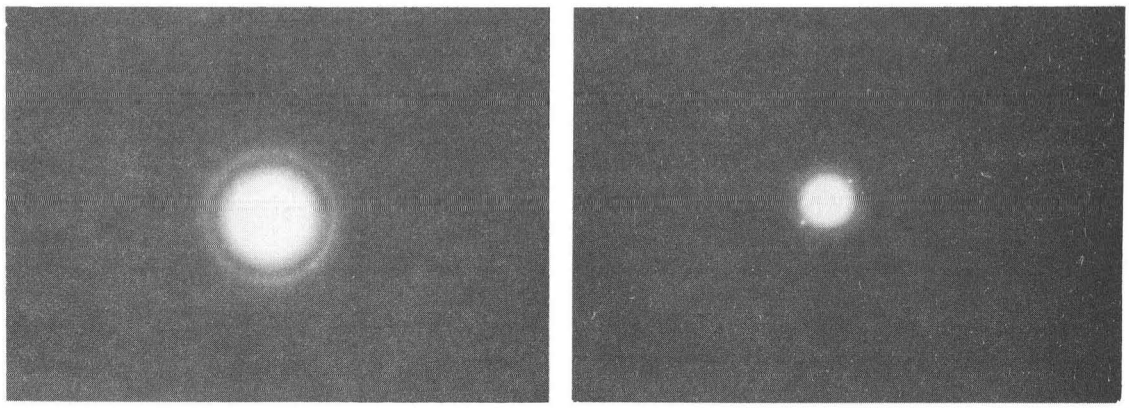
(a) (b) (c)

XBB 705-2394

Fig. 2



(a) mag = 20,000X



(b) mag = 0

XBB 705-2395

Fig. 3

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

TECHNICAL INFORMATION DIVISION
LAWRENCE RADIATION LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720