

Cortical Bandages in an Upper Ordovician Glyptograptid graptolite from Ohio

Peter R. CROWTHER

Department of Geology
Sedgwick Museum, Cambridge, U.K.

Stig M. BERGSTRÖM

Department of Geology & Mineralogy
The Ohio State University, Columbus, U.S.A.

(manuscript received March 20, 1980
accepted May 27, 1980)

KEY WORDS — Cortical Bandages, Glyptograptus, Graptolites, Ohio, Upper Ordovician.

ABSTRACT — SEM study of the periderm surface ultrastructure in specimens of *Glyptograptus lorrainensis anacanthus* Mitchell and Bergström, 1977 from the Richmondian (Late Ordovician) Arnheim Formation of Ohio revealed the presence of superposed, fibrillar, ribbon-shaped increments - cortical bandages - in the outer cortex. Such cortical bandages have recently been found in representatives of a few other graptolite genera, and their presence in *Glyptograptus* supports the idea that they are a basic type of structural element in the periderm of graptolites in general. The form and arrangement of the cortical bandages in our specimens are consistent with a mode of secretion similar to that in pterobranchs.

RIASSUNTO — [Struttura a bande corticali in un graptolite gliptograptoido dell'Ordoviciano superiore dell'Ohio] — Incrementi di crescita sotto forma di nastri sovrapposti e fibrillari (bande corticali) sono stati messi in evidenza studiando al microscopio elettronico a scansione la superficie del periderma di alcuni esemplari di *Glyptograptus lorrainensis anacanthus* Mitchell & Bergström, 1977 dell'Ordoviciano superiore dell'Ohio. Tale struttura a bande corticali è stata trovata recentemente in alcuni altri generi di graptoliti e la loro presenza in *Glyptograptus* è una ulteriore riprova a sostegno dell'idea che questo sia l'elemento strutturale fondamentale del periderma dei graptoliti. La forma e la disposizione delle bande corticali nei nostri esemplari sono compatibili con un modo di secrezione simile a quello dei pterobranchi.

INTRODUCTION

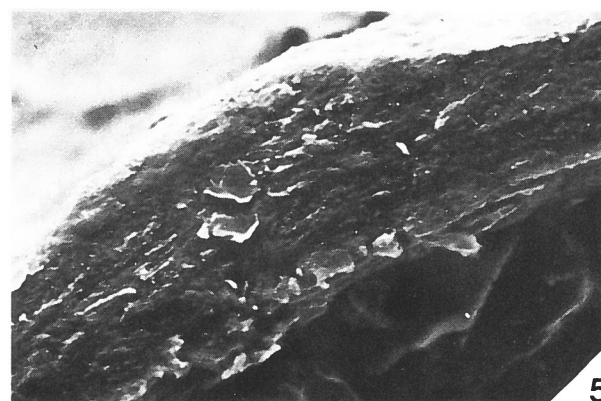
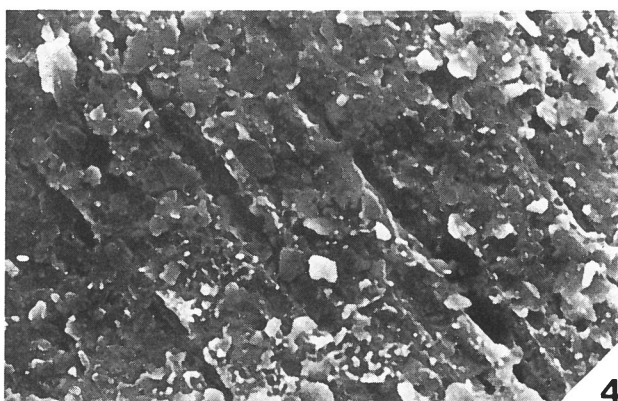
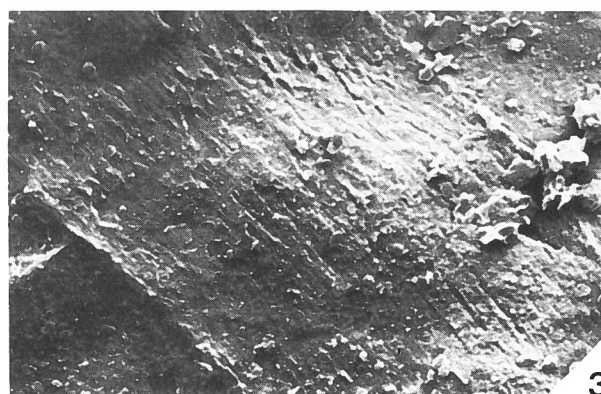
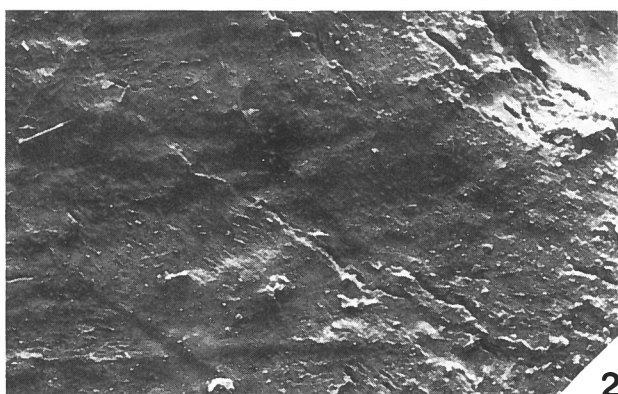
In a recent issue of the present journal, Mitchell and Bergström (1977) described in some detail the morphology of three-dimensionally preserved specimens of *Glyptograptus lorrainensis anacanthus* Mitchell and Bergström from the early Richmondian (Late

Ordovician) Arnheim Formation at Stonelick Lake State Park, Clermont County, Ohio. The best preserved specimens were obtained by acetic acid etching of nodules of wackestone. A few samples collected subsequently at this locality by one of us (S.M.B.) have produced additional representatives of *G. l. anacanthus* but no other graptoloids. Although Mitchell and

EXPLANATION OF PLATE 1

Figs. 1-5 - *Glyptograptus lorrainensis anacanthus* Mitchell & Bergström. SEM micrographs illustrating periderm ultrastructures in specimens SM A102614 (Figs. 1-4) and SM A102615 (Fig. 5). For location of micrographs on the rhabdosome, see text-fig. 1.

- 1, Surface of lateral wall of rhabdosome showing fusellar growth ridges and overlying cortical bandages (x 170).
- 2, Cortical bandages on lateral wall of rhabdosome. Note ribbon-like structure with distinct edges (x 350).
- 3, Cortical bandages at higher magnification showing parallel lineations (x 700).
- 4, Detail of surface of bandage illustrated in Fig. 3 showing loss of original fibrillar structure. Note that the fibrils have been welded into larger, somewhat irregular units during the fossilization process (x 3500).
- 5, Broken periderm wall showing very incomplete preservation of original fibrillar structure (x 3500).



Bergström (1977) illustrated some specimens using SEM micrographs (Pl. 2, figs. 1-11), they undertook no ultrastructural study of their graptolites.

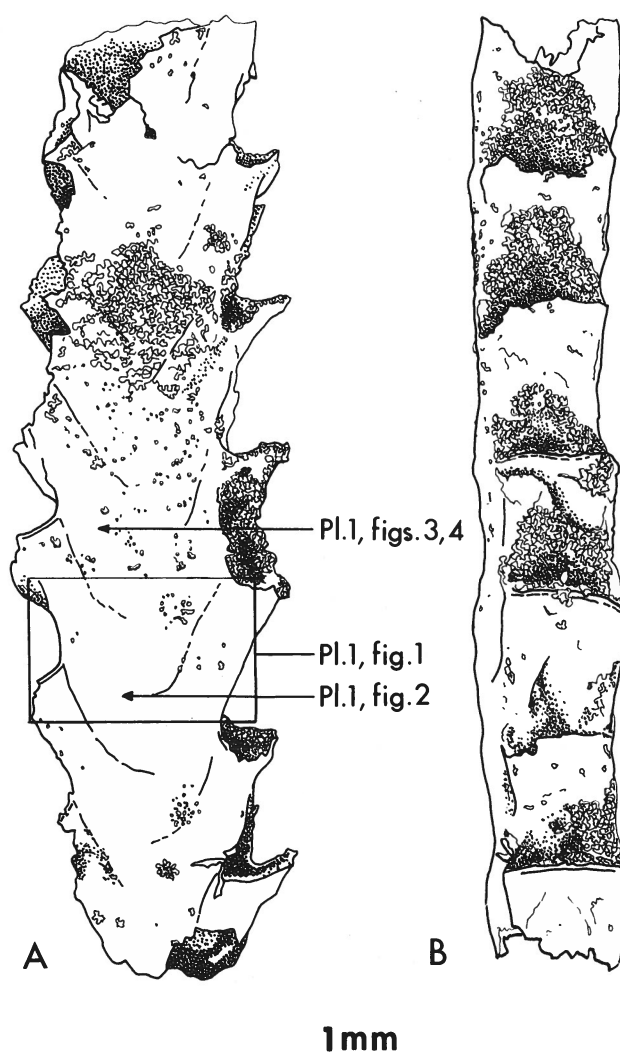
During the last few years, the use of the SEM has greatly increased our knowledge about the graptolite periderm ultrastructure. This applies particularly to one of the most important and characteristic structural elements of the periderm, the cortical bandages. Although these structures were discovered more than 50 years ago (Kraft, 1926), only recently (Andres, 1977; Crowther and Rickards, 1977; Urbanek and Mierzejewska, 1978, etc.) have their detailed morphology been studied and its paleobiological significance evaluated. Cortical bandages consist of thin, overlapping ribbons of periderm, often arranged in such a way that most ribbons make an angle with the rhabdosome length axis (Crowther and Rickards, 1977, fig. 1). Thus far, cortical bandages have been found in representatives of several different types of graptolites (Andres, 1977; Crowther and Rickards, 1977; Bates and Kirk, 1978; Crowther, 1978, in press; Urbanek and Mierzejewska, 1978) but they are particularly well developed in representatives of the suborder Diplograptina. Minute morphological structures such as the cortical bandages are commonly destroyed during the fossilization process, and their study requires excellently preserved specimens.

The good state of preservation of the specimens of *Glyptograptus lorrainensis anacanthus* described by Mitchell and Bergström (1977) suggested that it would be worth-while to examine these specimens in the SEM for the possible preservation of cortical bandages and other ultrastructures in the periderm. This was also justified in view of the fact that thus far, there is no published description of such structures in any representative of *Glyptograptus*, and they have been described in only five species of Ordovician graptolites from the entire North American continent. It should be noted, however, that one of us (Crowther, in press) has found cortical bandages in some additional Ordovician graptolites in North America, including *G. euglyphus*.

The SEM examination was carried out by P.R.C. following the mounting and study procedures described by Crowther and Rickards (1977, pp. 10-11). All SEM micrographs were taken on a Cambridge Instrument Company Stereoscan 600 housed at the Department of Geology, Cambridge University. The mounted specimens have been assigned the numbers SM A102612-A102615 and are stored in the collections of the Sedgwick Museum, Cambridge. Other specimens are kept in the collections of the Orton Geological Museum at the Ohio State University, Columbus, Ohio.

ULTRASTRUCTURES

The SEM study of the periderm of our specimens of *Glyptograptus lorrainensis anacanthus* revealed some ultrastructural details previously undescribed in this graptolite, including cortical bandages. The specimens investigated are preserved undistorted in full relief but most ventral apertural margins are damaged and the structure of some areas of the periderm surface is obscured by mineral debris (cf. Text-fig. 1). In areas without this debris, the outer surface of the periderm exhibits a complex network of linear features representing two distinct groups of structures (Pl. 1, fig. 1):



Text-fig. 1 - *Glyptograptus lorrainensis anacanthus* Mitchell & Bergström. Specimen SM A102614. A, lateral view showing location of SEM micrographs (Pl. 1, figs. 1-4). B, ventral view. Note that mineral debris partially covers the surface of the rhabdosome.

1) *Fusellar growth ridges* — These are generally oriented perpendicularly to the rhabdosome axis. They are particularly prominent on the metathecal walls where they show a more regular spacing than elsewhere on the rhabdosome.

2) *Cortical bandages* — These superposed ribbon-like structures of periderm overlie the fusellar growth ridges and are arranged in a superficially haphazard fashion.

The cortical bandages are of special interest and merit detailed description.

In general appearance and arrangement, the cortical bandages in *Glyptograptus lorrainensis anacanthus* are similar to those previously described in other representatives of Diplograptina (Crowther and Rickards, 1977; Crowther, 1978, in press). Each bandage is straight or slightly sinuous and has a constant width (Pl. 1, fig. 2). The width shows an increase from 40-50 μm in one incomplete proximal end (SM A102613) to 60-70 μm in a more distal portion of another specimen (SM A102614). This is in accordance with the normal width increase in a distal direction along the rhabdosome recognized by Crowther and Rickards (1977, p. 13). In most cases, the length of each cortical bandage is four to five times as large as the width. The bandages tend to be aligned crudely longitudinally down the ventral metathecal walls and there is some indication of a rudimentary radial arrangement round some thecal apertures. However, apart from the fact that few, if any, bandages are oriented parallel with the length axis of the colony, there is no clear evidence for any preferred orientation of the bandages on the lateral rhabdosomal walls.

A cortical bandage is typically composed of tightly packed, parallel fibrils and it is bounded by granular sheet fabric (Crowther and Rickards, 1977, p. 11). These elements are only partially preserved in our specimens. The ribbon-like morphology of most bandages remains distinct, and some bandages have quite conspicuous margins (Pl. 1, figs. 2-3). In each bandage, there are also well-developed lineations in the direction of its component fibrils (Pl. 1, fig. 3). However, individual fibrils can only in rare cases be distinguished in our specimens because the process of fossilization has tended to weld adjacent fibrils into larger, irregular units (Pl. 1, fig. 4). It is these units that form the prominent lineations. Also the fine details in the structure of the bounding sheet fabric have not been preserved in our specimens.

Another indication of the imperfect preservation of our specimens is provided by broken edges of periderm (Pl. 1, fig. 5) where one can study how little of the originally fibrillar structure that has survived the fossilization process. Thus, cortical and fusellar fabrics

(Urbanek and Towe, 1974, p. 4) can not be distinguished and only an indistinct lamination remains.

The form and arrangement of cortical bandages led Andres (1977) and Crowther and Rickards (1977) to suggest independently that the graptolite periderm was secreted in a similar manner as pterobranch tubes. Our specimens of *Glyptograptus lorrainensis anacanthus* provide another example of well developed cortical bandages and prove their presence in still another genus of graptolites. The cortical bandages described here are similar to those known previously in some other genera and may be taken as additional support for a pterobranch mode of secretion of the graptolite periderm.

ACKNOWLEDGEMENTS

Work by P.R.C. was carried out during the tenure of a Research Fellowship at Christ's College, Cambridge University. Photographic assistance was provided by Mr. D. Newling of the Department of Geology at the same university. We are also indebted to Dr. Barrie Rickards, Sedgwick Museum, Cambridge and Dr. Stanley C. Finney, Department of Geology and Mineralogy, The Ohio State University for reading the manuscript and offering valuable advice.

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