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The Jurassic dinoflagellate genus *Stephanelytron* : emendation and discussion

ABSTRACT
On the basis of recently acquired data, the fossil dinoflagellate genus *Stephanelytron* Sarjeant, 1961, is emended and designated as the type for the new family Stephanelytraceae. Revised descriptions are provided for *S. caytonense* Sarjeant, *S. redcliffense* Sarjeant, and *S. scarburghense* Sarjeant; a new species, *S. tabulophorum*, is proposed. The genus, known only from localities in the northern hemisphere extending from western Europe to western North America, ranges from Middle Jurassic (middle Callovian) to Upper Jurassic (lower Kimmeridgian).

INTRODUCTION

The fossil dinoflagellate genus *Stephanelytron* Sarjeant, 1961, is of interest to palynologists because of its unusual and distinctive morphological features, and to biostratigraphers because of its potential as an important uppermost Middle and lower Upper Jurassic stratigraphic marker. Thus the new information about this genus and its species presented herein should appeal to one or the other group, or to both. The purpose of this contribution is threefold: first, to review briefly the history of the genus prior to our study; second, to revise and recast in modern terminology the descriptions of previously established species and to propose a new one; and third, to present current geographical and stratigraphical data.

BACKGROUND

During research on organic walled microplankton from the Upper Jurassic Oxford Clay of England in the late 1950's, Sarjeant observed small ovoidal to ellipsoidal bodies bearing tubular processes arranged in rows or distributed apparently randomly over the entire surface. Arising from one pole of the body was an everted, subcylindrical structure which surrounded a dense concentration of setae; this came to be termed a corona. Although these microfossils resembled dinoflagellate cysts in their general organization, composition and size, no known tabulated dinoflagellate theca or cyst exhibited a corona; nor could a comparable structure be found among forms from other groups of organic walled microfossils. It was recognized from the outset that most hystrichospheres (not then known to be dinoflagellate cysts) do possess processes similar in character to those on the small ovoidal to ellipsoidal bodies seen by Sarjeant; even so, when these corona- and process-bearing microfossils were described under the name *Stephanelytron* by Sarjeant (1961), they were not assigned to the order Hystrichosphaeridia but were instead left *Incertae Sedis*. In the same publication *Stephanelytron caytonense*, *S. scarburghense*, and *S. redcliffense* were described and the last was designated as the type species.

After Evitt (1961) had demonstrated convincingly that all supposed fossil dinoflagellates were in fact cysts and that most of the Mesozoic and Cenozoic hystrichospheres were likewise dinoflagellate cysts, the residue of unassigned, problematical forms, most of them Paleozoic, were placed within his Group Acritarcha. In 1963, Downie, Evitt, and Sarjeant included *Stephanelytron* within the Acritarcha because its affinities were still uncertain, making it indeed the basis for their subgroup Stephanomorphitae. Subsequently, however, Stover (1967, personal communication) reported to Sarjeant that an opening is present

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in the body of *Stephanelytron* at the pole opposite the corona and that the opening (the archeopyle) is covered by an operculum apparently bearing a single large, central process. This information prompted Sarjeant (1970, p. 674) to write: "One of the subgroups originally placed in the Acritarcha, the Stephanomorphitae, has recently been shown to comprise dinoflagellate cysts (Lewis E. Stover, MS., in press)."

Although treated as a dinoflagellate cyst since 1970 (Sarjeant, 1970; Riley and Sarjeant, 1972; Lentin and Williams, 1973), *Stephanelytron* has not been assigned to a particular cyst family (Gitmez and Sarjeant, 1972; Sarjeant and Downie, 1974; Sarjeant, 1974), nor has a cyst family been proposed for its reception. This situation is rectified in the next section through the establishment of the new family Stephanelytraceae.

While some of the publications cited above were in preparation, Stover and Sarjeant undertook to revise the generic description of *Stephanelytron*. However, during discussions at the 1973 Anaheim meeting of the American Association of Stratigraphic Palynologists, it became evident that Drugg had observed other morphological features that merited attention and consideration. A joint effort was agreed upon; the results of this undertaking, which embody original observations by each author, are presented herein. The terminology used in the present paper is that proposed by Evitt *et al.* (1977).

SYSTEMATIC DESCRIPTIONS

Kingdom PLANTAE
Division PYRRHOPHYTA Pascher
Class DINOPHYCEAE Fritsch
Order PERIDINIALES Haeckel

Family **Stephanelytraceae** Stover, Sarjeant and Drugg, **n. fam.**

Description: Cysts subspherical to ellipsoidal, proximochorate; body two-layered, autophragm and ectophragm clearly separated; ectocoel occupied by parasutural or nontabular processes or a combination thereof; processes normally tubiform and expanded distally; paratabulation formula: 1′?, 5″, X-6c, 5‴, 1⁗, 2s; archeopyle apical, antapical pole with one or more coronas. Diagnostic feature: antapical corona or coronas.

Genus ***Stephanelytron*** Sarjeant, 1961, **emend.** Stover, Sarjeant and Drugg

Stephanelytron SARJEANT, 1961, p. 109.—DOWNIE and SARJEANT, 1965, pp. 145–146.—NORRIS and SARJEANT, 1965, p. 56.—BRITO, 1967, p. 14.—LENTIN and WILLIAMS, 1973, p. 132.

Emended description: Cysts proximochorate with subspherical to ellipsoidal body composed of two wall layers. Inner wall, the autophragm, gives rise to usually short processes; outer wall, the ectophragm, thin and may be discontinuous. Processes frequently arranged in parasutural rows, less commonly nontabular; some forms have parasutural and scattered nontabular processes, penitabular processes being present on one species. Processes cylindrical to tubiform, normally of uniform height or nearly so, but width may vary considerably. Paratabulation indicated by alignment of processes on some species, formula: 1′?, 5″, X-6c, 5‴, 0-1p, 1⁗, 2s. Archeopyle apical, operculum free, rarely attached; exact archeopyle shape and number of paraplates in operculum uncertain; antapical area typically with one or occasionally with two coronas.

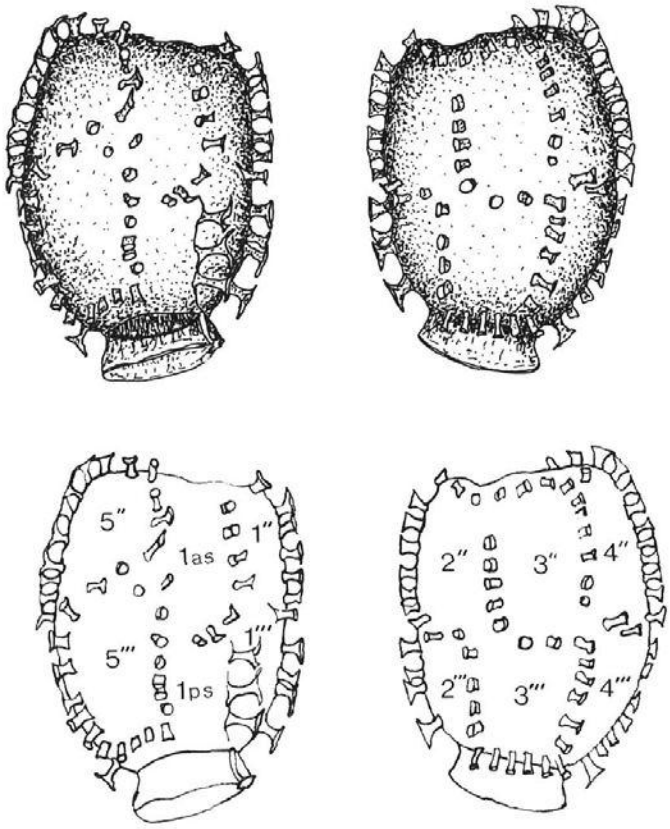
Remarks: The emended description provides a more precise interpretation of the morphology, presents new information about the paratabulation and the archeopyle, and allows for a greater range of variability. On some species the paratabulation is clearly evident, although small details may be elusive and difficult to decipher; on other species the paratabulation may be obscured entirely by the rather dense concentration of nontabular processes. The sulcus is sometimes determinable as the position of residual attachment of the operculum; more often it is indicated only by offset of the lines of processes marking one or both of its boundaries. It appears to be typically subdivided into two parts, here designated as anterior sulcal (1as) and posterior sulcal (1ps) paraplates.

Type species: Stephanelytron redcliffense Sarjeant, 1961, emend. Stover, Sarjeant and Drugg.

Stephanelytron redcliffense Sarjeant, 1961, **emend.** Stover, Sarjeant and Drugg
Plate 1, figures 1-6; text-figure 1

Organism A, SARJEANT, 1960, p. 404, pl. 13, fig. 13, table 2.
Stephanelytron redcliffense SARJEANT, 1961, pp. 109–110, pl. 15, fig. 11, text-figs. 10-15.—SARJEANT, 1962*a*, table 4.—SARJEANT, 1962*b*, p. 495, pl. 70, fig. 7, tables 2-3.—SARJEANT, 1964, table 4.—DOWNIE and SARJEANT, 1965, p. 146.—BRITO, 1967, pl. 2, fig. 3.—SARJEANT, 1968, p. 225, pl. 3, fig. 5, table 2A.—GITMEZ and SARJEANT, 1972, pp. 237-238, pl. 14, fig. 6, tables 5-6.—JOHNSON and HILLS, 1973, p. 194, pl. 2, fig. 8, table 1.—RILEY and SARJEANT, 1972, tables 3C-4C.—LENTIN and WILLIAMS, 1973, p. 132.

Emended description: Cysts proximochorate, subellipsoidal; outline tends to be roundly polygonal. Autophragm up to 1μ thick, smooth to faintly granulate, from which arise parasutural rows of processes. Processes tubiform, normally expanded slightly proximally, more so distally, smooth, 5μ to 9μ long and from 1μ to about 4μ diameter at midlength; distal tips of adjacent processes may be connected. Processes and intervening areas covered by ectophragm that is laevi-



TEXT-FIGURE 1
Stephanelytron redcliffense Sarjeant, emend. Stover, Sarjeant and Drugg. Specimen 950108 in ventral (left) and dorsal views. Upper: drawing shows character of processes and corona (ectophragm not shown). Lower: interpretation of tabulation. ×1000.

gate, thin (<0.5μ), commonly wrinkled and may be incomplete or even lacking; distance between autophragm and ectophragm essentially uniform.

Paratabulation indicated by parasutural alignment of processes, formula: 1′, 5″, Xc, 5‴, 1⁗, 2s. Precingular and postcingular paraplates large and with more or less rectangular outlines, although their exact shapes are difficult to verify because of folding and compression. A paracingulum is expressed only by the transverse alignment of groups of processes at about midlength. Archeopyle apical, operculum normally free. Archeopyle outline and shape of operculum unknown; however, a single process (often wider than others on the cyst) occurs apparently at or near the center of the operculum; hence the designation of 1′ in the paratabulation formula. Smooth-walled corona situated within antapical paraplate and covered by ectophragm; outline of corona in apical-antapical view subcircular to subquadrangular, distal diameter greater than proximal diameter; base of corona relatively thick, convex antapically, composed of compact mass of setae, and may have scattered longer setae or spinules. Overall length 40 to 75μ without opercula.

Type specimen: Holotype, specimen CB81/2/66 shown in Sarjeant (1961, pl. 15, fig. 11, text-fig. 10), now lodged in the British Museum (Natural History), London, England.

Type locality: Cayton Bay, Yorkshire, England.

Type stratum: Oxford Clay at High Red Cliff, 100 feet above top of the underlying Hackness Rock, Upper Jurassic (Oxfordian; *Cardioceras cordatum* Zone).

Remarks: The distal rim of the corona may be thickened slightly, and on some specimens the proximal diameter of the corona may approximate the distal diameter.

Stephanelytron caytonense Sarjeant 1961, **emend.** Stover, Sarjeant and Drugg
Plate 1, figures 7–8

Stephanelytron caytonense SARJEANT, 1961, p. 110, pl. 15, fig. 16, text-fig. 11.—SARJEANT, 1964, table 4.—DOWNIE and SARJEANT, 1965, p. 145.—SARJEANT, 1968, p. 225, pl. 1, fig. 19.—RILEY and SARJEANT, 1972, tables 3C-4C.—LENTIN and WILLIAMS, 1973, p. 132.
Stephanelytron scarburghense SARJEANT, 1974, pl. 11, fig. 3 (err. cit.)

Emended description: Cysts proximochorate, subspherical to broadly ellipsoidal, outline may be roundly angular. Autophragm up to 1μ thick, smooth, and forming relatively few processes arranged in ill-defined rows. Processes tubiform, normally expanded proximally and distally, commonly finely perforate, 6μ to 11μ long, from 1μ to nearly 2μ wide at midlength, and tips of adjacent processes rarely connected. Processes, corona, and intervening areas covered by thin (<0.5μ) ectophragm that is smooth, generally entire, whose distance above underlying autophragm is essentially constant.

Paratabulation usually not expressed (due to scarcity of processes) or, at best, vaguely indicated; paracingulum not indicated. Archeopyle apical, outline of archeopyle and shape of operculum unknown; the latter appears to bear a single, wider-than-usual process. Antapical corona with thick, densely setate, antapically convex base and smooth walls; distal diameter slightly to much greater than proximal diameter. Overall length 41μ to 66μ.

Type specimen: Holotype, specimen CB56/14/1 shown in Sarjeant (1961, pl. 15, fig. 16, text-fig. 11), now lodged in collections of the Micropaleontology Laboratory, Department of Geology, University of Sheffield, England; reg. no. ML403.

Type locality: Cayton Bay, Yorkshire, England.

Type stratum: Oxford Clay of High Red Cliff, 25 feet above top of the underlying Hackness Rock, Jurassic (Oxfordian; *Cardioceras cordatum* Zone).

Remarks: Stephanelytron caytonense seems to be intergradational with *S. redcliffense*. However, they do not always occur together and their total ranges differ; consequently, both species are retained.

Stephanelytron scarburghense Sarjeant 1961, **emend.** Stover, Sarjeant and Drugg
Plate 1, figures 9–10

Stephanelytron scarburghense SARJEANT, 1961, p. 111, pl. 15, figs. 12-13.—SARJEANT, 1962*b*, p. 495, pl. 70, fig. 11, tables 2-3. —SARJEANT, 1964, table 4. —DOWNIE and SARJEANT, 1965, p. 146.—RILEY and SARJEANT, 1972, tables 3C-4C.—LENTIN and WILLIAMS, 1973, p. 132.
Stephanelytron cf. *scarburghense* Sarjeant.—GITMEZ, 1970, p. 297, pl. 10, fig. 2; pl. 13, fig. 8, table 4B.—GITMEZ and SARJEANT, 1972, tables 3, 6.

Emended description: Cysts proximochorate, spheroidal to broadly ovoidal, body two-layered; autophragm smooth, up to 1μ thick, and forming numerous nontabular processes. Processes tubiform, normally expanded proximally and more so distally, smooth, 5μ to 8μ long, 1μ to about 2μ wide at midlength, tips of adjacent processes frequently connected distally. Processes and intervening areas covered by a thin (<0.5μ), smooth ectophragm whose distance from underlying autophragm is essentially uniform. Paratabulation not expressed. Archeopyle apical, outline of archeopyle and shape of operculum unknown; operculum apparently has many nontabular processes (exact number uncertain). Antapical area with one, or occasionally two, coronas; base of corona thicker than autophragm, densely setate, and convex distally; walls smooth, rim commonly thickened distally, distal diameter greater than proximal diameter. On forms with two coronas, the antapical corona is generally the larger. Overall length 41μ to 60μ.

Type specimen: Holotype, specimen Sc2/31/2 shown in Sarjeant (1961, pl. 15, figs. 12-13). Paratype, specimen SC2/31/12 (not illustrated). Both specimens lodged in collections of the Micropaleontology Department, University of Sheffield, England; reg. nos. ML399 and ML400, respectively.

Type locality: Scarborough Castle Cliff, Yorkshire, England.

Type stratum: Oxford Clay, one foot from the top of the underlying Hackness Rock, Upper Jurassic (Oxfordian; *Cardioceras cordatum* Zone).

Stephanelytron tabulophorum Stover, Sarjeant and Drugg, **n. sp.**
Plate 1, figures 12-13

Description: Cysts proximochorate, ellipsoidal, outline in dorsal-ventral view roundly hexagonal, longitudinally elongate. Body two-layered; autophragm thin (<1μ), smooth to faintly granulate, and bears relatively short, closely spaced, tubiform, parasutural and penitabular processes. Processes smooth, expanded slightly distally, 2μ to 4μ long, and 0.5μ to 1μ wide at midlength. Entire cyst enclosed by a thin, slightly folded or crumpled ectophragm.

Paratabulation indicated by parasutural penitabular features, formula: ?1′, 5″, 6c, 5‴, 1⁗, 1p, 2s. Outline of apical and antapical paraplates unknown; outlines of most precingular and postcingular paraplates subrectangular and longitudinally elongate, first postcingular paraplate generally smaller than others and trapezoidal; posterior intercalary paraplate also trapezoidal and smaller than first postcingular paraplate. Paracingulum clearly indicated by six rectangular, transversely elongate paraplates. Antapical corona smooth-walled, length about the same as that of the processes, base thicker than autophragm, and occupies a major part of the anterior surface. Overall length 47μ to 67μ.

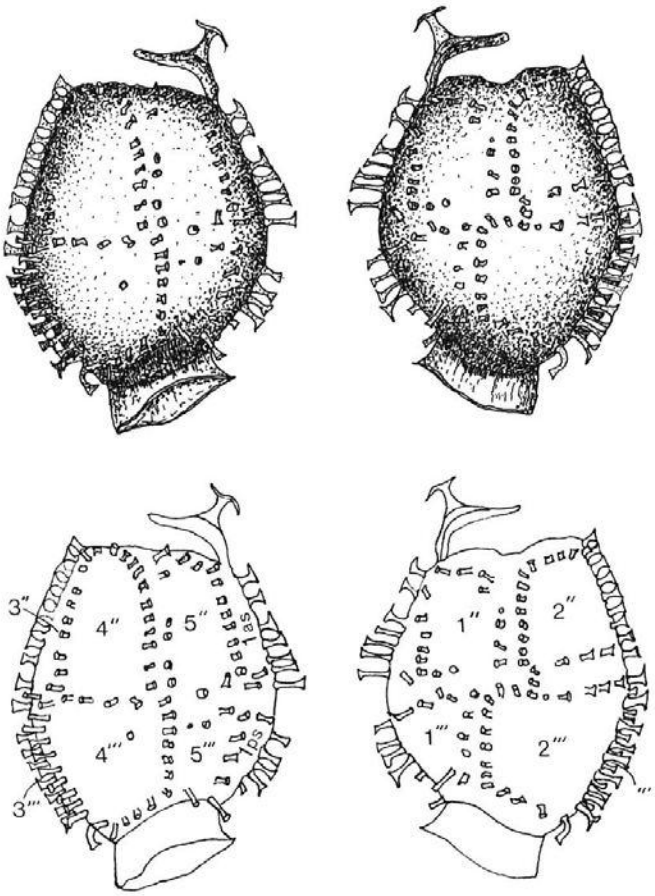
Type specimens: Holotype, specimen COFRC 31504(8)27-92. Isotype, specimen COFRC 31504(8)-22-108. Specimens presently in Chevron Oil Field Research Company collection, La Habra, California.

Type locality: Reutlingen, Germany.

Type stratum: Middle of Dogger Zeta (Callovian; *Peltoceras athleta* Zone).

Comparison: Stephanelytron tabulophorum is similar to *S. redcliffense* and *S. caytonense* in having the paratabulation indicated by parasutural and penitabular features, and differs from both species in having a well-developed paracingulum. The new species differs from *S. scarburghense* in having parasutural and penitabular rather than nontabular processes. The corona on *S. tabulophorum* is generally less prominent than on the other species of *Stephanelytron*.

Remarks: Specimens of *Stephanelytron tabulophorum* exhibit a tendency to develop penitabular rows of processes near the longitudinal boundaries of precingular and postcingular paraplates, and especially on the dorsal surface. Single parasutural rows of processes occur along and within the paracingulum and bordering the parasulcus. Longitudinal splits may occur on the epicyst and extend between the closely spaced rows of penitabular processes, if such rows are present.



TEXT-FIGURE 2
Stephanelytron sp. A. Specimen 750124 in ventral (left) and dorsal views. Upper: drawing shows character of processes and corona (ectophragm not shown). Lower: interpretation of tabulation. ×1000.

Stephanelytron sp. A
Plate 1, figure 14; text-figure 2.

Stephanelytron cf. *redcliffense* GITMEZ and SARJEANT, 1972, p. 238, pl. 14, fig. 7—SARJEANT, 1976, pl. 7, fig. 3.

Remarks: A few specimens included under this heading possess parasutural processes that are narrower and less expanded distally than those on specimens of *Stephanelytron redcliffense.* The parasutural rows may be composed of numerous, closely spaced processes or of a few separated processes. Additionally, some scattered processes are present on most paraplates. These processes tend to occur near the parasutural processes, sometimes forming incomplete rows; in consequence, they may give the erroneous impression that the cysts have penitabular rather than parasutural rows of processes (see text-figure 2). A ventrally adherent apical operculum with a single, central process that is wider than others on the cyst is present on the illustrated specimen; also discernible are remnants of the thin ectophragm. Overall length 41μ to 79μ.

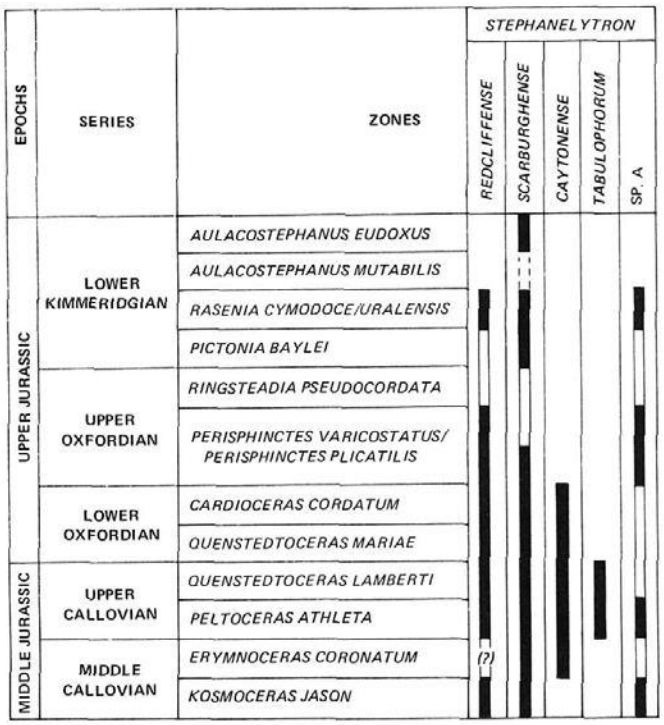
Illustrated specimen: Specimen 750124, Oxford Clay, Locality 1 (see p. 337); lodged in the collections of Exxon Production Research Company, Houston, Texas.

DISCUSSION OF SPECIES

Four species—*Stephanelytron caytonense, S. redcliffense, S. scarburghense, S. tabulophorum*—and an unnamed form, *Stephanelytron* sp. A, are now included in the genus. The fundamental morphology of these species is uniform in that the cysts are two-layered, having an autophragm that bears processes and an ectophragm that normally encloses the entire cyst. The single unifying and diagnostic feature, however, is the possession of an antapical corona or coronas. Tubiform processes are present on all species; however, the details of their morphology differ from one species to another and more importantly, their distribution is not the same on all species. Differences in the arrangement of the processes relate directly to the clarity with which the paratabulation is expressed and the ease with which it can be deciphered. In *S. redcliffense* the processes are arranged in parasutural rows and in *S. tabulophorum* in parasutural and penitabular rows; the paratabulation on these species is consequently relatively easy to determine because the precingular and postcingular paraplates are generally clearly delimited. The paratabulation is expressed most completely on *S. tabulophorum* on which the paracingulum is prominently indicated by parasutural features. In contrast, the paracingulum is either not expressed at all or, at best, vaguely indicated on *S. redcliffense.*

As indicated previously, differences between *S. caytonense* and *S. redcliffense* are less definitive than those between other species; the two species most likely represent the end members of a single morphological plexus. Justification for their individual retention rests in part on their different stratigraphic ranges and in part on *S. caytonense* having a more nearly circular outline and processes that are commonly perforate.

Stephanelytron sp. A differs from *S. redcliffense* by having scattered nontabular processes in addition to the parasutural processes. Its processes appear to be more slender than those observed on specimens of *S. redcliffense*; but too few specimens of *Stephanelytron* sp. A have been identified to enable any more detailed commentary. On *S. scarburghense* the processes are nontabular and, except for indefinite indications of possible alignments of processes, the



TEXT-FIGURE 3
Stratigraphic distribution of *Stephanelytron*. Solid rectangles = occurrences; open rectangles = nonoccurrences; dashed lines = possible extension of range; (?) = provisional identification.

paratabulation is only vaguely expressed or not expressed at all in this species.

DISTRIBUTION AND OCCURRENCE

Since first reported from the Upper Jurassic Oxford Clay of England (Sarjeant, 1961), *Stephanelytron* has been recorded from France (Gitmez, 1970; Gitmez and Sarjeant, 1972) and from the Queen Elizabeth Islands, northeastern Canada (Johnson and Hills, 1973). More extensive, unpublished records are from Middle and Upper Jurassic strata from West Germany, Scotland, the North Sea Basin, the Grand Banks area of offshore eastern Canada, the Arctic Slope of Canada and Alaska, peninsular Alaska (Cook Inlet), and the western United States (Wyoming).

Just as the knowledge of the geographic distribution of *Stephanelytron* has increased, so has information about the stratigraphic occurrences of its species; this is summarized in text-figure 3. The overall range of the genus is Middle Jurassic (middle Callovian, *Kosmoceras jason* Zone) to Upper Jurassic (lower Kimmeridgian, *Rasenia cymodoce* Zone). The occurrence in the lower Kimmeridgian *Aulacostephanus eudoxus* Zone is based on a single specimen that may be redeposited. If this is so, then *S. redcliffense* and *S. scarburghense* have the longest stratigraphic ranges and their ranges correspond exactly with that of the genus. *Stephanelytron redcliffense* is also the most frequently occurring species, whereas *S. tabulophorum* is known from the least number of specimens and has the shortest stratigraphic range.

The utility of *Stephanelytron* as an important stratigraphic indicator rests on its relatively limited vertical distribution within the Jurassic, and its rather wide geographic occurrence. Unfortunately, two factors reduce its effectiveness as a model index fossil. First, specimens are relatively rare (typically less than 2% of the total microplankton association) and therefore may not be present in sparse assemblages. Second, specimens are often crumpled and distorted; consequently, specific identifications may be difficult. Usually, however, the corona—the single most diagnostic feature of the genus—is easily discernible even in poorly preserved material. As more information about *Stephanelytron* accumulates, additional species may be recognized and the stratigraphic significance of the genus should be enhanced.

LOCALITIES—illustrated specimens only

Locality 1. East of Houlgate, Calvados, France, at geographic coordinates 49°19′ N., 00°03′ W.; Oxford Clay.

Locality 2. Warboys Brick Pit, Huntingdonshire, England; Upper Oxford Clay.

Locality 3. Reutlingen, West Germany; middle of Dogger Zeta, Callovian.

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PLATE 1

1–6 *Stephanelytron redcliffense* Sarjeant, emend. 1a-d, dorsal views of specimen shown at successive focus levels from dorsal to ventral surface. Relatively large (wide) single process in focus at center top of figure 1c. Locality 1, specimen 750108. ×625. 2a-c, dorsal views of specimen, from dorsal to ventral surfaces. Locality 2, specimen 4(3)44-101. ×650. 3a-b, posterior part of another specimen showing corona at two focus levels. Relatively thick, antapically convex setate base of corona shown in 3b. Locality 1, specimen 750104. ×1000. 4a-c, interior (apical) views of corona at successively higher focus levels. Locality 1, specimen 750101. ×625. 5, detail of processes, corona, and part of ectophragm in posterior area of another specimen. Locality 1, specimen 750129. ×625. 6, marginal part of another specimen showing parasutural alignment of processes. Locality 1, specimen 750109. ×625.

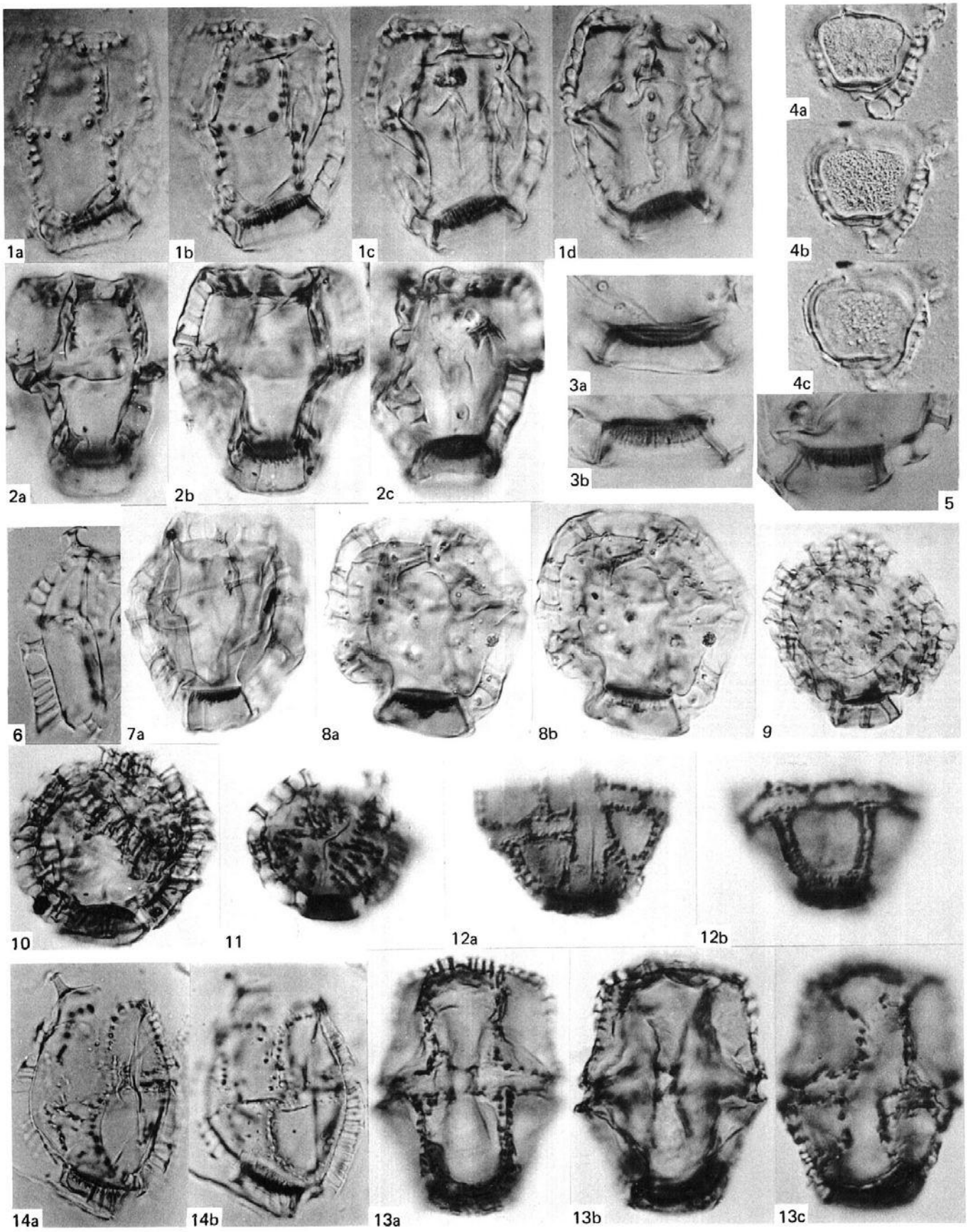
7–8 *Stephanelytron caytonense* Sarjeant, emend. 7a, specimen with relatively narrow corona. Locality 2, specimen 6(3)46-94. ×650. 8a-b, another specimen shown at high and low focus levels. Locality 2, specimen 6(3)33-102. Both specimens illustrate sparseness of processes, their finely perforate sculpturing and well-developed, complete ectophragm. ×650.

9–10 *Stephanelytron scarburghense* Sarjeant, emend.
9, specimen with single corona. Locality 2, specimen 6(3)44-102. ×650. 10, specimen with two coronas. Locality 2, specimen 7(3)18-100. ×650.

11 *Stephanelytron* sp. cf. *S. scarburghense* Sarjeant, emend.
Small specimen with processes apparently arranged in intratabular groups. Locality 3, specimen (12)17-98. ×650.

12–13 *Stephanelytron tabulophorum* Stover, Sarjeant, and Drugg, n. sp.
12a-b, ventral views of ventral and dorsal surfaces of isotype. Specimen (8)22-108 showing paracingulum and penitabular rows on hypocyst. Locality 3. ×650. 13a-c, dorsal views of holotype from dorsal to ventral surfaces. Locality 3, specimen (8)27-92. ×650.

14 *Stephanelytron* sp. A.
Left lateral views of specimen with adherent operculum, and with parasutural and penitabular rows of processes as well as isolated, scattered processes. Operculum appears to have a single, central process. Locality 1, specimen 750124. ×625.


1a
1b
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4a
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7a
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12a
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14a
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13b
13c

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