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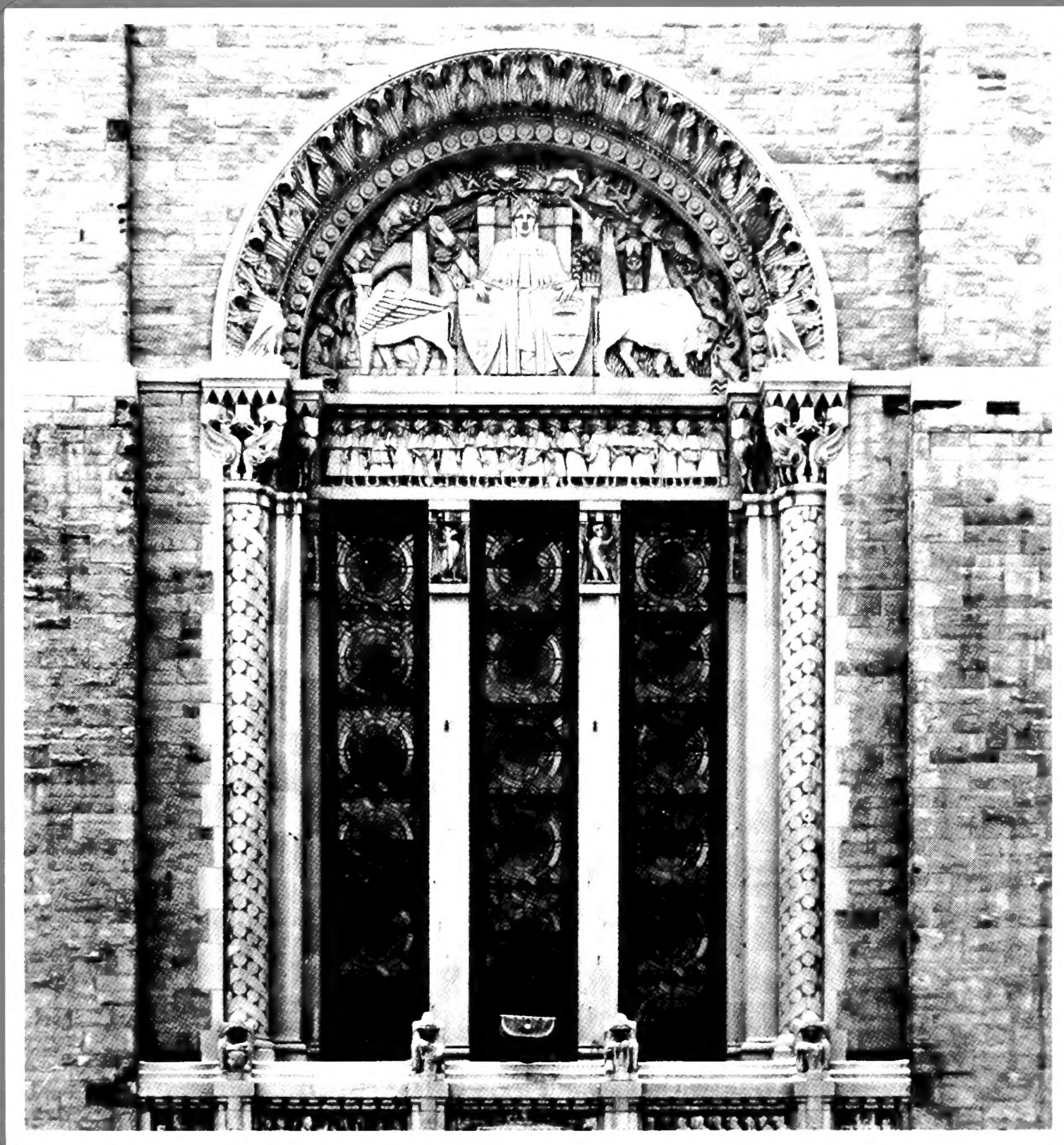

Late Palaeozoic Species of *Ellisonia* (Conodontophorida)

Evolutionary and Palaeoecological Significance

Peter H. von Bitter
and
Glen K. Merrill

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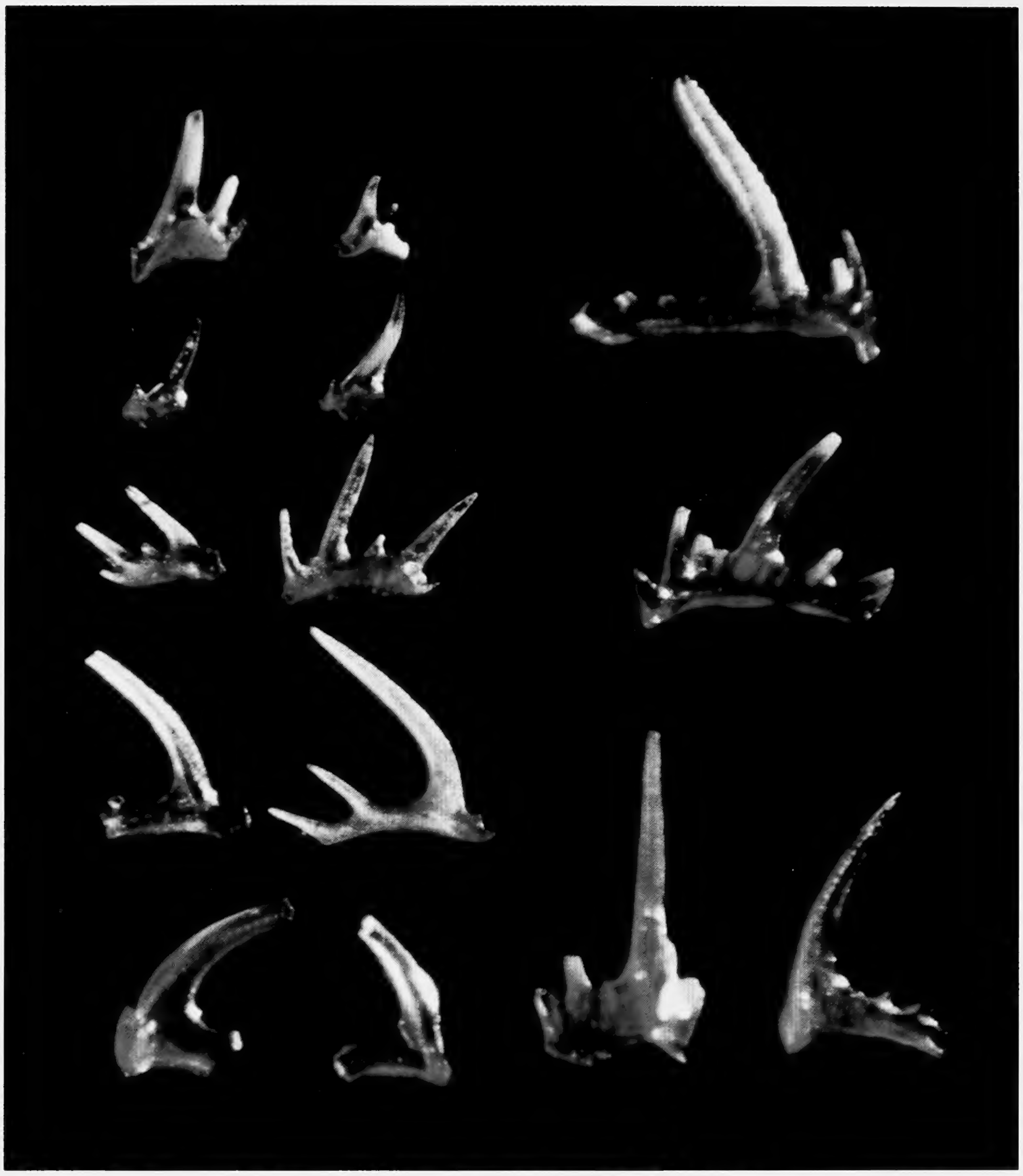

The apparatus of *Ellisonia conflexa* (Ellison), left and middle columns; and of *Ellisonia latilaminata* sp. nov., right column; showing typical colour, transparency, and white matter.

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Contents

Late Palaeozoic Species of *Ellisonia* (Conodontophorida) Evolutionary and Palaeoecological Significance

Abstract

Ellisonia latilaminata sp. nov. (Morrowan to middle Missourian), and its probable descendant *E. conflexa* (Ellison) (middle Desmoinesian to upper Virgilian), possibly evolved from a species of *Magnilaterella* during the Late Mississippian. These two rare Pennsylvanian ellisonid conodont species have distinct apparatus plans and possess up to five element types. The element composition of these two species is notable for its plasticity, and the five element types were not necessarily all present in any one animal (or population of animals) at a particular time. Hi and Tr elements were present most or all of the time, whereas the presence of Pl, Oz, and Ne elements was an exceptional biological event, increasing in rarity in the order listed.

The basal cavities of the two ellisonid species may be completely closed and everted (*E. latilaminata* sp. nov.) or shallow and flaring [*E. conflexa* (Ellison)]. Species of *Ellisonia* show a strong tendency towards the development of either of these two morphologies throughout the stratigraphic range of the genus, and both morphologic expressions may be found in the same species.

Unaltered glassy specimens of the two species lack appreciable white matter. In this respect, in terms of the large, flaring basal cavities of some of the elements, and in aspects of ultrastructure and micromorphology, they are similar to Ordovician neurodont hyaline conodonts. The similarities between Pennsylvanian ellisonids and Ordovician neurodont hyaline conodonts extend to similar palaeoenvironments as well. Neurodont hyaline conodonts were common in highly saline, shallow, warm-water seas as part of the nearshore marine community. Pennsylvanian ellisonids most commonly lived under nearshore, schizohaline, often high-energy environments in the *Cavusgnathus* biofacies.

Pennsylvanian ellisonids, although rare, are the ancestral stock that survived the Early Permian crisis documented by some conodont workers. From this stock evolved the abundant Ellisonidae that flourished during the Middle and Late Permian and the Triassic. Included in the latter group are Early Triassic ellisonids, some of which are remarkably similar in structure and morphology, and probably in palaeoecology, to Pennsylvanian ellisonids and to Ordovician neurodonts. Neurodonts and neurodontlike conodonts are interpreted to be similar functional adaptations to the same environmental stresses. Conodonts that adapted in this manner lived under nearshore, euryhaline (with characteristically abnormal salinity ranges), often high-energy conditions between Middle Ordovician and Early Triassic times.

Introduction

Virtually every North American conodont fauna of Pennsylvanian age ever processed contains conodonts that are difficult to identify; among these are certain conodont elements, generally present as only one or two specimens per sample, that may be referred to species of the genus *Ellisonia*. Researchers have generally been uncertain how to deal taxonomically with these uncommon conodonts and often have referred them to such open taxonomic assignments as "*Euprioniodina* ? sp." (Gunnell, 1933), or to such taxonomic categories as "Unassigned B_3 element" (Baesemann, 1973), "Unassigned Type 3 element" or "*Ligonodina* sp." (Perlmutter, 1975). Ellison (1941) was the first to name the species *Prioniodus ? conflexus* on the basis of conodonts from the Virgilian of

Kansas that we now consider to be components of a species of *Ellisonia*, and von Bitter (1972) reconstructed the apparatus of this species. The confused taxonomic history of the Pennsylvanian and Permian species, which we consider belong to *Ellisonia*, since 1933 is shown in Table 1.

Pennsylvanian and Lower Permian species of *Ellisonia* are noteworthy for several reasons. Although the elements of species of this genus are never abundant and the animals bearing them lived in various habitats and environments, their elements are predictably most abundant in the *Cavusgnathus* biofacies (Merrill and von Bitter, 1976; Merrill, 1980a, fig. 3). The conodonts of this biofacies lived in shallow water, under schizohaline, commonly high-energy conditions. Furthermore, elements of certain Pennsylvanian species of *Ellisonia* are internally and externally similar to the neurodont conodonts, a group that was common during the Ordovician. Similarities extend to parallels in environmental niches as well, and it is difficult not to consider Pennsylvanian ellisonids as late Palaeozoic neurodonts. Moreover, although Pennsylvanian and Early Permian species of *Ellisonia* are multielemental throughout their stratigraphic range, they display two strikingly different apparatus plans. Finally, although species of *Ellisonia* are rare in the Pennsylvanian and Lower Permian, they are important as the ancestral stock that survived the Permian crisis described by Clark (1972) and are ancestral to the abundant Ellisonidae (Clark, 1972:157) that flourished during the Middle and Late Permian and the Triassic.

Materials and Methods

The nearly 1200 specimens studied were recovered during the last 20 years, generally as a byproduct of our studies of the distribution of the more abundant, platform-bearing species of conodonts. These studies involved the sampling of rocks of Pennsylvanian and Permian age in four distinct geographic and geologic areas, the Appalachians, the Illinois Basin, the Midcontinent region, and Texas. Conodonts that were identified as belonging to species of *Ellisonia* were removed from each sample and mounted on standard micropalaeontological slides and the abundance of each element type was tabulated (Appendix 1). Selected specimens were photographed at the University of Toronto, using two Cambridge scanning electron microscopes, models S2 and S180.

The element terminology used has been modified from Jeppsson (1971). We recognize five clearly defined types of elements as being anatomical parts of species of *Ellisonia*. These are termed ozarkodiniform (Oz), neoprioniodontiform (Ne), plectospathodontiform (Pl), hindeodelliform (Hi) and trichonodelliform (Tr). For a consideration of the difficulties encountered in homologizing these five element types with those of other species of conodonts, we refer the reader to the section dealing with the biologic distribution of individual element types (p. 12).

Fager coefficients were derived by following the procedure outlined by Kohut (1969) for Ordovician conodont faunas. This coefficient was used previously by Ellison (1963) and by Valentine and Peddicord (1967) for calculating the degree of association of fossil assemblages. The coefficient was given by the latter authors (1967:503) as

$$FC = \frac{c}{\sqrt{ab}} - \frac{1}{2\sqrt{min\ (a,\ b)}}$$

where a and b are the number of variables (conodont elements in our case) contained in categories (samples) A and B respectively, and c is the number of variables common to both categories. *Min (a, b)* is the smaller of the numbers a and b.

Most specimens illustrated are housed in the micropalaeontological collections at the Royal Ontario Museum. Exceptions are those that have the abbreviations GSC (Geological Survey of Canada) and UKMIP (University of Kansas Museum of Invertebrate Paleontology) preceding catalogue numbers. Most unfigured specimens tabulated in Appendix 1 that are not at the University of Kansas (see von Bitter, 1972) are deposited in the micropalaeontological collections of the Royal Ontario Museum. The remainder are in the second author's research collection.

The Genus Ellisonia

The conodont genus *Ellisonia* was established by Müller (1956) on the basis of bilaterally symmetrical conodont elements of Lower Triassic age from the *Meekoceras* Zone of Nevada that possess a posterior bar but lack a basal cavity. Sweet (1970a, b) reconstructed the apparatus of the type species, *E. triassica*, and included four types of elements in the apparatus of this species. He included the unpaired bilaterally symmetrical Tr element and three paired elements (LA, LB, and LC in his terminology), all bladelike, with fully everted attachment surfaces.

Table 1. Prior citations of some Pennsylvanian and Lower (±) Permian specimens belonging or probably belonging to species of *Ellisonia*

These are arranged chronologically by date of publication and illustrate the widely differing opinions as to generic assignment.

NAME	AUTHOR	UNIT	AGE/LOCALITY	NUMBER OF SPECIMENS
Euprioniodina ? sp.	Gunnell (1933, pl. 33, fig. 24 only)	Americus Limestone(?)	Permian(?), Kansas	1(?)
Subprioniodus spp.	Gunnell (1933)	Quivira Shale to Americus Limestone(?)	Missourian to Lower Permian(?)	3(?)
Prioniodus ? *conflexus*	Ellison (1941)	Larsh-Mission Shale to Hughes Creek Shale	Virgilian to "Big Blue Series", Kansas	?
Lonchodina festiva	Bender and Stoppel (1965)	–	Sosio Stage, Middle Permian, Sicily	2
Neoprioniodus ? *expandofundus*	Webster (1969)	Bird Spring Formation	Derryan, Nevada	3
Hibbardella sp. A	Webster (1969)	Bird Spring Formation	Derryan, Nevada	1
Delotaxis ? *conflexa*	von Bitter (1972)	Shawnee Group	Virgilian, Kansas	105
Unassigned B_3 element	Baesemann (1973)	Kansas City Group	Missourian, Kansas	
Unassigned B_1 element	Baesemann (1973)	Kansas City Group	Missourian, Kansas	21
Magnilaterella cf. *M. contraria*	Baesemann (1973)	Kansas City Group	Missourian, Kansas	
Stepanovites meyeni	Kozur and Movschovitsch *in* Kozur (1975)	Dolgoscel Shale	upper lower Kazanian, USSR	?
Stepanovites dobruskinae	Kozur and Pjatakova *in* Kozur (1975)	–	lower Dzhulfian, USSR	?
Ligonodina sp.	Perlmutter (1975)	Stotter Limestone to Speiser Shale	Virgilian to Gearyan, Kansas	48
Unassigned Type 3 element	Perlmutter (1975)	Bennett Shale	Gearyan, Kansas	1
"*Delotaxis*"	Merrill (1975)	Kewanee and McLeansboro Formations	Desmoinesian, Illinois	133
Neoprioniodus? *expandofundus*	Rabe (1977)	Diamante Formation	Morrowan or Atokan, Colombia	1
Subprioniodus? sp.	Toomey et al. (1977)	Holder Formation	Virgilian, New Mexico	1
?*Ellisonia* elements	Szaniawski and Malkowski (1979)	Kapp Starostin Formation	Svalbardian, Spitzbergen	5(46?)
Stepanovites alienus	Kozur and Movschovitsch *in* Movschovitsch et al. (1979)	Kamai Formation	upper Artinskian, Urals, USSR	3
Stepanovites festivus	Kozur and Movschovitsch *in* Movschovitsch et al. (1979)	?Kamai Formation	upper Artinskian, Urals, USSR	?
Stepanovites conflexa	Bender (1980)	Nansen and Hare Fiord Formations	Morrowan-Atokan, Canadian Arctic	18
Ellisonia sp(p).	Merrill (1980a)	Shoal Creek Limestone	middle Missourian, Illinois	5
Ellisonia sp.	Merrill (1980b)	Marble Falls Limestone	Morrowan, Texas	2

As well as reconstructing the apparatus of the type species, Sweet (1970a, b) expanded the concept of *Ellisonia* by including in this genus six additional species. These six, and the type species *E. triassica,* apparently lack a platform in their apparatuses. These six species differ from each other and from the type species in a number of details. The white matter in *E. delicatula* was described as confined to the tips and the axial region, whereas elements of *E. triassica* were described as opaque and almost uniformly white. Similarly, although elements of the type species were described as possessing completely "everted" attachment surfaces, this feature was not noted on elements of the six other species of the genus. *E. teicherti* was described as possessing an escutcheonlike attachment surface on the inner side of the element; it would presumably be placed in the genus *Hindeodus* (see Sweet, 1976; *in* Ziegler, 1977) because it is known to have possessed a platformlike element in its apparatus (Baesemann, 1973).

Ellisonia, therefore, is a broad generic category, the breadth of which was not defined by Sweet (1970a, b). We include in this genus the Pennsylvanian and Permian species that were placed in *Delotaxis?* by von Bitter (1972) and in *Stepanovites* by Kozur (1975). Species of the latter were described as lacking platform elements and as having four different types of elements in their apparatuses. The basal groove of individual elements was described as broad with a slightly enlarged basal cavity. Kozur (1975) noted that in species of *Stepanovites* either the white matter was lacking or it was present only sporadically in individual denticle tips.

Our opinion is that the presence of a broad basal groove and the absence of white matter (except in some denticle tips) in species of *Stepanovites* are taxonomic characters that fall within the range of variability of species of *Ellisonia*. Not only were species of *Ellisonia* recognized to be variable with regard to the distribution and presence or absence of white matter, but characteristics of the aboral attachment surface were equally broad in definition (Sweet, 1970b). We conclude, as did Szaniawski and Malkowski (1979), that *Stepanovites* is a junior synonym of *Ellisonia* and we define characters of the latter genus in the section dealing with systematics.

We also include in *Ellisonia* the species that Staesche (1964) included in *Pachycladina* and in *Hadrodontina*, including *Hadrondontina, lapsus*. *Pachycladina* and *Hadrodontina,* conodont genera based on conodonts from the Scythian (Lower Triassic) of Austria, are junior synonyms of *Ellisonia* for reasons of priority and the fact that individual elements of species assigned to these genera by Staesche (1964) are morphologically indistinguishable from, and can be easily homologized with, those of species of *Ellisonia*. Staesche (1964) for the most part used histological characteristics to define these two genera; these internal characteristics are found in species of *Ellisonia*, and in addition the elements placed by Staesche (1964) in these two genera possess external morphological features diagnostic of species of *Ellisonia*. These external characteristics include element morphology and homology as well as the presence of symmetry transitions—criteria that have proven to be of great significance to multielement taxonomy since apparatus reconstruction began to be practised more extensively.

Pachycladina was defined by Staesche (1964:277): "Conodonts of the denticle-row type with a bar that is strongly thickened in breadth and height and on whose upper surface clearly visible, thickened lateral edges are present. Many germ denticles are present within the bar. The forms are glasslike and transparent." (Translation by P.H. von Bitter). The conodonts included in *Pachycladina* by Staesche (1964) show the discrete, strong denticulation that is characteristic of species of *Ellisonia* and they, like many species of *Ellisonia,* are glasslike and transparent, lacking appreciable white matter. As discussed elsewhere we regard broad, flaring basal cavities and closed, everted basal cavities to be closely related morphologic features that are characteristic of species of *Ellisonia*. Although the six species of *Pachycladina* defined by Staesche (1964) are strongly everted, they are morphologically remarkably similar to the five elements of *Ellisonia conflexa* (Ellison), a species whose elements are characterized by open, flaring basal cavities.

Although Staesche (1964:295) remarked on the histological similarity and common ranges of the six new species of *Pachycladina,* his belief that a conodont apparatus must have platform, lonchodiniform, and hindeodelliform elements—elements that he was unable to locate in the samples containing his six species—prevented him from considering the six as the component elements of a single species. Conodont workers now recognize that the apparatuses of many conodont species contained none of these elements. On the basis of histological similarity, common ranges, everted basal cavities, and homology with the elements of other conodont apparatuses, we conclude that the six element types belonged to a single species. They form an apparently complete symmetry transition with one another and each element can, for example, be homologized without difficulty with the elements of *Ellisonia conflexa* (Ellison). The *obliqua* element is homologous with the *E. conflexa* Pl element, the *symmetrica* element with the *E. conflexa* Tr element, the *longispinosa* element with the *E. conflexa* Hi element; and the *tricuspidata* element is part of a symmetry transition between the *obliqua* and *symmetrica* elements. The *inclinata* and *lata* elements are homologous to the *E. conflexa* Oz element, and the *lata* element is apparently a part of a symmetry transition with the *symmetrica* element.

Hadrodontina was defined by Staesche (1964): "Conodonts of the denticle-row type with strong thickening of the denticles. All denticles are clearly added consecutively after the previously added ones have reached a particular size. The interiors of denticles are entirely filled with bubbles that generally describe their own cone-in-cone structure." (Translation by P.H. von Bitter.)

The five species of *Hadrodontina* described by Staesche (1964) show the discrete, strong denticles characteristic of species of *Ellisonia* and both the open and everted basal cavities found in species of that genus. Their denticles contain abundant white matter in the form of bubbles, and, although we believe that this characteristic may be developed secondarily in some species of *Ellisonia,* in the distribution of white matter they are most similar to many specimens of *Ellisonia latilaminata* sp. nov. Of the five elements placed in species of *Hadrodontina* by Staesche (1964), two, the *aequabilis* and n. sp. A elements, have relatively open basal cavities and are easily homologized with and are morphologically remarkable similar to the Oz and Hi elements of *Ellisonia conflexa* (Ellison) and the *inclinata* and *longispinosa* elements of Staesche (1964). The *anceps, adunca,* and *biserialis* elements all have strongly everted basal cavities and are not as easily homologized with the elements of other apparatuses.

The subsymmetrical *adunca* element is probably a Tr element in form, function, and position, and is probably homologous with the Tr elements of *E. conflexa* and *E. latilaminata* sp. nov., as well as with the *symmetrica* element of Staesche (1964). The *anceps* element is morphologically homologous with the Pl element of *E. conflexa* (Ellison) and the *obliqua* element of Staesche (1964). Staesche (1964:273) noted transition forms between the *anceps* and *adunca* elements, indicating the possible existence of a symmetry transition. Finally, the *biserialis* element of Staesche (1964), although difficult to homologize, may represent an Oz element that is comparable with the *E. conflexa* Oz element, or with the *aequabilis, inclinata,* or *lata* elements of *Pachycladina* (Staesche, 1964).

Our attempt to homologize the five element types placed in *Hadrodontina* by Staesche (1964) with those present in species of *Ellisonia* has been moderately successful and we interpret all of these elements to have belonged to species of *Ellisonia.* The lack of convincing symmetry transitions between these elements and the disparate stratigraphic ranges of most of the five element types prevents us, however, from formulating any conclusions regarding the number of species of *Ellisonia* represented by the five element types.

The external and internal characteristics of some Pennsylvanian, Permian, and Triassic species of *Ellisonia* are sufficiently unusual to be notable. Large, flaring basal cavities and lack of appreciable white matter were reported in *Delotaxis*? [=*Ellisonia*] *conflexa* (Ellison) by von Bitter (1972) and in *Stepanovites* [=*Ellisonia*] *meyeni* and *S. dobruskinae* by Kozur and Movschovitch, and Kozur and Pjatakova respectively (*in* Kozur, 1975). The alternate expression of open, flaring basal cavities, everted basal cavities, and lack of appreciable white matter in glassy conodonts was noted by Staesche (1964) in the six species he placed in *Pachycladina* [=*Ellisonia*]. These species are strikingly similar in these and other characteristics to Ordovician neurodonts and we explore similarities and possible relationships of these two groups elsewhere.

We conclude that the tendency towards a flaring basal cavity found in some elements of species of *Ellisonia* is a persistent and diagnostic morphologic feature that recurs at different times. This tendency reaches full expression in the Pennsylvanian species *Ellisonia conflexa* (Ellison), in which three of the five element types making up the apparatus possess large, flaring basal cavities. This is in sharp contrast to the type species in which the basal cavity is totally everted and also to the apparent ancestor of *E. conflexa, E. latilaminata* sp. nov., which also has an everted basal cavity. In *E. conflexa* elements with large, flaring basal cavities are associated in the apparatus with two other elements that possess large and open basal cavities without noticeable flare. Of the three flaring elements in the apparatus of this species, it is the Pl element that is most common in our collections. The homologous element in Permian and Triassic species of *Ellisonia* is also the most commonly recognized element showing this tendency. Sweet (1970a, pl. 1, fig. 10) illustrated what we would consider a Pl element with a large, flaring cavity in the apparatus of the type species of *Ellisonia, E. triassica.* We assume that this element corresponds to the LA element of Sweet (1970b, pl. 5, fig. 15) that he (1970b:236) considered to be identical to the two element types that Müller (1956) described as *Hibbardella subsymmetrica* and *Neoprioniodus unicornis*. von Bitter (1972) pointed out the similarity between the Pl element of *E. conflexa* and the Permian species, *Lonchodina festiva* (Bender and Stoppel, 1965). The Hi element of the latter, according to Kozur (1975) and Kozur and Movschovitsch (*in* Movschovitsch et al., 1979, as *Stepanovites festivus*), is known, and we place this Permian species in *Ellisonia*. *Lonchodina inflata* Bender and Stoppel, the apparatus of which is, according to Kozur (1975), completely known and assigned to *Stepanovites* by Kozur and Movschovitsch (*in* Movschovitsch et al., 1979) appears to have a similar Pl element in its apparatus, and we consider that it too should be placed in *Ellisonia*. Finally, the two Permian species, *E. meyeni* (Kozur and Movschovitsch) and *E. dobruskinae* (Kozur and Pjatakova), both contain Pl elements, termed prioniodiniform or PB elements by Kozur (1975), that are morphologically homologous to those of the other

Pennsylvanian, Permian, and Triassic species of *Ellisonia* considered. Thus complete reversal between broad, flaring expanded basal cavities and those that are everted appears to be a generic characteristic of *Ellisonia*.

The conodonts making up the apparatus of the type species of *Ellisonia, E. triassica,* were characterized by Sweet (1970b) as having a completely "everted" attachment surface beneath all elements representing the late stages of growth. As well as being a feature dependent upon ontogenetic development in Late Permian and Triassic material (observed by Sweet, 1970b) the presence or absence of eversion in Pennsylvanian (and probably Permian) species of *Ellisonia* was also influenced by other factors. These may have been either evolutionary or environmental, but conodonts bearing everted basal cavities have been found only at certain stratigraphic levels. This morphological feature is shown most clearly by two species, *E. latilaminata* sp. nov. and *E. triassica,* representing the opposite ends of the known stratigraphic range of the genus. Between the stratigraphic occurrences of these two species are several species of *Ellisonia,* some elements of which show either this feature or large, flaring basal cavities, which in our view are related to and intergradational with everted basal attachment surfaces.

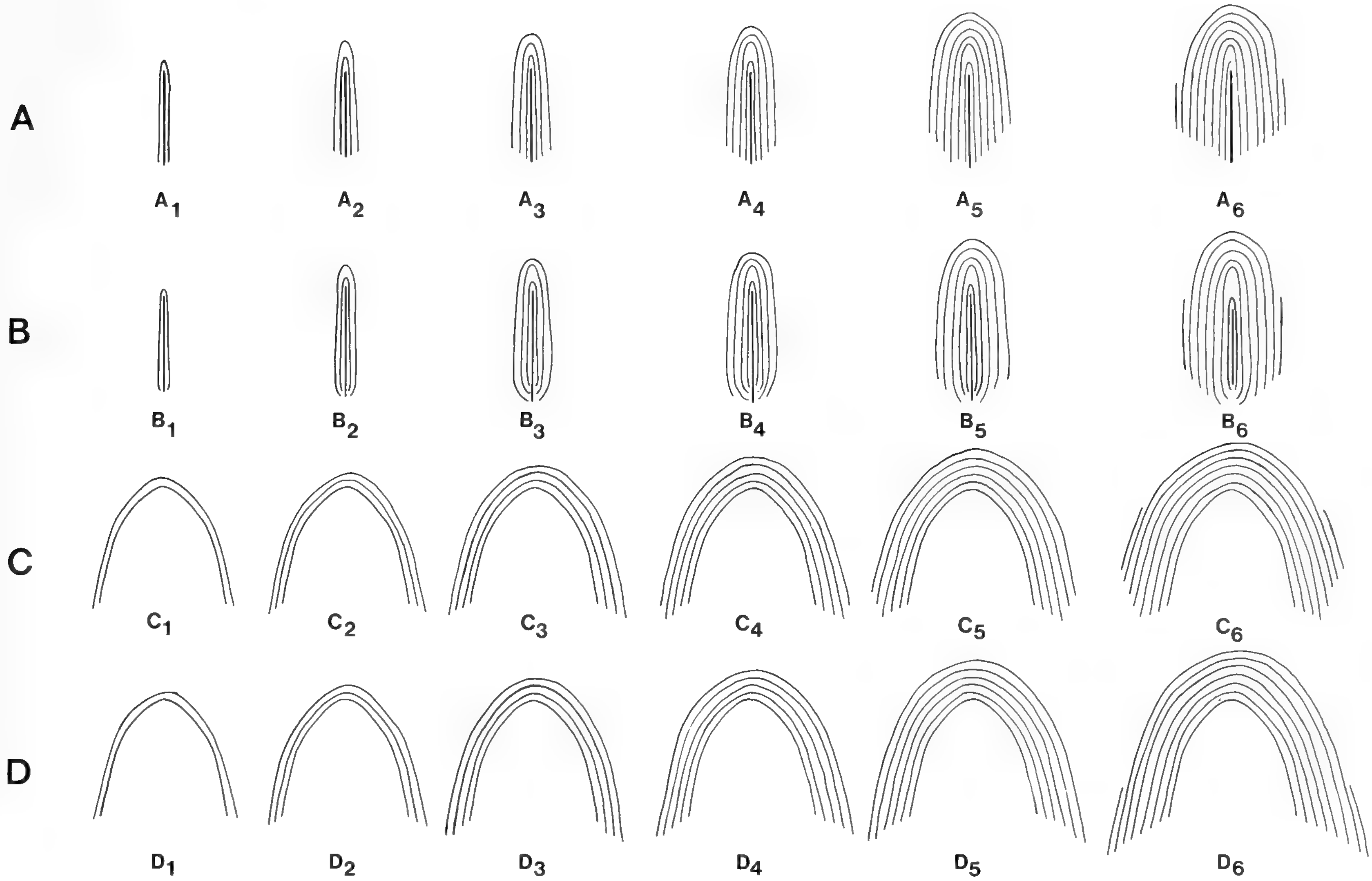
Younger Permian and Triassic ellisonid species contain at least three element types. Two, the Hi and Tr elements, may show strong basal cavity eversion, whereas the third, the Pl element, commonly shows a combination of eversion of the basal attachment surface and the flaring basal cavity discussed previously. Kozur and others (*in* Kozur, 1975) described the species *E. meyeni* and *E. dobruskinae* as possessing open basal cavities that flare in the Pl element. Nevertheless, their illustrations (pl. 4, figs. 4, 6, 7, 8, 10) suggest some eversion of the basal cavity. As was noted, *E. conflexa* is characterized by elements that have large, open basal cavities. Occasionally, individual elements, specimens ROM 39748 and ROM 39752 (Pl. 6, figs. 5, 9) for example, are found that appear to be atypical because of a tendency towards filled basal cavities, a tendency that we consider to represent "eversion" of the attachment surface. We also regard the large, shallow, flaring basal cavities and everted basal cavities to be similar growth phenomena. In both morphological features the surface that is normally confined to the narrow inside of the grooves (constituting the basal cavity) becomes directed outwards so that more of the surface area is exposed.

Sweet (1970b) observed that eversion of the basal attachment area in *E. triassica* is an ontogenetic feature pronounced in large and more massive specimens. Although a possible exception is provided by the narrow "eversion strip" added as the final growth stage in some Hi and Tr elements of *E. conflexa* that possess deep, flaring basal cavities, specimens ROM 39770, 40387, 40408, 40409, 40432 (Pl. 3, fig. 18; Pl. 4, figs. 16, 17; Pl. 5, fig. 19; Pl. 6, fig. 27) for example, we find Sweet's observation difficult to reconcile with our observations of Pennsylvanian species of *Ellisonia*. Specimens of *E. latilaminata* sp. nov. and *E. conflexa* show no evidence of such change in morphology with ontogeny. Moreover, evidence of the last lamella secreted on the outermost part of the conodont in both species, the presence of steplike progressively younger lamellae orally, and the centrifugal arrangement of lamellae force us to conclude that the morphology of the basal attachment area was determined at the earliest stage of growth of the conodont (Text-fig. 1). Even at the stage at which the first laminae were secreted in *E. latilaminata* sp. nov., a narrow basal cavity would already have been present. Subsequent laminae would have been secreted successively on the outside by the two methods outlined in Text-figure 1; the basal cavity, or actually a basal groove, would have remained exceedingly narrow throughout the growth of the conodont element. A similar situation would have prevailed in *E. conflexa* (Text-fig. 1), and we conclude that Pennsylvanian species of *Ellisonia* determined their basal attachment (everted versus open) type at their earliest ontogenetic stage and that unlike Permian and Triassic species studied by Sweet (1970b), they could not alter the type of attachment surface they possessed during ontogenetic development. In view of the plasticity in the form of the basal cavity shown by Pennsylvanian species of *Ellisonia*, the variation that Sweet observed in geologically younger species of *Ellisonia* is hardly surprising.

Distribution of Individual Elements of Pennsylvanian Species of Ellisonia

STATISTICAL DISTRIBUTION

Approximately 1200 conodont elements of Pennsylvanian and Permian species of *Ellisonia* were available for study (Appendix 1). Our combined Pennsylvanian and Permian conodont collections total nearly 500 000 individual elements, yet elements of this genus account for fewer than 1200 specimens (Appendix 1) or roughly 0.2 of one per cent of the fauna. Although individual beds of some stratigraphic units at specific localities are moderately productive in yield of elements of species of *Ellisonia* (e.g., samples from localities 5, 8, 32, and 95; Appendix



Text-fig. 1 Models of lamellar growth in *Ellisonia latilaminata* sp. nov. (A and B) and *Ellisonia conflexa* (Ellison) (C and D). Schematic cross-sections are taken between denticles, for example, in transverse sections through posterior bars of Hi or Tr elements. Although we represent two possible models of lamellar accretion for each species, we consider the sequence represented by A and C to represent most accurately the sequence of lamellar deposition that occurred in the two species. In both *E. latilaminata* sp. nov. (A and B) and *E. conflexa* (Ellison) (C and D), the shape of the aboral attachment surface is determined at the initial stage (A_1 and C_1 respectively). Gradual shortening of the lamellae as they are secreted in an oral direction (stages C_4 and C_6) results in basal cavity eversion and deposition of an eversion strip even in *E. conflexa* (Ellison), a species characterized by elements having broad, flaring basal cavities.

1), and bulk sampling of these beds could yield collections equalling our total, most samples produce few elements of species of *Ellisonia*. Stating this rarity in another way: of every 500 conodonts collected from the late Palaeozoic, only one is an element of a species of *Ellisonia,* and there is a 36 per cent probability (426 fragmentary elements assignable to *Ellisonia* but not to species or element type divided by 1183, the total number of elements belonging to species of *Ellisonia*) that that element will be fragmentary and not assignable with confidence to element type or species. To obtain one specimen of the Ne element, the least common element of *Ellisonia conflexa* (Ellison), an average of 50 000 conodonts must be collected. In view of this, it is remarkable that this element, or an homologous element, has been reported by previous authors (Webster, 1969; Rabe, 1977). This is more remarkable because this is the only element of a species of *Ellisonia* present in material studied by Rabe (1977).

One of the greatest difficulties in studying species of *Ellisonia,* therefore, is the small number of samples containing any of the elements of species of the genus and the high proportion of these containing only a specimen or two. In contrast to samples from localities 5, 8, 32, and 95 (Appendix 2A) that produced a third of our specimens, 125 samples, or more than half the total containing any ellisonids whatsoever, yielded only one or two specimens. A total of 173 elements assignable to species of *Ellisonia* were recovered from the 125 samples. These 125 samples represented more than half of the samples available, yet they yielded only about 10 per cent of the total number of ellisonids. The one or two specimens of *Ellisonia* present in many samples represent genuine rarity within the environmental range, since overall conodont frequencies in most samples were hundreds, or even thousands per kilogram. Furthermore, there are several times as many Pennsylvanian samples that contain no specimens of species of *Ellisonia* as there are those that contain elements of the genus. These absences reflect either generic rarity or environments inhospitable to species of *Ellisonia*, or both.

ENVIRONMENTAL DISTRIBUTION

The environmental association of species of *Ellisonia* with those of *Cavusgnathus* is obvious in faunas of all ages within their common range from all areas. Species of *Cavusgnathus* frequently occur without those of *Ellisonia*, but the reverse is seldom true. Indeed, we (von Bitter, 1972; Merrill, 1973a, 1980a; Merrill and von Bitter, 1976) have already classified the various elements of *Ellisonia* as characteristic of the *Cavusgnathus* biofacies. Occasional specimens occur without species of *Cavusgnathus* (usually in the *Aethotaxis* biofacies of Merrill and von Bitter, 1976), but that is rare. Brackish and hypersaline (at least schizohaline) conditions seem to be represented by the association of species of *Ellisonia* with those of *Cavusgnathus*.

STRATIGRAPHIC DISTRIBUTION

Species of *Ellisonia* are less rare in geologically younger

Table 2 Stratigraphic units in the Pennsylvanian and Lower Permian of North America that yielded specimens of species of *Ellisonia* studied here

No attempt has been made to reflect the amount of time represented by the several series in this table, but individual lithostratigraphic units are roughly correlated following Moore et al. (1944), except as noted.

	TEXAS	MIDCONTINENT	ILLINOIS BASIN	APPALACHIANS
		Schroyer		
		Florence		
PERMIAN[1]		Sallyards		
	Saddle Creek	Burr		
	Harpersville			
	Belknap			
		Americus		
		Elmont		Ames[2]
		Holt		
		DuBois		
		Sheldon		
		Jones Point		
		Curzon		
		Iowa Point		
		Hartford		
		Calhoun		
		Ervine Creek		
		Larsh-Burroak		
		Oskaloosa		
VIRGILIAN		Avoca		
		Beil		
		Queen Hill		
		Doniphan		
		Spring Branch		
		Kereford		
		Heumader		
		Plattsmouth		
		Heebner		
		Leavenworth		
		Snyderville		
		Toronto		

Table 2 (continued)

	TEXAS	MIDCONTINENT	ILLINOIS BASIN	APPALACHIANS
		Stoner		
		Eudora		
		Captain Creek		
		Vilas		
		Merriam		
		Spring Hill		
		Bonner Springs		
		Farley		
		Island Creek		
		Argentine	unnamed ls.	
		Quindaro		
MISSOURIAN		Frisbie	Little Vermilion	
		Lane		
	Winchell	Raytown	La Salle	
	Wolf Mountain	Muncie Creek	Hall	
	(=Jasper Creek)	Drum		
		Westerville		Portersville
		Fontana		Cambridge
		Winterset		
		Bethany Falls		Upper Brush Creek
			Cramer	Lower Brush Creek
		Ladore		
	Wiles	Sniabar		
			Exline	
			Lonsdale	
			"Sparland"	Dorr Run
	East Mountain		Pokeberry	
DESMOINESIAN		Myrick Station	Brereton	
		Anna		
		Higginsville	St. David	
		Blackjack Creek	Hanover	
			Oak Grove	
				Vanport
			Seville[3]	
ATOKAN				Upper Mercer
				Lower Mercer
				Kendrick
MORROWAN				Dingess
	Marble Falls			Eagle

[1] The Pennsylvanian/Permian age of these units is in dispute.

[2] Our stratigraphic placement of the Ames Member, based on conodont evidence, is much younger than that in Moore et al. (1944).

[3] The Seville is given as Atokan in age by Moore et al. (1944) and as Desmoinesian in age by Willman et al. (1967). We generally accept the former placement.

Table 3 **Percentages of Hi and Tr elements with everted basal cavities (*Ellisonia latilaminata* sp. nov.) to all Hi and Tr elements (*E. latilaminata* sp. nov. plus *E. conflexa* and *E.* sp. A) by region and age**

Numbers in parentheses are the total numbers of Hi and Tr elements on which percentages are based.

	TEXAS	MIDCONTINENT	ILLINOIS BASIN	APPALACHIANS
PERMIAN	0%(11)	0%(13)	–	–
UPPER VIRGILIAN	–	0%(1)	–	0%(84)
MIDDLE VIRGILIAN	–	0%(159)	–	–
UPPER MISSOURIAN	–	11%(27)	–	–
MIDDLE MISSOURIAN	0%(9)	8%(48)	8%(26)	45%(31)
LOWER MISSOURIAN	–	30%(10)	44%(108)	10%(20)
UPPER DESMOINESIAN	0%(3)	33%(3)	35%(48)	100%(1)
LOWER DESMOINESIAN	–	78%(9)	15%(39)	100%(28)
PRE-DESMOINESIAN	0%(4)	–	–	100%(73)

strata in all areas studied. This relative abundance is correlated with increasing environmental restriction in geologically younger Palaeozoic rocks of central and eastern North America, but probably does not indicate any real increase in the abundance of species of the genus. Species of *Ellisonia,* however, seem to be less common in the Lower-Middle Pennsylvanian (Morrowan, Atokan), but this may only reflect our less concentrated sampling in older rocks.

Distributional data for species of *Ellisonia* studied by us are provided in Appendix 1, and North American stratigraphic units known by us to contain species of this genus are shown in Table 2. The range of two Pennsylvanian species of *Ellisonia,* and that of possible ancestors and descendants are shown in Text-figure 2.

When the distribution of the homologous elements of North American Pennsylvanian ellisonids is analysed (Table 3), it is apparent that *E. latilaminata* sp. nov., the species characterized by limited element diversity and basal cavity eversion, was generally most common during the pre-Desmoinesian and Desmoinesian (Pl. 1), decreased in abundance during the Missourian (Pl. 2), and became extinct by the late Missourian.

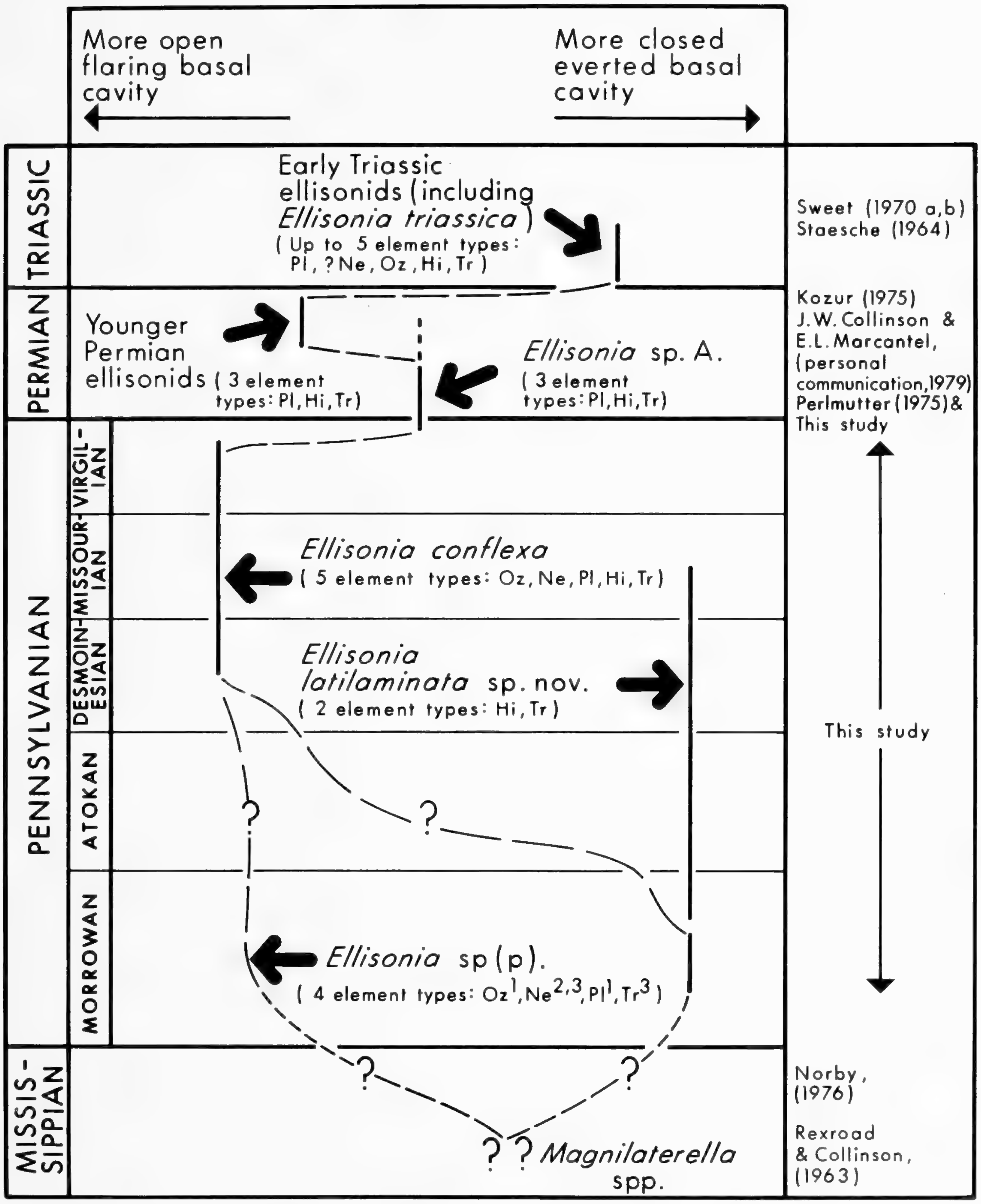
The youngest occurrence of *E. latilaminata* sp. nov. is Missourian (Text-fig. 2; Pl. 2), though the rocks from which these conodonts were recovered at locality 154 in Iowa (Appendix 2A) were correlated with the Oread Formation of Virgilian age by Welp et al. (1968). von Bitter (1976:40) suggested that the strata involved had been miscorrelated. Subsequent work (von Bitter and Heckel, 1978) substantiates a Missourian age and suggests that the strata should be correlated with the Stanton Formation of the Kansas City Group.

Ellisonia conflexa, a species characterized by possessing five types of elements with large, flaring basal cavities, became relatively abundant during the middle and late Desmoinesian (Pl. 3), increased in abundance during the early and late Missourian (Pls. 4, 5, 6), and was evidently the only ellisonid in most of the Virgilian (Pl. 7).

GEOGRAPHIC DISTRIBUTION

The greatest number of specimens (Appendix 1) of species of *Ellisonia* are from the Appalachians, where most samples were taken, and the smallest number are from Texas, where fewest samples were taken. Numbers of specimens of species of *Ellisonia* are best correlated with the number of samples taken rather than with the total numbers of conodonts recovered, otherwise the Appalachians would rank third instead of first.

Some individual stratigraphic units in each area have especially large numbers of specimens for environmental reasons. The stratigraphic unit producing the greatest number of specimens of species of *Ellisonia* is the Ames Member (Conemaugh Group, Virgilian) in the Huntington area of West Virginia. Here the Ames represents a complex of barrier-lagoon-tidal-flat environments (Merrill, 1973b). The greatest concentrations of conodont elements of species of *Ellisonia* are found in the Cramer Member (McLeansboro Group, Modesto Formation) of Missourian age in northern Illinois. These occur with numerous species of *Cavusgnathus, Idioprioniodus, Aethotaxis,* and *Gondolella* in an unsorted biosparite. The nature of the environment represented by these beds is unclear, but if sedimentological transport is responsible, minimal breakage of the different kinds of conodont elements occurred, and ratios between the morphologically distinct element types of species of the four conodont genera mentioned do not indicate high levels of ''sorting''.



Text-fig. 2 Stratigraphic distribution and possible phylogeny within the genus *Ellisonia*.

Derived from an unknown ancestor (possibly *Magnilaterella*), the earliest ellisonid (*Ellisonia* sp. or spp.) had four (perhaps five) types of elements. The bulk of the Early Pennsylvanian history of *Ellisonia* is dominated by apparatuses with only two element types (*E. latilaminata* sp. nov.), but these overlapped in time with five-element type apparatuses (*E. conflexa*). Latest Pennsylvanian and all younger species of *Ellisonia* seem to have stabilized the three-element type apparatus. (Superscripts on elements types refer to: [1]this study: Marble Falls Limestone; [2]Rabe, 1977, pl. 2, fig. 10; [3]Webster, 1969, pl. 7, figs. 15, 16; pl. 8, fig. 14. Stratigraphic order between 1, 2, and 3 unknown.

BIOLOGIC DISTRIBUTION

Species of *Ellisonia* possessed a type B apparatus (Jeppsson, 1972) containing more than a single element type but lacking platform elements. A finite number of element types was present in the body of each species of *Ellisonia,* and our record of this genus and its species is based on the distribution of these elements. Every element of these several kinds was borne by an animal of this group; but, no *a priori* assumption of the reverse can be made, i.e., that each type of element was present throughout the range of the genus, or that all were borne by any one animal, or that ratios between the types of elements within individuals were constant within any included taxon. As pointed out in the *Materials and Methods* section we recognize five clearly defined types of elements (Oz, Ne, Pl, Hi, and Tr) as being anatomical parts of species of *Ellisonia*. We have utilized the conodont element designations of Jeppsson (1971), established for Silurian conodont faunas, because they are reasonably simple and easily applied. There is no adequate system for designating these elements, and homology between these different elements and those of apparatuses of other genera that have received the same designations are uncertain; those for the Tr and Hi elements seem to be reasonably certain, but the Pl, Oz, and Ne designations for the remainder are assignments based on gross similarities, and other authors may designate them differently. As an example, G. Nowlan (pers. comm., 1980) has suggested that the element we have identified as the Hi element of *E. latilaminata* sp. nov. may in fact be two elements, a hindeodelliform and a plectospathodiform element. He believes that preservation commonly does not permit differentiation of these two element types but that candidates for the plectospathodiform element may be seen in Plate 1, figures 11, 18; and Plate 2, figures 15, 18. He suggests that if this is the case, then *E. latilaminata* sp. nov. is a three-element type apparatus, bearing only the first transition series of Barnes et al. (1979) and is therefore a type II apparatus, as are many of the Ordovician hyaline and neurodont conodont apparatuses, such as *Multioistodus, Evencodus, Stereoconus,* and *Tricladiodus*. Dr. Nowlan notes that the Ne, Pl, and Oz elements of *E. conflexa* (Ellison) closely resemble each other (particularly in their flaring basal cavities) and have morphologies suggestive of the e, f, and g positions in the element classification of Barnes et al. (1979). The similar application of the hypothesis that the Hi element of *E. conflexa* (Ellison) may in reality be two element types has caused Dr. Nowlan to suggest homologies between the elements of this species and those of Ordovician conodont apparatuses, using the element notation of Barnes et al. (1979). The Ne element of *E. conflexa* (Ellison) would be homologized with the e position, the Pl with the f, the Oz with the g, and the Tr with the c. The element we have designated the Hi element of *E. conflexa* (Ellison) would, in Dr. Nowlan's hypothesis, really be two distinct element types, a hindeodelliform and a plectospathodiform element, and he would homologize these with the a and b positions.

Some specimens cannot be readily classified in any of the five categories (Pl. 1, figs. 6, 7; Pl. 3, fig. 4; Pl. 6, figs. 5, 9; Pl. 7, figs. 8, 9, 30; Pl. 13, figs. 10–14) and their uncertain identity is indicated by a question mark. Most may be pathologic or genetic aberrants of one or more of the seven elements, but one or two have been found in more than one sample. Their significance is unknown. With up to five distinct types of elements consistently present in most samples, the suggestion by Merrill (1975) that this genus is sexually dimorphic as has been documented for species of *Idioprioniodus* (Merrill and Merrill, 1974) is not supported.

The morphologically distinctive Hi elements of *E. conflexa* and *E. latilaminata* sp. nov. are by far the most common element types representing the largest number of species. They are 2.5 times as abundant as any other element. These ratios remain relatively constant in different regions and in rocks of different ages. Hindeodelliform elements also occur in more samples than any of the other elements and are the only ones present in nearly four times as many samples as the second most common element. They are also the elements that occur most commonly with each of the others, even with each pair of others. For whatever reasons, possibly the rarity of elements of species of the genus, attempts to use the regression technique of Marsal and Lindström (1972) have not been successful. Although the Hi elements are 1.82 times more abundant than Tr elements, the correlation coefficient is only 0.52. Nonetheless, the presence of sinistral and dextral Hi elements indicates that *E. conflexa* and *E. latilaminata* sp. nov. each bore at least two Hi elements. Because ratios do not support any number greater than two, and because dextral and sinistral Hi elements occur in about equal numbers, a single pair of Hi elements may have been the normal complement of both *E. conflexa* and *E. latilaminata* sp. nov.

Relative abundance of the Tr elements of *E. conflexa* and *E. latilaminata* sp. nov. mirror those of the Hi elements of the respective species. Tr elements with everted basal cavities belonging to *E. latilaminata* sp. nov. are dominant in samples from older rocks (Morrowan through Desmoinesian) with the first broad cavity-bearing Hi and Tr elements (belonging to *E. conflexa*) appearing about the middle of the Desmoinesian. Both types of basal cavities are present throughout the remainder of the Desmoinesian, with "normal" ones gradually replacing "everted" ones in the section. Specimens with everted basal cavities disappear near or slightly above the middle

Table 4 Fager coefficients between and among the elements of *Ellisonia conflexa* (Ellison) and *Ellisonia latilaminata* sp. nov.

		E. latilaminata sp. nov.		*E. conflexa* (Ellison)				
		Tr	Hi	Tr	Hi	Pl	Oz	Ne
E. latilaminata sp. nov.	Tr	X	0.467	−0.032	0.018	0.051	−0.004	−0.047
	Hi	–	X	0.061	0.074	0.096	0.101	−0.033
E. conflexa (Ellison)	Tr	–	–	X	0.363	0.278	0.177	0.232
	Hi	–	–	–	X	0.344	0.196	0.142
	Pl	–	–	–	–	X	0.343	0.344
	Oz	–	–	–	–	–	X	0.106
	Ne	–	–	–	–	–	–	X

of the Missourian (La Salle Limestone in Illinois, Wyandotte Formation in the Midcontinent). Tr elements are consistently second in abundance to hindeodelliform elements with the same kinds of basal cavities both in total numbers of elements and in the proportion of samples in which they are found through the overlapping ranges of the two species. Distribution of these elements, in lesser numbers, nearly constant association with Hi elements, and bilateral symmetry suggest that Tr elements were represented by a single (unpaired) element in any one individual.

The Oz, Pl, and Ne elements of *E. conflexa* occur less regularly, and consequently their distribution is more difficult to describe. Of the three, the Pl element occurs most frequently and has been recovered from middle Desmoinesian through Permian strata. The rare Ne element has the same distribution, although *Neoprioniodus*? *expandofundus* of Webster (1969) and Rabe (1977) may represent an earlier (?Morrowan) record of this element type. The second most abundant of the three is the Oz element. Except for two elements from the Marble Falls Limestone (Morrowan) of Texas, one of which (Pl. 3, fig. 24) is more confidently assigned to this category than is the other, our oldest examples of this element are from rocks of Desmoinesian age. ?*Lonchodina* sp. of Rabe (1977, pl. 4, fig. 13), of questionable Wolfcampian age, possibly represents an Oz element and if so would be the highest stratigraphic occurrence of this element type of which we are aware. The scarcity of Oz, Ne, and Pl elements in faunas older than middle Desmoinesian (a category that includes about one fourth of our conodont collections) suggests that they were uncommon associates in the apparatus of *E. latilaminata* sp. nov., a species that generally only bore Hi and Tr elements. The greatest number of Oz, Pl, and Ne elements relative to the Hi and Tr elements recovered is in rocks of Virgilian age. Nonetheless, the relative rarity of the Ne, Oz, and Pl elements makes it unrealistic to attempt to consider them to be invariably present in the apparatus of *E. conflexa*. Rather, the presence of an Ne element in the apparatus of *E. conflexa* must have been an exceptional biological event, perhaps present in no more than two per cent of the individuals of the species living at any one time. The Oz and Pl elements were present as pairs within a greater number of individuals of *E. conflexa* than was the Ne element, but it is unlikely that they were consistently present in all individuals of the species. The Pl element was present in *E. conflexa* more commonly than was the Oz element, and the presence or absence of any of the three could result from a variety of causes including ontogenetic development, dimorphism, ecophenotypic variation, or other such factors.

The Fager coefficient, a standard measure of bioassociation (Kohut, 1969), was applied to the occurrences of these seven types of elements (Table 4). As expected, elements that occur rarely, in very small numbers, or small numbers of kinds, have low Fager indices. Taking the highest coefficient as a basis for comparison, however, we have drawn the following conclusions about the occurrences of these seven elements. The element pair with the highest index of mutual occurrence, the Hi and Tr elements of *E. latilaminata* sp. nov., has an index of 0.467. Indices below 0.700 are generally unsatisfactory for apparatus reconstruction, but in many statistical procedures any index ±0.500 would be considered significant, and we consider this index indicative of a relatively high level of association, at least as a basis for comparison with the others. The second highest index associating Hi and Tr elements of *E. conflexa* was predicted from the stratigraphic occurrences. The reason that this index is lower (0.363 versus 0.467) is probably that the Hi and Tr elements of *E. latilaminata* sp. nov. occurred exclusively in the apparatus in such a combination that the only possible reconstruction could consist of all Hi elements, all Tr elements, or both Hi and Tr elements, whereas many or most Hi and Tr elements of *E. conflexa* also occurred with Oz, Pl, and Ne elements in the apparatus of that species. Given this association of five or fewer types of elements within a species, chance would dilute the proportion of the aliquots in which Hi and Tr occur together as the two options drawn from the population.

The next three highest indices are noteworthy because they are virtually identical and each involves the Pl element. From this, and stratigraphic and morphologic evidence, the implication is that the Oz and Pl elements are biologically associated wherever they are found. Further, the dependent relationship of the rare Ne element upon the Pl is shown by its higher coefficient with that element than with any other. The Pl element shows an identical coefficient with the Hi elements having "normal" basal cavities (i.e., the most common geologically younger ones).

In sharp contrast are indices of the Oz, Pl, and Ne elements of *E. conflexa* with the Hi and Tr elements of *E. latilaminata* sp. nov. The six indices average only 0.027, and three, Oz and Tr elements of *E. latilaminata* sp. nov., Ne and Tr elements of *E. latilaminata* sp. nov., and Ne and Hi elements of *E. latilaminata* sp. nov., are negative (−0.004, −0.047, −0.033). Statistically no positive or negative correlation exists between the occurrences of the Oz, Pl, and Ne elements of *E. conflexa* with the Hi and Tr elements of *E. latilaminata* sp. nov., but a positive correlation exists between these three elements and Hi and Tr elements of *E. conflexa*.

In summary, our observations suggest that the apparatus of the pre-middle Desmoinesian *E. latilaminata* sp. nov. consisted of only an unpaired symmetric Tr element and sinistral and dextral Hi elements, all with everted basal cavities. Nonetheless, reports of Ne elements from older strata by Webster (1969) and Rabe (1977) indicate the existence of more complex apparatuses in the earliest Pennsylvanian. With the development of noneverted, flaring basal cavities, increasing numbers of individuals added paired Pl and Oz elements, the addition of the former being more common. The presence of Pl, Oz, and Ne elements was probably restricted to those individuals bearing elements with open, flaring basal cavities. As this type of basal cavity became more common during later Desmoinesian and Missourian times, the proportions of individuals of *E. conflexa* bearing Oz and Pl elements in the total population increased. Not all individuals whose Tr and Hi elements had large, flaring basal cavities developed or retained Oz and Pl elements however, and an even smaller number developed or retained the infrequently recovered Ne element. This trend continued through the Late Pennsylvanian and Permian, but youngest known ellisonids, of Triassic age, reverted to basal cavities similar to those of *E. latilaminata* sp. nov., and retained the more complex apparatus in which only the Ne element has not been reported.

Ultrastructure of Species of Ellisonia *and Relationship of Upper Palaeozoic Ellisonids to Lower Palaeozoic Neurodont and Non-Neurodont Hyaline Conodonts*

Barnes et al. (1973) recognized two main groups of conodonts, hyaline and cancellate conodonts. They characterized cancellate conodonts as having abundant and characteristically porous white matter. Hyaline conodonts were recognized to be those that generally lacked white matter (although this could be present along the growth axis) and possessed lamellar structure throughout. Neurodonts were classed as a subgroup of hyaline conodonts and were characterized by Barnes et al. (1973) as being robust, having broad, shallow basal excavations, lacking white matter, having round noncompressed denticles, and possessing a sheetlike septum.

Our investigations using the scanning electron microscope show that the Pennsylvanian species *Ellisonia conflexa* (Ellison) and *E. latilaminata* sp. nov. possess characteristics of both non-neurodont hyaline and neurodont conodonts. Neurodont characteristics include the strikingly large, shallow, flaring basal cavities and few massive but discrete peglike denticles, characteristics particularly well developed in the Oz, Ne, and Pl elements of *E. conflexa*. These elements are remarkably similar to species of the lower Palaeozoic neurodont genera *Chirognathus, Polycaulodus, Cardiodella,* and *Erismodus* among others. The Oz, Pl, and Ne elements of *E. conflexa* (and to a lesser degree the Hi and Tr elements of *E. conflexa* and *E. latilaminata* sp. nov.) also possess the "robust form" characteristic of neurodonts. Nonetheless, many non-neurodont hyaline conodonts also possess a "robust" form (Barnes et al., 1973).

Unaltered elements of *E. conflexa,* in particular, possess only minimal white matter, which is either concentrated in the central axial portion of the cusp and the denticles or occurs as solid white translucent areas in the middle part of some but not all denticles. The axial concentration is in "trains" of white triangular interlamellar spaces. The basal portion of these elements is transparent, lacks white matter, and has a characteristic golden-brown colour that is distinct from that of associated elements of species of *Idioprioniodus* for example. Distribution of white matter in *E. conflexa* (Ellison) is thus most similar to non-neurodont hyaline conodonts described by Barnes et al. (1973). Elements of *E. conflexa* are also remarkably similar in the amount and distribution of white matter and the colour and clarity of the basal portion to the conodonts that Staesche (1964) placed in *Pachycladina,* a genus that we place in synonymy with *Ellisonia*.

Barnes et al. (1973) concluded that a sheetlike septum that does not pass through the central growth canal bisects neurodont elements longitudinally. Transverse sections of naturally broken denticles of *E. conflexa* examined at high magnifications reveal (Pl. 8, figs. 13–15) a septumlike structure that, although apparently passing through the growth canal, may be comparable to that described for neurodont conodonts. This internal structure terminates externally in a keel or carina on the anterior and posterior edges of denticles and cusps of *E. conflexa* (Pl. 8, figs. 13–15). Lateral compression of the cusp and denticles and the presence of sharp-edged keels are characteristic of non-neurodont hyaline rather than neurodont conodonts, although Barnes et al. (1973, figs. 2–11, 2–13) described keeled margins on the denticles of *Erismodus asymmetricus* and we observed this feature on *Chirognathus* sp. (Pl. 9, figs. 2, 3).

Another internal feature documented for *E. conflexa* is a central growth canal (Pl. 9, figs. 5, 6). This structure has been documented in the neurodont *Polycaulodus* (Barnes et al., 1973) and in cancellate conodonts (Barnes et al., 1973). These authors concluded that growth axes, represented by a system of open growth canals, are probably present in all conodonts. They also observed that the basal end of the growth canal of neurodonts was sealed, an observation that could not be substantiated in our examination of neurodonts (Pl. 9, figs. 7–9). This sealing, however, was observed in the Ne and Pl elements of *E. conflexa* (Pl. 8, figs. 3, 4, 6).

The internal structure of neurodonts was found by Barnes et al. (1973) to be lamellar with cone-in-cone structure. The lamellae of the neurodont *Ptiloconus* sp. averaged 2μm to 3μm in thickness (Pl. 9, figs. 11, 12). Neurodonts generally lack interconnecting crystallites between the lamellae (Barnes et al., 1973), and we observed discrete lamellae in the neurodont *Ptiloconus* sp. (Pl. 9, figs. 11–12). Non-neurodont hyaline conodonts, which are similar to cancellate conodonts in lamellar structure, possess fused lamellae with irregular interlamellar spaces. The lamellae of *E. conflexa* are conspicuous in or near the basal cavity where lamellae overlap (Pl. 9, figs. 14, 15; Pl. 10, figs. 12–15) or in natural breaks on denticles or cusps (Pl. 11, figs. 1–3, 6, 7). Laminae at or near the aboral surface (Pl. 9, fig. 16) vary in thickness (1μm to 1.5μm) and although distinct interlamellar spaces cannot be demonstrated to have been present, they possess a characteristic overlapping that implies a pause between the deposition of individual lamellae.

Lamellae of *E. latilaminata* sp. nov. were studied in greater detail. Lamellae are well developed, each being regular (Pl. 10, figs. 1–11) as in sedimentary varves and having a thickness of 1μm to 2μm (Pl. 10, figs. 3, 8). The regular thickness of these lamellae is interpreted to mean that each represented a distinct secretional event. Although interlamellar spaces were not seen, apparently lamellae or crystallites were not fused and appear to pass from one lamella to the next. We were unable to see the lamellar arrangement and relationship of one lamella to the other in the broken denticles and cusps of either *E. conflexa* or *E. latilaminata* sp. nov. Lamellae of *E. conflexa* (Pl. 9, fig. 16) appear to be indistinct and poorly defined. Lamellar characteristics of *E. conflexa* and *E. latilaminata* sp. nov. appear to be intermediate between those of the non-neurodont hyaline conodonts and of the neurodont subgroup.

Apart from the thickness of lamellae the general arrangement of the lamellae is of interest. The relationship of lamellae to one another in neurodont and hyaline conodonts has been described as cone-in-cone. In cone-in-cone structures the apex of each lamellar arch would be expected to be directed orally, as appears to be the case in the Ordovician neurodont *Ptiloconus* (Pl. 11, fig. 4). This is also the arrangement of the lamellae of the Pl element of *E. conflexa* (Pl. 11, figs. 1, 2) which, although apparently recrystallized, form an upward closing arch. In contrast is the fibrous ''inverted'' cone-in-cone lamellar structure in an Hi element of *E. conflexa* (Pl. 11, figs. 3, 6, 7). We also observed this inverted cone-in-cone structure in an unidentified element of *Idioprioniodus* sp. from the Canadian Arctic (Pl. 10, figs. 8–11). Although it is difficult to explain this lamellar arrangement with the use of accepted models of conodont growth and accretion, inverted lamellar structure would be functional if the inverted conodont model of Jordan (1974) is accepted.

Finally, the size and arrangement of the crystallites is important. According to Barnes et al. (1973) neurodonts possess two crystallite types: needlelike crystallites (average diameter 0.5μm) that comprise the bulk of the neurodont and blocky granular crystallites (average diameter 0.5μm) that are found only in the aboral region of neurodonts. Crystallites of the non-neurodont hyaline conodonts are long and narrow, irregular, and apparently partially fused to each other (Barnes et al., 1973:12). Crystallites of cancellate conodonts are long and narrow, irregular, partially fused to each other, and have a diameter of 0.5μm to 1.0μm. Crystallites in aboral regions of *E. conflexa* and *E. latilaminata* sp. nov. are

Table 5 Physical characteristics of neurodont hyaline, Pennsylvanian ellisonid, non-neurodont hyaline, and cancellate conodonts

Data for conodont groups other than ellisonids largely from Barnes et al. (1973).

	NEURODONT HYALINE CONODONTS	PENNSYLVANIAN ELLISONIDS	NON-NEURODONT HYALINE CONODONTS	CANCELLATE CONODONTS
Composition of apparatus	Ramiform and cone elements only	Ramiform elements only	Ramiform and cone elements only	Platform, ramiform, and cone elements
Basal cavity	Broad and shallow; rarely everted [see *Stereoconus* of Moskalenko (1972)] Usually sealed	Broad and shallow to nearly completely everted and nearly closed ?Sealed	Broad, shallow to deep Probably open	Narrow, deep Open
White matter	Absent; clear and translucent throughout	Absent in fresh specimens or present along growth axis; altered specimens white throughout	Generally absent; may be present along growth canal	Present; contains no lamellae
Growth habit	Robust	Robust	Many robust	Often delicate in ramiform elements; Platform elements may be massive
Denticulation	Discrete, massive, and peglike	Discrete, massive, and peglike	Discrete	Hindeodellid and/or fused denticles common
Denticle cross-section	Most round and laterally uncompressed	Laterally compressed, bearing keel	Rounded to laterally compressed	Generally laterally compressed with keels
Growth canals	Circular	Present, probably circular	Probably present	Circular
Septum	Present, sheetlike	?Present as a parting on groovelike structure	Absent	Absent
Surface ultrastructure	Mostly smooth	Smooth with minor discontinuous ridges	–	Generally ornamented with bifurcating and parallel striae
Growth	Lamellar	Lamellar	Lamellar	Lamellar with partial transformation of lamellar phosphate to white matter
Fracture pattern	Fibrous; lengthwise fracture	–	–	–
Lamellar arrangement	Cone-in-cone; concentric; normal	Cone-in-cone; concentric; both normal and inverted	Cone-in-cone	–
Lamellar characteristics	Not fused; interlamellar spaces distinct (0.5μm to 1.0μm); minor penetration of interlamellar spaces by crystallites Lamellae relatively constant in thickness (2μm to 3μm)	– –	Partially fused; interlamellar spaces irregular –	Partially fused; interlamellar spaces irregular Lamellae 2μm to 4μm thick
Crystallites	Present Needlelike (0.5μm); parallel to interlamellar spaces; equidimensional and granular near basal cavity (0.5μm); random arrangement in each lamella	Present –	Present Long and narrow but irregular, with partial fusion	Present Long and narrow but irregular, with partial fusion; 0.5μm to 1.0μm in diameter
Spheres on crystallites	Present	Absent	Absent	Absent
Basal filling	Present; resembles bone	Absent	Probably present	Present in some species

granular and blocky (Pl. 9, fig. 16; Pl. 10, fig. 8 respectively) as in neurodonts. Crystallites of the cusp and denticles of *E. conflexa* are more difficult to distinguish and describe. Crystallites of the Pl element of *E. conflexa* showing a cone-in-cone lamellar arrangement (Pl. 11, figs. 1, 2) have been recrystallized. Those of the Hi element of the same species with an inverted lamellar arrangement (Pl. 11, fig. 7), while difficult to distinguish from one another, are elongate, seemingly fibrous and needlelike, and have an average diameter of less than $1\mu m$. Crystallites of *Idioprioniodus* sp., the only other conodont with inverted lamellar structure that we have studied, are about $0.5\mu m$ in diameter, rodlike, and not arranged in well-defined lamellae (Pl. 11, figs. 10, 11).

From the discussion and data in Table 5 it is apparent that *E. conflexa* and *E. latilaminata* sp. nov. have characteristics of both hyaline and neurodont conodonts. Neurodonts were common in Ordovician seas of North America and were a part of the littoral and sublittoral nearshore community common in warm, shallow seas with above normal salinity (Barnes et al., 1973). Moskalenko (1972, 1973) reported neurodonts as being common in Ordovician shallow-water sediments of the Siberian platform. Hyaline conodonts "range stratigraphically beyond the Ordovician, but geographically they are most abundant during this period on shelf and miogeosynclinal belts" (Barnes et al., 1973:25). Neurodontlike characteristics of the two species of *Ellisonia* are significant when the environmental conditions under which neurodonts lived are compared with those of Pennsylvanian ellisonids. These species of *Ellisonia* are most common under nearshore schizohaline, often high-energy conditions (von Bitter, 1972; Merrill and von Bitter, 1976). Internal and external morphological features previously discussed were probably as ecologically advantageous in Pennsylvanian seas as they presumably were in earlier Ordovician environments. Barnes et al. (1973) speculated that the partial development of white matter in hyaline, non-neurodont conodonts strengthened the central growth canal, a desirable feature in nearshore, high-energy environments. They also pointed out that white-matter development also may have facilitated weight reduction, a desirable feature for a nektonic mode of life (see von Bitter and Ludvigsen, 1979, for resorption of phosphate by larval acrotretid brachiopods as a means of decreasing weight and assuming buoyancy).

The apparent absence of neurodont and hyalinelike conodonts in strata of middle Palaeozoic age makes it difficult to postulate a direct phylogenetic connection between Ordovician neurodonts and hyaline conodonts with Pennsylvanian neurodontlike and hyalinelike conodonts. We have demonstrated that Pennsylvanian ellisonids share many features with Ordovician neurodonts and hyaline conodonts and we consider it likely that Pennsylvanian ellisonids solved their problems of adaptation and survival in the same or similar environments in an identical manner. This hypothesis may reasonably be extended to include Early Triassic species of *Ellisonia*, particularly those placed in *Pachycladina* and *Hadrodontina* by Staesche (1964). Not only are these similar in structure and appearance to Pennsylvanian ellisonids and Ordovician neurodonts and hyaline conodonts but they apparently (Kozur, 1976) lived under similar environmental conditions as well.

Systematic Palaeontology

Order Conodontophorida Eichenberg, 1930
Family Ellisonidae Clark, 1972

Genus *Ellisonia* Müller, 1956

Ellisonia Müller, 1956:822
Hadrodontina Staesche, 1964:271
Pachycladina Staesche, 1964:277
Stepanovites Kozur, 1975:22

DIAGNOSIS

A conodont genus with a type-B skeletal apparatus consisting of a minimum of two types of elements (Hi and Tr, herein) that may be elaborated by the addition of as many as three additional types of elements (Oz, Ne, and Pl, herein). The morphology of all elements is characterized by extreme massiveness, wide denticle spacing, strong denticle recurvature, a tendency towards everted basal cavities (particularly in Hi and Tr elements) of some species, and the lack of ultrasculpture and presence of minimal amounts of white matter in some species.

Species of *Ellisonia* differ from those of *Idioprioniodus* in greater massiveness of all processes, wider denticle spacing, details of the basal cavity (especially absence of eversion in *Idioprioniodus*), and *Ellisonia*'s virtual lack of white matter. *Ellisonia* differs from *Aethotaxis* in the more massive nature of elements, large versus small pitlike basal cavity, and the general shapes of elements. *Ellisonia* differs from *Magnilaterella* primarily in the shape of the elements (absence of a magnilaterelliform element), by wider denticle spacing, and by being more massive.

Ellisonia latilaminata sp. nov.

Pls. 1, 2; Pl. 10, figs. 1–11; Pl. 13, figs. 8, 9, 11

DIAGNOSIS

A species of *Ellisonia* with two element types, a paired Hi element, and a probable unpaired Tr element, in its apparatus. Both elements exhibit strong basal cavity eversion that may be complete or nearly complete. White matter may be well developed in altered specimens.

DESCRIPTION

The Hi and Tr elements are similar except for number of anterior processes, the Hi possessing one, and the Tr two anterior bars. Both elements are long and massive, and the posterior bar of these elements is about equal in length when preserved (Pl. 2, figs. 19, 21), although it may be shorter in transition elements (Pl. 2, fig. 15).

The anterior bar of the Hi element is often scooplike and forms an angle of ≃90 degrees with the remainder of the element (Pl. 2, figs. 11, 14, 19; Pl. 10, fig. 1); but the anterior bar of other Hi elements (Pl. 2, figs. 10, 15, 18, 20) is directed slightly laterally and almost no lateral flexure (Pl. 2, fig. 15) to only slight flexure is evident (Pl. 2, figs. 10, 18). Anterior bars of the Tr element are apparently more uniform in this regard, and, where not broken (Pl. 2, figs. 9, 16, 17, 21), form an angle of ≃90 degrees with the more posterior portion of the conodont. The anterior bar of many, but not all, Hi elements (Pl. 1, figs. 13, 17; Pl. 2, figs. 11, 14; Pl. 10, fig. 1) is directed not only laterally but also aborally. Anterior bars of all Tr elements are apparently directed aborally to a noticeable degree (Pl. 1, fig. 16; Pl. 2, figs. 9, 17).

The denticulations of the Hi and Tr elements are similar. The two elements are dominated by a large, recurved cusp that is laterally compressed and may possess anterior and posterior carinae. An anterior carina is commonly present on the cusp of the Hi element. In the Tr element an anterior carina may begin on the oral surface of each of the two anterior bars and unite as a single carina on the cusp (Pl. 1, fig. 16).

Other denticles on the anterior and posterior bars of Hi and Tr elements are also similar in that they are numerous, discrete, and widely separated. Anterior bar denticles of some and possibly all Hi elements bear a carina on the anterior lateral edge (Pl. 2, figs. 11, 14; Pl. 10, fig. 1).

Well-developed, everted basal cavities are characteristic of the two element types of this species, the cause of which is considered elsewhere. Eversion causes the basal grooves of the anterior and posterior bars to be almost completely closed, often leaving only a small portion below the cusp open (Pl. 10, figs. 2, 9; Pl. 13, figs. 8, 9). On some elements the last lamella forms an eversion strip (Pl. 10, fig. 11).

Both Hi and Tr elements are smooth to irregular and lack surface ornamentation; but surfaces of some specimens show effects of recrystallization.

DISCUSSION

We consider the Hi and Tr elements here assigned to *E. latilaminata* sp. nov. to have been parts of the same apparatus because they share such similar morphologic characteristics as eversion and denticulation, they consistently occur with one another in rocks of Morrowan to about middle Missourian age, and they form the end members of a relatively inflexible symmetry transition. Our experience with elements of the apparatus of *E. conflexa* (Ellison) leads us to suspect that the apparatus of *E. latilaminata* sp. nov. should contain Oz, Pl, and Ne elements. With few exceptions (Webster, 1969; Rabe, 1977; this study) elements of this type have not been reported in the lower part of the stratigraphic range of *E. latilaminata* sp. nov. although they are present in the upper part of the range, but there they are considered to represent *Ellisonia conflexa* (Ellison).

ETYMOLOGY

Latin—*latus,* broad, and *lamina,* leaf, sheet; with reference to the laminated, everted basal cavity.

Stratum typicum—Vanport Limestone, Allegheny Group, Desmoinesian.

Locus typicus—Locality 14, Vinton County, Ohio, U.S.A.

TYPES

Holotype ROM 40339 Tr element, Vanport Limestone, locality 14. Figured paratypes ROM 40337 (locality 15), ROM 40338 (locality 10), Hi elements, Vanport Limestone; ROM 40340 Tr element, Vanport Limestone, locality 9.

DISTRIBUTION

Morrowan to ≃middle Missourian of the Appalachians, Illinois Basin, Midcontinent region, and Texas (Appendix 1).

Ellisonia conflexa (Ellison)

Pl. 3, figs. 1–23; Pls. 4–6; Pl. 7, figs. 2–36; Pl. 8, figs. 1–4, 6, 12–15; Pl. 9, figs. 1, 4–6, 14–16; Pl. 10, figs. 12–14; Pl. 11, figs. 1–3, 6–7; Pl. 13, figs. 3–7, 10, 12, 13

Euprioniodina ? sp.—Gunnell, 1933:269, pl. 33, fig. 24

Prioniodus ? *conflexus* Ellison, 1941:114, pl. 20, fig. 25

Delotaxis ? *conflexa*—von Bitter, 1972:72, pl. 12, figs. 1a–c; pl. 14, figs. 1a–c, 2a, b, 4a, b; pl. 16, figs. 1a–d

Unassigned B_1 element—Baesemann, 1973:708, pl. 1, fig. 1

Magnilaterella cf. *M. contraria* Rhodes, Austin and Druce—Baesemann, 1973:708, pl. 1, fig. 2

Ellisonia sp(p).—Merrill, 1980a:196, 199, 201, figs. 2-26, 2-27
?*Ellisonia* sp.—Merrill, 1980b:195, pl. 7, figs. 10, 11

DIAGNOSIS

A species of *Ellisonia* having as many as four paired element types (Oz, Ne, Pl, and Hi) and probably an unpaired Tr element in its apparatus. White matter is minimal in each element, generally being restricted to the central axis where it forms white-matter "trains". The basal portion of each element is a characteristic brown to amber colour and is transparent. The Oz, Ne, and Pl elements, not all of which may have been present in any one individual of the species, possess large, characteristic flaring basal cavities. The Hi and Tr elements possess well-defined grooved basal cavities that lack the flare of those of the other three element types. Individual elements of this species were characterized in detail by Ellison (1941) and by von Bitter (1972).

DESCRIPTION

The pectinate Oz element is elongate and laterally flexed, has a large, elongate, flaring basal cavity, and bears a small number of large, discrete, posteriorly inclined denticles. The flaring, open, basal cavity is generally subelliptical in outline (Pl. 8, figs. 1, 2, 5) but may be completely or almost closed because of eversion in some atypical elements (Pl. 6, figs. 5, 9; Pl. 13, figs. 10, 12, 13). The aboral outline of the element is sinuous (Pl. 8, figs. 1, 2) because of the flare of the sides of the basal cavity and lateral flexing of the element. The size of the Oz element and number of denticles borne by it vary and the increase in number correlates with an increase in size. In general one to three denticles are present anterior to the cusp and two to four denticles posterior to the cusp. The cusp may not be the longest denticle on the oral surface of the Oz element and may be surpassed in length by one of the posterior bar denticles (generally the second from the end of the element).

The rare Ne element is hornlike and is dominated by the cusp. It has a large elliptical to almost round basal cavity, a basal groove that extends from the pit anteriorly into a short anterior bar, and a basal pit below the cusp (Pl. 8, figs. 2, 6). (The orientation of this element is problematic; but the direction in which the cusp is inclined is considered to be posterior, even though the slight curvature within the cusp is inclined in the opposite direction). Anterior to the cusp one or two denticles are common (Pl. 4, fig. 15; Pl. 6, fig. 2; Pl. 7, figs. 7, 20).

The Pl element of this species is the most common of the three element types that have a noticeably large, flaring basal cavity. This and homologous elements in other species of *Ellisonia* have been known for some time (Table 1). The Pl element is characterized by a large cusp over a large, shallow basal cavity. The cusp is laterally compressed, recurved, and directed both posteriorly and inwardly. The basal cavity opens towards the inner side of the conodont and contains a shallow basal groove that extends into both anterior and posterior bars. The posterior bar bears as many as four discrete, slightly compressed denticles. The anterior bar is generally short and bears only a stub or a single, stublike denticle (Pl. 6, fig. 17; Pl. 7, fig. 16). The anterior bar is longer in only a few specimens and then more than one denticle may be present (Pl. 3, fig. 1). The interested reader is referred to the original description of this element type by Ellison (1941:114).

The Hi element is slightly laterally flexed and is elongate and massive when complete. More commonly it is broken, and then only the anterior portion of the element can be identified with any degree of certainty. The element is dominated by a large, recurved, laterally compressed cusp. The anterior bar is directed aborally to varying degrees, generally deviating from the horizontal only slightly. It bears up to three discrete, laterally compressed denticles (Pl. 6, figs. 11, 15; Pl. 7, figs. 26, 29, 32). The posterior bar is longer than the anterior bar and bears as many as four laterally compressed, posteriorly directed, discrete denticles. Denticles of the posterior bar are noticeably discrete in spacing and reach maximum length in the second element from the posterior tip. The element is gently arched. A wide basal cavity containing a central basal groove is present aborally in anterior and posterior bars (Pl. 9, fig. 14; Pl. 13, figs. 1, 2).

The Tr element, like the Hi element, is elongate and massive when complete; this, however, is rare. This element is identical to the Hi element except that instead of a single anterior bar it possesses two symmetrically arranged anterior bars (Pl. 13, fig. 7). Anterior bars are directed both anteriorly and slightly aborally and may bear a few, commonly one or two, recurved, laterally compressed denticles. Posterior bar is robust, slightly arched, and bears numerous large, discrete, posteriorly inclined and laterally compressed denticles that are generally broken. These denticles vary in length and reach a maximum length in the second or third denticle from the posterior tip when preserved. The element is dominated by a recurved, laterally compressed cusp that bears anterior and posterior carinae. A wide basal groove is present on the aboral side of anterior and posterior bars.

Elements of this species lack well-defined surface ornamentation (Pl. 13, fig. 6); but some specimens exhibit evidence of corrosion (Pl. 4, fig. 17; Pl. 13, figs. 3, 4). An eversion strip is particularly noticeable in Hi and Tr elements (Pl. 3, fig. 18; Pl. 4, figs. 16, 17; Pl. 13, figs. 4, 7), but traces of it may be present less commonly in Pl elements (Pl. 5, fig. 14). Rare Oz elements (Pl. 6, figs. 5, 9; Pl. 13, figs. 10, 12, 13) show tendencies to eversion.

Various micromorphological features observed with the scanning electron microscope were considered in the section dealing with ultrastructure and in the comparison with Ordovician neurodonts.

DISCUSSION

The five element types in the apparatus of this species share characteristics that include similarities of distribution (stratigraphic as well as palaeoecologic), morphology (denticulation, a slight tendency to eversion, large, flaring basal cavities, partial symmetry transition), and such subtle features as similarities in colour and white-matter distribution.

DISTRIBUTION

Middle Desmoinesian to upper Virgilian of the Appalachians, Illinois Basin, Midcontinent region, and Texas.

Ellisonia sp. A

Pl. 7, fig. 1; Pl. 12, figs. 17–26; Pl. 13, figs. 1, 2

Ligonodina sp.—Perlmutter, 1975:102, pl. 2, figs. 18, 22
Unassigned Type 3 element—Perlmutter, 1975:103, pl. 2, fig. 19

PRELIMINARY DIAGNOSIS

A species of *Ellisonia* with three element types, Pl, Hi, and Tr elements, in its apparatus. Individual elements possess wide, flaring basal cavities in contrast with younger Permian and Triassic species from the western United States and Europe (Pl. 12, figs. 1–16). For example, the Pl element from the Lower Permian of Kansas illustrated by Perlmutter (1975, pl. 2, fig. 19) has a large, flaring basal cavity with no eversion, whereas younger homologous Pl elements from the Gerster Formation, Nevada, have a flaring, open basal cavity that has been partially everted (Pl. 12, fig. 13).

DISCUSSION

Our view that this group of conodonts represents one or more species distinct from stratigraphically lower and higher species is based on Late Pennsylvanian and Early Permian collections studied by us and on Late Pennsylvanian and Early Permian collections from Kansas studied by Perlmutter (1975). Late Pennsylvanian and Early Permian ellisonids that we assign to *Ellisonia* sp. A have open flaring basal cavities (Pl. 7, fig. 1; Pl. 12, figs. 17–26; Pl. 13, figs. 1, 2) (Perlmutter, 1975, pl. 2, figs. 18, 19, 22) identical to those found in the homologous elements of *E. conflexa*.

Our principal reason for suggesting that one or more species distinct from *E. conflexa* existed during latest Pennsylvanian and Early to Middle Permian times is that we have no evidence of Oz and Ne elements of the *E. conflexa* type occurring stratigraphically higher than the Shawnee Group (Virgilian, Upper Pennsylvanian of Kansas) or the Ames Member (Conemaugh Group, Virgilian, Upper Pennsylvanian, Ohio, Kentucky, and West Virginia). Although these elements are admittedly intermittent in occurrence in *E. conflexa,* we suspect that they were no longer present in Late Pennsylvanian and Early to Middle Permian ellisonids. ?*Lonchodina* sp. of Rabe (1977, pl. 4, fig. 13) from the Wolfcampian of Colombia may represent the first record of an Oz element of the *E. conflexa* type from the Early Permian. But until more specimens are available nothing more can be said about the possible Permian occurrence of this rare element type and of the morphologically related Ne element.

DISTRIBUTION

Upper Pennsylvanian and Lower Permian of Kansas and Texas.

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Appendix 1

Distribution of elements of species of *Ellisonia* in the four areas studied

Uppermost row of numbers represents localities

A P P A L A C H I A N S

SPECIES AND ELEMENT		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
E. CONFLEXA	OZ																	1							1	
	NE																									
	PL																		2	1	1	1		1		
	HI																			1			4			
	TR																						5			
E. LATILAMINATA	HI		1	2	5	17	3	2	20	7	1	1	1	2		2	1								1	1
	TR	1	2	5	2	9		1	3	11				1	2											
	FRAGMENTS		1	12	7	69	12	5	50	12	1			6	1					1			2			3
	TOTAL	1	4	19	14	95	15	8	73	30	2	1	1	9	3	2	1	1	2	3	1	1	11	1	2	4

SPECIES AND ELEMENT		26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	TOTAL
E. CONFLEXA	OZ			1		1		1	1	2						1			1	1			1			1		13
	NE							1																				1
	PL			1	1	4		5	1	2	1			1						3			1	1	2	1	1	31
	HI	1	2	1			1	13	2	1		1	4		1					1		1		8	2		1	45
	TR			1		4		9	2				3				1				1	1					1	28
E. LATILAMINATA	HI			2		12																						81
	TR																											37
	FRAGMENTS	5	4		5	27		43	26		1		11			1		1			1			2	1	1	1	312
	TOTAL	6	6	6	6	48	1	72	32	5	2	1	16	1	1	2	1	1	1	5	2	2	2	11	5	3	4	548

I L L I N O I S B A S I N

SPECIES AND ELEMENT		52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
E. CONFLEXA	OZ																							1						1
	NE								1				1													1				
	PL						1	1						2				1					1			1				1
	HI	1				1	3	2			1	2	4	6	1		1	1	1		1	2		1	1	2	1			
	TR									1		2	2	1						1										
E. LATILAMINATA	HI							3																				1	1	8
	TR	3																												3
	FRAGMENTS	4						2		3		4	6	6		1			2		3	6					4			
	TOTAL	8	0	0	0	1	4	8	1	4	1	8	13	15	1	1	1	2	3	1	4	8	1	2	1	4	5	1	1	13

SPECIES AND ELEMENT		81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	TOTAL
E. CONFLEXA	OZ															4		1			1		1		1					1	11
	NE															1															4
	PL							1		1			1			7		1			1			1	1	1	1		1		25
	HI		1				1		1		1	1		2	1	22	3	6		1	1	1			1		1	1	4	2	83
	TR	1								1						10		3						1				1	1		25
E. LATILAMINATA	HI			1	2											32	5	3	1						1						58
	TR			1												6	1									1					15
	FRAGMENTS					4			2		4	1			2														3	5	62
	TOTAL	1	1	2	2	4	1	1	3	2	5	2	1	2	3	82	9	14	1	1	3	1	1	2	4	2	2	2	9	8	283

M I D C O N T I N E N T

SPECIES AND ELEMENT		110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136
E. CONFLEXA	OZ													1	1												1	
	NE																											
	PL											1		1	2		1										1	1
	HI					1	1	1	1	2					2	1	1		1	1	1	3		1	3	2		
	TR	1		1						1	1		1		1		1	1						1			1	
E. LATILAMINATA	HI		3	4	1			3															1					
	TR																											2
E. SP. A	HI																											
	TR																											
FRAGMENTS				4						3									2			2			4			
TOTAL		1	3	9	1	1	1	4	1	6	1	1	1	2	6	1	3	1	3	1	1	5	1	2	7	2	3	3

SPECIES AND ELEMENT		137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163
E. CONFLEXA	OZ		1								1				1							1						
	NE																							1				
	PL	5								1		1	1								2		2		1	2	6	1
	HI	6		1		1		1	2				1	1		1	3	1						3			3	6
	TR	2					2					1	1			1	1							1			3	
E. LATILAMINATA	HI	1			1														2									
	TR				2														1									
E. SP. A	HI																											
	TR																											
FRAGMENTS		1				10	8	2							1	1	5			1						1	1	1
TOTAL		15	1	1	3	11	10	3	2	1	1	2	3	1	2	3	9	1	3	1	2	1	2	5	1	3	13	8

SPECIES AND ELEMENT		164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190
E. CONFLEXA	OZ		1	2					1		1			1	1				1						1			
	NE			1																	1							
	PL				1		1		1		1		1	1					1			1						1
	HI			1		1			1		1	1	1		1	1					8	3	1	1		1	1	
	TR	1		1				1		1	1	1					1	5		1	1							
E. LATILAMINATA	HI																											
	TR																											
E. SP. A	HI																											
	TR																											
FRAGMENTS												1																
TOTAL		1	1	5	1	1	1	1	3	1	4	3	2	2	2	1	1	5	2	1	10	4	1	1	1	1	1	1

M I D C O N T I N E N T (C O N T ' D)

SPECIES AND ELEMENT		191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
E. CONFLEXA	OZ					1				1															1		
	NE	1								1																	
	PL	1			1	1				1	2		1			1				1			2				1
	HI		1	1	2	2	2		1		1	1				2	1	1	1	1	1	2	1	3	1	1	1
	TR				1	3		1		1				2	1					1				1	1	1	
E. LATILAMINATA	HI																										
	TR																										
E. SP. A	HI																										
	TR																										
FRAGMENTS																											
TOTAL		2	1	1	4	7	2	1	1	4	3	1	1	2	1	3	1	1	1	3	1	2	3	4	3	2	2

SPECIES AND ELEMENT		217	218	219	220	221	222	223	224	225	226	227	228	229	230	TOTAL
E. CONFLEXA	OZ															19
	NE			1												6
	PL		1								1					52
	HI	1			2	1		1	1	1	1					110
	TR			1		1	2		1		1					55
E. LATILAMINATA	HI															16
	TR															5
E. SP. A	HI											2	2	3	2	9
	TR											1				1
FRAGMENTS								1			1					50
TOTAL		1	1	2	2	2	2	2	2	1	4	3	2	3	2	323

T E X A S

SPECIES AND ELEMENT		231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	TOTAL
E. CONFLEXA	OZ	1	2			1											4
	PL		1					1									2
	HI			1	1					1	1	1	2				7
	TR				1		1		1								3
E. SP. A	PL													2			2
	HI													3		4	7
	TR													1	1		2
FRAGMENTS									2								2
TOTAL		1	3	1	2	1	1	1	3	1	1	1	2	6	1	4	29

TOTAL SPECIMENS FOR EACH TAXON, ALL AREAS, AND ALL UNITS

TAXON		TOTAL
Ellisonia conflexa (Ellison)	Oz element	47
	Ne element	11
	Pl element	110
	Hi element	245
	Tr element	111
Ellisonia latilaminata sp.nov.	Hi element	155
	Tr element	57
Ellisonia sp.A	Pl element	2
	Hi element	16
	Tr element	3
Fragments		426
	GRAND TOTAL	1183

Appendix 2A

Register of localities of Pennsylvanian and Permian ellisonids collected and examined by the authors

APPALACHIANS

	State	*County*	*Location**	*Stratigraphic unit*	*Sample code*	*Position†*
1.	West Virginia	Mingo	37-46-09 82-19-28	Eagle Limestone	1ELS	0–50 a.b.
2.	West Virginia	Mingo	37-22-36 81-59-26	Eagle Limestone	2ELS	0–15 a.b.
3.	West Virginia	Mingo	37-56-12 82-15-36	Dingess Limestone	1DLS	0–30 a.b.
4.	West Virginia	Mingo	37-46-09 82-19-28	Dingess Limestone	4DLS	0–20 a.b.
5.	Kentucky	Carter	38-19-44 82-56-12	Kendrick Shale	1KLSA	0–36 a.b.
6.	Kentucky	Floyd	37-37-40 82-38-10	Kendrick Shale	3KLSA	274–335 a.b.
7.	Ohio	Muskingum	NE-20-Newton	Lower Mercer Limestone	9LMLSA	30–45 a.b.
8.	Ohio	Muskingum	NE-20-Newton	Upper Mercer Limestone	6UMLSA	0–8 a.b.
9.	Ohio	Vinton	NE-NW-27-Elk	Vanport Limestone	4VLSA	122–137 a.b.
10.	Ohio	Vinton	NE-NW-27-Elk	Vanport Limestone	4VLSC	122–137 a.b.
11.	Ohio	Vinton	NE-NW-27-Elk	Vanport Limestone	4VLSD	122–168 a.b.
12.	Ohio	Vinton	NE-NW-27-Elk	Vanport Limestone	4VLSE	0–122 a.b.
13.	Ohio	Stark	SE-SW-21-Lake	Vanport Limestone	5VLSD	91–182 a.b.
14.	Ohio	Vinton	SE-22-Elk	Vanport Limestone	22VLSB	38–69 a.b.
15.	Ohio	Vinton	NE-NE-14-Elk	Vanport Limestone	24VLSC	61–213 a.b.
16.	Ohio	Hocking	NW-NW-16-Starr	Dorr Run Shale	2DRSH	0–70 a.b.
17.	Ohio	Morgan	SE-NE-31-Union	Lower Brush Creek Ls.	35LBCLS	0–46 a.b.
18.	Ohio	Muskingum	SW-NW-32-Harrison	Lower Brush Creek Ls.	39LBCLSB	51–112 a.b.
19.	Ohio	Athens	NE-NW-12-Athens	Upper Brush Creek Ls.	4UBCLSD	51–71 a.b.
20.	Ohio	Athens	NE-NW-12-Athens	Upper Brush Creek Ls.	4UBCLSF	15–51 a.b.
21.	Ohio	Athens	NE-NW-12-Athens	Upper Brush Creek Ls.	4UBCLST	15–51 a.b.
22.	Ohio	Athens	NE-NW-12-Athens	Upper Brush Creek Ls.	4UBCLSX	15–51 a.b.
23.	Ohio	Athens	NW-14-Dover	Upper Brush Creek Ls.	6UBCLSA	15–46 a.b.
24.	Ohio	Lawrence	NW-SE-36-Aid	Upper Brush Creek Ls.	21UBCLSB	0–20 a.b.
25.	Ohio	Gallia	SW-SW-28-Morgan	Upper Brush Creek Ls.	34UBCLS	0–31 a.b.
26.	Ohio	Athens	NE-SW-9-Trimble	Cambridge Limestone	9CLSB	0–91 a.b.
27.	Ohio	Lawrence	SW-NW-1-Aid	Cambridge Limestone	22CLST	0–76 a.b.
28.	Ohio	Lawrence	SW-NW-1-Aid	Cambridge Limestone	22CLSX	0–76 a.b.
29.	Ohio	Muskingum	SW-NW-32-Harrison	Cambridge Limestone	46CLST	0–61 a.b.
30.	Ohio	Athens	NW-NW-10-Athens	Portersville Shale	3PLSB	0–102 a.b.
31.	Ohio	Athens	NW-SW-2-Trimble	Ames Limestone	18ALSB	0–61 a.b.
32.	Ohio	Lawrence	NW-32-Union	Ames Limestone	25ALSX	0–46 a.b.
33.	West Virginia	Wayne	38-20-00 82-27-12	Ames Limestone	31ALSC	0–48 a.b.
34.	West Virginia	Wayne	38-20-00 82-27-12	Ames Limestone	31ALSE	0–3 a.b.
35.	Ohio	Athens	SW-SE-1-Trimble	Ames Limestone	37ALS	0–20 a.b.
36.	Ohio	Perry	SE-33-Monroe	Ames Limestone	46ALS	0–74 a.b.
37.	West Virginia	Cabell	38-24-26 82-26-26	Ames Limestone	83ALS	0–38 a.b.
38.	Ohio	Lawrence	NW-NW-2-Fayette	Ames Limestone	84ALSA	610–686 a.b.
39.	Ohio	Lawrence	NW-NW-2-Fayette	Ames Limestone	84ALSB	610–686 a.b.
40.	Ohio	Lawrence	NW-SW-13-Fayette	Ames Limestone	85ALS	0–17 a.b.
41.	West Virginia	Cabell	38-23-56 82-28-44	Ames Limestone	88ALSA	84–94 a.b.
42.	West Virginia	Wayne	38-23-50 82-30-11	Ames Limestone	91ALSA	13–76 a.b.
43.	West Virginia	Wayne	38-23-41 82-31-16	Ames Limestone	93ALSA	752–798 a.b.
44.	West Virginia	Wayne	38-23-40 82-31-52	Ames Limestone	95ALSC	0–51 a.b.
45.	Kentucky	Boyd-Lawrence	38-14-54 82-36-02	Ames Limestone	97ALSH	0–30 a.b.
46.	Kentucky	Lawrence	38-14-14 82-36-49	Ames Limestone	98ALSE	297–328 a.b.

Appendix 2A (continued)

	State	*County*	*Location**		*Stratigraphic unit*	*Sample code*	*Position†*
47.	Kentucky	Lawrence	38-14-14	82-36-49	Ames Limestone	98ALSH	0–86 a.b.
48.	West Virginia	Wayne	38-16-22	82-34-19	Ames Limestone	103ALSD	28–99 a.b.
49.	West Virginia	Wayne	38-16-22	82-34-19	Ames Limestone	103ALSE	0–28 a.b.
50.	West Virginia	Wayne	38-17-13	82-34-34	Ames Limestone	104ALS	0–30 a.b.
51.	West Virginia	Wayne	38-19-41	82-34-25	Ames Limestone	106ALSD	714–777 a.b.
			ILLINOIS BASIN				
52.	Illinois	Warren	NE-NE-26-9N-1W		Seville Limestone	10KSSSB	0–122 a.b.
53.	Illinois	Henry	SE-SW-21-7N-2E		Seville Limestone	14KSSSA	0–10 a.b.
54.	Illinois	Henry	SE-SW-21-7N-2E		Seville Limestone	14KSSSB	10–13 a.b.
55.	Illinois	Henry	SE-SW-21-7N-2E		Seville Limestone	14KSSSC	13–18 a.b.
56.	Illinois	Mercer	SE-NE-36-15N-3W		Oak Grove Limestone	7KCLOB	0–30 a.b.
57.	Illinois	Peoria	NW-SE-26-10N-6E		Hanover Limestone	3KCSHD	15–17 a.b.
58.	Illinois	Peoria	NW-SE-26-10N-6E		Hanover Limestone	3KCSHE	0–15 a.b.
59.	Illinois	La Salle	SE-SW-26-3N-3E		Hanover Limestone	4KCSHC	0–30 a.b.
60.	Illinois	La Salle	SE-SW-8-32N-2E		Hanover Limestone	6KCSHA	314–355 a.b.
61.	Illinois	Knox	Cen-SW-25-11N-1E		Hanover Limestone	8KCSH	0–13 a.b.
62.	Illinois	Fulton	SW-30-7N-4E		St. David Limestone	2KCDDB	15–61 a.b.
63.	Illinois	Fulton	NE-SE-26-5N-1E		St. David Limestone	10KCDD	float
64.	Illinois	Schuyler	SW-26-2N-1W		St. David Limestone?	21KCDD?	0–10 a.b.
65.	Illinois	Peoria	N-SW-16-9N-6E		St. David Limestone	24KCDDB	305–313 a.b.
66.	Illinois	Peoria	N-SW-16-9N-6E		St. David Limestone	24KCDDC	313–322 a.b.
67.	Illinois	Fulton	SE-NE-1-7N-4E		Brereton Limestone	1KCBB	11–63 a.b.
68.	Illinois	Schuyler	NW-NW-26-2N-1W		Brereton Limestone	2KCBBE	0–15 a.b.
69.	Illinois	Knox	S.Cen-35-9N-4E		Brereton Limestone	5KCBBA	0–30 a.b.
70.	Illinois	Peoria	SW-NE-25-9N-6E		Brereton Limestone	8KCBBA	76–107 a.b.
71.	Illinois	Peoria	W-NW-34-8N-6E		Brereton Limestone	9KCBBB	0–38 a.b.
72.	Illinois	Peoria	NW-SE-15-9N-5E		Brereton Limestone	10KCBBB	137–152 a.b.
73.	Illinois	Knox	SW-SW-26-12N-3E		Brereton Limestone	12KCBBA	23–46 a.b.
74.	Illinois	Knox	W-NW-4-11N-4E		Brereton Limestone	14KCBBB	0–10 a.b.
75.	Illinois	Peoria	SW-SW-18-10N-6E		Brereton Limestone	18KCBBB	160–170 a.b.
76.	Illinois	Peoria	SW-SW-18-10N-6E		Brereton Limestone	18KCBBC	145–160 a.b.
77.	Illinois	Peoria	NW-SW-26-7N-6E		Brereton Limestone	21KCBB	0–61 a.b.
78.	Illinois	Peoria	SE-SE-17-11N-5E		Brereton Limestone	24KCBBB	0–20 a.b.
79.	Illinois	Schuyler	NW-NW-26-2N-1W		Pokeberry Limestone	1KCJPC	198–290 a.b.
80.	Illinois	Schuyler	NW-NW-26-2N-1W		Pokeberry Limestone	1KCJPF	76–122 a.b.
81.	Illinois	Schuyler	NE-SE-26-2N-1W		Pokeberry Limestone	2KCJPC	163–193 a.b.
82.	Illinois	Schuyler	NE-SE-26-2N-1W		Pokeberry Limestone	2KCJPD	102–163 a.b.
83.	Illinois	Schuyler	SE-SE-26-2N-1W		Pokeberry Limestone	3KCJP	200–275 a.b.
84.	Illinois	Peoria	NW-SE-21-8N-6E		"Sparland" Shale	2KCCSD	15–36 a.b.
85.	Illinois	Peoria	NW-SW-26-9N-5E		"Sparland" Shale	3KCCSA	30–61 a.b.
86.	Illinois	Peoria	NW-6-8N-7E		Lonsdale Limestone	1AMGLB	122–244 a.b.
87.	Illinois	Peoria	SW-NE-28-8N-6E		Lonsdale Limestone	6AMGLA	61–122 a.b.
88.	Illinois	Peoria	E-SE-33-8N-6E		Lonsdale Limestone	7AMGLA	259–340 a.b.
89.	Illinois	Peoria	NW-SE-7-8N-7E		Lonsdale Limestone	8AMGLA	173–234 a.b.
90.	Illinois	Peoria	NW-SE-4-10N-6E		Lonsdale Limestone	11AMGL	0–25 a.b.
91.	Illinois	Peoria	SE-NW-4-11N-7E		Lonsdale Limestone	12AMGLA	91–152 a.b.
92.	Illinois	Peoria	NW-NW-9-11N-9E		Lonsdale Limestone	13AMGLB	15–30 a.b.
93.	Illinois	Peoria	NW-SE-33-9N-6E		Exline Limestone	2AMGEX	0–10 a.b.

Appendix 2A (continued)

	State	*County*	*Location**	*Stratigraphic unit*	*Sample code*	*Position†*
94.	Illinois	Peoria	NE-SW-3-8N-5E	Cramer Limestone	1AMTCB	18–36 a.b.
95.	Illinois	Bureau	NW-NW-2-15N-11E	Cramer Limestone	2AMTCA	61–122 a.b.
96.	Illinois	Bureau	NW-NW-2-15N-11E	Cramer Limestone	2AMTCB	0–61 a.b.
97.	Illinois	Bureau	NW-NW-2-15N-11E	Cramer Limestone	2AMTCC	61–122 a.b.
98.	Illinois	Peoria	NE-SW-15-8N-5E	Cramer Limestone	3AMTCB	40–47 a.b.
99.	Illinois	Peoria	NE-SW-15-8N-5E	Cramer Limestone	3AMTCD	0–30 a.b.
100.	Illinois	La Salle	Cen-6-32N-1E	Hall Limestone	2ABSH	0–91 a.b.
101.	Illinois	La Salle	Cen-6-32N-1E	La Salle Limestone	1ABLLD	732–884 a.b.
102.	Illinois	Bureau	SE-NW-33-16N-11E	La Salle Limestone	3ABLLB	617–678 a.b.
103.	Illinois	La Salle	SW-SW-24-33N-1E	La Salle Limestone	4ABLLB	823–884 a.b.
104.	Illinois	La Salle	SW-SW-24-33N-1E	La Salle Limestone	4ABLLC	762–823 a.b.
105.	Illinois	La Salle	SW-SW-24-33N-1E	La Salle Limestone	4ABLLD	732–762 a.b.
106.	Illinois	La Salle	SW-NE-11-33N-1E	La Salle Limestone	5ABLLD	671–678 a.b.
107.	Illinois	La Salle	SW-SW-27-33N-1E	Little Vermilion Ls.	1AOVLA	23–46 a.b.
108.	Illinois	La Salle	SW-NE-11-33N-1E	Little Vermilion Ls.	2AOVLD	0–61 a.b.
109.	Illinois	La Salle	SW-NE-11-33N-1E	Unnamed Limestone	1AOXX	0–30 a.b.
				MIDCONTINENT		
110.	Missouri	Boone	NE-SW-8-48N-13W	Blackjack Creek Ls.	7DFBX	30–79 a.b.
111.	Missouri	Boone	NE-SE-33-49N-12W	Higginsville Limestone	1DFHXC	30–335 a.b.
112.	Missouri	Bates	SW-19-40N-31W	Higginsville Limestone	5DFHXE	0–55 a.b.
113.	Missouri	Bates	SW-19-40N-31W	Anna Shale	4DAPA	0–30 a.b.
114.	Missouri	Lafayette	NE-NW-33-51N-27W	Myrick Station Ls.	1DAPY	0–91 a.b.
115.	Oklahoma	Nowata	NE-33-26N-17E	Myrick Station Ls.	3DAPY	0–91 a.b.
116.	Iowa	Madison	16-75N-28W	Sniabar Limestone	3MKHSA	253–283 a.b.
117.	Missouri	Jackson	SE-22-50N-32W	Ladore Shale	1MKLX	0–76 a.b.
118.	Iowa	Madison	E-NW-22-75N-28W	Ladore Shale	2MKLXE	0–50 a.b.
119.	Missouri	Jackson	SE-NE-28-49N-33W	Bethany Falls Ls.	1MKSBA	145–251 a.b.
120.	Missouri	Jackson	NW-NE-9-47N-33W	Bethany Falls Ls.	3MKSBB	0–183 a.b.
121.	Missouri	Jackson	SE-22-50N-32W	Winterset Limestone	3MKDWE	640–655 a.b.
122.	Iowa	Madison	E-NW-22-75N-28W	Winterset Limestone	4MKDWD	183–244 a.b.
123.	Missouri	Jackson	SE-22-50N-32W	Fontana Shale	1MKCFB	0–61 a.b.
124.	Iowa	Madison	NW-22-75N-28W	Fontana Shale	2MKCFC	107–122 a.b.
125.	Missouri	Jackson	SE-22-50N-32W	Westerville Limestone	4MKCWB	76–137 a.b.
126.	Iowa	Madison	NW-22-75N-28W	Westerville Limestone	5MKCWA	61–122 a.b.
127.	Iowa	Madison	NW-11-75N-28W	Westerville Limestone	6MKCW	0–70 a.b.
128.	Missouri	Platte	SW-SW-3-50N-33W	Westerville Limestone	7MKCWC	61–152 a.b.
129.	Missouri	Jackson	SW-NE-6-49N-33W	Drum Limestone	2MKRC	0–411 a.b.
130.	Missouri	Platte	SW-SW-3-50N-33W	Drum Limestone	6MKRCC	194–259 a.b.
131.	Missouri	Jackson	SE-22-50N-28W	Muncie Creek Shale	4MKIM	0–30 a.b.
132.	Missouri	Jackson	NE-SW-18-49N-33W	Raytown Limestone	3MKIR	0–122 a.b.
133.	Missouri	Jackson	SE-22-50N-28W	Raytown Limestone	4MKIRA	122–173 a.b.
134.	Iowa	Madison	NW-22-75N-28W	Raytown Limestone	5MKIRA	244–299 a.b.
135.	Iowa	Madison	NW-22-75N-28W	Raytown Limestone	5MKIRD	85–122 a.b.
136.	Iowa	Madison	NW-22-75N-28W	Raytown Limestone	5MKIRE	55–85 a.b.
137.	Iowa	Madison	NW-11-75N-28W	Raytown Limestone	6MKIRA	175–229 a.b.
138.	Iowa	Madison	NW-11-75N-28W	Raytown Limestone	6MKIRE	0–61 a.b.
139.	Missouri	Jackson	SE-22-50N-28W	Lane Shale	3MKNXC	396–457 a.b.
140.	Missouri	Jackson	NE-SW-18-49N-33W	Frisbie Limestone	3MKWF	0–30 a.b.

Appendix 2A (continued)

	State	*County*	*Location**	*Stratigraphic unit*	*Sample code*	*Position†*
141.	Missouri	Jackson	SE-SW-8-49N-33W	Quindaro Shale	1MKWQ	0–91 a.b.
142.	Missouri	Jackson	SE-SW-8-49N-33W	Argentine Limestone	1MKWA	0–61 a.b.
143.	Missouri	Jackson	SW-NE-6-49N-33W	Argentine Limestone	2MKWAB	0–61 a.b.
144.	Missouri	Jackson	SE-22-50N-28W	Argentine Limestone	4MKWAC	305–366 a.b.
145.	Missouri	Jackson	SE-22-50N-28W	Argentine Limestone	4MKWAE	183–244 a.b.
146.	Missouri	Jackson	SE-22-50N-28W	Argentine Limestone	4MKWAF	122–183 a.b.
147.	Iowa	Madison	NE-10-75N-28W	Argentine Limestone	5MKWAD	128–143 a.b.
148.	Iowa	Madison	NW-SE-5-75N-29W	Island Creek Shale	1MKWI	0–45 a.b.
149.	Missouri	Clay	NE-NE-34-51N-33W	Farley Limestone	1MKWLA	277–368 a.b.
150.	Missouri	Clay	SE-SE-22-51N-33W	Farley Limestone	2MKWLE	0–168 a.b.
151.	Iowa	Madison	NW-SE-5-75N-29W	Bonner Springs Shale	1MKBXA	61–122 a.b.
152.	Iowa	Madison	NW-SE-5-75N-29W	Spring Hill Member	2MLPS	0–161 a.b.
153.	Iowa	Madison	NW-SE-5-75N-29W	Merriam Member	3MLPM	0–91 a.b.
154.	Iowa	Madison	NW-7-75N-29W	Vilas Shale	1VSOS	0–30 below top
155.	Iowa	Madison	NW-7-75N-29W	Captain Creek Member	Le-16-1	0–31 a.b.
156.	Iowa	Madison	NW-7-75N-29W	Eudora Shale	He-16-1	0–17 a.b.
157.	Iowa	Cass	SE-NE-16-75N-37W	Eudora Shale	He-15-3	28–53 a.b.
158.	Iowa	Cass	SE-NE-16-75N-37W	Stoner Limestone	P-15-1	0–81 a.b.
159.	Iowa	Cass	SE-NE-16-75N-37W	Stoner Limestone	P-15-3	198–325 a.b.
160.	Iowa	Madison	NW-7-75N-29W	Stoner Limestone	P-16-2	21–170 a.b.
161.	Iowa	Madison	NW-7-75N-29W	Stoner Limestone	P-16-3	170–403 a.b.
162.	Iowa	Madison	NW-7-75N-29W	Stoner Limestone	P-16-4	403–461 a.b.
163.	Iowa	Madison	NW-7-75N-29W	Stoner Limestone	3VSOPA	344 a.b. to top
164.	Kansas	Douglas	NW-21-12S-19E	Toronto Limestone	T-1-6	180–294 a.b.
165.	Kansas	Douglas	NW-21-12S-19E	Snyderville Shale	Sn-1-1A	0–5 a.b.
166.	Kansas	Douglas	NW-21-12S-19E	Snyderville Shale	Sn-1-4B	313–323 a.b.
167.	Kansas	Douglas	NW-21-12S-19E	Leavenworth Limestone	Le-1-1	0–53.5 a.b.
168.	Oklahoma	Osage	SW-SW-19-29N-10E	Leavenworth Limestone	Le-9-1	0–38 a.b.
169.	Nebraska	Cass	NW-15-12N-10E	Heebner Shale	He-14-3	102–412 a.b.
170.	Kansas	Douglas	NW-21-12S-19E	Heebner Shale	He-1-4A	204–222 a.b.
171.	Kansas	Douglas	NW-21-12S-19E	Plattsmouth Limestone	P-1-5	279–310 a.b.
172.	Kansas	Chautauqua	NW-21-12S-19E	Plattsmouth Limestone	P1-2-2D	329–412 a.b.
173.	Oklahoma	Osage	SW-SW-19-29N-10E	Plattsmouth Limestone	P-5-1	0–53 a.b.
174.	Oklahoma	Osage	SW-SW-19-29N-10E	Plattsmouth Limestone	P-6-2	153–231 a.b.
175.	Missouri	Andrew	N-34-59N-35W	Plattsmouth Limestone	P-13-5	287–411 a.b.
176.	Nebraska	Cass	NW-15-12N-10E	Plattsmouth Limestone	P-14-1	0–25 a.b.
177.	Nebraska	Cass	NW-15-12N-10E	Plattsmouth Limestone	P-14-2	25–108 a.b.
178.	Nebraska	Cass	NW-15-12N-10E	Plattsmouth Limestone	P-14-3	108–222 a.b.
179.	Kansas	Chautauqua	SW-SE-33-33S-11E	Plattsmouth Limestone	2VSOPB	0–183 a.b.
180.	Kansas	Douglas	NW-SW-35-11S-18E	Heumader Shale	Heu-	bottom 5.1 of Heu-1-1
181.	Kansas	Douglas	NW-SW-35-11S-18E	Heumader Shale	Heu-1-1	0–13 a.b.
182.	Kansas	Douglas	NW-SW-35-11S-18E	Heumader Shale	Heu-1-2	13–41 a.b.
183.	Kansas	Douglas	NW-SW-35-11S-18E	Heumader Shale	Heu-1-3A	41–69 a.b.
184.	Kansas	Douglas	NW-SW-35-11S-18E	Heumader Shale	Heu-1-3B	69–71 a.b.
185.	Kansas	Douglas	NW-SW-35-11S-18E	Kereford Limestone	Ke-1-2B	24–52 a.b.
186.	Kansas	Douglas	NW-SW-35-11S-18E	Kereford Limestone	Ke-1-3	52–67 a.b.
187.	Kansas	Douglas	NW-SW-35-11S-18E	Kereford Limestone	Ke-1-6	146–239 a.b.
188.	Kansas	Douglas	NW-SW-35-11S-18E	Kereford Limestone	Ke-1-7	239–256 a.b.
189.	Kansas	Douglas	NW-NW-24-12S-18E	Spring Branch Limestone	SB-1-1C	69–93 a.b.

Appendix 2A (continued)

	State	*County*	*Location**	*Stratigraphic unit*	*Sample code*	*Position†*
190.	Kansas	Douglas	NW-NW-24-12S-18E	Spring Branch Limestone	SB-1-2B	180–216 a.b.
191.	Kansas	Douglas	NW-NW-24-12S-18E	Spring Branch Limestone	SB-1-3	216–241 a.b.
192.	Kansas	Douglas	NW-NW-24-12S-18E	Spring Branch Limestone	SB-1-4A	241–265 a.b.
193.	Kansas	Douglas	NW-NW-24-12S-18E	Spring Branch Limestone	SB-1-5A	326–333 a.b.
194.	Kansas	Douglas	NW-NW-24-12S-18E	Doniphan Shale	Dos-1-2	36–59 a.b.
195.	Kansas	Douglas	NW-NW-24-12S-18E	Queen Hill Shale	QH-1-2	48–102 a.b.
196.	Kansas	Douglas	NW-NW-24-12S-18E	Beil Limestone	B-1-1	0–69 a.b.
197.	Kansas	Douglas	NW-NW-24-12S-18E	Doniphan Shale	B-1-7	267–272 a.b.
198.	Kansas	Jefferson	SE-NW-SE-8-11S-18E	Avoca Limestone	Av-3-4	102–114 a.b.
199.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Oskaloosa Shale	Os-1-3	172–190 a.b.
200.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Larsh-Burroak Shale	LB-1-1	0–3 a.b.
201.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Larsh-Burroak Shale	LB-1-2	3–37 a.b.
202.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Larsh-Burroak Shale	LB-1-3A	37–54 a.b.
203.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Larsh-Burroak Shale	LB-1-3B	54–71 a.b.
204.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Larsh-Burroak Shale	LB-1-3C	71–88 a.b.
205.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-1A	0–14 a.b.
206.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-1B	14–28 a.b.
207.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-1D	42–56 a.b.
208.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-1H	98–113 a.b.
209.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-1J	127–141 a.b.
210.	Kansas	Douglas	NE-NW-NW-22-12S-18E	Ervine Creek	EC-1-2	avg. 141–196 a.b.
211.	Kansas	Shawnee	SE-SW-2-12S-16E	Calhoun Shale	Cal-Sp-1	top 31
212.	Kansas	Shawnee	SE-SW-2-12S-16E	Hartford Limestone	H-1-1	0–13 a.b.
213.	Kansas	Shawnee	SE-SW-2-12S-16E	Hartford Limestone	H-1-2	13–25 a.b.
214.	Kansas	Shawnee	SE-SW-2-12S-16E	Hartford Limestone	H-1-3A	25–40 a.b.
215.	Kansas	Shawnee	SE-SW-2-12S-16E	Hartford Limestone	H-1-3D	68–82 a.b.
216.	Kansas	Shawnee	SE-SW-2-12S-16E	Hartford Limestone	H-1-3G	111–124 a.b.
217.	Kansas	Shawnee	NW-SE-14-11S-16E	Iowa Point Shale	IP-2-3	18–39 a.b.
218.	Kansas	Shawnee	NW-SE-14-11S-16E	Curzon Limestone	Cur-1-1B	38–48 a.b.
219.	Kansas	Shawnee	NW-SE-14-11S-16E	Jones Point Shale	JPS-1-1	0–8 a.b.
220.	Kansas	Shawnee	NW-SE-14-11S-16E	Sheldon Limestone	She-1-1	0–22 a.b.
221.	Kansas	Shawnee	NW-SE-14-11S-16E	Sheldon Limestone	She-1-3	27–67 a.b.
222.	Kansas	Chautauqua	SW-SW-SE-3-34S-9E	DuBois Limestone	2VSTD	0–45 a.b.
223.	Kansas	Chautauqua	SW-SW-SE-3-34S-9E	Holt Shale	2VSTH	30–61 a.b.
224.	Kansas	Shawnee	NE-NE-NW-16-11S-16E	Holt Shale	1VSTH	0–30 a.b.
225.	Kansas	Lyon	NW-SW-9-19S-12E	Elmont Limestone	1VWERB	0–131 a.b.
226.	Kansas	Lyon	NW-SW-14-18S-10E	Americus Limestone	1BCFA	0–30 a.b.
227.	Kansas	Lyon	NW-SW-15-15S-11E	Burr Limestone	1BCGBC	0–15 a.b.
228.	Kansas	Lyon	NW-SW-15-15S-11E	Sallyards Limestone	1BCGS	0–9 a.b.
229.	Kansas	Marion	SE-SE-SE-6-21S-5E	Florence Limestone	3BHBFC	0–122 a.b.
230.	Kansas	Chase	SW-NW-1-21S-6E	Schroyer Limestone	1BHWS	0–625 a.b.
			TEXAS			
231.	Texas	Mason	30-41-17 99-19-13	Marble Falls Limestone	ZR-9	1219–1250 a.b.
232.	Texas	San Saba	31-05-34 98-31-13	Marble Falls Limestone	1RMCXX	0–60 below top
233.	Texas	Palo Pinto	38-48-25 98-06-10	East Mountain Shale	1SLEXE	2440–2470 a.b.
234.	Texas	Palo Pinto	38-48-25 98-06-10	East Mountain Shale	1SLEXF	1220–1250 a.b.
235.	Texas	Stephens	32-31-55 98-34-45	Wiles Limestone	1NWPW	0–45 a.b.
236.	Texas	Wise	33-13-20 97-49-45	Wolf Mountain Shale	1NGMJC	434–439 a.b.

Appendix 2A (continued)

	State	County	Location*		Stratigraphic unit	Sample code	Position†
237.	Texas	Wise	33-13-20	97-49-45	Wolf Mountain Shale	1NGMJE	867–985 a.b.
238.	Texas	Wise	33-13-20	97-49-45	Wolf Mountain Shale	1NGMJI	1199–1232 a.b.
239.	Texas	Brown	31-50-15	99-00-00	Winchell Limestone	3NGWXF	2744–2774 a.b.
240.	Texas	Brown	31-50-15	99-00-00	Winchell Limestone	3NGWXP	244–274 a.b.
241.	Texas	Brown	31-50-15	99-00-00	Winchell Limestone	3NGWXQ	152–182 a.b.
242.	Texas	Brown	31-50-15	99-00-00	Winchell Limestone	3NGWXR	0–30 a.b.
243.	Texas	Stephens	32-33-05	98-59-45	Belknap Limestone	1WPDW-2	unknown
244.	Texas	Eastland	32-17-00	98-59-00	Harpersville Limestone	1WPDX	0–61 a.b.
245.	Texas	Eastland	32-17-00	98-59-00	Saddle Creek Limestone	1WPDS	0–150 a.b.

* Expressed as latitude and longitude (to one or five minutes depending on the scale of the map from which it was determined) for West Virginia, Kentucky, and Texas; as (¼ section), ¼ section, section, and political township for Ohio; and as (¼ section), ¼ section, section, township, and range for other states.

† Expressed in centimetres above base (a.b.) of unit (base of outcrop when base of unit not exposed), but may include unnamed marine beds continuous with the named unit.

N.B. Localities 9 and 10, 95 and 97 are collections of the same stratigraphic interval made at different times. The stratigraphic identity of the unit sampled at locality 64 is in doubt.

Appendix 2B

Register of localities of Ordovician neurodonts, Permian and Triassic ellisonids, and Pennsylvanian idioprioniodids studied comparatively and subsequently illustrated

LOCALITY 246 Ordovician, Tyrone Limestone, sparry layer above Pencil Cave Bentonite along road by quarry near Buena Vista, 37°45′31″N, 84°39′06″W, Garrard Co., Kentucky, U.S.A. Collected by Glen K. Merrill, April 1964.

LOCALITY 247 Ordovician, Tyrone Limestone, micrite below "Spaghetti Bed" along road by quarry near Buena Vista, 37°45′31″N, 84°39′06″W, Garrard Co., Kentucky, U.S.A. Collected by Glen K. Merrill, April 1964.

LOCALITY 248 Ordovician, Tyrone Limestone, "Lower Hash Bed", along road by quarry, 37°45′31″N, 84°39′06″W, Buena Vista, Garrard Co., Kentucky, U.S.A. Collected by Glen K. Merrill, April 1964.

LOCALITY 249 Ordovician, Tyrone Limestone, "Bentonite Bed", along east side of Kentucky River fault, ±90 m west of road junction, 37°45′03″N, 84°37′24″W, Garrard Co., Kentucky, U.S.A. Collected by Glen K. Merrill, April 1964.

LOCALITY 250 Pennsylvanian, west side of Blue Mountains, 13.2 km southwest of peak (Bonham-Carter Reef), Ellesmere Island, Northwest Territories, Canada. Geological Survey of Canada locality C-4085b.

LOCALITY 251 Late (?) Permian, Gerster Formation, Butte Mountains, sections 27 and 28 T20N R60E, Pine Co., Nevada, U.S.A. Sample of E. Marcantel; given to G.K.M. by J. Collinson.

LOCALITY 252 Early Kazanian (=early Capitanian), Borehole Bororga (Vologda), northern Russian platform, USSR.

LOCALITY 253 *Meekoceras* Zone, Early Triassic, on road from Diamond Creek to Smokey Canyon, T8S R45E Crow Creek Quadrangle, Caribou Co., Idaho, U.S.A. Sample 68SK-113 of B. Kummel; given to G.K.M. by W. Sweet.

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Plate 1, figs. 1–24

Figs. 1–16 *Ellisonia latilaminata* sp. nov., Desmoinesian, U.S.A.

1. ?Hi element, lateral view, locality 16, Dorr Run Shale, Hocking Co., Ohio, sample 2DRSH, ROM 40331, × 43

2. Hi element, sinistral, inner lateral view, locality 83, Pokeberry Limestone, Schuyler Co., Illinois, sample 3KCJP, ROM 40325, × 42

3. Hi element, ?dextral, ?inner lateral view, locality 80, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPF, ROM 40326, × 54

4. ?Hi element, ?sinistral, ?inner lateral view, locality 80, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPF, ROM 40327, × 66

5. Tr element, lateral view, locality 83, Pokeberry Limestone, Schuyler Co., Illinois, sample 3KCJP, ROM 40330, × 71

6. ?Hi element, dextral, inner lateral view, locality 80, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPF, ROM 40328, × 78

7. ?Hi element, ?sinistral, inner lateral view, locality 79, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPC, ROM 40329, × 59

8. Tr element, anterolateral view, locality 80, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPF, ROM 40336, × 80

9. ?Hi element, ?inner lateral view, locality 78, Brereton Limestone, Peoria Co., Illinois, sample 24KCBBB, ROM 40332, × 52

10. Hi element, sinistral, inner lateral view, locality 111, Higginsville Limestone, Boone Co., Missouri, sample 1DFHXC, ROM 40333, × 40

11. Hi element, dextral, inner lateral view, locality 58, Hanover Limestone, Peoria Co., Illinois, sample 3KCSHE, ROM 40334, × 43

12. Hi element, sinistral, inner lateral view, locality 58, Hanover Limestone, Peoria Co., Illinois, sample 3KCSHE, ROM 40335, × 54

13. Hi element, sinistral, inner lateral view, locality 15, Vanport Limestone, Vinton Co., Ohio, sample 24VLSC, Paratype ROM 40337, × 70

14. Hi element, sinistral, inner lateral view, locality 10, Vanport Limestone, Vinton Co., Ohio, sample 4VLSC, Paratype ROM 40338, × 74

15. Tr element, lateral view, locality 14, Vanport Limestone, Vinton Co., Ohio, sample 22VLSB, Holotype ROM 40339, × 118

16. Tr element, anterior view, locality 9, Vanport Limestone, Vinton Co., Ohio, sample 4VLSA, Paratype ROM 40340, × 81

Figs. 17–24 *Ellisonia latilaminata* sp. nov., Morrowan and Atokan, U.S.A.

17. Hi element, dextral, inner lateral view, locality 8, Upper Mercer Limestone, Muskingum Co., Ohio, sample 6UMLSA, ROM 40341, × 82

18. Hi element, lateral view, locality 3, Dingess Limestone, Mingo Co., West Virginia, sample 1DLS, ROM 40342, × 46

19. Hi element, sinistral, inner lateral view, locality 4, Dingess Limestone, Mingo Co., West Virginia, sample 4DLS, ROM 40343, × 66

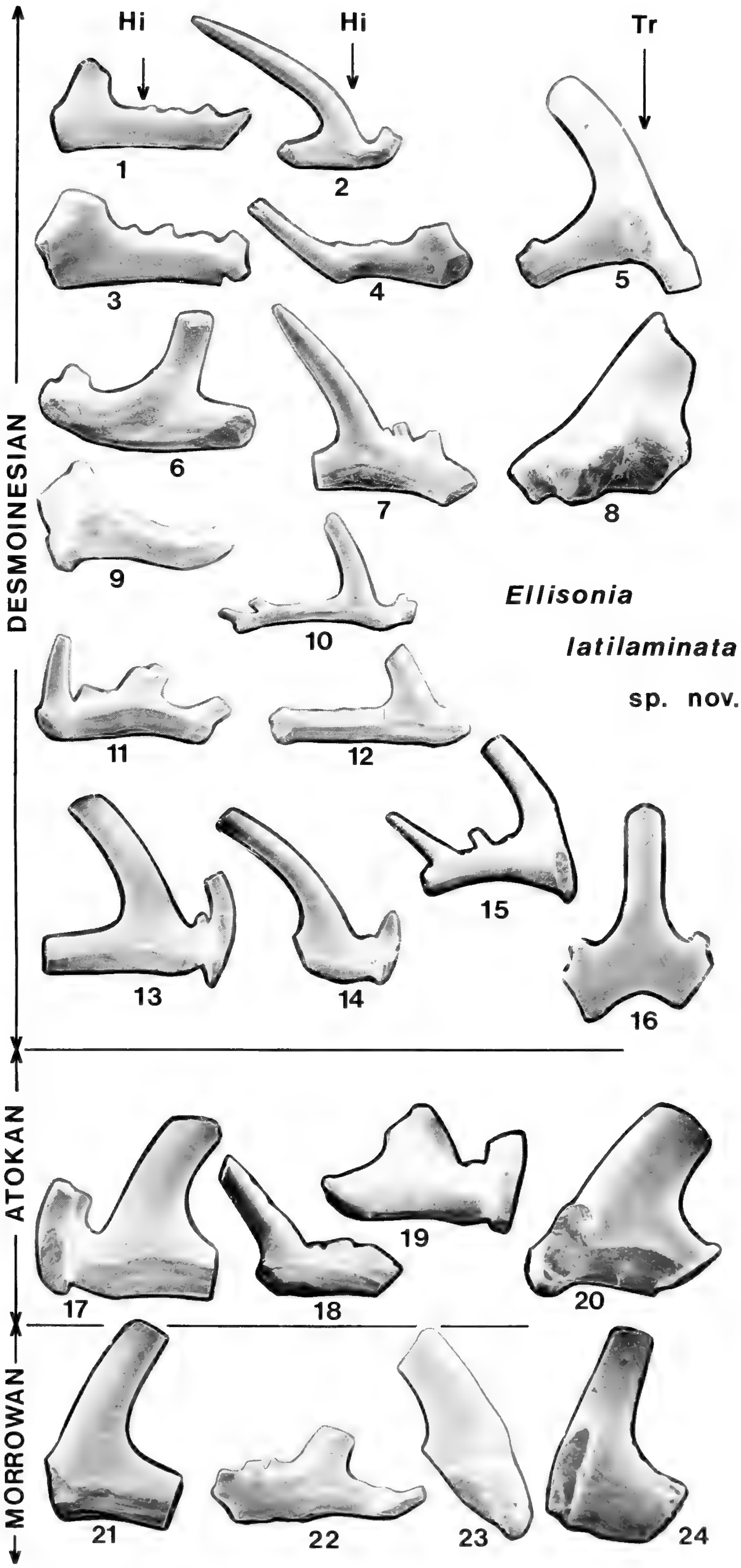
20. Tr element, lateral view, locality 4, Dingess Limestone, Mingo Co., West Virginia, sample 4DLS, ROM 40344, × 87

21. Hi element, ?inner lateral view, locality 2, Eagle Limestone, Mingo Co., West Virginia, sample 2ELS, ROM 40345, × 94

22. Hi element, inside lateral view, locality 5, Kendrick Limestone, Carter Co., Kentucky, sample 1KLSA, ROM 40346, × 52

23. Tr element, lateral view, locality 5, Kendrick Limestone, Carter Co., Kentucky, sample 1KLSA, ROM 40348, × 64

24. Tr element, lateral view, locality 2, Eagle Limestone, Mingo Co., West Virginia, sample 2ELS, ROM 40347, × 116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DESMOINESIAN
ATOKAN
MORROWAN
Ellisonia
latilaminata
sp. nov.

Plate 2, figs. 1–21
Ellisonia latilaminata sp. nov., Missourian, U.S.A.

1. Hi element, dextral, inner lateral view, locality 154, Vilas Shale, Madison Co., Iowa, sample 1VSOS, ROM 40349, × 53

2. Tr element, lateral view, locality 154, Vilas Shale, Madison Co., Iowa, sample 1VSOS, ROM 40350, × 164

3. Hi element, dextral, ?lateral view, locality 140, Frisbie Limestone, Jackson Co., Missouri, sample 3MKWF, ROM 40351, × 93

4. Hi element, dextral, inner lateral view, locality 30, Portersville Shale, Athens Co., Ohio, sample 3PLSB, ROM 40352, × 95

5. Tr element, anterolateral view, locality 140, Frisbie Limestone, Jackson Co., Missouri, sample 3MKWF, ROM 40353, × 87

6. Hi element, ?sinistral, ?inner lateral view, locality 28, Cambridge Limestone, Lawrence Co., Ohio, sample 22CLSX, ROM 40354, × 54

7. Hi element, ?dextral, ?inner lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40355, × 116

8. Hi element, ?dextral, ?inner lateral view, locality 131, Muncie Creek Shale, Jackson Co., Missouri, sample 4MKIM, ROM 40356, × 53

9. Tr element, lateral view, locality 105, La Salle Limestone, La Salle Co., Illinois, sample 4ABLLD, ROM 40357, × 104

10. Hi element, sinistral, inner lateral view, locality 116, Sniabar Limestone, Madison Co., Iowa, sample 3MKHSA, ROM 40358, × 81

11. Hi element, sinistral, inner lateral view, locality 25, Upper Brush Creek Limestone, Lawrence Co., Ohio, sample 34UBCLS, ROM 40359, × 80

12. Hi element, ?dextral, ?inner lateral view, locality 24, Upper Brush Creek Limestone, Lawrence Co., Ohio, sample 21UBCLSB, ROM 40360, × 83

13. Hi element, sinistral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40361, × 39

14. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40362, × 80

15. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40363, × 58

16. Tr element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40364, × 69

17. Tr element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40365, × 50

18. Hi element, inner lateral view, locality 97, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCC, ROM 40366, ×80

19. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40367, × 43

20. Hi element, sinistral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40368, ×68

21. Tr element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40369, × 69

MISSOURIAN

Ellisonia latilaminata sp. nov.

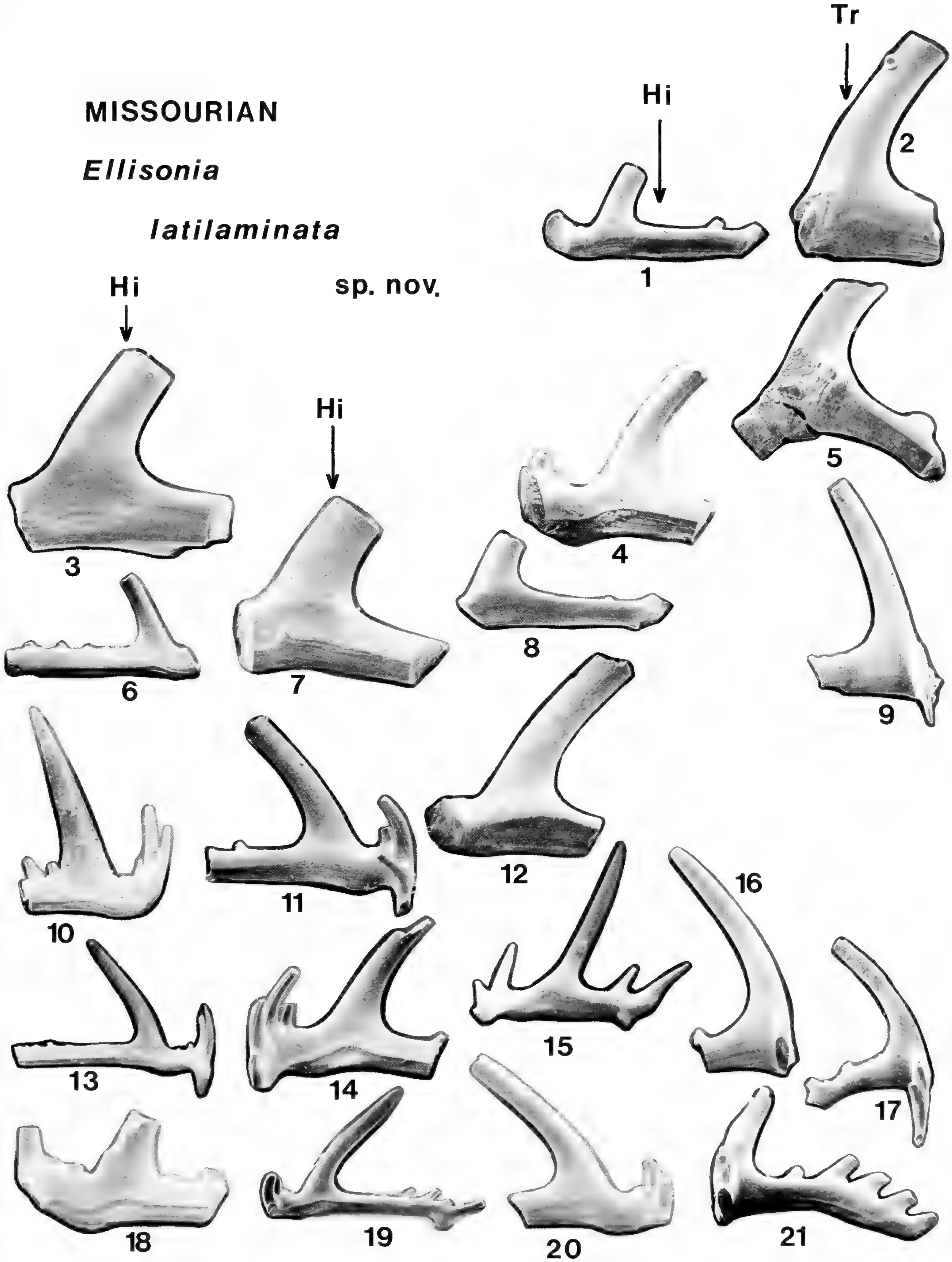

Plate 3, figs. 1–25

Figs. 1–23 *Ellisonia conflexa* (Ellison), middle and late Desmoinesian, U.S.A.

1. Pl element, dextral, inner lateral view, locality 92, Lonsdale Limestone, Peoria Co., Illinois, sample 13AMGLB, ROM 40370, × 43

2. Hi element, dextral, inner lateral view, locality 86, Lonsdale Limestone, Peoria Co., Illinois, sample 1AMGLB, ROM 40371, × 23

3. Tr element, lateral view, locality 89, Lonsdale Limestone, Peoria Co., Illinois, sample 8AMGLA, ROM 40372, × 35

4. ?Oz element, ?dextral, ?inner lateral view, locality 80, Pokeberry Limestone, Schuyler Co., Illinois, sample 1KCJPF, ROM 40373, × 65

5. Pl element, sinistral, inner lateral view, locality 87, Lonsdale Limestone, Peoria Co., Illinois, sample 6AMGLA, ROM 40374, × 69

6. Hi element, dextral, inner lateral view, locality 234, East Mountain Shale, Palo Pinto Co., Texas, sample 1SLEXF, ROM 40375, × 37

7. Tr element, lateral view, locality 234, East Mountain Shale, Palo Pinto Co., Texas, sample 1SLEXF, ROM 40376, ×68

8. ?Oz element, ?dextral, ?inner lateral view, locality 74, Brereton Limestone, Knox Co., Illinois, sample 14KCBBB, ROM 40377, × 61

9. Pl element, dextral, inner lateral view, locality 73, Brereton Limestone, Knox Co., Illinois, sample 12KCBBA, ROM 40378, × 33

10. Hi element, dextral, inner lateral view, locality 75, Brereton Limestone, Peoria Co., Illinois, sample 18KCBBB, ROM 40379, × 32

11. Hi element, dextral, inner lateral view, locality 115, Myrick Station Limestone, Nowata Co., Oklahoma, sample 3DAPY, ROM 40380, × 54

12. Ne element, aborolateral view, locality 75, Brereton Limestone, Peoria Co., Illinois, sample 18KCBBB, ROM 40381, × 56

13. Pl element, sinistral, inner lateral view, locality 76, Brereton Limestone, Peoria Co., Illinois, sample 18KCBBC, ROM 40382, × 41

14. Hi element, sinistral, inner lateral view, locality 63, St. David Limestone, Fulton Co., Illinois, sample 10KCDD, ROM 40383, × 51

15. Tr element, lateral view, locality 70, Brereton Limestone, Peoria Co., Illinois, sample 8KCBBA, ROM 40384, × 24

16. Ne element, aborolateral view, locality 63, St. David Limestone, Fulton Co., Illinois, sample 10KCDD, ROM 40385, × 84

17. ?Pl element, ?sinistral, inner lateral view, locality 58, Hanover Limestone, Peoria Co., Illinois, sample 3KCSHE, ROM 40386, × 73

18. Hi element, ?sinistral, ?inner lateral view, locality 65, St. David Limestone, Peoria Co., Illinois, sample 24KCDDB, ROM 40387, × 36

19. Tr element, lateral view, locality 63, St. David Limestone, Fulton Co., Illinois, sample 10KCDD, ROM 40388, × 59

20. Ne element, aborolateral view, locality 59, Hanover Limestone, La Salle Co., Illinois, sample 4KCSHC, ROM 40389, × 95

21. Pl element, sinistral, inner lateral view, locality 57, Hanover Limestone, Peoria Co., Illinois, sample 3KCSHD, ROM 40390, × 72

22. Hi element, dextral, inner lateral view, locality 61, Hanover Limestone, Knox Co., Illinois, sample 8KCSH, ROM 40391, × 51

23. Tr element, lateral view, locality 110, Blackjack Creek Limestone, Boone Co., Missouri, sample 7DFBX, ROM 40392, × 27

Figs. 24, 25. *Ellisonia* cf. *conflexa,* Morrowan, U.S.A.

24. Oz element, sinistral, inner lateral view, locality 232, Marble Falls Limestone, San Saba Co., Texas, sample 1RMCXX, ROM 39802, × 51

25. Pl element, sinistral, inner lateral view, locality 232, Marble Falls Limestone, San Saba Co., Texas, sample 1RMCXX, ROM 39476, × 28

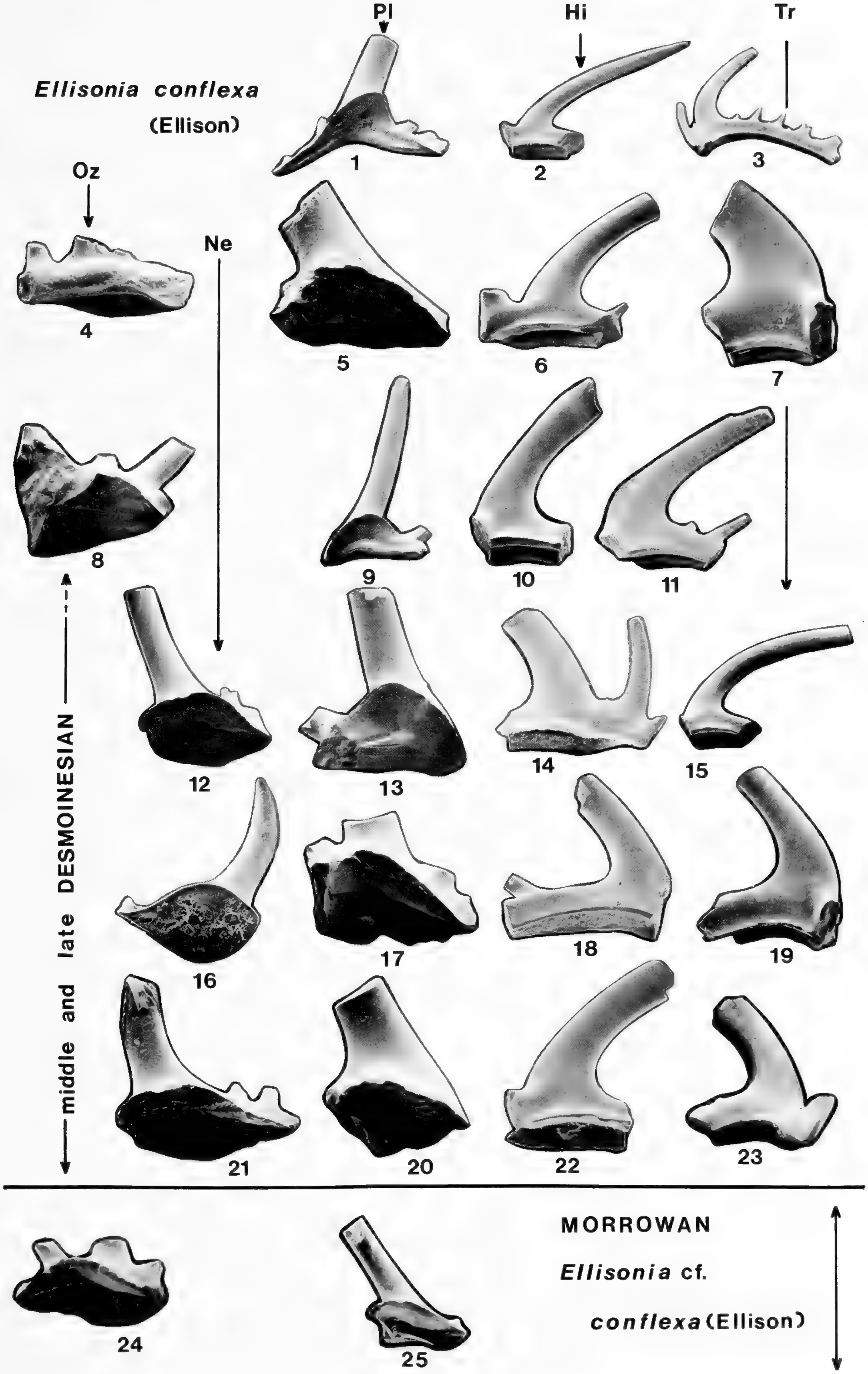

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Plate 4, figs. 1–21
Ellisonia conflexa (Ellison), early Missourian, U.S.A.

1. Oz element, dextral, inner lateral view, locality 24, Upper Brush Creek Limestone, Lawrence Co., Ohio, sample 21UBCLSB, ROM 40393, × 84

2. Pl element, dextral, inner lateral view, locality 21, Upper Brush Creek Limestone, Athens Co., Ohio, sample 4UBCLST, ROM 40394, × 103

3. Hi element, sinistral, inner lateral view, locality 22, Upper Brush Creek Limestone, Athens Co., Ohio, sample 4UBCLSX, ROM 40395, × 32

4. Oz element, sinistral, inner lateral view, locality 17, Lower Brush Creek Limestone, Morgan Co., Ohio, sample 35LBCLS, ROM 40396, × 53

5. Pl element, sinistral, inner lateral view, locality 20, Upper Brush Creek Limestone, Athens Co., Ohio, sample 4UBCLSF, ROM 40397, × 60

6. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40398, × 60

7. Oz element, dextral, inner lateral view, locality 235, Wiles Limestone, Stephens Co., Texas, sample 1NWPW, ROM 40399, × 47

8. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40400, × 83

9. Tr element, lateral view, locality 22, Upper Brush Creek Limestone, Athens Co., Ohio, sample 4UBCLSX, ROM 40401, × 45

10. ?Oz element, ?dextral, ?inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40402, × 77

11. Pl element, sinistral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40403, × 137

12. Hi element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40404, × 48

13. Tr element, lateral view, locality 97, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCC, ROM 40405, × 74

14. ?Oz element, ?dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40406, × 107

15. Ne element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40407, × 87

16. Hi element, sinistral, inner lateral view, locality 99, Cramer Limestone, Peoria Co., Illinois, sample 3AMTCD, ROM 40408, × 68

17. Tr element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40409, × 71

18. Oz element, dextral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40410, × 96

19. Pl element, sinistral, inner aborolateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40411, × 99

20. Hi element, sinistral, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40412, × 70

21. Tr element, lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40413, × 50

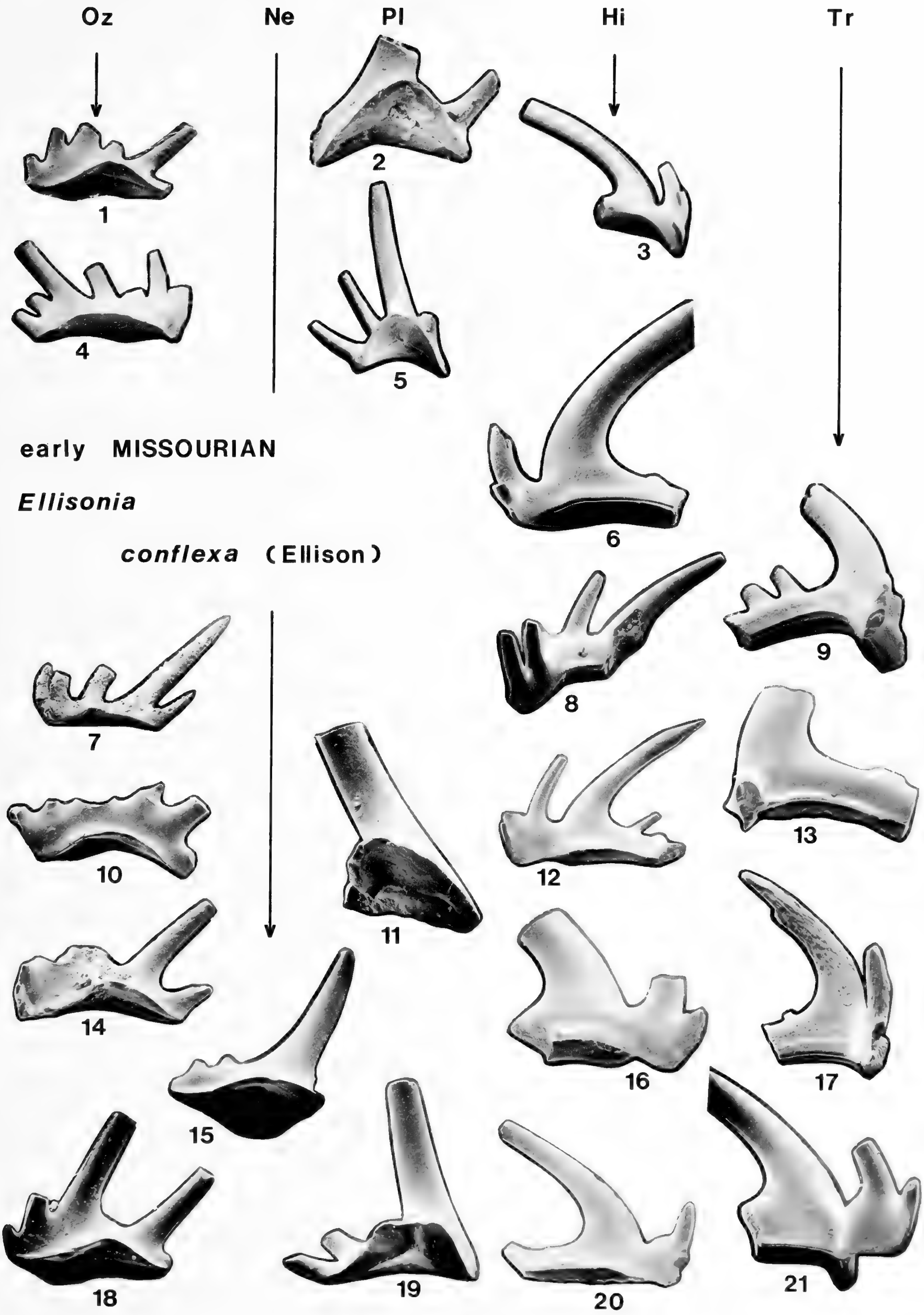
Oz
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Plate 5, figs. 1–21
Ellisonia conflexa (Ellison), late early Missourian, U.S.A.

1. Pl element, sinistral, inner aborolateral view, locality 28, Cambridge Limestone, Lawrence Co., Ohio, sample 22CLSX, ROM 40414, × 90

2. Hi element, sinistral, inner lateral view, locality 27, Cambridge Limestone, Lawrence Co., Ohio, sample 22CLST, ROM 40415, × 61

3. Hi element, dextral, inner lateral view, locality 28, Cambridge Limestone, Lawrence Co., Ohio, sample 22CLSX, ROM 40416, × 87

4. Pl element, sinistral, inner lateral view, locality 29, Cambridge Limestone, Muskingum Co., Ohio, sample 46CLST, ROM 40417, × 73

5. Pl element, sinistral, inner lateral view, locality 237, Jasper Creek (Wolf Mountain) Shale, Wise Co., Texas, sample 1NGMJE, ROM 40418, × 86

6. Hi element, sinistral, inner lateral view, locality 240, Winchell Limestone, Brown Co., Texas, sample 3NGWXP, ROM 40419, × 50

7. Tr element, lateral view, locality 28, Cambridge Limestone, Lawrence Co., Ohio, sample 22CLSX, ROM 40420, × 60

8. Pl element, dextral, inner lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40421, × 54

9. Pl element, dextral, inner lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40422, × 86

10. Hi element, dextral, inner lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40423, × 70

11. Tr element, lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40424, × 88

12. Oz element, dextral, inner lateral view, locality 138, Raytown Limestone, Madison Co., Iowa, sample 6MKIRE, ROM 40425, × 52

13. Pl element, dextral, inner lateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40426, × 119

14. Pl element, sinistral, inner lateral view, locality 123, Fontana Shale, Jackson Co., Missouri, sample 1MKCFB, ROM 40427, × 127

15. Hi element, dextral, inner lateral view, locality 127, Westerville Limestone, Madison Co., Iowa, sample 6MKCW, ROM 40428, × 73

16. Pl element, dextral, inner lateral view, locality 123, Fontana Shale, Jackson Co., Missouri, sample 1MKCFB, ROM 40429, × 106

17. Pl element, dextral, inner lateral view, locality 122, Winterset Limestone, Madison Co., Iowa, sample 4MKDWD, ROM 40430, × 97

18. Hi element, dextral, inner lateral view, locality 123, Fontana Shale, Jackson Co., Missouri, sample 1MKCFB, ROM 40431, × 96

19. Tr element, lateral view, locality 123, Fontana Shale, Jackson Co., Missouri, sample 1MKCFB, ROM 40432, × 97

20. Oz element, sinistral, inner lateral view, locality 122, Winterset Limestone, Madison Co., Iowa, sample 4MKDWD, ROM 40433, × 83

21. Pl element, dextral, inner lateral view, locality 120, Bethany Falls Limestone, Jackson Co., Missouri, sample 3MKSBB, ROM 40434, × 87

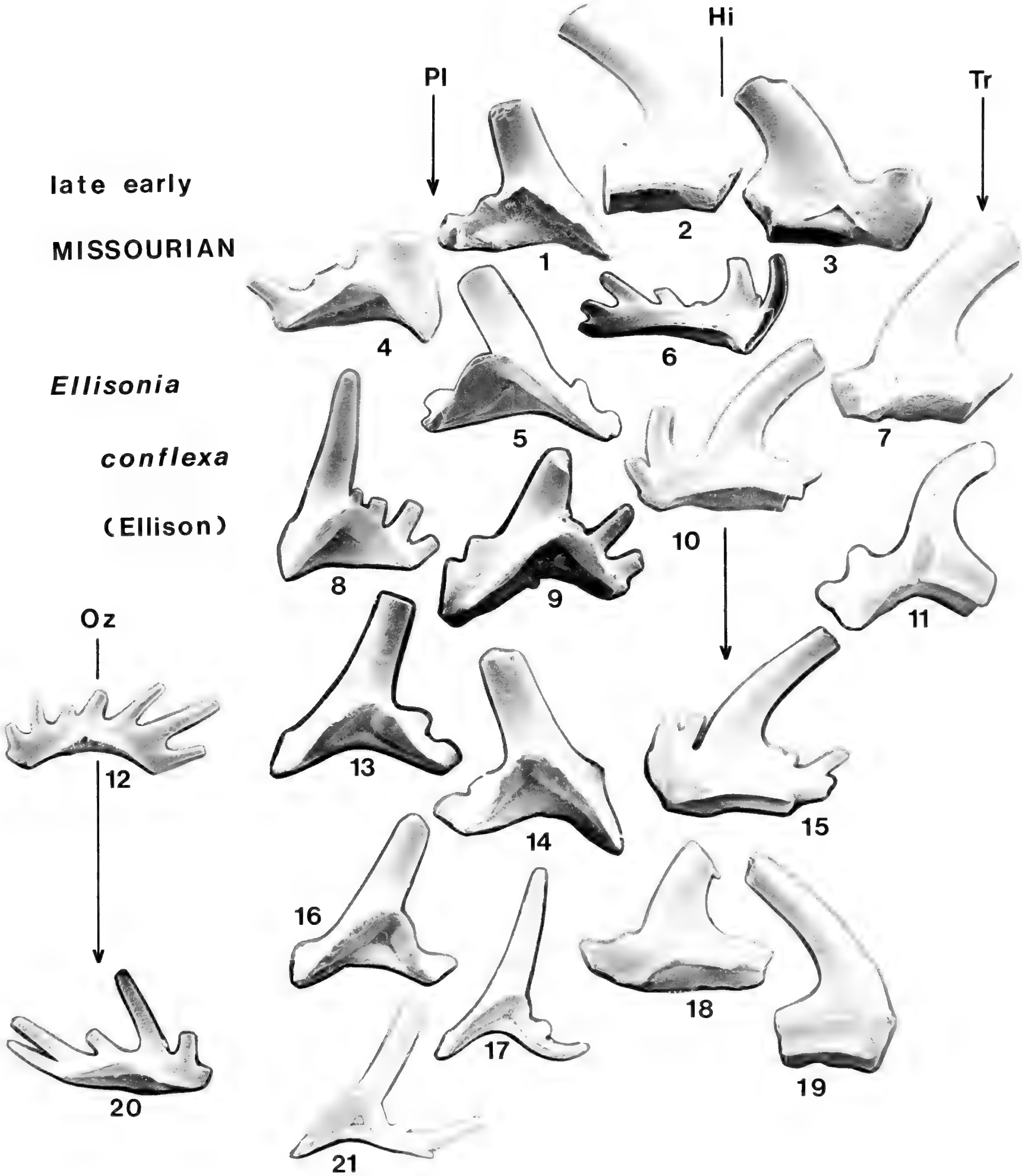
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Plate 6, figs. 1–29
Ellisonia conflexa (Ellison), late Missourian, U.S.A.

1. Oz element, sinistral, inner lateral view, locality 157, Eudora Shale, Cass Co., Iowa, sample He–15–3, ROM 40435, × 125

2. Ne element, lateral view, locality 159, Stoner Limestone, Cass Co., Iowa, sample P–15–3, ROM 40436, × 139

3. Pl element, sinistral, inner aborolateral view, locality 158, Stoner Limestone, Cass Co., Iowa, sample P–15–1, ROM 39746, × 62

4. Hi element, sinistral, inner lateral view, locality 163, Stoner Limestone, Madison Co., Iowa, sample 3VSOPA, ROM 39747, × 38

5. ?Oz element, aborolateral view, locality 155, Captain Creek Limestone, Madison Co., Iowa, sample Le–16–1, ROM 39748, × 80

6. Pl element, sinistral, inner aborolateral view, locality 162, Stoner Limestone, Madison Co., Iowa, sample P–16–4, ROM 39749, × 71

7. Pl element, dextral, inner aborolateral view, locality 162, Stoner Limestone, Madison Co., Iowa, sample P–16–4, ROM 39750, × 71

8. Hi element, dextral, inner lateral view, locality 144, Argentine Limestone, Jackson Co., Missouri, sample 4MKWAC, ROM 39751, × 30

9. ?Oz element, aborolateral view, locality 150, Farley Limestone, Clay Co., Missouri, sample 2MKWLE, ROM 39752, × 55

10. Pl element, dextral, inner aborolateral view, locality 163, Stoner Limestone, Madison Co., Iowa, sample 3VSOPA, ROM 39753, × 56

11. Hi element, dextral, inner lateral view, locality 143, Argentine Limestone, Jackson Co., Missouri, sample 2MKWAB, ROM 39754, × 32

12. Tr element, lateral view, locality 147, Argentine Limestone, Madison Co., Iowa, sample 5MKWAD, ROM 39755, × 44

13. Oz element, sinistral, inner lateral view, locality 146, Argentine Limestone, Jackson Co., Missouri, sample 4MKWAF, ROM 39756, × 52

14. Pl element, dextral, inner aborolateral view, locality 147, Argentine Limestone, Madison Co., Iowa, sample 5MKWAD, ROM 39757, × 44

15. Hi element, dextral, inner lateral view, locality 109, unnamed limestone unit above Little Vermilion Limestone, La Salle Co., Illinois, sample 1AOXX, ROM 39758, × 37

16. Oz element, dextral, inner lateral view, locality 109, unnamed limestone unit above Little Vermilion Limestone, La Salle Co., Illinois, sample 1AOXX, ROM 39759, × 70

17. Pl element, dextral, inner aborolateral view, locality 107, Little Vermilion Limestone, La Salle Co., Illinois, sample 1AOVLA, ROM 39760, × 69

18. Hi element, dextral, inner lateral view, locality 109, unnamed limestone unit above Little Vermilion Limestone, La Salle Co., Illinois, sample 1AOXX, ROM 39761, × 46

19. Tr element, lateral view, locality 108, Little Vermilion Limestone, La Salle Co., Illinois, sample 2AOVLD, ROM 39762, × 75

20. Oz element, dextral, inner lateral view, locality 104, La Salle Limestone, La Salle Co., Illinois, sample 4ABLLC, ROM 39763, × 57

21. Hi element, dextral, inner lateral view, locality 101, La Salle Limestone, La Salle Co., Illinois, sample 1ABLLD, ROM 39764, × 44

22. Tr element, lateral view, locality 103, La Salle Limestone, La Salle Co., Illinois, sample 4ABLLB, ROM 39765, × 52

23. Oz element, dextral, inner lateral view, locality 100, Hall Limestone, La Salle Co., Illinois, sample 2ABSH, ROM 39766, × 56

24. Pl element, sinistral, inner aborolateral view, locality 100, Hall Limestone, La Salle Co., Illinois, sample 2ABSH, ROM 39767, × 80

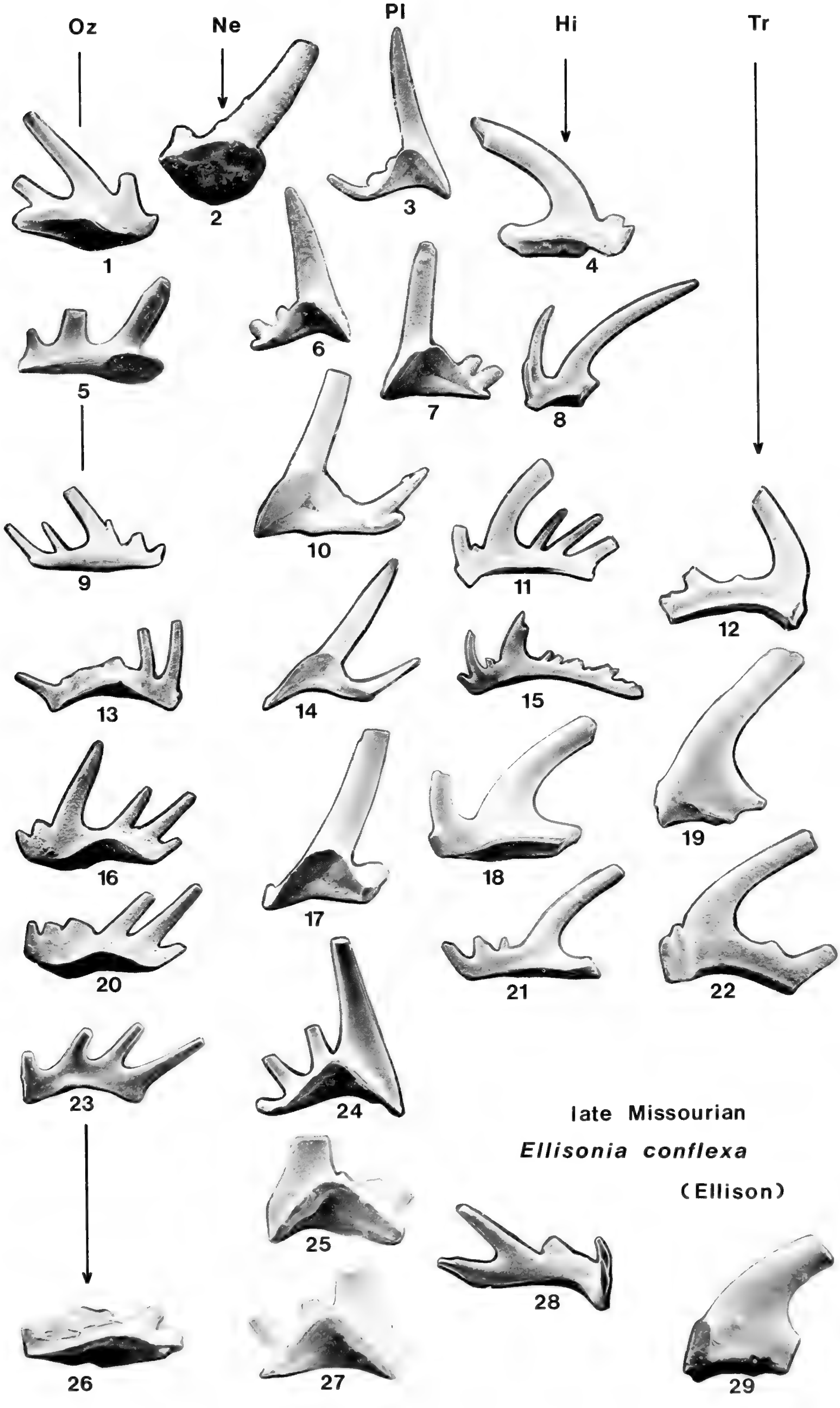
25. Pl element, dextral, inner aborolateral view, locality 30, Portersville Shale, Athens Co., Ohio, sample 3PLSB, ROM 39768, × 61

26. Oz element, dextral, inner aborolateral view, locality 30, Portersville Shale, Athens Co., Ohio, sample 3PLSB, ROM 39769, × 82

27. Pl element, sinistral, inner aborolateral view, locality 30, Portersville Shale, Athens Co., Ohio, sample 3PLSB, ROM 39770, × 67

28. Hi element, sinistral, inner lateral view, locality 100, Hall Limestone, La Salle Co., Illinois, sample 2ABSH, ROM 39771, × 80

29. Tr element, lateral view, locality 30, Portersville Shale, Athens Co., Ohio, Sample 3PLSB, ROM 39772, × 69



late Missourian
Ellisonia conflexa
(Ellison)

Plate 7, figs. 1–36

Fig. 1 *Ellisonia* sp. A, late Virgilian, U.S.A. Hi element, sinistral, inner lateral view, locality 225, Elmont Limestone, Lyon Co., Kansas, sample 1VWERB, ROM 39773, × 25

Figs. 2–36 *Ellisonia conflexa* (Ellison), early and middle Virgilian, U.S.A.

2. Tr element, lateral view, locality 215, Hartford Limestone, Shawnee Co., Kansas, sample H–1–3D, UKMIP 1,901,087, × 41

3. Pl element, sinistral, inner aborolateral view, locality 218, Curzon Limestone, Shawnee Co., Kansas, sample Cur–1–1B, UKMIP 1,901,069, × 61

4. Tr element, lateral view, locality 195, Queen Hill Limestone, Douglas Co., Kansas, sample QH–1–2, UKMIP 1,901,086, × 13

5. Hi element, dextral, inner lateral view, locality 206, Ervine Creek Limestone, Shawnee Co., Kansas, sample EC–1–1B, UKMIP 1,901,047, × 40

6. Tr element, lateral view, locality 41, Ames Limestone, Cabell Co., West Virginia, sample 88ALSA, ROM 39774, × 48

7. Ne element, lateral view, locality 219, Jones Point Shale, Shawnee Co., Kansas, sample JPS–1–1, UKMIP 1,901,072, × 107

8. ?Hi element, dextral, inner lateral view, locality 51, Ames Limestone, Wayne Co., West Virginia, sample 106ALSD, ROM 39775, × 67

9. ?Hi element, sinistral, inner lateral view, locality 40, Ames Limestone, Lawrence Co., Ohio, sample 85ALS, ROM 39776, × 54

10. Tr element, lateral view, locality 46, Ames Limestone, Lawrence Co., Kentucky, sample 98ALSE, ROM 39777, × 51

11. Oz element, sinistral, inner lateral view, locality 50, Ames Limestone, Wayne Co., West Virginia, sample 104ALS, ROM 39778, × 80

12. Pl element, dextral, inner lateral view, locality 38, Ames Limestone, Lawrence Co., Ohio, sample 84ALSA, ROM 39779, × 62

13. Hi element, dextral, inner lateral view, locality 33, Ames Limestone, Wayne Co., West Virginia, sample 31ALSC, ROM 39780, × 43

14. Tr element, lateral view, locality 51, Ames Limestone, Wayne Co., West Virginia, sample 106ALSD, ROM 39781, × 34

15. Oz element, sinistral, inner aborolateral view, locality 43, Ames Limestone, Wayne Co., West Virginia, sample 93ALSA, ROM 39782, × 63

16. Pl element, sinistral, inner lateral view, locality 44, Ames Limestone, Wayne Co., West Virginia, sample 95ALSC, ROM 39783, × 62

17. Hi element, dextral, inner lateral view, locality 36, Ames Limestone, Perry Co., Ohio, sample 46ALS, ROM 39784, × 40

18. Tr element, lateral view, locality 32, Ames Limestone, Lawrence Co., Ohio, sample 25ALSX, ROM 39785, × 62

19. Oz element, sinistral, inner lateral view, locality 40, Ames Limestone, Lawrence Co., Ohio, sample 85ALS, ROM 39786, × 71

20. Ne element, lateral view, locality 32, Ames Limestone, Lawrence Co., Ohio, sample 25ALSX, ROM 39787, × 99

21. Pl element, sinistral, inner lateral view, locality 51, Ames Limestone, Wayne Co., West Virginia, sample 106ALSD, ROM 39788, × 61

22. Hi element, dextral, inner lateral view, locality 51, Ames Limestone, Wayne Co., West Virginia, sample 106ALSD, ROM 39789, × 40

23. Oz element, dextral, inner lateral view, locality 171, Plattsmouth Limestone, Douglas Co., Kansas, sample P–1–5, UKMIP 1,901,074, × 46

24. Pl element, sinistral, inner lateral view, locality 33, Ames Limestone, Wayne Co., West Virginia, sample 31ALSC, ROM 39790, × 71

25. Hi element, sinistral, inner lateral view, locality 39, Ames Limestone, Lawrence Co., Ohio, sample 84ALSB, ROM 39791, × 35

26. Hi element, sinistral, inner lateral view, locality 178, Plattsmouth Limestone, Cass Co., Nebraska, sample P–14–3, ROM 39792, × 44

27. Tr element, lateral view, locality 33, Ames Limestone, Wayne Co., West Virginia, sample 31ALSC, ROM 39793, × 74

28. Oz element, dextral, inner lateral view, locality 177, Plattsmouth Limestone, Cass Co., Nebraska, sample P–14–2, ROM 39794, × 147

29. Hi element, dextral, inner lateral view, locality 175, Plattsmouth Limestone, Andrew Co., Missouri, sample P–13–5, ROM 39795, × 31

30. ?Oz, element, ?sinistral, ?inner lateral view, locality 174, Plattsmouth Limestone, Osage Co., Oklahoma, sample P–6–2, ROM 39796, × 51

31. Pl element, dextral, inner lateral view, locality 171, Plattsmouth Limestone, Douglas Co., Kansas, sample P–1–5, UKMIP 1,901,068, × 110

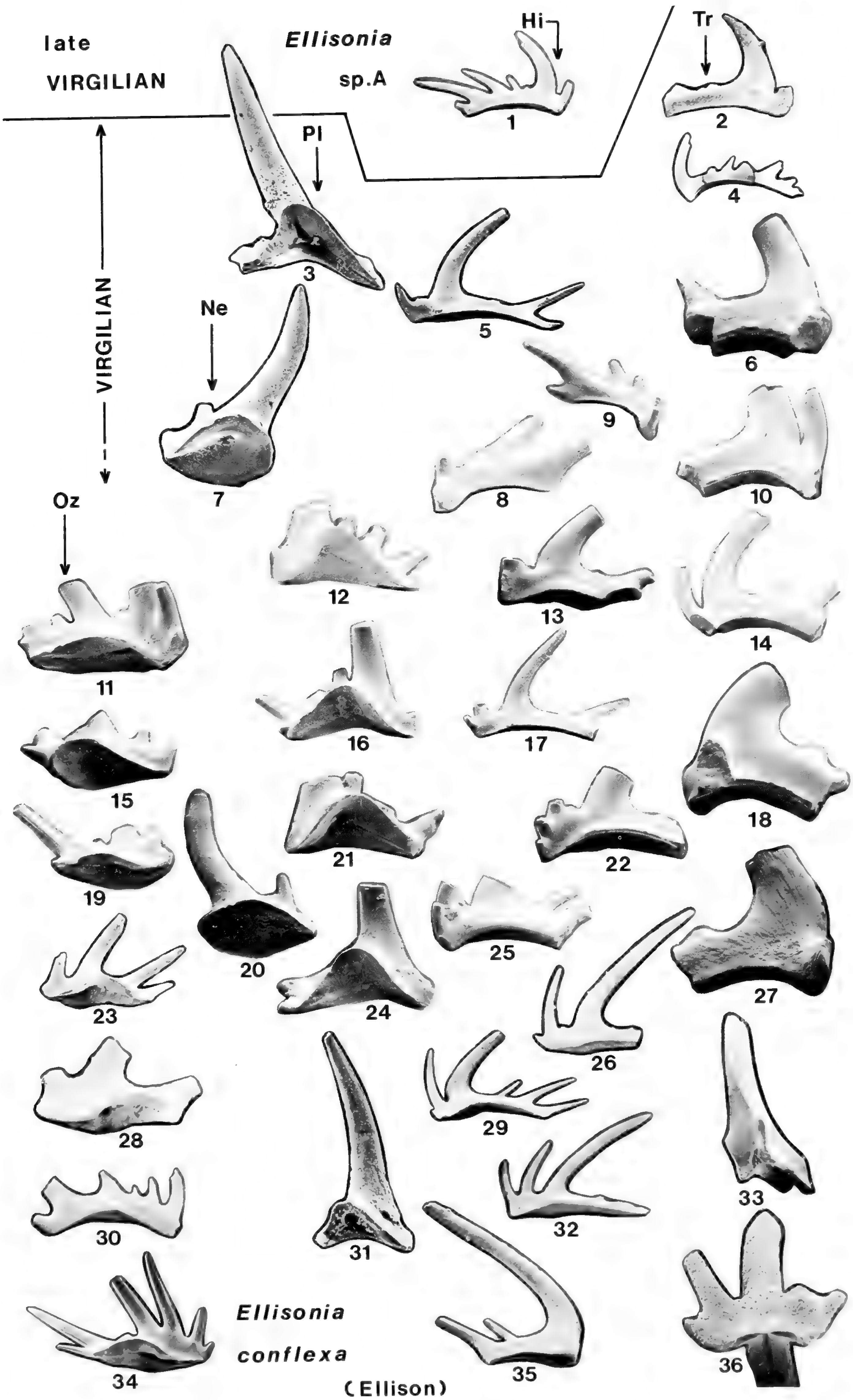
32. Hi element, dextral, inner lateral view, locality 177, Plattsmouth Limestone, Cass Co., Nebraska, sample P–14–2, ROM 39797, × 30

33. Tr element, anterior lateral view, locality 173, Plattsmouth Limestone, Osage Co., Oklahoma, sample P–5–1, ROM 39798, × 51

34. Oz element, sinistral, inner lateral view, locality 173, Plattsmouth Limestone, Osage Co., Oklahoma, sample P–5–1, ROM 39799, × 45

35. Hi element, sinistral, inner lateral view, locality 168, Leavenworth Limestone, Osage Co., Oklahoma, sample Le–9–1, ROM 39800, × 37

36. Tr element, anterior aboral view, locality 172, Plattsmouth Limestone, Chautauqua Co., Kansas, sample P–2–2D, ROM 39801, × 70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Ellisonia
conflexa
(Ellison)

Plate 8, figs. 1–15

Figs. 1–4, 6, 12–15 *Ellisonia conflexa* (Ellison), detailed views.

1. Oz element, sinistral, aboral view, locality 173, Plattsmouth Limestone, Osage Co., Oklahoma, sample P–5–1, ROM 39799, × 122

2. Oz element, enlarged aboral view, ROM 39799, × 330

3. Ne element, aboral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40407, × 146

4. Pl element, dextral, aborolateral view, locality 73, Brereton Limestone, Knox Co., Illinois, sample 12KCBBA, ROM 40378, × 107

6. Ne element, aboral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40407, × 364

12. Oz element, lateral edge of denticle, ROM 39799, × 627

13. Tr element, cross-section of broken denticle, locality 110, Blackjack Creek Limestone, Boone Co., Missouri, sample 7DFBX, ROM 39806, × 230

14. Tr element, cross-section of broken denticle, ROM 39806, × 512

15. Oz element, cross-section of cusp, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40402, × 880

Fig. 5 *Ellisonia* cf. *conflexa,* (Ellison), detailed view. Oz element, aboral view, locality 232, Marble Falls Limestone, San Saba Co., Texas, sample 1RMCXX, ROM 39802, × 78

Figs. 7–11 Ordovician neurodont conodonts, Tyrone Limestone, Garrard Co., Kentucky.

7. *Chirognathus* sp., locality 247, aborolateral view, ROM 39803, × 51

8. *Cardiodella* sp., locality 248, aborolateral view, ROM 39804, × 81

9. *Ptiloconus,* sp., locality 247, inner lateral view, ROM 39805, × 45

10. *Chirognathus* sp., locality 247, aboral view, ROM 39803, × 165

11. *Ptiloconus* sp., locality 247, aboral view, ROM 39805, × 150

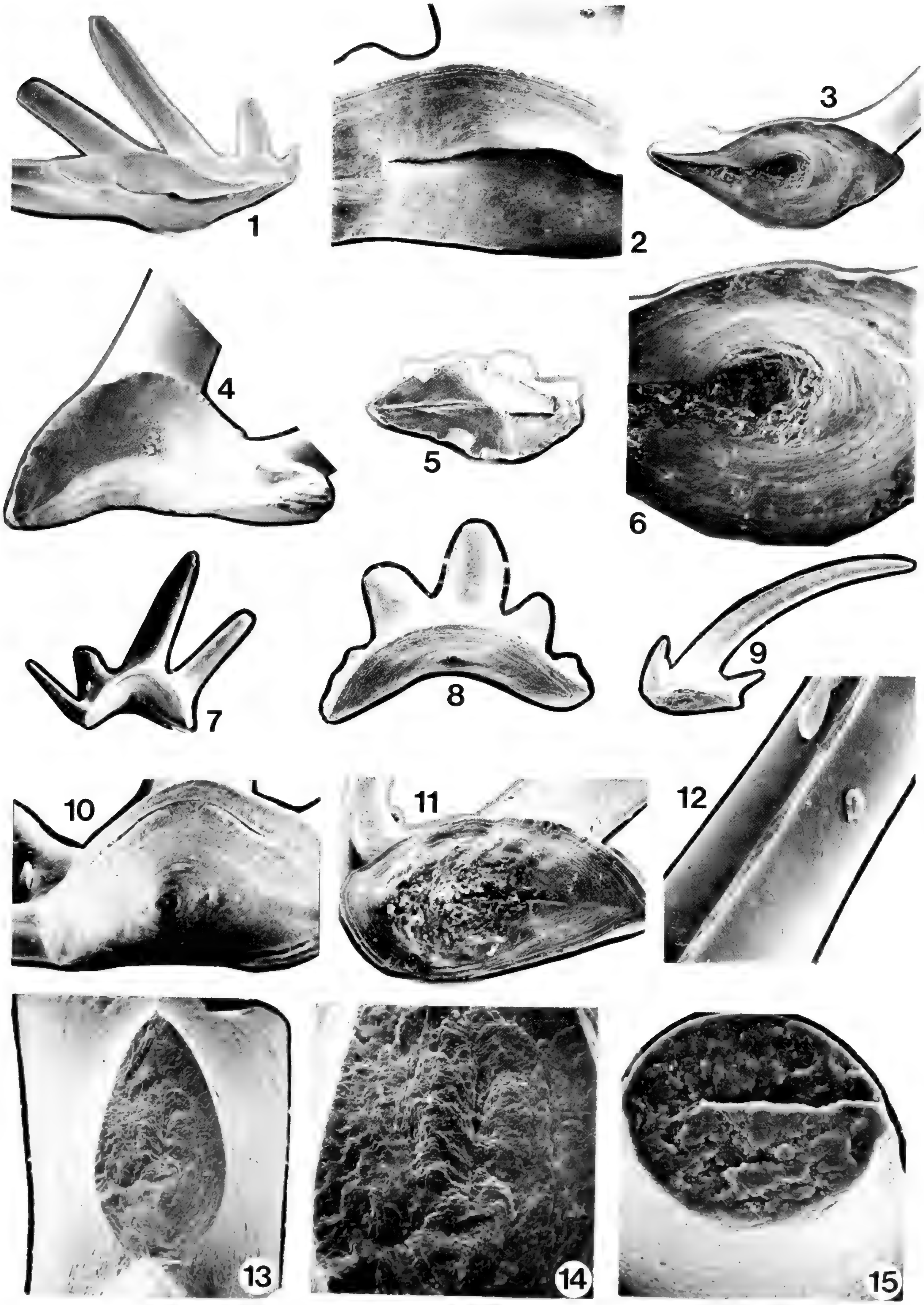
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Plate 9, figs. 1–16

Figs. 1, 4–6, 14–16 *Ellisonia conflexa* (Ellison), detailed views.

1. Hi element, dextral, lateral edge of anterior denticles, locality 144, Argentine Limestone, Jackson Co., Missouri, sample 4MKWAC, ROM 39751, × 167

4. Hi element, sharp anterior edge of cusp, locality 115, Myrick Station Limestone, Nowata Co., Oklahoma, sample 3DAPY, ROM 40380, × 170

5. Hi element, cross-section of cusp, locality 39, Ames Limestone, Lawrence Co., Ohio, sample 84ALSB, ROM 39791, × 513

6. Hi element, central growth canal, ROM 39791, × 1411

14. Hi element, aborolateral view of edge of basal cavity, locality 101, La Salle Limestone, La Salle Co., Illinois, sample 1ABLLD, ROM 39764, × 446

15. Hi element, enlarged view of lamellae, ROM 39764, × 1789

16. Pl element, aboral view, crystallites perpendicular to lamellae, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40411, × 586

Figs. 2, 3, 7–9 *Chirognathus* sp., detailed views, locality 247, Tyrone Limestone, Garrard Co., Kentucky, ROM 39803

2. lateral edge of denticle, × 459
3. lateral edge of denticle, × 1485
7. aboral view, × 149
8. aboral view, basal pit, × 459
9. enlarged view of basal pit, × 1485

Figs. 10, 13 *Cardiodella* sp., detailed views, locality 246, Tyrone Limestone, Garrard Co., Kentucky, ROM 39807

10. aboral view, × 61
13. aboral view, enlarged view of lamellae, × 459

Figs. 11, 12 *Ptiloconus* sp., detailed views, locality 247, Tyrone Limestone, Garrard Co., Kentucky, ROM 39805

11. lamellae at edge of basal cavity, × 1485
12. enlarged view of lamellae at edge of basal cavity, × 4590

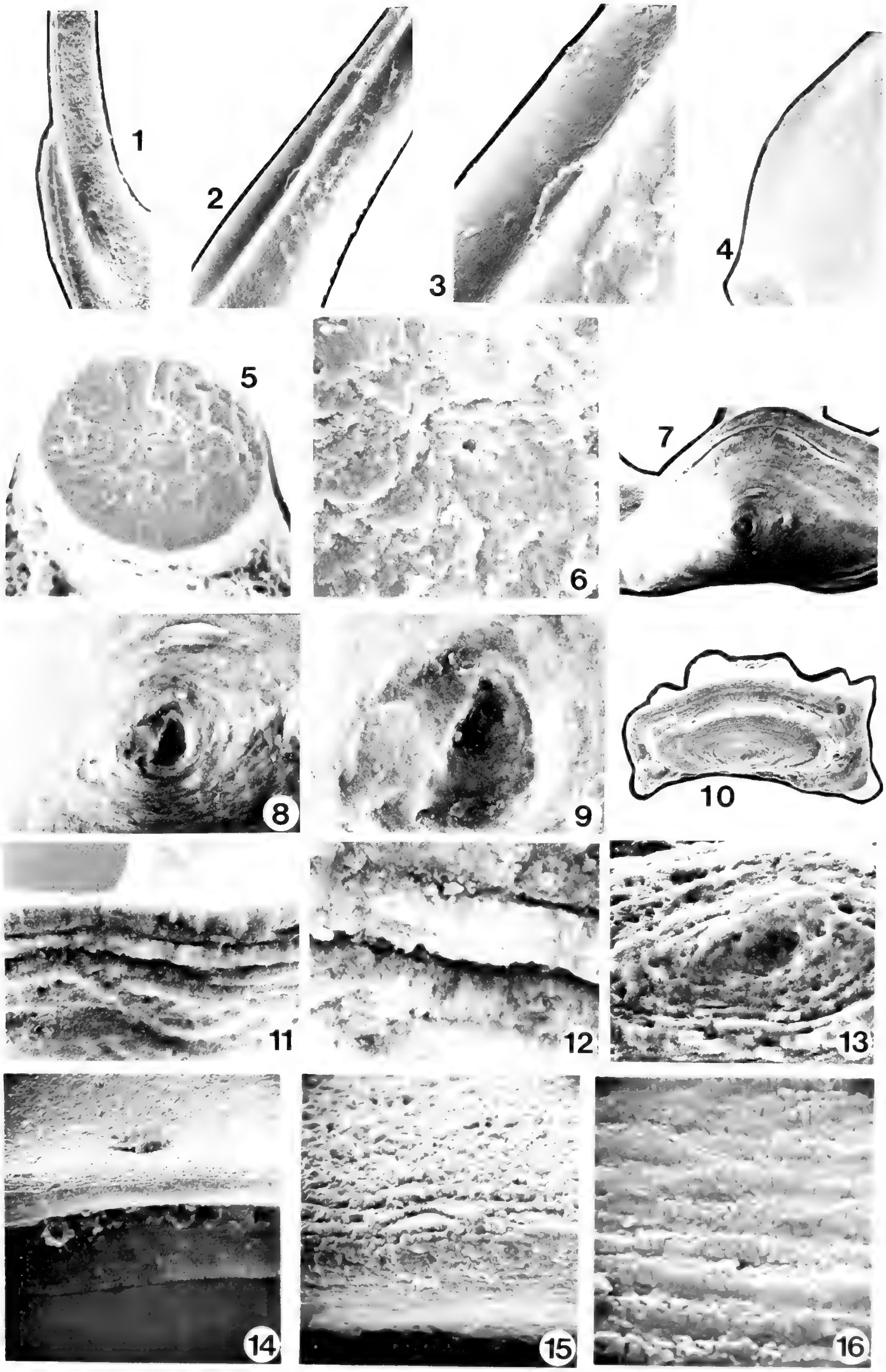
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Plate 10, figs. 1–15

Figs. 1–11 *Ellisonia latilaminata* sp. nov., detailed views.

1. Hi element, sinistral, inner lateral view, locality 25, Upper Brush Creek Limestone, Lawrence Co., Ohio, sample 34UBCLS, ROM 40359, × 127

2. Hi element, sinistral, inner lateral view, detail of overlapping lamellae, ROM 40359, × 324

3. Hi element, detail of overlapping lamellae at aborolateral edge, locality 15, Vanport Limestone, Vinton Co., Ohio, sample 24VLSC, ROM 40337, × 936

4. Hi element, aborolateral view, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40355, × 297

5. Hi element, detail of lamellae, aborolateral edge, ROM 40355, × 1179

6. Hi element, detail of lamellae, aborolateral edge, ROM 40355, × 2970

7. Hi element, view of overlapping lamellae, aborolateral edge, ROM 40355, × 1188

8. Hi element, detail of lamellae, aborolateral edge, locality 15, Vanport Limestone, Vinton Co., Ohio, sample 24VLSC, ROM 40337, × 936

9. Hi element, aboral view of nearly totally enclosed basal cavity, locality 140, Frisbie Limestone, Jackson Co., Missouri, sample 3MKWF, ROM 40351, × 248

10. Tr element, aborolateral view, details of overlapping lamellae, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40364, × 583

11. Tr element, aborolateral view of overlapping lamellae, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40365, × 1294

Figs. 12–14 *Ellisonia conflexa* (Ellison), detailed views.

12. Pl element, aboral view of basal cavity, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40411, × 614

13. Pl element, aboral view of basal cavity, locality 237, Jasper Creek (Wolf Mountain Shale), Wise Co., Texas, sample 1NGMJE, ROM 40418, × 691

14. Pl element, aboral view, locality 76, Brereton Limestone, Peoria Co., Illinois, sample 18KCBBC, ROM 40382, × 223

Fig. 15 *Ellisonia* cf. *conflexa,* (Ellison), detailed view. Oz element, detail of lamellae in basal cavity, locality 232, Marble Falls Limestone, San Saba Co., Texas, sample 1RMCXX, ROM 39802, × 1296

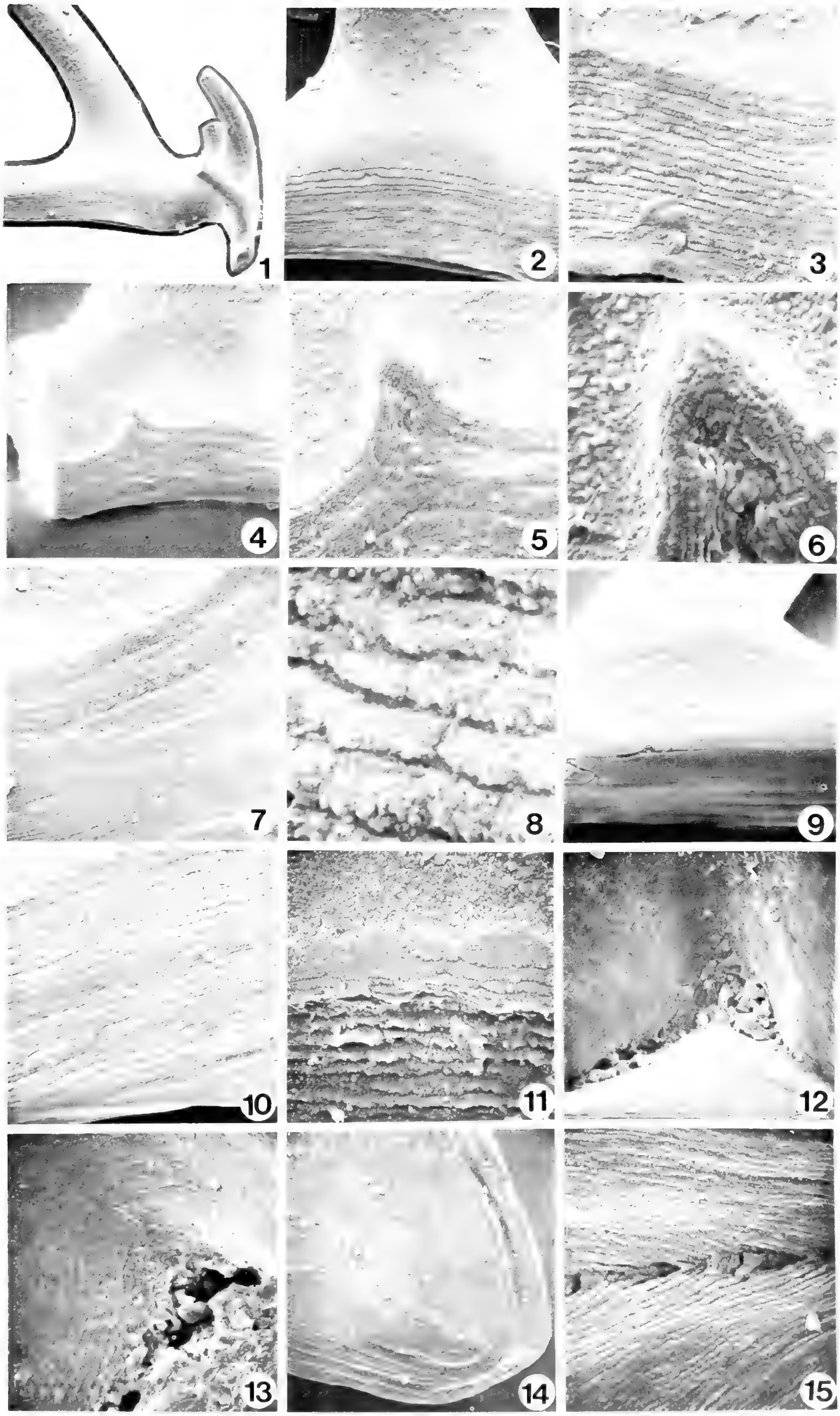

Plate 11, figs. 1–11

Figs. 1, 2 *Ellisonia conflexa* (Ellison), detailed views. Pl element, locality 137, Raytown Limestone, Madison Co., Iowa, sample 6MKIRA, ROM 40421

1. View of second denticle from posterior end, × 726
2. Detail of second denticle from posterior end, × 1441

Figs. 3, 6, 7 *Ellisonia conflexa* (Ellison), Hi element, locality 240, Winchell Limestone, Brown Co., Texas, sample 3NGWXP, ROM 40419

3. Inner lateral view, × 138
6. View of broken cusp showing radiating lamellar structure, × 567
7. View of broken cusp showing radiating lamellar structure, × 1134

Figs. 4, 5 Ordovician neurodont conodonts, detailed views, Tyrone Limestone, Garrard Co., Kentucky.

4. *Ptiloconus* sp., view of broken cusp, locality 249, ROM 39808, × 486
5. *Chirognathus* sp., view of crystallites arranged parallel to lamellae, locality 247, ROM 39809, × 5610

Figs. 8–11 *Idioprioniodus* sp., detailed views. Naturally broken longitudinal section of crystallites arranged parallel to lamellae, locality 250, Pennsylvanian, Ellesmere Island, Northwest Territories, Canada. GSC locality C–4085b, GSC 49885.

8. × 358 10. × 3575
9. × 1375 11. × 7150

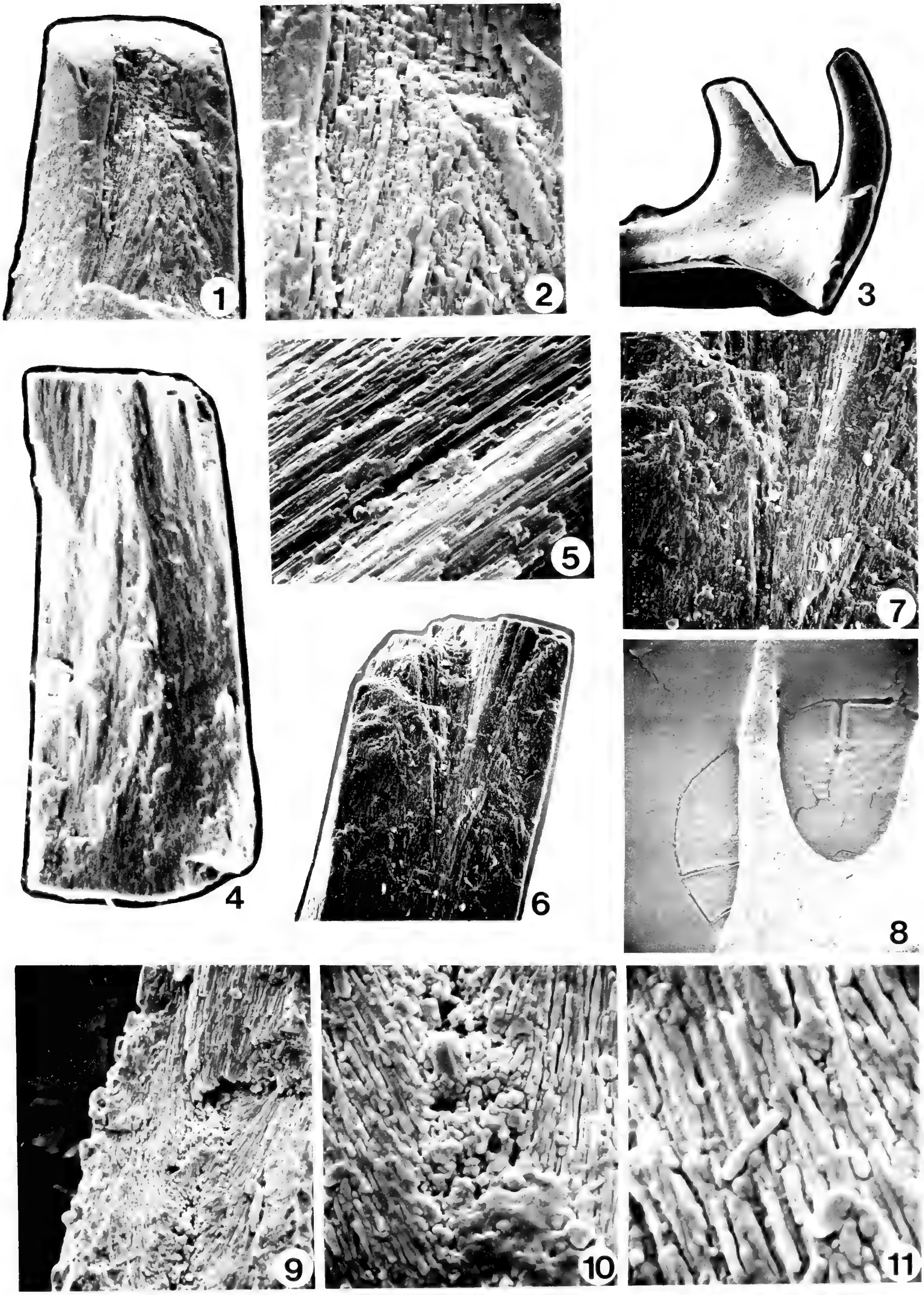
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Plate 12, figs. 1–26

Figs. 1–4 Early Triassic ellisonids, U.S.A. Similar to or conspecific with the type species, *Ellisonia triassica,* locality 253, *Meekoceras* Zone, Early Triassic, Caribou Co., Idaho, sample 68SK–113

1. Pl element, inner lateral view, ROM 39810, × 81
2. Hi element, inner lateral view, ROM 39811, × 45
3. Hi element, inner lateral view, ROM 39812, × 50
4. Tr element, lateral view, ROM 39813, × 36

Figs. 5–12 Younger Permian ellisonids, USSR. Showing morphologic or phylogenetic continuity between ancestral Carboniferous-Early Permian ellisonids and Early Triassic ellisonids (Plate 12, figs. 1–4) that are similar to the type species of *Ellisonia* [Kozur and Movschovitsch in Kozur (1975) referred specimens like these to *Stepanovites meyeni.*], locality 252, early Kazanian (= early Capitanian), Borehole Bororga (Vologda).

5. Pl element, inner lateral view, ROM 39814, × 71
6. Hi_1 element, ?inner lateral view, ROM 39815, × 81
7. Hi_2 element, inner lateral view, ROM 39816, × 68
8. Tr element, lateral view, ROM 39817, × 68
9. Pl element, inner lateral view, ROM 39818, × 86
10. ?Hi_1 element, ?inner lateral view, ROM 39819, × 86
11. Hi_2 element, inner lateral view, ROM 39820, × 89
12. Hi_1 element, inner lateral view, ROM 39821, × 50

Figs. 13–16 Younger Permian ellisonids, locality 251, Gerster Formation, Late (?) Permian, Butte Mountains, Pine Co., Nevada, U.S.A.

13. Pl element, inner lateral view, ROM 39822, × 54
14. Hi element, inner lateral view, ROM 39823, × 63
15. Hi element, inner lateral view, ROM 39824, × 68
16. Tr element, lateral view, ROM 39825, × 68

Figs. 17–26 *Ellisonia* sp. A, Permian, U.S.A.

17. Pl element, dextral, inner lateral view, locality 226, Americus Limestone, Lyon Co., Kansas, sample 1BCFA, ROM 39826, × 137
18. Hi element, sinistral, inner lateral view, locality 228, Sallyards Limestone, Lyon Co., Kansas, sample 1BCGS, ROM 39827, × 58
19. Hi element, dextral, inner lateral view, locality 229, Florence Limestone, Marion Co., Kansas, sample 3BHBFC, ROM 39828, × 93
20. Pl element, ?dextral, inner lateral view, locality 243, Belknap Limestone, Stephens Co., Texas, sample 1WPDW–2, ROM 39829, × 84
21. Hi element, dextral, inner lateral view, locality 226, Americus Limestone, Lyon Co., Kansas, sample 1BCFA, ROM 39830, × 93
22. Hi element, sinistral, inner lateral view, locality 245, Saddle Creek Limestone, Eastland Co., Texas, sample 1WPDS, ROM 39831, × 47
23. Tr element, lateral view, locality 244, Harpersville Limestone, Eastland Co., Texas, sample 1WPDX, ROM 39832, × 105
24. Pl element, dextral, inner lateral view, locality 243, Belknap Limestone, Stephens Co., Texas, sample 1WPDW–2, ROM 39833, × 133
25. Hi element, sinistral, inner lateral view, locality 245, Saddle Creek Limestone, Eastland Co., Texas, sample 1WPDS, ROM 39834, × 39
26. Tr element, lateral view, locality 243, Belknap Limestone, Stephen Co., Texas, sample 1WPDW–2, ROM 39835, × 70

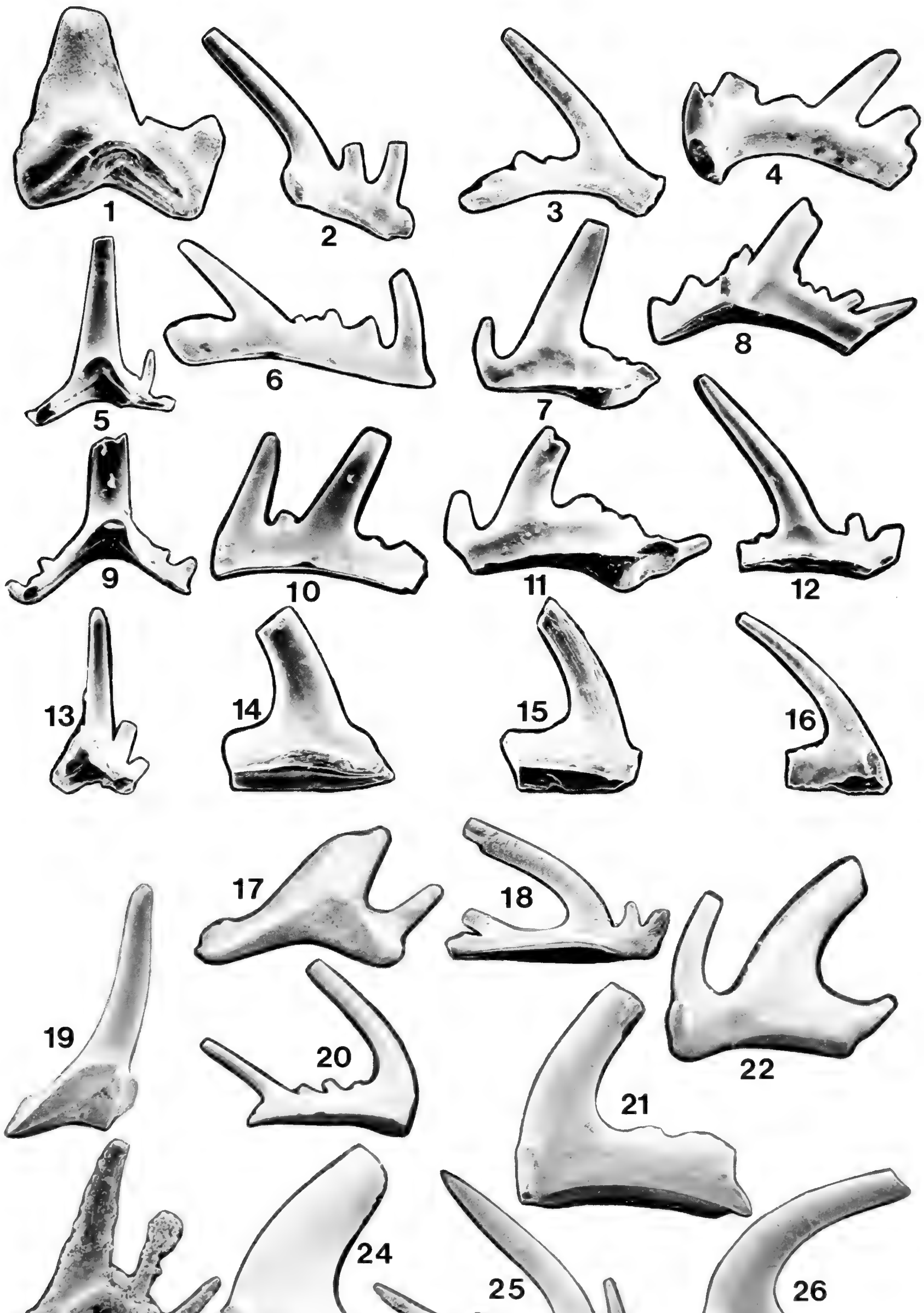
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Plate 13, figs. 1–13

Figs. 1, 2 *Ellisonia* sp. A, detailed views, Permian, U.S.A.

1. Hi element, sinistral, inner lateral view of eversion strip, locality 245, Saddle Creek Limestone, Eastland Co., Texas, sample 1WPDS, ROM 39834, × 113

2. Hi element, sinistral, inner lateral view showing eversion strip, ROM 39834, × 225

Figs. 3–7, 10, 12, 13 *Ellisonia conflexa* (Ellison), detailed views, Missourian, U.S.A.

3. Tr element, inner lateral view, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40409, × 147

4. Tr element, inner lateral view, ROM 40409, × 664

5. Tr element, detail of surface of cusp, ROM 40409, × 405

6. Hi element, detail of surface of cusp, locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA, ROM 40398, × 673

7. Tr element, aborolateral view, ROM 40409, × 168

10. ?Oz element, aborolateral view, locality 155, Captain Creek Limestone, Madison Co., Iowa, sample Le–16–1, ROM 39748, × 288

12. ?Oz element, aborolateral view, locality 150, Farley Limestone, Clay Co., Missouri, sample 2MKWLE, ROM 39752, × 171

13. ?Oz element, aborolateral view, ROM 39748, × 109

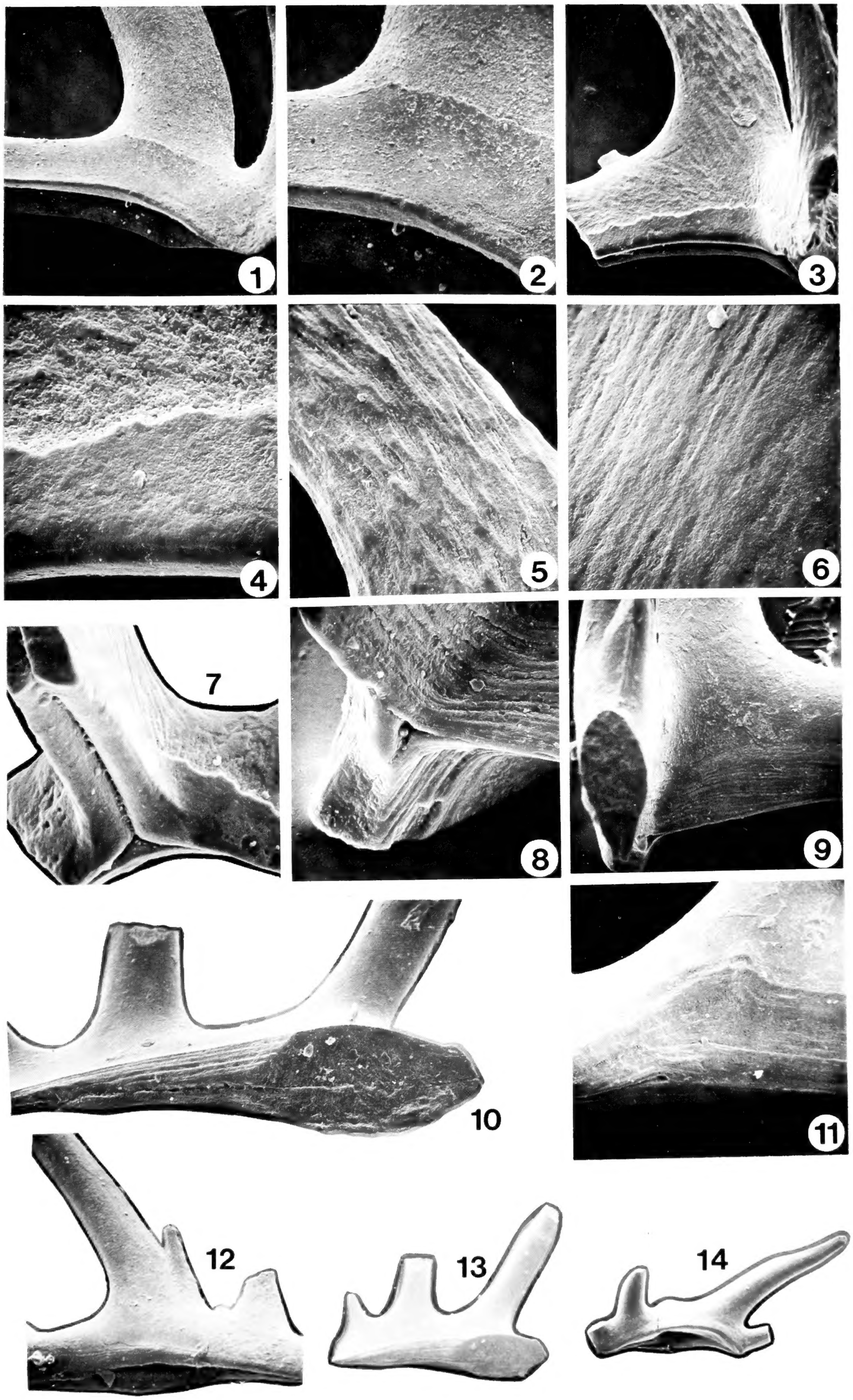
Fig. 14 *Ellisonia* cf. *conflexa* (Ellison), Morrowan, U.S.A. ?Oz element, lateral view, locality 231, Marble Falls Limestone, Mason Co., Texas, sample ZR–9, ROM 39836, × 66

Figs. 8, 9, 11 *Ellisonia latilaminata* sp. nov., detailed views, Missourian, U.S.A., locality 95, Cramer Limestone, Bureau Co., Illinois, sample 2AMTCA.

8. Tr element, aborolateral view, ROM 40369, × 675

9. Tr element, lateral view, ROM 40369, × 284

11. Hi element, aborolateral view, ROM 40363, × 272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