Tertiary Charophytes from the Ogallala Formation of Ellis County, Kansas

FAY KENOYER DAILY
Butler University, Box 169, Indianapolis, Indiana 46208

and

JOSEPH R. THOMASSON
Science and Mathematics Division, Black Hills State College, Spearfish, South Dakota 57783

ABSTRACT: Four fossil charophytes, *Amblyochara thomassonii* Daily n. sp. *Chara sadleri* (Ung.) H. af R., *Chara globularis* Thuill. and *Croftiella escheri* (Ung.) H. af R., are described and illustrated. They were found in diatomaceous marl from the Ogallala Formation in Kansas at sites determined to be late Miocene-early Pliocene in age. This is the first systematic study of charophytes from the widespread late Tertiary Ogallala Formation of central North America.

INTRODUCTION

In view of the scanty information on charophytes from the late Tertiary of North America, preliminary studies on some charophytes from the late Miocene-early Pliocene Ogallala Formation of western Ellis Co., Kans., are reported here. Although the presence of charophytes in the Ogallala Formation has been previously noted (Leonard and Franzen, 1944; Kiener, 1944), the charophytes in the present paper are the first to be described systematically. The second author first discovered them in 1973 while conducting research on fossil angiosperm endocarps, nutlets and anthoecia (Thomasson, 1976b). Subsequent samples were discovered and collected during 1974 and 1975. In this report, Thomasson discusses the geology and biostratigraphy and gives a revised age of the deposits. Daily provides the systematics.

MATERIALS AND METHODS

Lime shells used for scanning electron microscopy were extracted from sediments under a binocular microscope and cleaned in distilled water or a 5% acetic acid solution. Well-preserved examples were selected and mounted on double-stick, nonmetallic tape which had been previously attached to brass specimen plates. Silver cement was applied around the contact of tape and plates and touched to the specimen at two points to assure good conductivity. Specimens were coated with carbon and gold in a vacuum evaporator and subsequently viewed at an accelerating voltage of 15kv in a JEOL Stereoscan 35 electron microscope. A photographic record was kept on type 105 Polaroid positive-negative film.

The following system of abbreviations is used:

J.R.T. 11.1 = J. R. Thomasson collection at Site 11, specimen number 1 isolated by Thomasson

J.R.T. 11 = Thomasson marl collection at Site 11

J.R.T. BP37-1 (or BP37-A, B, etc.) = Brass Plate 37, piece 1 (or A, B, etc.) prepared for SEM by Thomasson.

F.K.D. – K = ground section K prepared by F. K. Daily

Ml-1 = micropaleontological slide, square 1

When isolated specimens are cited by only the J.R.T. site number, they were isolated by Daily. All specimens are located at the Sternberg Memorial Museum, Fort Hays Kansas State College (FMSM), Hays, Kans., except for the ground sections which are located at the Friesner Herbarium, Butler University (BUT), Indianapolis, Indiana.

ELLIS COUNTY CHAROPHYTE DEPOSITS

Charophytes described and illustrated in this paper were found in beds which crop out among three discontinuous exposures of the Ogallala Formation in western Ellis Co., Kans. Site 9 is located on the E wall of the northernmost roadcut on the WL SW¼NW¼NW¼ Sec. 3, T. 12 S, R. 20 W; *see* Hill City 4 SE, Kansas Quadrangle, U.S.G.S. topographic map, 1963. Angiosperm endocarps, nutlets and anthoecia ("seeds") at or very near this site have been extensively studied (Thomasson, 1976b), as have the vertebrates (Zehr, 1974). Site 11 is located W of Guss Riedel lease well number 6 and slightly SE of a small pond in the center of SW¼ Sec. 32, T. 12 S, R. 19 W; *see* Yocemento Quadrangle, U.S.G.S. topographic map, 1961. Sediments exposed at this site contain charophytes, molluscs, ostracods, diatoms, some small vertebrate remains and a good flora of fossil "seeds." Site 31 is located on the SW end of a small knoll in the NW¼SW¼SE¼NW¼ Sec. 28, T. 13 S, R. 19 W; *see* Yocemento Quadrangle, U.S.G.S. topographic map, 1961. The exposure at this site is rather limited. Nevertheless, in addition to the charophytes, a good assortment of "seeds," as well as diatoms, ostracods and molluscs were recovered.

GEOLOGY AND BIOSTRATIGRAPHY

The Ogallala Formation was named by Darton (1899) from a locality in southwestern Nebraska that he later (1920) referred to as Ogallala Station. Elias (1931, 1932, 1935, 1942) made detailed studies of the Ogallala in western Kansas and described fossil endocarps, nutlets and anthoecia from the formation. In 1956, Frye *et al.*, described molluscan remains of one bed in the Ogallala Formation in northwestern Kansas and maintained it as a formation consisting of three members, which, in ascending order, are Valentine, Ash Hollow and Kimball. Silicified vegetative plant remains from the same bed were recently described by Thomasson (1976a).

Bass (1926) briefly outlined the distribution of the Ogallala in Ellis County, and Frye *et al.* (1956) examined a single site during their study. Zehr (1974) described the Clarendonian Hamburg local vertebrate fauna and deposits from the western edge of Ellis County, but did not discuss the Ogallala of the remaining parts of Ellis County. Evidence from recent studies by the second author (1976b) indicates that, if the Ogallala sediments in Ellis County can be assigned within this framework, then they most likely would represent Kimball and Ash Hollow strata. There is considerable question, however, as to the applicability of the Valentine, Ash Hollow, Kimball sequence in a regional sense outside Nebraska (Gregory, 1942; Zehr, 1974; Breyer, 1975; Thomasson, 1976b), and a precise placement in that framework is not given here.

Regional stratigraphic correlations of the Ogallala Formation (Ogallala Group in Nebraska sense) have proved difficult because of the fluvial nature of the sediments. This led Gregory (1942) to suggest that, although sediments from widely separated localities in the High Plains may be adequately contained within the Ogallala Group, individual deposits in these depositional basins might more properly be considered as different formations. A similar course was suggested by D. D. Zehr (pers. comm., 1974) as a possible solution for the placement of the deposits that he studied in Ellis County. The reader is referred to Zehr (1974) for a discussion of what he has termed the "Ogallala Problem."

On the basis of endocarps, nutlets and anthoecia, a late Pliocene age had been assigned to the bed at Site 9 from which charophytes were collected (Thomasson, 1976a). However, subsequent studies of the collections upon which the floral seed zones are established indicate that they are no longer tenable (Thomasson, 1976b). Thus, floral zones are not used in this article to determine the age of the charophytes.

An important new vertebrate fauna was discovered at Site 29 in Ellis County.

SYSTEMATIC PALEOBOTANY

Genus *Amblyochara* L. Grambast 1962

Amblyochara thomassonii Daily, n. sp.

Plates 1 and 2, Figs. 1-12

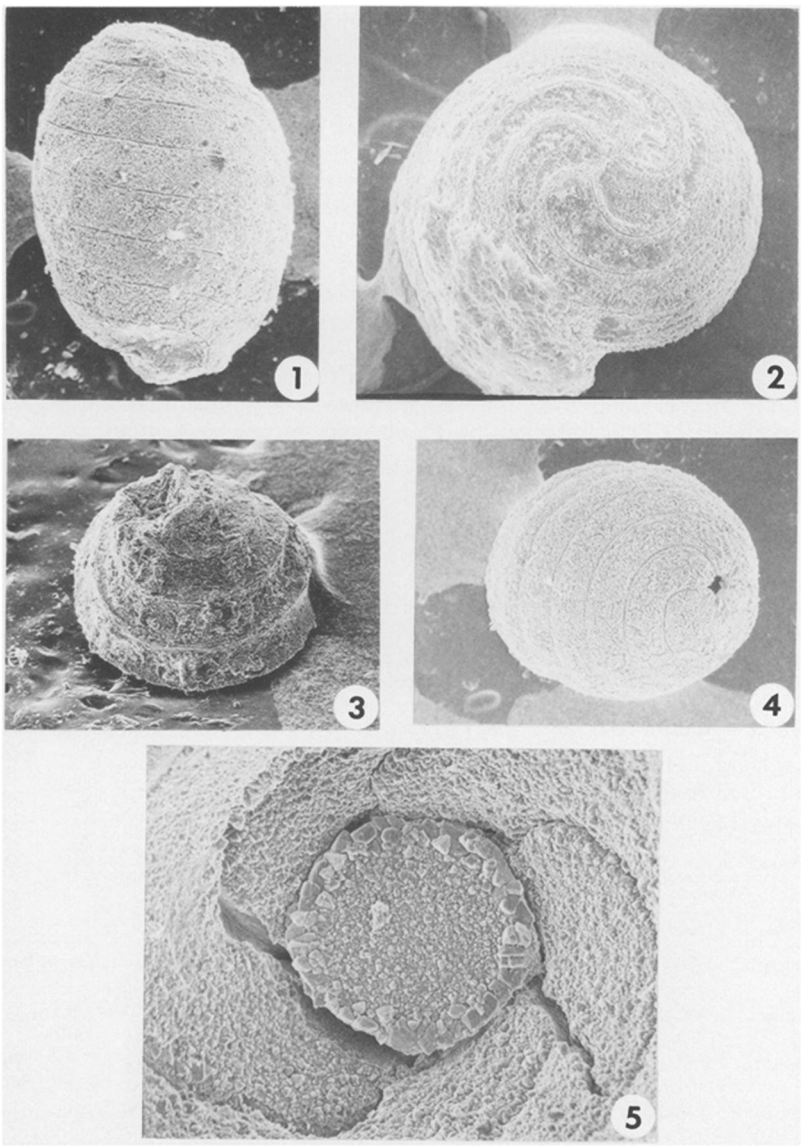

Plate 1.—Fossil charophytes from the Ogallala Formation of Kansas (SEM photomicrographs by Thomasson). Figs. 1-5.—*Amblyochara thomassonii* Daily n. sp. 1, Immature lime shell, J.R.T. 31.3, J.R.T. BP 36-C, lateral view × 65; 2, immature lime shell, J.R.T. 31.2, J.R.T. BP 24-2, apical view × 83; 3, mature lime shell, J.R.T. 31.5, J.R.T. BP 36-A1, basal view × 65; 4, immature lime shell, J.R.T. 31.4, J.R.T. BP 36-B, basal view × 65; 5, mature lime shell, J.R.T. 31.1, J.R.T. BP 37-1, internal view of base showing basal plug × 267

The fauna lies stratigraphically below Sites 11 and 31 and above Site 9. Vertebrate forms represented have been provisionally assigned to Hemphillian land mammal age (R. J. Zakrzewski, pers. conversation, 1976), which geochronologically would be considered late Miocene-early Pliocene (Berggren and Van Couvering, 1974). This vertebrate fauna lies well above the Hamburg local fauna described by Zehr (1974), which was assigned Clarendonian land mammal age (middle-early late Miocene). Tentatively, the charophytes from all sites are considered to be late Miocene-early Pliocene age.

Daily and Durham (1966) indicated that very few charophytes have been reported from the Tertiary of the Americas, and this certainly is the case in Tertiary High Plains strata. Because of this paucity of previous studies, no definitive statement can be made with regard to their regional biostratigraphic significance. The widespread temporal and aerial distribution of marl deposits in the Ogallala, however, makes this an important field for future study. Within the study area, Sites 11 and 31 are approximately contemporaneous, and Site 9 is older.

Two charophyte species from these collections, *Croftiella escheri* and *Chara sadleri,* originally were described from the Miocene; *Amblyochara thomassonii* Daily, n. sp., is most similar to *A. neogenica* from the Neogene of the USSR. *Chara globularis (=C. fragilis)* is a modern species with a previous fossil distribution of Quaternary and Pliocene. Therefore, nothing in these results precludes the assignment to late Miocene-early Pliocene given by Thomasson to these collections.

Description.—Lime shells obovoid (immature, prolate spheroidal), 0.84-1.0 mm long, 0.60-0.87 mm wide, 9- or 10-striate in lateral view, apex broadly rounded, base more or less protruding. Spirals concave to flat, 0.10-0.12 mm wide at the equator, 0.10-0.12 mm thick at equator, angle 15-20° at equator, thickness and width ca. 0.065 mm at apical periphery, ca. 0.085 mm at apical center, concave with prominent intercellular ridges to almost flat on top, meeting on apex in a short zigzag line, not much change in width, but more concave at base. Basal opening ca. 0.08 mm in diam. Basal pore cup-shaped to funnel-shaped in axial view. Basal plug more or less filling the pore, depending on maturity, upper and lower faces flat to convex, upper face 0.15-0.17 mm wide, 0.07-0.085 mm thick, lower face 0.07-0.085 mm wide.

Specimens seen.—Twenty-five specimens from Sites 9, 11, and 31, Ellis Co., Kansas, in the Ogallala Formation, considered late Miocene to early Pliocene.

Holotype.—Mature lime shells, J.R.T. 11.13, Ml-16, Fig. 9.

Discussion.—*Amblyochara thomassonii* was named in honor of J. R. Thomasson who collected and isolated the material. A comparison of some species of *Amblyochara* and *Lychnothamnites* is made in Table 1. The lime shells of *Amblyochara*

TABLE 1. — Comparison of some lime shells of *Amblyochara* and *Lychnothamnites*

Species	In micrometers			Occurrence
	Length	Width	Striae	
A. latifasciata	650-800	500-700	8-10	Wyoming, USA (as a *Sphaerochara*) Cretaceous (Peck, 1957).
A. begudiana	900-1200	875-1100	8-10	Gardanne (Boches du Rhone), France Cretaceous (Grambast, 1962).
A. peruviana	725-1200	675-1150	8-10	Lake Titacaca area, Puno, Peru, S.A. Cretaceous (Grambast *et al.,* 1967).
A. thomassonii	835-1002	600-865	8.10	Kansas, USA Late Miocene-early Pliocene (n.sp).
A. ?	766	638	9	USSR Miocene (Maslov, 1966).
A. neogenica	700-911	675	9-11	USSR Neogene (Gluckovskaja, 1970).
A. rollii	690	610	7-8	Peru, S.A. (as *Rhabdochara rollii)* Cretaceous (Koch and Blissenbach, 1960).
L. narynensis	646-700	532-550	8-9	USSR Pliocene (Maslov, 1966).

In the article by Daily, F. K. and J. R. Thomasson, Tertiary charophytes from the Ogallala Formation of Ellis County, Kansas, Volume 101(1), the four-line heading at the top of page 101 above Plate 1 should be on page 102 immediately above the description following line 21.

latifasciata, A. thomassonii and *Amblyochara* sp. are slightly more elongate in length to width ratio than *A. begudiana, A. peruviana* and *A. rollii* and can be differentiated from them by this characteristic. The two North American species, *A. latifasciata* and *A. thomassonii,* can be differentiated from each other by size range. Immature specimens of *A. thomassonii* are somewhat similar to *A. neogenica,* but mature specimens of *A. thomassonii* are more obovoid. *Amblyochara thomassonii* and *A. latifasciata* are intermediate in shape between *A. begudiana* and the extant *Lychnothamnus barbatus,* which is ellipsoid (occasionally subobovoid). *Lychnothamnites narynensis* (Maslov, 1966) seems too obovoid to be similar to *Lychnothamnus* and compares favorably with *A. latifasciata* in shape, size and number of striae.

Peckichara coronata (Peck & Reker) L. Grambast (to which immature lime shells of *Amblyochara thomassonii* might be assigned on superficial examination) differs from *A. thomassonii* chiefly in having an apical rosette and a prolate spheroidal to ellipsoidal shape.

Another similar lime shell is shown by *Psilochara (Charites) bitruncata* (Reid & Groves) M. Feist-Castel (1971), which originally was reported from England by Reid and Groves (1921) as *Chara strobilocarpa* var. *bitruncata.* It also was reported in glacial and postglacial sediments of America by Daily (1961). *Amblyochara thomassonii* differs from it in the broad, flattened apex, obovoid shape, and lack of widening of the lime spirals basally.

Immature stages in lime shell formation may produce specimens of *Amblyochara thomassonii* superficially similar to *Rhabdochara* in shape, but lacking the typical decoration of the genus. In Plate 1 are some SEM photomicrographs showing the surface of some *A. thomassonii* specimens for comparison. They do not show the alternating high and low areas of lime-spiral calcification typical of *Rhabdochara.* This, in itself, does not exclude reference to that genus (Grambast, 1957), but general characteristics substantiate the interpretation that these represent lime shells of *A. thomassonii.*

Grambast (1962, p. 79) described the spirals in lime shells of *Amblyochara* as joining on the summit: "gardent leur largeur mais tendent à perdre leur relief, cellulaire ou intercellulaire, au niveau de la zone apicale." Measurements from his figures, however, show some spirals as narrow as 2/3 the equatorial width where they turn onto the apex at the periphery. *Amblyochara thomassonii* compares favorably with this as well as in losing relief over the apex.

Genus *Croftiella* Horn af Rantzien 1959
Croftiella escheri (A. Br. ex Unger) H. af R.
Plate 2, Figs. 16-18

Description.—Lime shells ellipsoid with projecting apex and base, 0.92 mm long by 0.67 mm wide with nine striae. Five concave spirals ca. 0.10 mm in diam at equator, equatorial angle 15°, narrowing at apical periphery with distinct depressions reducing the thickness, then expanding on the apex to produce a rosette, 0.35 mm in diam, meeting at the apex in a point, approaching the base with little change in size, meeting around a small irregular opening. Details of basal pore and plug not seen.

Specimen seen.—One lime shell from Site 11, Ellis Co., Kans., Ogallala Formation, assigned to late Miocene-early Pliocene.

Discussion.—This specimen compares favorably with the dimension and other lime shell characteristics of this species described and illustrated by Heer (1855) and Horn af Rantzien (1959). Stratigraphic distribution is Oligocene to Pliocene in freshwater sedimentary deposits (Molasse). This species was originally described from freshwater marl of the Miocene at Oetling near Lorrach (Baden) and Schwamendingen near Zurich, Switzerland.

Genus *Chara* L.
Chara globularis Thuill. 1799
Plate 2, Figs. 19-21

Description.—Lime shells ellipsoid, 0.83 mm long, 0.53 mm wide (slightly damaged) with 17 striae. Spirals at equator ca. 0.05 mm wide, flat, narrowing slightly at apical periphery and forming a peripheral groove, expanding on apex to about twice the size of spirals at the equator, meeting in a long zigzag line on the apex; approaching with not much change in width, and at an angle then narrowing at the basal pore. Basal pore 0.05 by 0.65 mm in size, forming an irregular pentagonal opening; internal details not seen.

Specimens seen.—Two damaged lime shells were examined from Site 9, Ellis Co., Kans., Ogallala Formation, assigned to late Miocene-early Pliocene.

Discussion.—These fossil lime shells do not differ from those of the modern cosmopolitan species that occurs in a wide variety of habitats. Numerous Quaternary reports of this species have been made and also a report from the Pliocene (Sordelli, 1873). Also, *Chara woodringii* Berry (1922), described from the Miocene of Haiti, is somewhat similar. Horn af Rantzien (1951) assumed that the description and drawings by Berry represented oospores despite Dr. Berry's statement that these were "calcareous and very fragile oogonia." Horn af Rantzien also thought that the species could not be identified with any recent or fossil species. The shape and number of ridges are within the limits for the species, *C. globularis,* but the large size is a distinguishing characteristic.

Chara sadleri Unger 1850
Plate 2, Figs. 13-15

Description.—Lime shells ellipsoidal, 0.6 mm long, 0.47 mm wide, apex rounded, base rounded with 10 inconspicuous striae on prominent ridges in lateral view. Spirals concave, ca. 0.07 mm wide at equator, slightly narrower at the apical periphery, then widening at the apex where they meet along a short zigzag line. Spirals meet around a small opening 0.06 mm in diam at the base with slight widening.

Specimen seen.—One lime shell from Site 9, Ellis Co., Kans., in the Ogallala Formation considered late Miocene or early Pliocene.

Discussion.—Only one specimen was found that was kept intact, so details of internal structure are not known. This species was originally described from the Miocene near Oedenberg, Hungary. It was referred to the genus *Charites* by Horn af Rantzien (1959), but returned to *Chara* by Grambast (1962). See Mädler (1955) for a recent description and illustrations of material from the Tortonian, Miocene, of Southern Germany.

Vegetative Specimens

Description of ecorticate vegetative material.—Whorled channels of graduated size found in the marl (Fig. 23) and the isolated tube (Fig. 24) are interpreted as ecorticate charophyte fragments similar to modern species of the Chareae. The large tube slightly above the center in Figure 23 may be the cross section of a stem 0.33 mm wide, surrounded by ecorticate branchlets extending upright or horizontal (ca. 6) 0.1 mm in diam. There are smaller tubes at right angles to the branchlets, which could have been made by bracteoles or bracts 0.03 mm in diam.

Description of corticated vegetative material.—Corticated stem and branchlet fragments similar to modern Chareae were also found. A broken stem (Fig. 22) is 0.67 mm in external diam, 0.42 mm in internal diam across lumen with 24 cortical cells in cross section. The cortex is triplostichous with primary cells slightly prominent. Single-spine cell bases can be seen as small black dots with circles of calcite built up around them. Three occur at about the same level just below the remains of a node. The lumen of large cortical cells ranges from 0.05-0.08 mm in diam. Small cortical

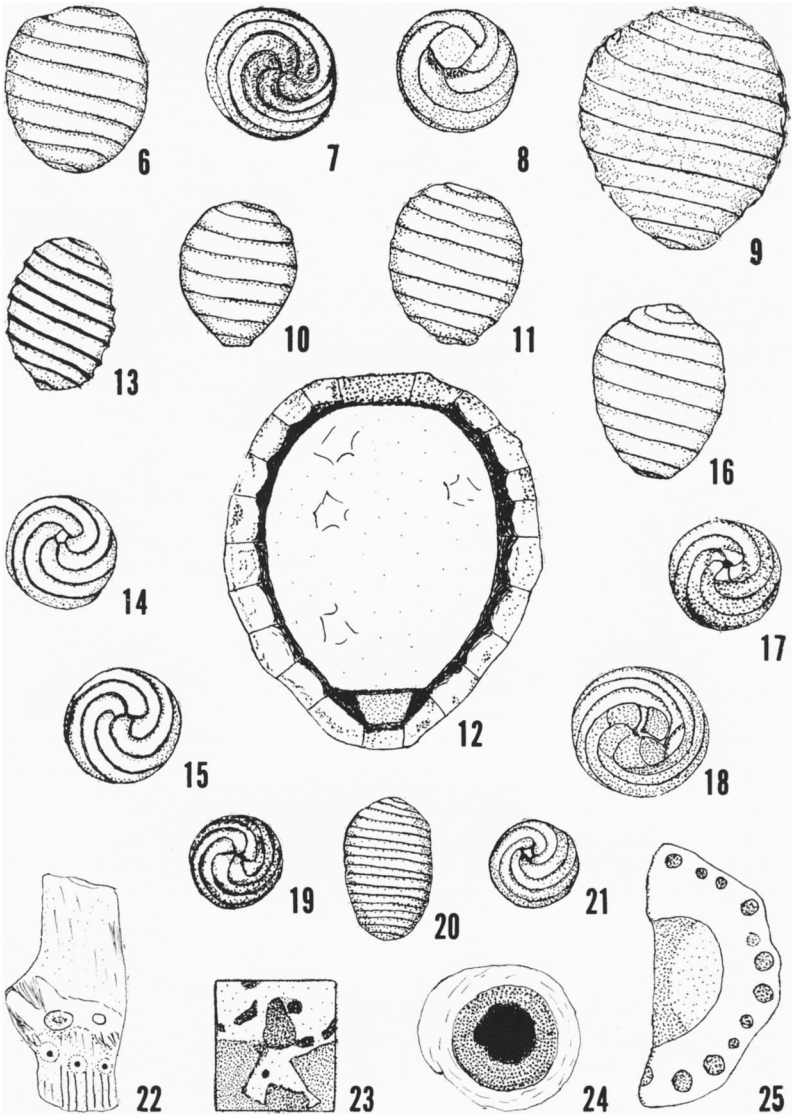

Plate 2.—Fossil charophytes from the Ogallala Formation of Kansas (drawing by Daily). Figs. 6-12.—*Amblyochara thomassonii* Daily n. sp., 6, mature lime shell, J.R.T. 31.1A, F.K.D.-B, lateral view × 29; 7, 8, 11, immature lime shell, J.R.T. 31.8, M1-21, apical, basal and lateral views × 29; 12, mature lime shell in thin section, J.R.T. 31.1A, F.K.D.-K, axial view × 70; 9, mature lime shell, holotype, J.R.T. 11.13, M1-16, lateral view × 42; 10, immature lime shell, J.R.T. 9.7, M1-3, lateral view × 29. 13-15.—*Chara sadleri* Unger, lime shell, J.R.T. 9.8, M1-4, lateral, basal and apical views × 42. 16-18.—*Croftiella escheri* (Unger) H. af R., lime shell, J.R.T. 11.14, M1-17, lateral, basal and apical views × 29. 19-21.—*Chara globularis* Thuill, lime shell, J.R.T. 9.5, M1.1, apical, lateral and basal views × 29. 22-25.—Charophyte, vegetative material, 22, lateral view of corticated stem fragment, J.R.T. 31.15, M1-29, × 17; 23, marl enclosing ecorticate vegetative material, J.R.T. 11, M2, stem and branchlet whorl in section × 17; 24, ecorticate stem fragment, J.R.T. 11.16, M1-25, cross section × 75; 25, corticate stem fragment, J.R.T. 31.7, M1-20, cross section × 75

cells are 0.03 mm wide. Another broken stem section seen in end view (Fig. 25) has 23 cortex tubes, with the largest measuring 0.08 mm in diam, the smallest 0.05 mm. The outer diameter of the stem is 0.53 mm. The central cell lumen is 0.40 mm in diam.

Specimens seen.—Several corticated stem and branchlet pieces were found at Site 31, and the ecorticate material came from Site 11, Ellis Co., Kans., Ogallala Formation, assigned to late Miocene-early Pliocene.

Discussion. — Vegetative material was found associated with *Amblyochara (Sphaerochara) latifasciata* by Peck (1957), but no oogonia were attached. The organization of the stems differed considerably from modern charophytes. Heer (1855) also illustrated vegetative material associated with lime shells of *Croftiella (Chara) escheri*. The dichotomous branching of the striated stem shown by him also is not like modern charophytes and may represent some other plant. The specimens studied here, however, both corticate and ecorticate, are similar to modern species with whorled branchlets.

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