KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 2000-12

Upper Pennsylvanian (Virgilian) Fusulinid Biozonation
Preliminary Report

Amoco Production Company, Research Department
Report No. M81-G-11

by

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G.J. Verville

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Amoco Production Company

Research Department

UPPER PENNSYLVANIAN (VIRGILIAN) FUSULINID BIOZONATION - PRELIMINARY REPORT

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and

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Report No.: M81-G-11
Date: September 21, 1981
Research Proposal No.: 80-3

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SUMMARY

Fusulinids from the Kansas Virgilian are being studied to provide a more diverse faunal component to that portion of the "U" Composite Standard which now contains only a more restricted fauna from Arrow Canyon. The result will be a reference standard of greater applicability in the Late Pennsylvanian.

Our Kansas reference sequence comprises 35 measured sections in Elk and Chautauqua counties which have been stacked to produce a continuous rock succession through the Virgilian. We have recognized and sampled 50 fusulinid-bearing beds from the sedimentary cycles which make up the Midcontinent Virgilian.

Essentially all sample processing has been completed, and interpretive study of the fusulinids has begun. A number of stratigraphically significant fusulinids already can be recognized. However, the close sample control, the short geologic time span, and the pronounced morphologic variability of the fusulinids will require quantitative analysis for adequate definition of phyletic lineages as well as recognition of paleoecologic influences.

STATEMENT OF PROBLEM

The Virgilian portion of Amoco's reference section in Arrow Canyon, Nevada, contains an abundant microfauna of relatively low diversity, which is characteristic of a somewhat restricted environment. In order to create a Pennsylvanian composite standard of widespread applicability, it is necessary to integrate the Arrow Canyon succession with other sections containing more diversified faunas. In the case of the Virgilian, this is being approached through the study of a cratonic sequence in Kansas, where sediments representing very different environmental conditions may be found in close juxtaposition. This investigation has been initiated as Research Proposal 80-3.

OBJECTIVES OF STUDY

The primary objective of Research Proposal 80-3 is to establish a detailed fusulinid biozonation in a continuous rock succession of Virgilian age in Kansas. A secondary, albeit important, goal is to provide paleoecologic insights into the spatial distribution of fusulinid faunas and their paleogeographic significance. The project is a joint effort involving Tulsa Research and Denver Region personnel.

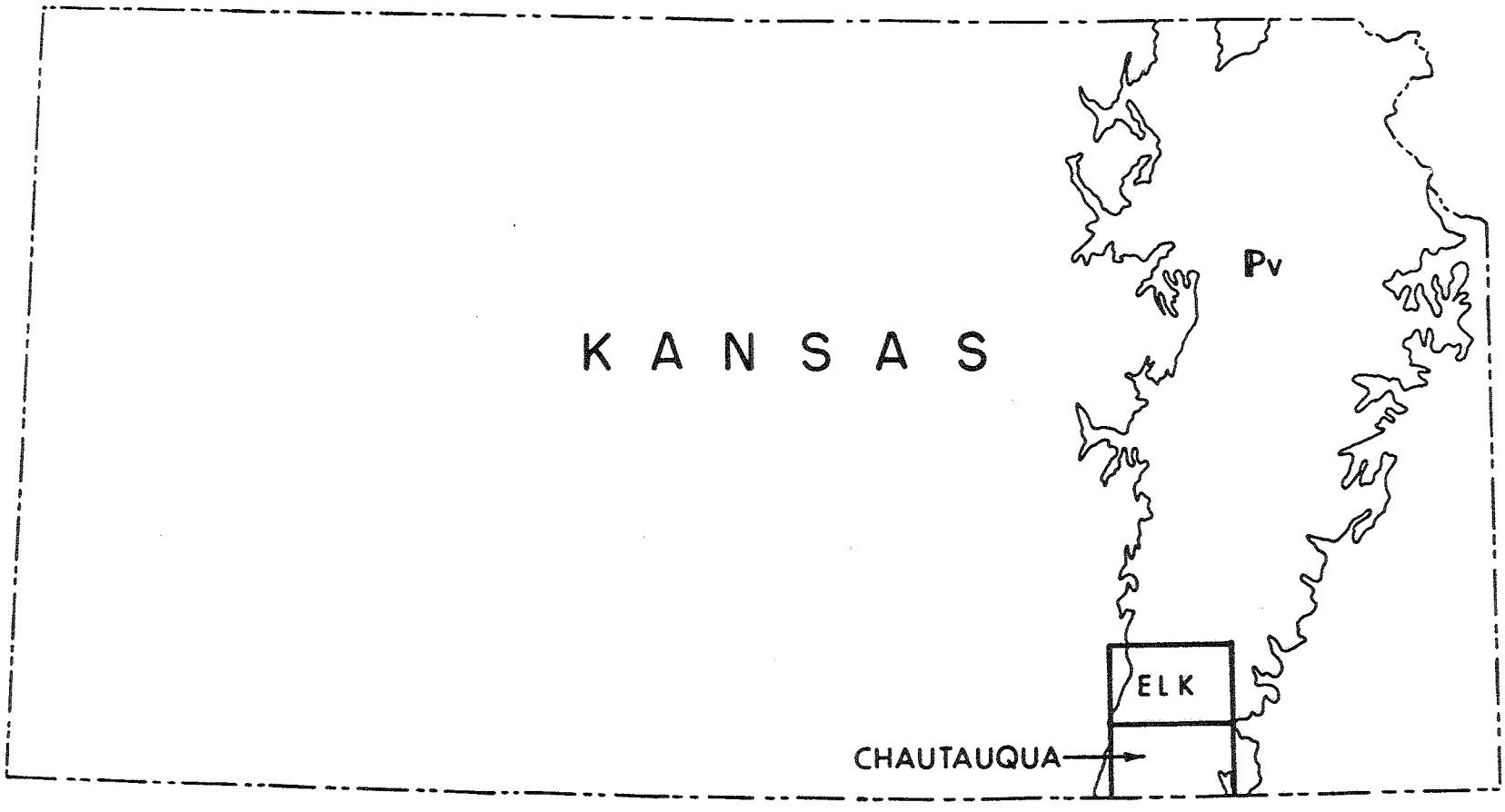


FIG. 1 MAP OF STUDY AREA

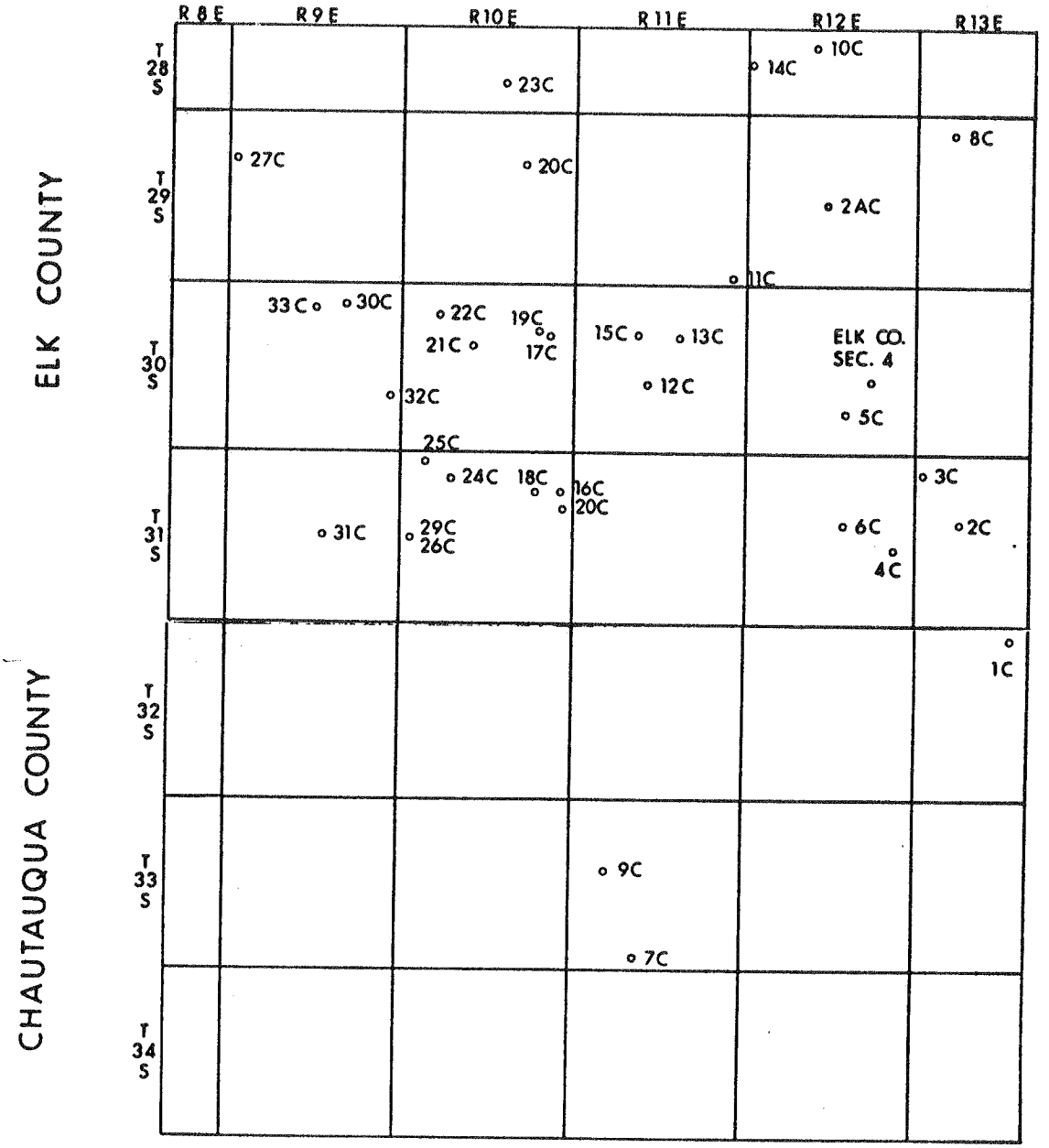


FIG. 2 LOCATION OF MEASURED SECTIONS

STUDY AREA

The primary reference succession for this study is located in southeastern Kansas (Figure 1), and comprises a series of contiguous, or overlapping, measured sections. All but two of the thirty-four sections are located in Elk County; the remaining two are in Chautauqua County (Figure 2). A listing of all collecting localities may be found in Appendix I. Most of the sections were measured and collected by G. J. Verville some years ago, although a number of supplementary collections were made recently to fill in gaps in stratigraphic control.

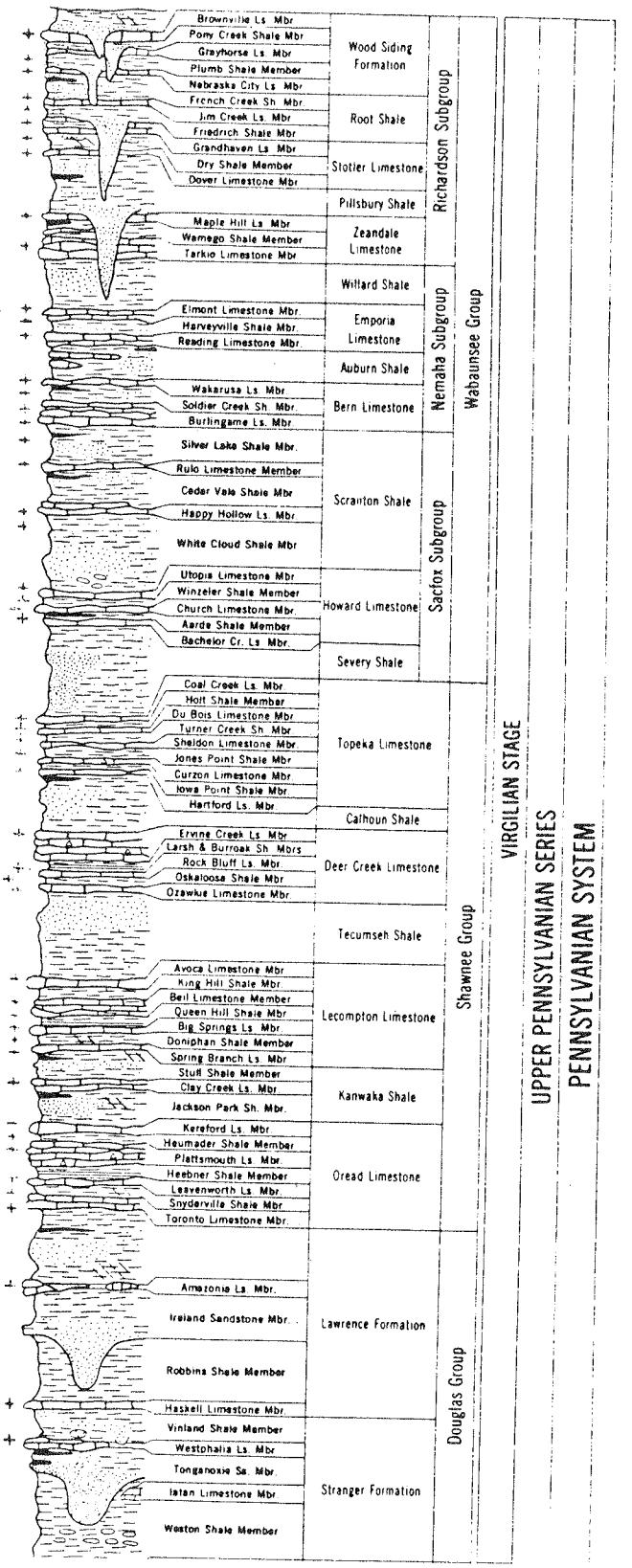
In addition to our in-house material, we have been given an extensive collection of Kansas Virgilian fusulinid thin sections, which were acquired over the years by Dr. M. L. Thompson, formerly with the Illinois Geological Survey. Dr. Thompson's plans to publish the Virgilian fusulinids were thwarted by failing health, and custody of the material was given to us. For purposes of our composite standard work, the Elk County succession must form our basic control, but the Thompson collections will provide us with insight into the geographic and paleoecologic variability of the Virgilian fusulinids throughout Kansas. Such additional control is very important, because we know that considerable lateral variability is exhibited by fusulinids in the Toronto and Leavenworth limestones and, presumably, in other units as well.

STRATIGRAPHY

The Virgilian Stage of the Upper Pennsylvanian Series consists of three groups; in ascending order they are Douglas, Shawnee, and Wabaunsee (Figure 3). Each of these groups comprises a number of sedimentary cycles lumped as formations by their dominant lithology. These, in turn, are subdivided into members which generally have been named. For example, the Oread Formation, or megacyclothem, consists of a number of members, again in ascending order, the Toronto Limestone, the Snyderville Shale, the Leavenworth Limestone, the Heebner Shale, the Plattsmouth Limestone, the Heumader Shale, and the Kereford Limestone. Many of these members are fossilferous, and the distribution of fusulinids is shown by the + symbol in Figure 3. All the fossiliferous horizons indicated are represented in our collections.

CYCLIC SEDIMENTATION

The cyclical nature of sedimentation in the Midcontinent during Pennsylvanian time has been recognized and studied for many years. The cyclicity is highly complex with many variations in the development of individual cyclothems as well as in the successions of the cyclothems which make up the megacyclothems. Nevertheless, it is possible to recognize a basic sequence of events comprising the transgressive and regressive



+ = FUSULINID

FIG. 3. STRATIGRAPHIC CHART WITH FUSULINID HORIZONS

aspects of the depositional cycle. As shown in Figure 4, a representative cyclical succession embraces a transition from nonmarine sediments to marine sediments and back to nonmarine units. The completeness of expression of transgressive and regressive phases is variable, and marine and nonmarine units often are in close juxtaposition, which provides an excellent opportunity for observing ecologic controls. Fusulinids are, of course, confined to the marine phases of the cyclothems, but within them they occur in different lithologies representing differing habitats, which offer the potential of improved understanding of paleoecology.

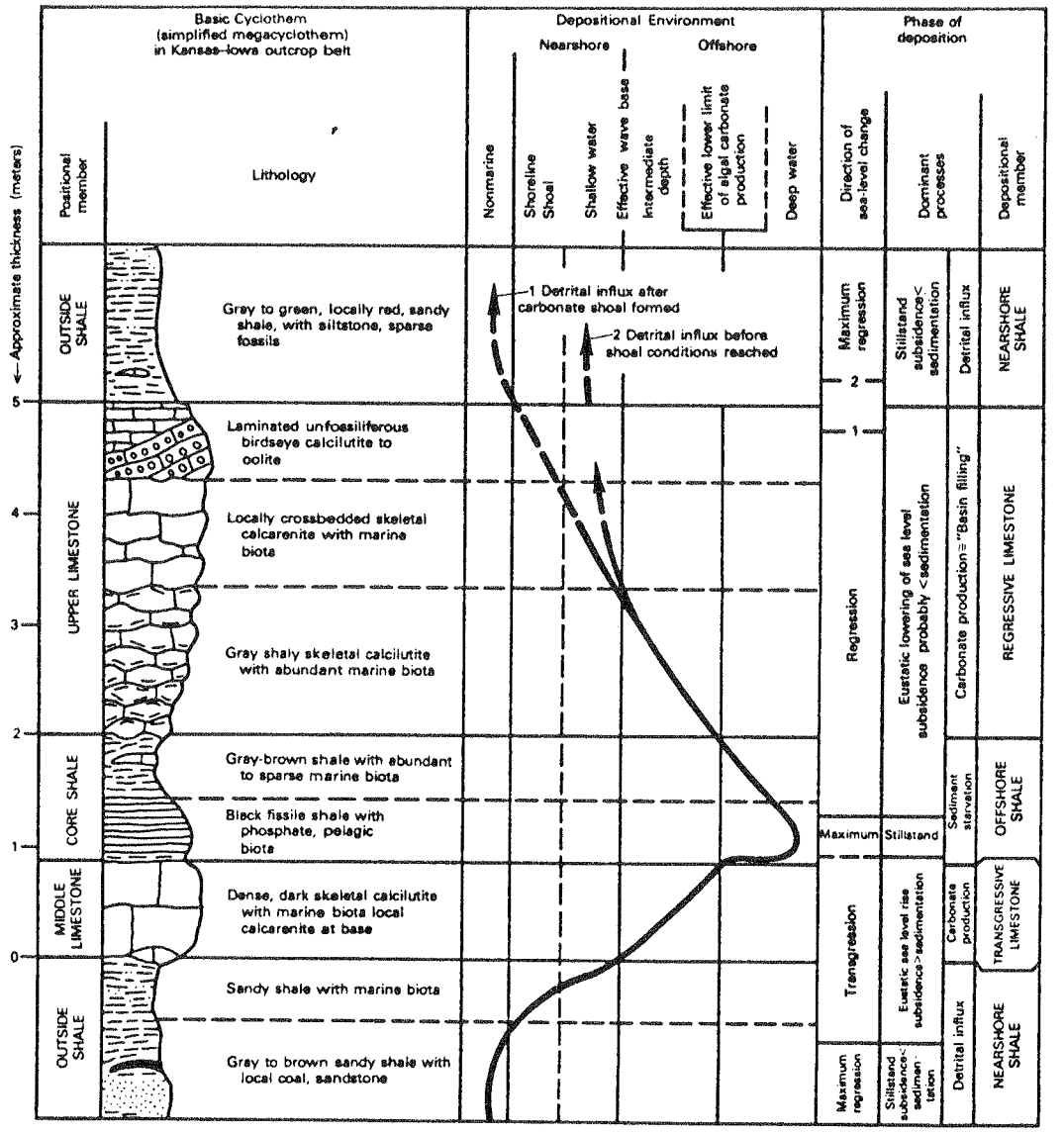
SAMPLE CONTROL

Numerous collections have been made from fifty stratigraphic horizons within the Virgilian of Kansas (Figure 3). For purposes of our composite standard construction, we have established a continuous reference sequence through the Virgilian in Elk and Chautauqua counties. In all, thirty-five measured sections, representing nearly twelve hundred feet of rock, were stacked to provide the reference standard (Figure 5). Our datum is the top of the Tonganoxie Sandstone near the base of the Douglas Group, and all sections stacked above have either overlapping or contiguous relationships (Figure 5). The total range of each measured section is represented by the solid and dashed lines. The solid bar is the portion of a given section used in the stacked sequence, whereas the dashed lines represent overlap. Appendix III summarizes the salient features of the composite sequence, including thicknesses of all the lithic units, portions of the individual sections included in the stacked sequence and cumulative footages of all units above the datum.

Fusulinids generally are abundant if they occur at all, and preservation is good for the most part, although surface weathering has had a degrading effect upon some samples. As previously noted (Figure 3), the fusulinid-bearing horizons are rather well distributed throughout the Virgilian sequence.

PROJECT STATUS

Essentially all sample processing, such as thin-sectioning, has been completed, and specimens representative of all levels have been photographed, not only to characterize faunas but also to delineate phyletic lineages. Visual interpretation has begun, but the closeness of sample control and the abundance of specimens require quantitative study for precise differentiation of intra-specific variability from evolutionary or environmental effects. This involves making numerous measurements of morphologic parameters and their subsequent statistical analysis. Recent acquisition of new measuring equipment, which not only has improved accuracy but also computer interfacing capability, should greatly expedite this aspect of the project.



(AFTER EBANKS *ET AL*, 1979)

FIG. 4. REPRESENTATIVE KANSAS CYCLOTHEM

Even without the quantitative data, it is already possible to recognize a number of stratigraphically significant fusulinids as well as several instances of ecologic effect. Fusulinids of obvious stratigraphic value include Waeringella spiveyi, Dunbarinella ervinensis, Triticites plummeri, Triticites beedi, Triticites ex. gr. T. secalicus, Kansanella spp., Schubertella kingi, Triticites ex. gr. T. ventricosus, and unnamed precursors of the genus Leptotriticites. From a paleoecological standpoint, it is apparent that lateral differentiation of the fusulinid fauna occurs; this can be demonstrated in the Toronto Limestone, for example, by the differing distribution patterns of Triticites plummeri, Kansanella osagensis, and Triticites secalicus. There seems little doubt that this study will provide us with an excellent, regional, stratigraphic reference standard as well as with a vehicle for paleoecologic investigation.

CONCLUSIONS

1. Preliminary examination of the fusulinids from Kansas indicates that the objectives of the study can be achieved using the continuous succession through the Virgilian in Elk County.

2. Both biostratigraphic and environmental data will be derived from study of the material on hand.

3. Evaluation of the fusulinids by qualitative means has already demonstrated a significant stratigraphic subdivision of the Kansas Virgilian.

4. In view of the levels of precision in sampling, quantitative analysis will be necessary to differentiate among details of intraspecific variation, evolution, and paleoenvironmental effects.

G. A. Sanderson

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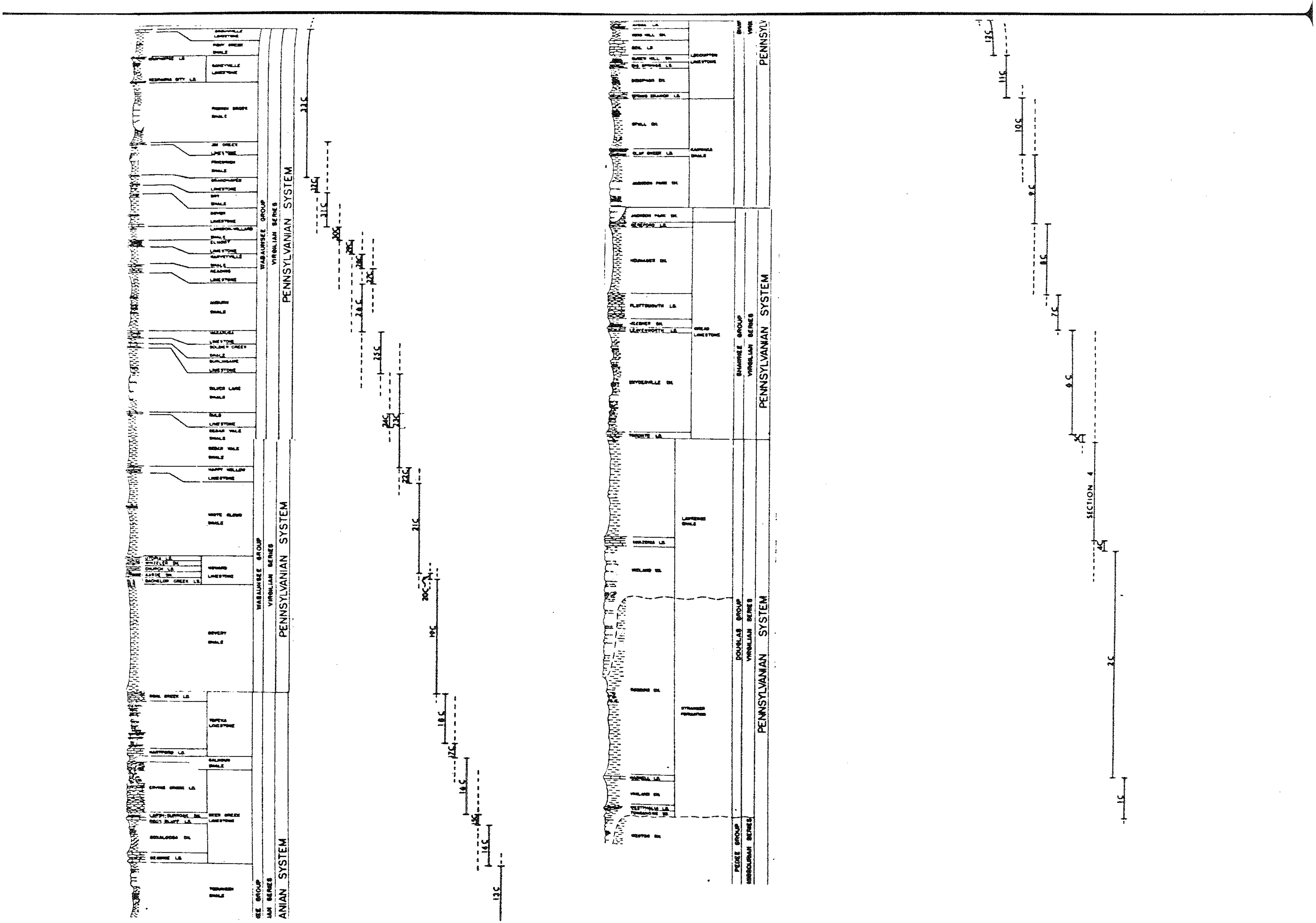

FIG. 5. STRATIGRAPHIC RANGE OF MEASURED SECTIONS

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APPENDIX I

AMOCO MEASURED SECTIONS

MEASURED SECTIONS - VIRGILIAN REFERENCE STANDARD
ELK & CHAUTAUQUA COUNTIES, KANSAS

Section No.	Field No.	Location	Locality No.
33-C	Meas. Sec. 9	Sec. 4/9, T30S, R9E	11004
32-C	Meas. Sec. 18	Sec. 24, T30S, R9E	11377
31-C	Meas. Sec. 19	Sec. 15, T31S, R9E	11002
30-C	Meas. Sec. 15	Sec. 2, T30S, R9E	11010
29-C	Meas. Sec. 14	Sec. 19/18, T31S, R10E	11011
28-C	Meas. Sec. 24	Sec. 13/18, T31S, R10E	11014
27-C	Meas. Sec. 36	Sec. 7, T29S, R10E	11033
26-C	Meas. Sec. 24	Sec. 13/18, T31S, R10E	11014
25-C	Meas. Sec. 34	Sec. 6, T31S, R10E	11013
24-C	Meas. Sec. 35	Sec. 5, T31S, R10E	11012
23-C	Meas. Sec. 27	Sec. 27, T28S, R10E	11015
22-C	Meas. Sec. 77	Sec. 8, T30S, R10E	11286
21-C	Meas. Sec. 28	Sec. 16, T30S, R10E	11017
20-C	Meas. Sec. 30	Sec. 11, T29S, R10E	11309
19-C	Meas. Sec. 31	Sec. 11, T30S, R10E	11376
18-C	Meas. Sec. 52	Sec. 11, T31S, R10E	11020
17-C	Meas. Sec. 33	Sec. 12, T30S, R10E	11021
16-C	Meas. Sec. 38	Sec. 12, T31S, R10E	11023
15-C	Meas. Sec. 42	Sec. 9, T30S, R11E	11024
14-C	Meas. Sec. 68	Sec. 29, T28S, R12E	10999
13-C	Meas. Sec. 41	Sec. 10, T30S, R11E	11026
12-C	Meas. Sec. 39	Sec. 21, T30S, R11E	11027
11-C	Meas. Sec. 40	Sec. 36, T29S, R11E	11029
10-C	Meas. Sec. 80	Sec. 21, T28S, R12E	10997
9-C	Meas. Sec. 59	Sec. 17, T33S, R11E	11375
8-C	Meas. Sec. 49	Sec. 5, T29S, R13E	10998
7-C	Meas. Sec. 54	Sec. 33, T33S, R11E	10994
6-C	Meas. Sec. 44	Sec. 15, T31S, R12E	11031
5-C	Meas. Sec. 45	Sec. 27, T30S, R12E	11028
4-C	Meas. Sec. 67	Sec. 24, T31S, R12E	11032
3-C	Meas. Sec. 69	Sec. 6, T31S, R13E	11374
2-C	Meas. Sec. 63	Sec. 17, T31S, R13E	11373
2A-C	USGS Sect. 3	Sec. 21, T29S, R13E	11371
1-C	Meas. Sec. 64	Sec. 3, T32S, R13E	10993
4	Elk Co. Sec. 4	Sec. 23, T30S, R12E	11372

APPENDIX II

M. L. THOMPSON COLLECTIONS

VIRGILIAN OF KANSAS - M. L. Thompson Collection

COLLECTION NO.	HORIZON AND LOCATION
K-1	Beil limestone, ½ mile NE of Virgil.
K-2	Elmont limestone, NW¼ Sec. 9, T. 34 S., R. 8 E.
K-4	Topeka limestone, Hartford ls. mbr., NW¼ Sec. 16, T. 11 S., R. 16 E.
K-5	Reading limestone, SE¼ NW¼ Sec. 35, T. 11 S., R. 14 E.
K-7	Tarkio limestone, NW¼ SW¼ Sec. 25, 11 S., R. 15 E.
K-8	Maple Hill limestone, NE cor. Sec. 19, T. 11 S., R. 13 E.
K-9	Rulo limestone, NE¼ Sec. 12, T. 34 S., R. 8 E.
K-11	Wakarusa limestone, NW SE¼ Sec. 35, T. 11 S., R. 14 E.
K-12	Grandhaven ls., Hwy cut, Creek exp., S. cent. Sec. 13, T. 16 S., R. 12 E.
K-13	Tarkio ls., Hwy cut, SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E.
K-14	Brownville ls., Hwy cut, c. W line Sec. 33, T. 12 S., R. 13 E.
K-15	Happy Hollow ls., SE¼ SW¼ Sec. 4, T. 26 S., R. 10 E.
K-16	Jim Creek ls., Creek exp., c. w line, Sec. 33, T. 12 S., R. 13 E.
K-17	Big Springs ls., 1.5 miles north of Big Springs. Syntypes: Triticites cullomensis Dunbar and Condra.
K-19	Dover ls., Hwy cut, and creek exp., S cent. Sec. 13, T. 16 S., R. 12 E.
K-21	Oread ls., top of ls., near Tourist Inn, Lawrence, Douglas County.
K-22	Beil ls., center of east line SE¼ Sec. 15, T. 12 S., R. 18 E.

COLLECTION NO.	HORIZON AND LOCATION
K-23	Westphalia ls., 0.5 mile north of Westphalia, T. secalicus oryziformis Newell (=K-141).
K-24	Big Spring ls., center east line SE¼ Sec. 15, T. 12 S., R. 18 E.
K-25	Ozawkie ls? "Haynies ls." = "Middle Deer Creek ls.", SE¼ SW¼ Sec. 32, T. 11 S., R. 18 E.
K-26	Ervine Creek sh., Deer Creek, SW¼ Sec. 32, T. 11 S., R. 18 E.
K-27	Deer Creek ls., base of Rock Bluff ls., Hwy cut, NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936, 2nd day.
K-29	Deer Creek ls., 8 ft above base of Ervine Creek ls., Hwy cut, NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-30	Lecompton ls., base of Big Springs ls. mbr., Hwy 7, abt. 2.0 miles N of Atchison. South part, SW¼ NW¼ Sec. 18, T. 5 S., R. 20 E., Atchison County.
K-31	Beil ls., Lecompton ls., Hwy cuts Hwy 40, NW¼ NE¼ Sec. 24, T. 12 S., R. 18 E., Douglas County, east side valley wall, Stp. 18, KGS 1936.
K-32	Kanwaka sh., base of Clay Creek ls., Creek exp., NE¼ SE¼ Sec. 11, T. 5 S., R 20 E., Atchison County, Stp. 13, KGS 1936.
K-36	Clay Creek ls., basal part, Kereford Bros. Quarry on left. NW¼ Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS, 1936.
K-37	Oread ls., top of Kereford ls., Kereford Bros. Quarry on left, NW¼ Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-39	Spring Branch mbr., Lecompton Fm., 2.0 miles north of north edge, Atchison, Ks., SW¼ NW¼ Sec. 18, T. 5 S., R. 20 E. Mileage 34.0, 2nd day, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-41	Shale at top of Heumader shale, Kereford Bros. Quarry, NW¼ Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-42	Oread ls., basal Plattsmouth ls., Hwy cut in NW¼ Sec. 22, T. 8 S, R. 22 E., Leavenworth County, Stp. 16, KGS 1936.
K-43	Hartford ls., about 3.0 ft above base of lower ls. mbr., Hwy cut NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, KGS 1936, Stp. 21.
K-44	Clay Creek ls., basal part, road cut on each side of valley along Hwy 40, NE¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County.
K-45	Grandhaven, basal part, road cut, SE¼ Sec. 35, T. 17 S., R. 12 E., Lyon County, Stp. 36, KGS 1936.
K-46	Deer Creek ls., Ervine Creek ls., 3 ft below top and 8 ft above base, Hwy cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-47	Brownville ls., mileage 5.0, 4th day, KGS 1936, Stp. 37, W side Neosho, NW of Emporia, NE¼ Sec. 31, T. 18 S., R. 11 E., Lyon County.
K-48	Dover ls., Creek exposure in S cen. part Sec. 13, T. 16 S., R. 12 E., Lyon County, Stp. 32, KGS 1936.
K-50	Deer Creek ls., top Ervine Creek ls., Hwy cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-51	Reading ls., Hwy cut NE¼ NE¼ Sec. 20, T. 17 S., R. 13 E., Lyon County, Stp. 34, KGS 1936.
K-52	Lecompton ls., base of Big Spring ls., Hwy cuts in NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Hwy 40, Stp. 18, KGS 1936.
K-53	Brownville ls., creek exposure, NW¼ NW¼ Sec. 21, T. 16 S., R. 12 E., Lyon County, Stp. 31, KGS 1936.
K-55	Lecompton ls., Spring Branch ls., Hwy cuts, NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-56	Burlingame ls., quarry in SE¼ NE¼ Sec. 33, T. 17 S., R. 13 E., Lyon County, KGS 1936.
K-57	Avoca ls., SE¼ SW¼ Sec. 36, T. 11 S., R. 17 E.
K-58	Doniphan sh., Hwy cut, NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E.
K-59	Ozawkie ls., Hwy cut NE corner Sec. 6, T. 12 S., R. 17 E.
K-62	Top Topeka ls., small creek on J. E. Kirkham's farm, NE¼ SE¼ Sec. 5., T. 11 S., R. 16 E.
K-64	Middle of Reading ls., Hwy cut, SE¼ NW¼ Sec. 35, T. 11 S., R. 14 E., Shawnee County, Stp. 24, KGS 1936.
K-63	Glenrock ls., 2.5 ft below top, NW¼ NW¼ Sec. 3, T. 20 S., R. 7 E., (=K-85).
K-65	Top Clay Creek ls., cut bank on east wall of valley along Hwy near NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.
K-66	Base Burlingame ls., Hwy cuts near center E. line Sec. 36, T. 11 S., R. 14 E., Shawnee County, Stp. 23, KGS 1936.
K-67	Jim Creek ls., creek exposure south of highway near center of W line, Sec. 33, T. 12 S., R. 13 E., Wabaunsee County, Stp. 29, KGS 1936.
K-68	Base Wakarusa ls., road cut Hwy 10, NW¼ Sec. 34, T. 11 S., R. 14 E., Shawnee County, Stp. 25, KGS 1936.
K-69	Tarkio ls., Hwy cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-70	Upper Reading and sh. just below Elmont, road cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-71	Ozawkie ls., top bed 1, Hwy cut at NE corner Sec. 6, T. 12 S., R. 17 E., Shawnee County, Stp. 19, KGS 1936.
K-72	Maple Hill ls., creek bank NE¼ NW¼ Sec. 19, T. 16 S., R. 13 E., Lyon County, Stp. 33, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-56	Burlingame ls., quarry in SE¼ NE¼ Sec. 33, T. 17 S., R. 13 E., Lyon County, KGS 1936.
K-57	Avoca ls., SE¼ SW¼ Sec. 36, T. 11 S., R. 17 E.
K-58	Doniphan sh., Hwy cut, NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E.
K-59	Ozawkie ls., Hwy cut NE corner Sec. 6, T. 12 S., R. 17 E.
K-62	Top Topeka ls., small creek on J. E. Kirkham's farm, NE¼ SE¼ Sec. 5., T. 11 S., R. 16 E.
K-64	Middle of Reading ls., Hwy cut, SE¼ NW¼ Sec. 35, T. 11 S., R. 14 E., Shawnee County, Stp. 24, KGS 1936.
K-63	Glenrock ls., 2.5 ft below top, NW¼ NW¼ Sec. 3, T. 20 S., R. 7 E., (=K-85).
K-65	Top Clay Creek ls., cut bank on east wall of valley along Hwy near NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.
K-66	Base Burlingame ls., Hwy cuts near center E. line Sec. 36, T. 11 S., R. 14 E., Shawnee County, Stp. 23, KGS 1936.
K-67	Jim Creek ls., creek exposure south of highway near center of W line, Sec. 33, T. 12 S., R. 13 E., Wabaunsee County, Stp. 29, KGS 1936.
K-68	Base Wakarusa ls., road cut Hwy 10, NW¼ Sec. 34, T. 11 S., R. 14 E., Shawnee County, Stp. 25, KGS 1936.
K-69	Tarkio ls., Hwy cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-70	Upper Reading and sh. just below Elmont, road cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-71	Ozawkie ls., top bed 1, Hwy cut at NE corner Sec. 6, T. 12 S., R. 17 E., Shawnee County, Stp. 19, KGS 1936.
K-72	Maple Hill ls., creek bank NE¼ NW¼ Sec. 19, T. 16 S., R. 13 E., Lyon County, Stp. 33, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-78	Plattsmouth ls., Kereford Bros. Quarry, NW¼ Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-79	Wakarusa ls., Hwy cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Hwy 10, Stp. 25, KGS 1936.
K-85	Glenrock ls., 2½ ft below top, NW¼ NW¼ Sec. 3, T. 20 S., R. 7 E., Chase County (=K-63).
K-115	Big Spring ls., basal 1 ft, Hwy cut NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County.
K-118	Lecompton ls., upper, Sedan, Kansas.
K-119	Kereford ls., quarry just south of RR, NE of Lecompton, Kansas.
K-122	Snyderville sh., top, Hwy 40 road cut W edge of Lawrence, Kansas.
K-129	Stull sh., lower 1 ft, sh. on top blue ls. of Deer Creek, NW¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, 0.3 mile E Stp. 18, KGS 1936.
K-130	Toronto ls., top, at spillway of Lone Star Lake, 15± miles W of Lawrence, Kansas.
K-132	Stull sh., top, Hwy cut NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County.
K-133	Clay Creek ls., 0.9-1.7 ft above lower ls. of Clay Creek, 0.3 mile E Stp. 18, KGS 1936, NE¼ Sec. 35, T. 12 S., R. 18 E., Douglas County road cut.
K-134	Ervine Creek ls., very top of cut, Hwy cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-135	Clay Creek ls., Grey sh., 0.3 mile E of Stp. 18, KGS 1936, NW¼ NE¼ NE¼ Sec. 34, T. 12 S., R. 18 E.
K-136	Spring Branch ls., NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-137	Queen Hill sh., upper, NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.
K-138	Beil ls., top, NW¼ NE¼ Sec. 34, T. 12 S., R 18 E., Douglas County, Stp. 18, KGS 1936.
K-139	Kereford ls., Quarry NE edge of Lecompton, just S of RR.
K-141	Westphalia ls., type locality, Westphalia, Anderson County (=K-23).
K-142	Ozawkie ls., Hwy cut NE cor. Sec. 6, T. 12 S., R. 17 E., Shawnee County, Stp. 19, KGS 1936.
K-143	Kereford ls., middle, SE corner of Kereford Quarry, Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-144	Hartford ls., Hwy cut NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, Stp. 1, KGS 1936 (called Dashner ls.).
K-145	Ervine Creek ls., Hwy cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-146	Clay Creek ls., creek exposure NE¼ SE¼ Sec. 11, T. 5 S., R. 20 E., Atchison County, Stp. 13, KGS 1936.
K-147	Snyderville sh., upper, Hwy cut NW¼ Sec. 22, T. 8 S., R. 22 E., Leavenworth County, Stp. 16, KGS 1936.
K-148	Coal Creek, Hwy cut NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, Stp. 21, KGS 1936.
K-149	Wakarusa ls., Hwy cut and creek exp., SE¼ NW¼ Sec. 35, T. 11 S., R. 14 E., Shawnee County, Stp. 24, KGS 1936.
K-150	Rock Bluff ls., Hwy cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-152	Reading ls., lower, Hwy cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-153	Sheldon ls., sh. above and below, Hwy cut on S facing bluff, NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, Stp. 21, KGS 1936, Bed 8.

COLLECTION NO.	HORIZON AND LOCATION
K-154	Reading ls., Hwy cut, SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-156	Curzon ls., Hwy cut on S facing bluff, NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, Stp. 21, KGS 1936.
K-157	Turner Creek sh., road cut on S facing bluff, NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, Stp. 21, KGS 1936, Bed 13.
K-158	Larsh-Mission Creek sh., road cut NW¼ NW¼ Sec. 13, T. 5 S., R. 20 E., Atchison County, Stp. 14, KGS 1936.
K-160	Wakarusa ls., Hwy cut NW¼ Sec. 34, T. 11 S., R. 14 E., Shawnee County, Stp. 25, KGS 1936.
K-161	Reading ls., Hwy cut SE¼ NW¼ Sec. 35, T. 11 S., R. 14 E., Shawnee County, Stp. 24, KGS 1936.
K-162	Plattsmouth ls., SE cor. Kereford Quarry, Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-163	Tarkio ls., sh. below, road cut SW¼ NW¼ Sec. 20, T. 12 S. R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-164	Topeka ls. (1), upper of 3 thin ledges of ls. in shale, just SW of fork of Hwys 99 and 160, 6± ft above (2), Elk County, E of Moline.
K-165	Topeka ls. (2), middle of 3 thin ls. in sh., just SW of forks of Hwys 99 and 160, 6± ft below (1), E of Moline, Elk County.
K-166	Heumader sh., Kereford Quarry, S of Leavenworth, SE cor. quarry, Sec. 18, T. 6 S., R. 21 E., Atchison County, Stp. 15, KGS 1936.
K-167	Hartford ls., sh. below Sheldon ls., road cut on S facing hill, NW¼ Sec. 16, T. 11 S., R. 16 E., Shawnee County, KGS 1936, Stp. 21.
K-168	Long Creek ls., lower, road cut SE¼ NE¼ Sec. 4, T. 13 S., R. 12 E., Wabaunsee County, Stp. 30, KGS 1936.

COLLECTION NO.	HORIZON AND LOCATION
K-169	Elmont ls., Hwy cut SW¼ NW¼ Sec. 20, T. 12 S., R. 14 E., Shawnee County, Stp. 26, KGS 1936.
K-170	Clay Creek ls., SE cor. Kereford Quarry, Stp. 15, KGS 1936.
K-171	Leavenworth ls., Hwy cut NW¼ Sec. 22, T. 8 S., R. 22 E., Leavenworth County, Stp. 16, KGS 1936, type section.
K-172	Big Spring ls., Hwy cut NE¼ SE¼ Sec. 11, T. 5 S., R. 20 E., Atchison County, Stp. 13, KGS 1936.
K-173	Toronto ls., basal, Hwy cut NW¼ Sec. 22, T. 8 S., R. 22 E., Leavenworth County, Stp. 16, KGS 1936.
K-174	Big Spring ls., NW¼ NE¼ Sec. 34, T. 12 S., R. 18 E., Douglas County, Stp. 18, KGS 1936.
K-175	Jim Creek ls., creek exposure near center of W line, Sec. 33, T. 12 S., R. 13 E., Wabaunsee County, just S of Hwy, Stp. 29, KGS 1936.
K-176	Topeka ls., NE¼ Sec. 20, T. 28 S., R. 11 E., just S of Greenwood-Elk County line.
K-177	"Jim Creek" ls., SE¼ Sec. 11, T. 10 S., R. 9 E., Pottawatomie County.
K-178	Happy Hollow ls., 12 ft below, NW¼ NW¼ Sec. 7, T. 34 S., R. 9 E., 7 miles E of Cedarvale, Kansas.
K-180	Dover ls., 1 ft zone, 5 ft above base, 3 miles S Maple Hill, Kansas.
K-181	Tarkio ls., 6½ miles W of Burlingame, Kansas, center Sec. 15, T. 15 S., R. 13 E.
K-183	Topeka ls., between "Curzon ls." and Wolf River ls., SE¼ Sec. 31, T. 29 S., R. 11 E., near golf course.
K-184	Oread ls., lower, 1-2 ft below top, SW¼ NW¼ Sec. 27, T. 14 S., R. 20 E., 1 mile N of Baldwin, Kansas.
K-185	Topeka ls, 12 ft above base; center of N½, Sec. 16, T. 11 S., R. 10 E.

COLLECTION NO.	HORIZON AND LOCATION
K-186	Oread ls., lower, W end of KU campus, Lawrence, Kansas.
K-187	Clay Creek ls., 5 miles W of Quenemo, Osage County, Waymire Farm.
K-189	Topeka ls., basal, E of junction Hwys 116 and 11, Moline, Elk County.
K-190	Lecompton ls., just below lower, 1 mile west of intersection of Hwys 50 S and 75, west of Waverly, Kansas.
K-193	Topeka ls., thin limestones between Coal Creek and Curzon. NW¼ SW¼ Sec. 11, T. 31 S., R. 10 E.
K-194	Dover ls., upper, 10 ft above Dover ls., Sec. 13, T. 16 S., R. 12 E., on Hwy 50 N., in road ditch.
K-196	Clay Creek ls., just west of Kanwaka, Kansas.
K-198	Ervine Creek ls., west edge of Calhoun Bluffs at Ervine Creek Quarry.
K-199	Topeka ls., lower, "Dashner ls.", center Sec. 12, T. 18 S., R. 14 E., Osage County.
K-200	Topeka ls., between "Curzon" and "Wolf River", SE¼ Sec. 31, T. 29 S., R. 11 E., near golf course.
K-201	Toronto ls., SW¼ NW¼ Sec. 27, T. 14 S., R. 20 E., 2.4 miles south of Vinland, Kansas.
K-202	Coal Creek mbr., Topeka fm., SW¼ SW¼ Sec. 9, T. 10 S., R. 17 E., 3± miles E of Meriden, Kansas.
K-203	Topeka ls., type section of Jones Point, NE¼ NW¼ Sec. 16, T. 11 S., R. 16 E.
K-204	Oread ls., lower, West Campus Quarry at KU, Lawrence, lower ledge of ls.
K-205	Spring Branch, upper, NE¼ Sec. 33, T. 13 S., R. 17 E.
K-206	Topeka ls., calc. sh. just above Hartford, part of Curzon(?), NW cent. Sec. 9, T. 17 S., R. 15 E.

COLLECTION NO.	HORIZON AND LOCATION
K-207	Topeka ls., between "Curzon" and "Wolf River", SE Sec. 31, T. 29 S., R. 11 E., near golf course.
K-208	Topeka ls., "Curzon" mbr., W cent. Sec. 7, T. 2 S., R. 20 E.
K-209	Tecumseh sh., sh. below fusulinid ls., 57 ft above Beil ls., 2 miles S of Lynden, Kansas.
K-210	Westphalia ls., NE¼ Sec. 12, T. 29 S., R. 12 E.
K-211	Ozawkie ls., Deer Creek ls., 1/8 mile S on US Hwy 75 from cent. Sec. 7, T. 15 S., R. 16 E.
K-212	Topeka ls., sh. just below "Curzon", Atchison County, center Sec. 12, T. 5 S., R. 19 E.
K-213	Upper Oread ls., near base, Willard cut, Lawrence, Kansas.
K-227	Toronto ls., sh. just below, cont. E side Sec. 15, T. 31 S., R. 12 E., Elk County, on road cut at bottom of hill.
K-228	Happy Hollow ls., sh. breaks within, near SW cor. SE¼ SE¼ Sec. 27, T. 28 S., R. 10 E., Elk County, road cuts at top of creek bank.
K-230	Soldier Creek sh., just below Wakarusa ls., cont. E side NE¼ NE¼ Sec. 6, T. 31 S., R. 10 E., Elk County, road cut on N-S road.
K-231	Howard ls., Aarde sh. mbr., sh. 1 ft above road cut just below Church ls., center of N line Sec. 5, T. 29 S., R. 11 E., on E-W road, Elk County.
K-232	Happy Hollow ls., lower part, SE¼ NW¼ Sec. 18, T. 19 S., R. 13 E., Lyon County.
K-233	Ervine Creek ls., 3-5 ft below top, Moline Quarry, Sec. 11, T. 31 S., R. 10 E., Elk County.
K-234	Heumader sh., 2.1 miles S of Longton in road cut on N-S road, west side of NE¼ NE¼ Sec. 21, T. 31 S., R. 12 E., Elk County.

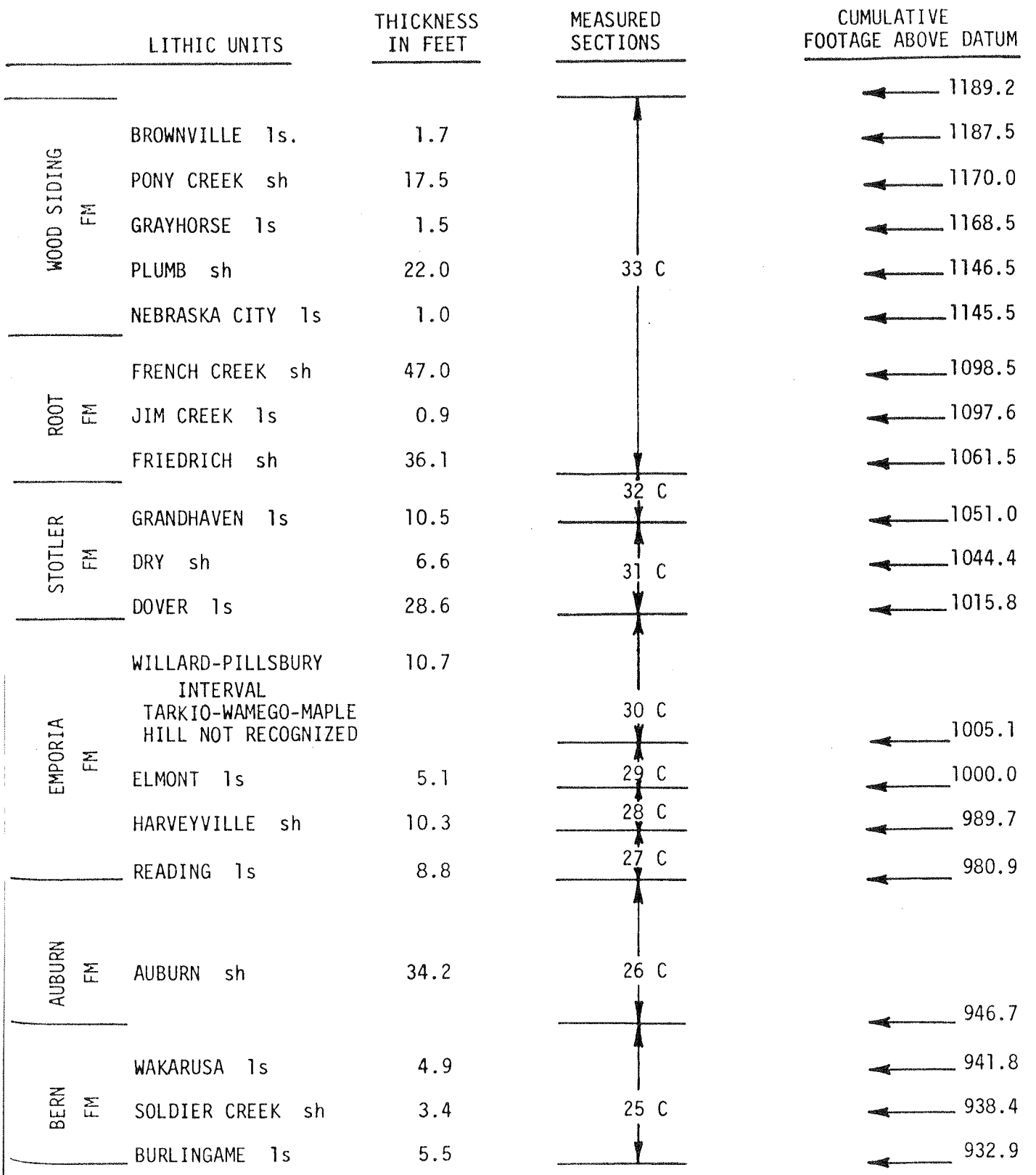
COLLECTION NO.	HORIZON AND LOCATION
K-236	Beil ls., sh. break 5 ft from top, center Sec. 21, T. 30 S., R. 11 E., Elk County, road cut on N-S road.
K-237	Burlingame ls., lower 2-3 ft, E center NE¼ Sec. 6, T. 31 S., R. 10 E., Elk County (Burlingame 4.5 ft thick).
K-229	Avoca ls., 3.5 from bottom, E side of N-S road at center of Sec. 21, T. 30 S., R. 11 E., Elk County, road cut.
K-238	Avoca ls., sh. breaks 5 ft above base, cont. Sec. 21, T. 30 S., R. 11 E., Elk County, road cut on N-S road and on E side of road.
K-239	Brownville ls., SW¼ SW¼ Sec. 3, T. 30 S., R. 9 E., on north-facing hill and on N-S road.
K-240	Topeka ls., 2-3 ft below top, NW¼ SW¼ Sec. 12, T. 30 S., R. 10 E., Elk County, road cut on N-S road just south of low-water bridge.
K-241	Ervine Creek sh., 7 ft below top, Moline Quarry, Sec. 11, T. 31 S., R. 10 E., Elk County.
K-242	Church ls., limestones and shales in lower part, at contact with Aarde sh., SW¼ Sec. 25, T. 29 S., R. 10 E., Elk County, road cut at high creek banks and at top of bank on N-S road.
K-243	Big Spring ls., middle, S line of SW¼ SE¼ Sec. 36, T. 29 S., R. 11 E., Elk County, road cut on E-W road.
K-244	Topeka ls., lower part, north rim of Moline Quarry, Sec. 11, T. 31 S., R. 10 E., Elk County.
K-249	Haskell ls., near cen. E line NE¼ Sec. 21, T. 11 S., R. 21 E., Leavenworth County.
K-250	Spring Hill ls., quarry at NW corner of junction old US Hwy 59 and Santa Fe RR 5 miles SW of Garnett, Kansas, 5 miles from 7th St. and new US 59 in City of Garnett.
K-260	Haskell ls., sh. just below, S side of E-W road, NW¼ NW¼ NE¼ Sec. 13, T. 29 S., R. 13 E., Wilson County.

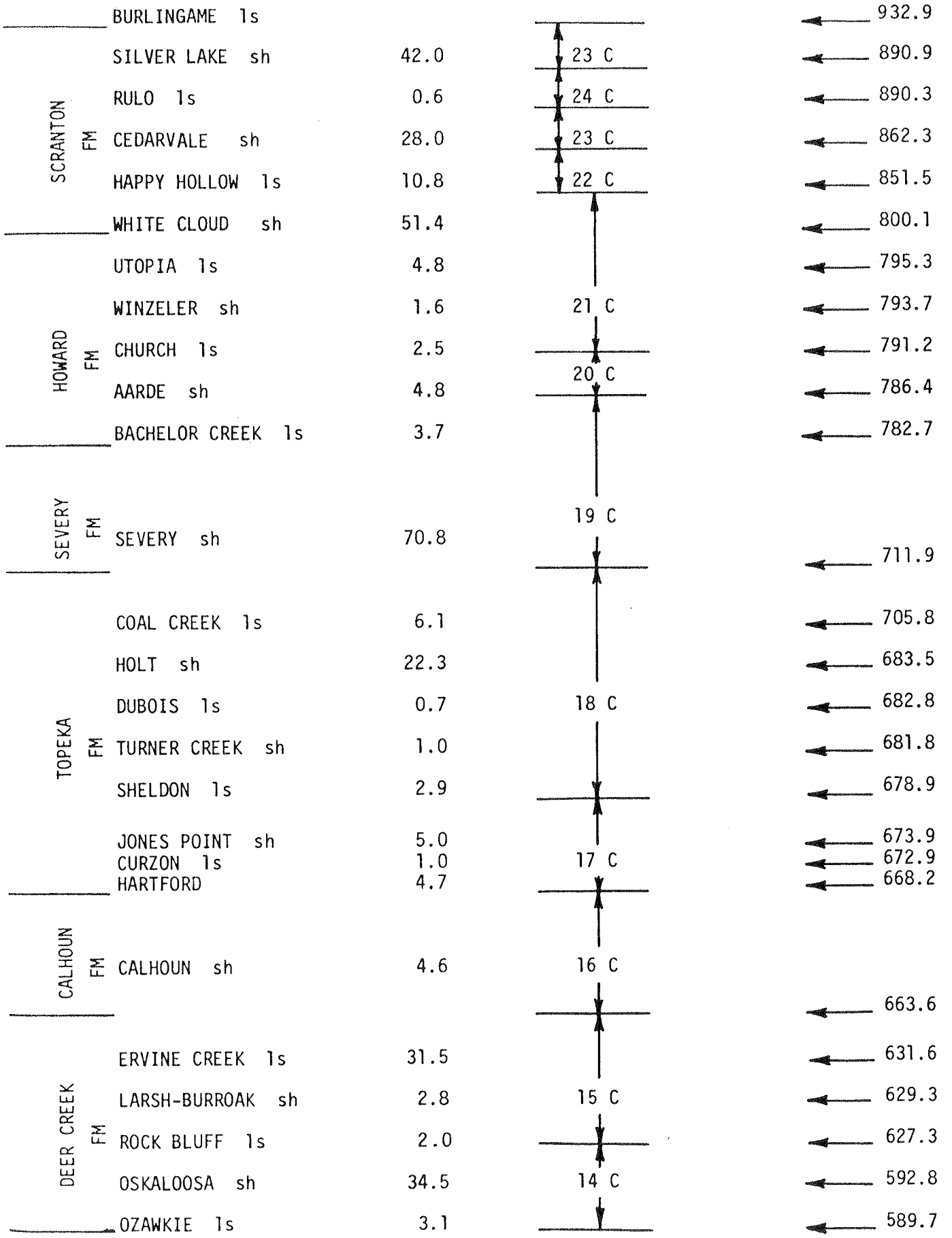
COLLECTION NO.	HORIZON AND LOCATION
K-91	Ozawkie ls.
K-124	Deer Creek ls.
K-125	Elmont ls. mbr.
K-20	Jim Creek ls. mbr.

APPENDIX III

COMPOSITED OUTCROP SECTIONS

VIRGILIAN REFERENCE SEQUENCE
COMPOSITED OUTCROP SECTIONS

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WINZELER sh
CHURCH ls
AARDE sh
BACHELOR CREEK ls
SEVERY sh
COAL CREEK ls
HOLT sh
DUBOIS ls
TURNER CREEK sh
SHELDON ls
JONES POINT sh
CURZON ls
HARTFORD
CALHOUN sh
ERVINE CREEK ls
LARSH-BURROAK sh
ROCK BLUFF ls
OSKALOOSA sh
OZAWKIE ls
SCRANTON FM
HOWARD FM
SEVERY FM
TOPEKA FM
CALHOUN FM
DEER CREEK FM
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0.6
28.0
10.8
51.4
4.8
1.6
2.5
4.8
3.7
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6.1
22.3
0.7
1.0
2.9
5.0
1.0
4.7
4.6
31.5
2.8
2.0
34.5
3.1
23 C
24 C
23 C
22 C
21 C
20 C
19 C
18 C
17 C
16 C
15 C
14 C
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890.9
890.3
862.3
851.5
800.1
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793.7
791.2
786.4
782.7
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705.8
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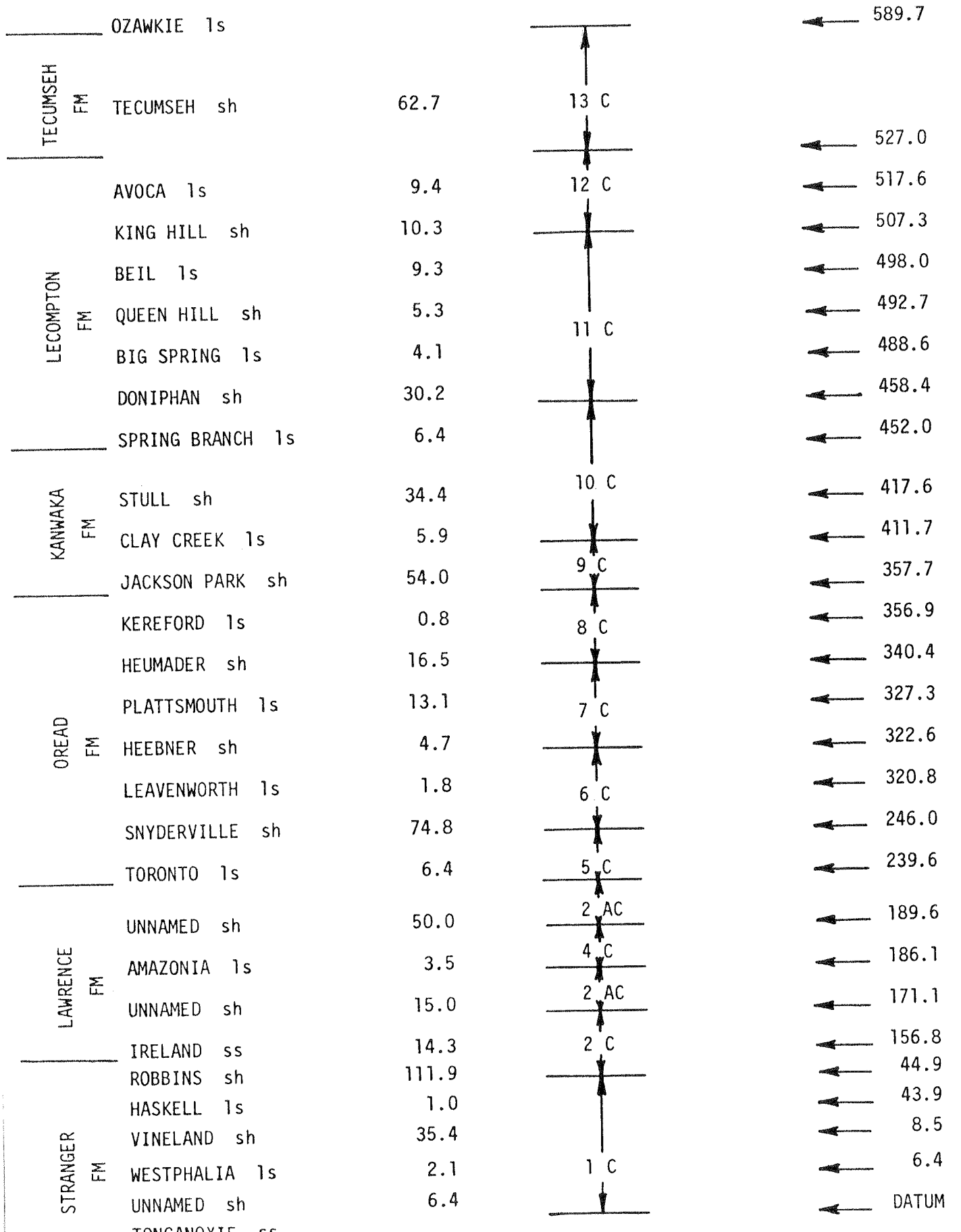
592.8
589.7


OZAWKIE ls
TECUMSEH FM
TECUMSEH sh
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AVOCA ls
9.4
KING HILL sh
10.3
LECOMPTON FM
BEIL ls
9.3
QUEEN HILL sh
5.3
BIG SPRING ls
4.1
DONIPHAN sh
30.2
SPRING BRANCH ls
6.4
KANWAKA FM
STULL sh
34.4
CLAY CREEK ls
5.9
JACKSON PARK sh
54.0
KEREFORD ls
0.8
HEUMADER sh
16.5
OREAD FM
PLATTSMOUTH ls
13.1
HEEBNER sh
4.7
LEAVENWORTH ls
1.8
SNYDERVILLE sh
74.8
TORONTO ls
6.4
UNNAMED sh
50.0
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AMAZONIA ls
3.5
UNNAMED sh
15.0
IRELAND ss
14.3
ROBBINS sh
111.9
HASKELL ls
1.0
STRANGER FM
VINELAND sh
35.4
WESTPHALIA ls
2.1
UNNAMED sh
6.4
TONGANOXIE ss
13 C
12 C
11 C
10 C
9 C
8 C
7 C
6 C
5 C
2 AC
4 C
2 AC
2 C
1 C
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527.0
517.6
507.3
498.0
492.7
488.6
458.4
452.0
417.6
411.7
357.7
356.9
340.4
327.3
322.6
320.8
246.0
239.6
189.6
186.1
171.1
156.8
44.9
43.9
8.5
6.4
DATUM

KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 2000-12

Upper Pennsylvanian (Virgilian) Fusulinid Biozonation
Final Report

Amoco Production Company, Research Department
Report No. F83-G-18

by

G.A. Sanderson
G.J. Verville

KANSAS GEOLOGICAL SURVEY
1930 Constant Avenue
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Lawrence, KS 66047

AMOCO PRODUCTION COMPANY
Tulsa, Oklahoma
November 21, 1983

83325ART0168

TO: Division Geologists
Managers, Geology, APC (USA and INTL), Chicago
Regional Geologists
Regional Paleontologists

SUBJECT: Transmittal of Geological Research Department Report F83-G-18, "Upper Pennsylvanian (Virgilian) Fusulinid Biozonation - Final Report"

The attached report marks the completion of a study undertaken to strengthen our Upper Pennsylvanian biostratigraphic control which previously had been based upon a low diversity, provincial fauna. The primary result of this project is the establishment of a tightly controlled reference standard which will significantly improve the precision and applicability of our fusulinid zonation in the subsurface. Although the study was fundamentally stratigraphic in nature, some very useful insights into fusulinid response to environmental factors also emerged.

The results achieved in this investigation were due in part to the application of our new, computer-based, FUSDATA system to the discrimination of fusulinid populations and their distribution. We anticipate further enhancements in quantitative methods in the future.

Eric R. Michaelis

Eric R. Michaelis

GAS:lmw
Attachment

cc: Exploration Systems Manager, TDC
Regional Exploration Libraries

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ABSTRACT

A Virgilian reference standard has been established in the Midcontinent (Kansas) using fusulinids from 50 stratigraphic levels within a stacked sequence of 35 measured outcrop sections. Quantitative data generated and processed by a newly developed computer system have been employed to help discriminate fusulinid populations and their stratigraphic ranges.

INTRODUCTION

This project was undertaken (see Research Department Report M81-G-11) to strengthen our control in the Upper Pennsylvanian portion of the U. Composite Standard which was represented only by the Arrow Canyon succession. The latter is characterized by abundant fusulinid faunas of low diversity which provide a reference of restricted applicability. Not only does the Kansas Virgilian contain a much greater faunal diversity, but it may be a more complete section as well. Thus, the fortified standard will provide better control in the subsurface, and it will be of wider applicability because it will contain fossil elements from different provinces.

Although the bulk of this report is devoted to documentation of the fauna (mainly in the Appendices) for use by paleontologists, the exploration geologist will benefit from the enhanced control which now can be provided in the subsurface.

SUMMARY

The main objective of this study has been accomplished in the creation of an excellent fusulinid reference section for the Midcontinent Virgilian. This control can be expanded with little additional effort to include the Wolfcampian, since much of that information is already in hand, and we recommend that as the next logical step in our Composite Standard development.

This study also marks the first use of our new, computer-based FUSDATA system to generate and display quantitative data used in the discrimination of fusulinid populations and their distribution, both vertical and lateral. This technology is being disseminated, and two Regions have already taken steps to acquire at least part of appropriate hardware needed to use FUSDATA. Further development of this modular system is planned.

Since this study employed in-house material which was not collected with environmental studies in mind, our paleoecologic results are not definitive. However, we have been able to demonstrate empirically that the fusulinids exhibit considerable ecologic sensitivity within their relatively short stratigraphic ranges, and the effects of environmental controls can be seen in both their vertical and lateral distribution. A repetitive pattern of occurrence can be linked to functional morphology, but this pattern does not correlate well with the lithologic sequences seen in typical Pennsylvanian cyclothems, suggesting a different set of controls. A better understanding of those controlling factors would provide a powerful predictive capability, and additional research in that direction is strongly recommended.

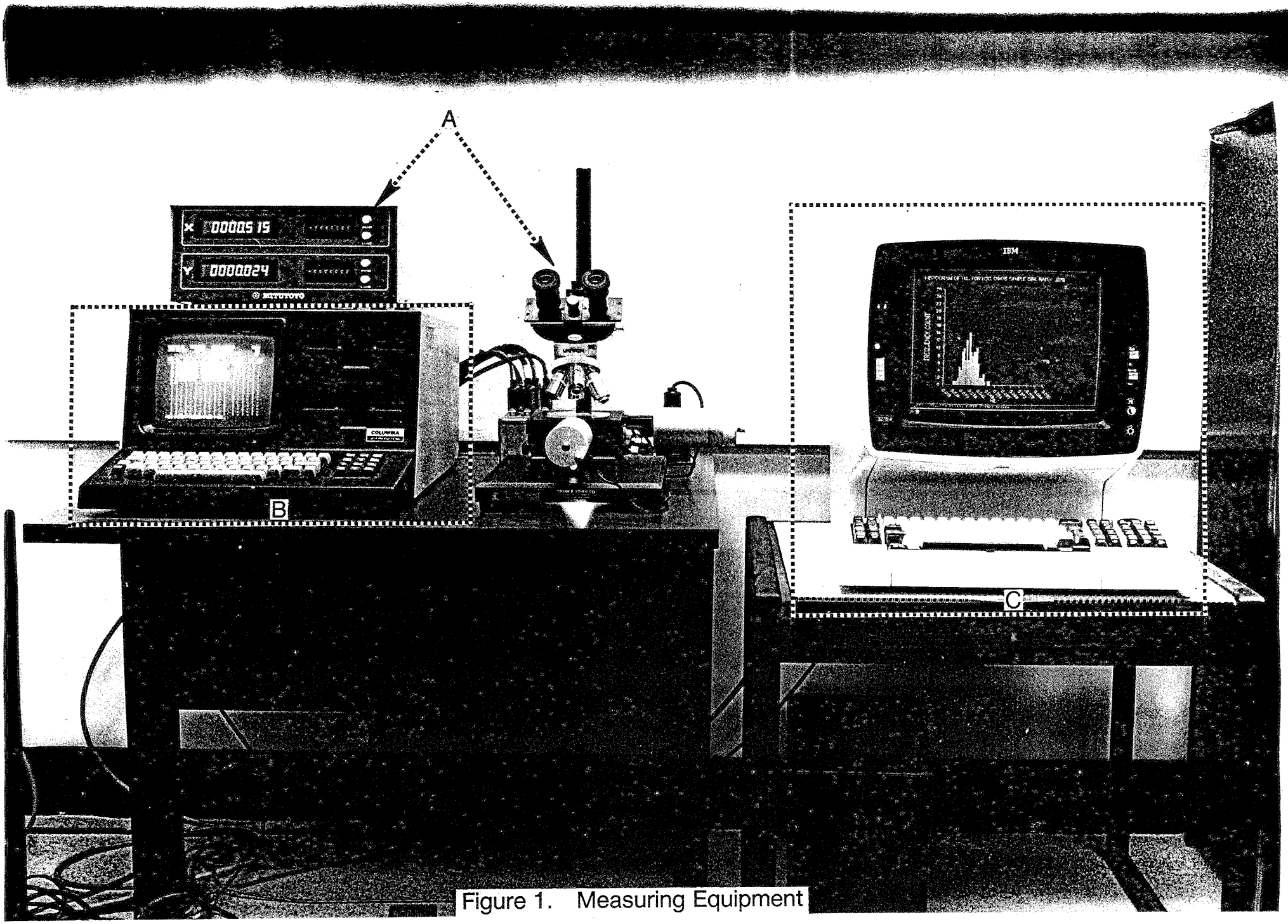


Figure 1. Measuring Equipment

CONCLUSIONS

1. The Midcontinent Virgilian contains a diversified fusulinid fauna with well-defined taxonomic ranges, and excellent biostratigraphic control has been established in the Virgilian utilizing 56 fusulinid taxa.

2. Several evolutionary lineages have been recognized, and subtle morphologic changes have been identified with the aid of our new FUSDATA computer system of quantitative data analysis.

3. Fusulinid occurrences are episodic, reflecting ecologic pressures within the cyclothems. They are not simply related to lithology per se, but are apparently influenced by factors such as depth, agitation, turbidity, and salinity which can vary within the sedimentary cycle.

4. There is evidence of a fusulinid succession within the depositional cycle, but the relationship to bathymetry is still unclear, since it is not known in our material whether minor fluctuations have interrupted the main transgressive-regressive depositional cycle.

5. Lateral distribution of fusulinid species also varies within a given cycle, apparently reflecting the same ecologic controls observed in stratigraphic distribution. These are potentially mappable parameters.

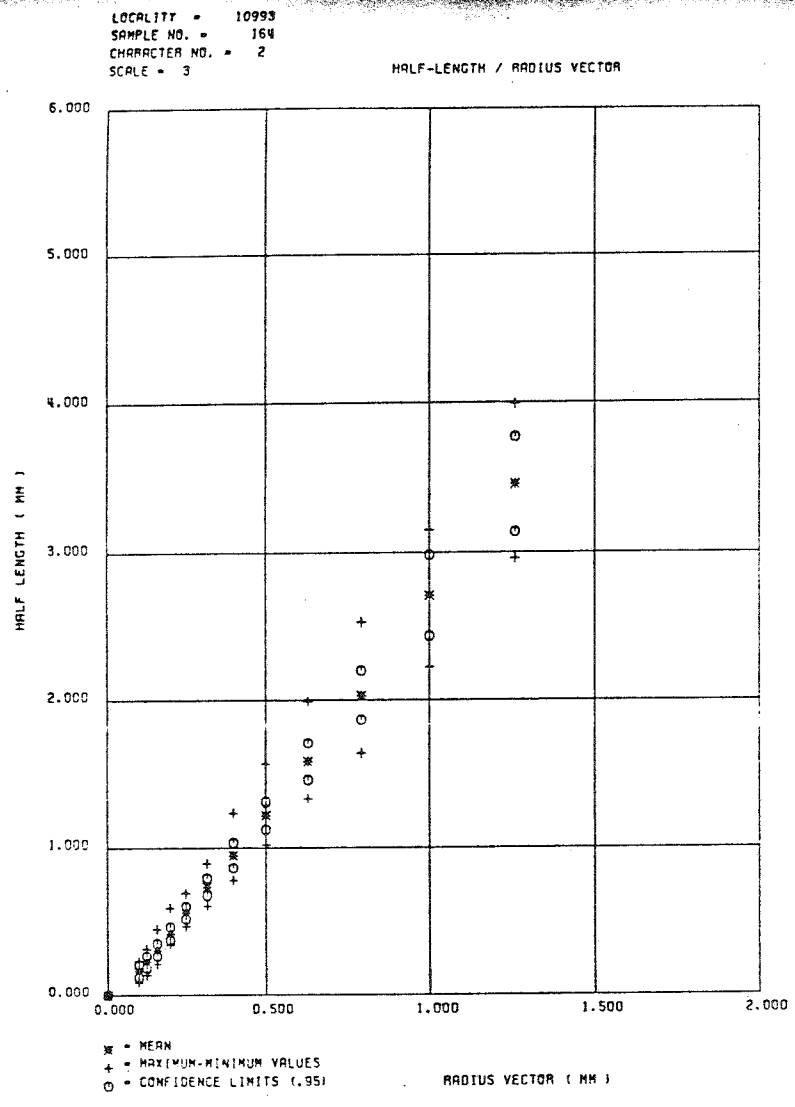
6. The Midcontinent data will greatly strengthen our U Composite Standard in its Late Pennsylvanian portion.

RECOMMENDATIONS

1. The stratigraphic data generated in the course of this study which are now in the Paleofile should be integrated with part of the Arrow Canyon section as soon as possible so that the improved control is available for operational use as needed.

2. We already have in house detailed fusulinid range data from a Wolfcampian surface section, which is actually a continuation of the Virgilian succession just completed, as well as from an Amoco core. These can be combined readily to extend our stratigraphic control through most of the Wolfcampian without mounting a major project. The potential benefits of doing so far outweigh the limited time expenditure required, and the resultant control will have operational application.

3. The samples used in the Virgil study had been collected previously for purely stratigraphic purposes and, as such, were limited in their



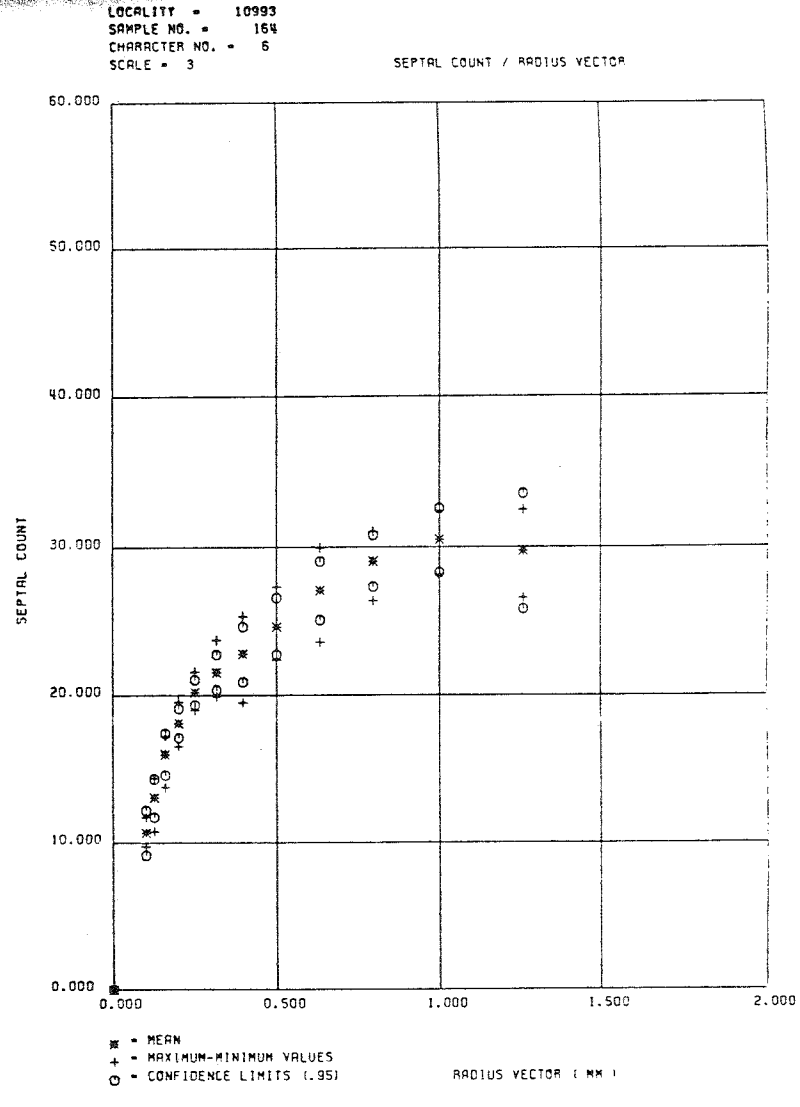


Figure 2. Ontogenetic Plots

applicability to detailed paleoecologic analysis. Inasmuch as we have established significant ecologic sensitivity on the part of the fusulinids, we should attempt to improve our understanding of the environmental controls over their distribution.

4. A newly implemented computer system (FUSDATA) for processing morphologic measurements was used in this study to evaluate quantitative data and to help define fusulinid species. FUSDATA has proved to be a valuable tool for discriminating fossil populations and evolutionary change. It is particularly flexible because of its modular nature. Development of this system should be continued, and, where possible, adapted to other fossil groups.

DISCUSSION

Methodology

Designed for compatibility with our Composite Standards, our approach involved the use of stacked or overlapping, measured successions to provide a continuous physical section representing the entire Virgilian time interval. A detailed discussion of the physical stratigraphy and sampling procedures may be found in Research Department Report M81-G-11.

This study differs from previous fusulinid projects in the substantial use of quantitative data, statistical treatment, and graphic displays to aid in the discrimination of species. The biometric approach is supplementary to purely visual examination, not a replacement for it, since many structural features are not quantified at present and will not be until image analysis is integrated into our system. Nevertheless, the FUSDATA/CUTLASS system provided calculations and graphic displays which rendered subtle differences more obvious and eliminated purported distinctions which, in fact, were more apparent than real. It is clear that biometrics will play a significant role in paleontology in the future.

Instrumentation

The FUSDATA/CUTLASS system will be described in detail in a separate report; in simplest terms it consists of a semi-automated measuring system with digital display and direct input to a microprocessor, plus a modular, interactive software system in VM which is used for statistical analysis and the generation of graphic displays, such as ontogenetic growth curves, frequency distribution diagrams, etc. (Fig. 1).

The measuring equipment (Fig. 1-a) can be used in almost any thin section application, but it is particularly convenient for study of planispirally-coiled foraminifers such as the fusulinids. Similar units are being acquired by two Regions at the present time.

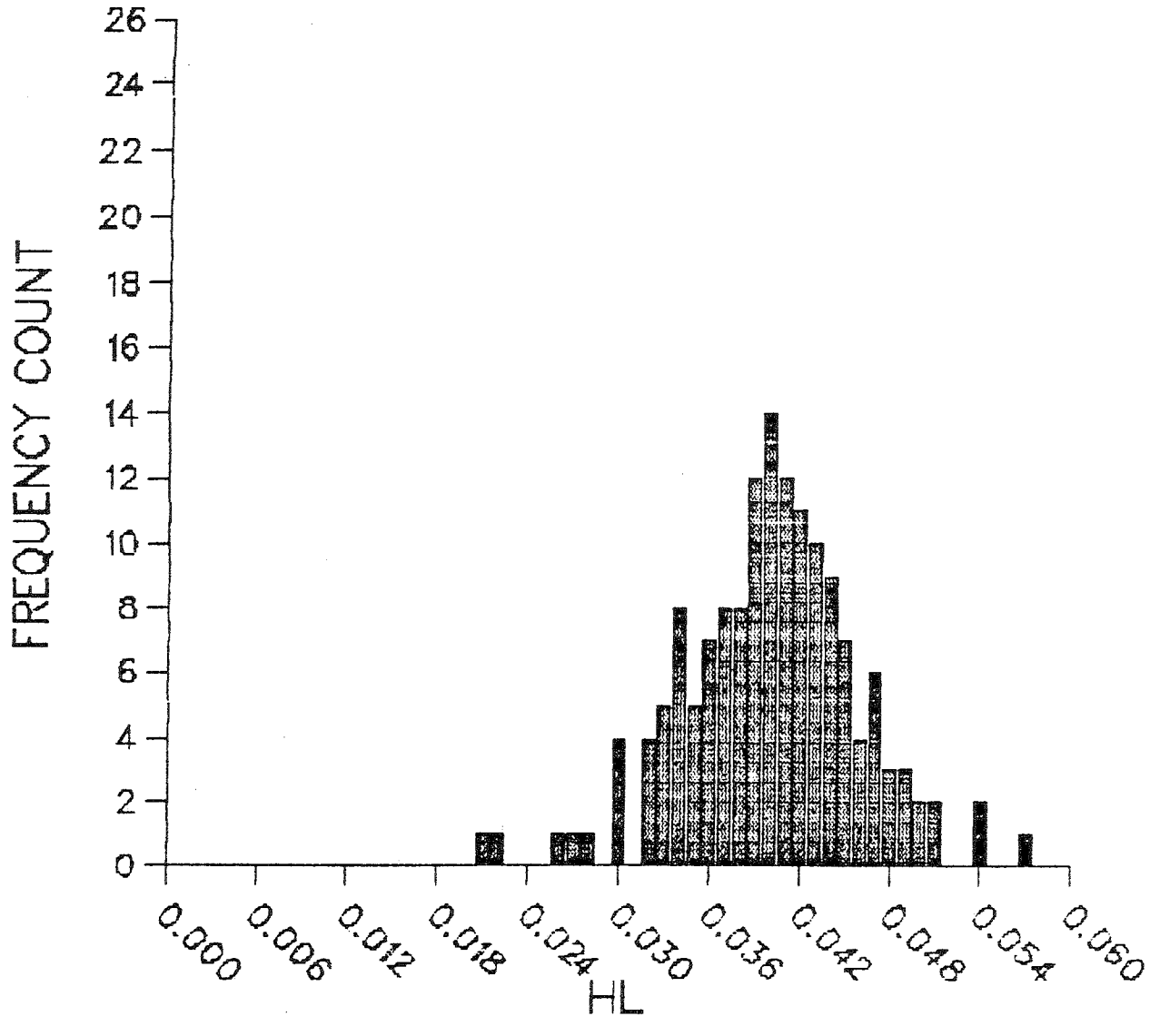


Figure 3. Frequency Distribution Of Half Length

Measured data are formatted, edited and stored on floppy disk by the microprocessor (Fig. 1-b) which is menu driven and self-prompting. The software is, of course, specifically designed for fusulinid measurements, but the method can be applied to a variety of data acquisition situations--vitrinite reflectance, for example. The potential uses are limited only by need and imagination.

Raw data stored on floppy disk can be transferred to VM at will and manipulated interactively (Fig. 1-c) by accessing a series of modules to generate data lists, statistics, and graphic displays. Numerous options are available, and more will be added to the system in the future. For example, ontogenetic plots may be made of various parameters in a population (Fig. 2). Histograms illustrating the frequency distribution of measured or calculated data are easily produced, both on the CRT and in hard copy (Fig. 3). These and other options are currently operational and, there doubtless will be additions, improvements, and refinements as the system evolves. The emphasis is on usefulness and ease of operation.

Biostratigraphy

The fusulinid zonation established in our Kansas reference succession consists of 89 fusulinid collections from 50 named stratigraphic units in a stacked sequence of 35 measured sections. In all some 56 taxonomic entities were recongized, of which the 45 most significant ranges are plotted on the composite stratigraphic chart (Fig. 4). Computer plots of all occurrences arranged by Tops and by Bases are in Appendix I (Figs. 5 & 6).

The fusulinids characteristic of each of the stratigraphic horizons are illustrated on Plates 1-50 in Appendix II. An effort has been made to show the spectrum of morphologic variability wherever possible, and the facing pages have plate descriptions as well as stratigraphic keys, so the plates should be useful for preliminary identifications. More detailed information will be available in the individual taxon folders, including various graphic displays of biometric data.

It is readily apparent from Figure 4 that the Virgil Stage and its 3 Groups, Douglas, Shawnee and Wabaunsee are clearly defined by the fusulinid forams. Some taxa are, in fact, confined to specific formations or even members. All have relatively restricted ranges, which is due in part to ecologic factors inherent in cyclical deposition, but the net result of compositing these ranges will be an excellent reference standard. Even without the Composite Standard it is possible to make some significant observations.

The Douglas Group, for example, is devoid of inflated, highly fluted fusulinids, such as Triticites beedei, T. plummeri, etc. The units below the Toronto are characterized by T. secalicus, T. oryziformis and a form of

Kansanella which is distinct from succeeding species of that genus. The type level of T. oryziformis is, in fact, the Westphalia Limestone.

A much greater diversity of forms is evident in the Shawnee Group, including the afore-mentioned, inflated forms such as T. beedei, several new species of Kansanella and Triticites, and, in its upper part, the first occurrence of the genus Dunbarinella. Nevertheless, Triticites secalicus, T. oryziformis and their descendents are very prominent in the Shawnee, recurring in a number of beds, but they did not survive into Wabaunsee time. The lower part of the Shawnee contains a species of Waeringella, which is closely related to W. spiveyi found in the lower Cisco in Texas. The genus appears to be very restricted stratigraphically in both the northern and southern Midcontinent, but a very similar form, generally referred to Pseudofusulinella, has a longer range in the Cordilleran region.

Evolutionary trends are also in evidence. The occurrences of the genus Kansanella, which arose in the mid-Missourian, come to an end in the lower part of the Deer Creek Formation and is replaced in the middle of the Deer Creek by Dunbarinella, which appears to be an offshoot of the Kansanella stock. Within the latter genus are changes as well--subtle, but demonstrable. In particular, there is a trend toward looser coiling and reduction of septal count, which is discernable in the more advanced forms only in the outer volution. Such changes, which are invaluable for phylogenetic interpretations, require quantitative methods that are now available.

The faunal aspect of the Wabaunsee Group is quite different. Inflated forms such as T. beedei, T. plummeri, and T. happyhollowensis are prominent in the lower portion with species of Dunbarinella and several rather undistinguished species of Triticites whose significance is not understood. The upper part of the Wabaunsee, on the other hand, has different faunal elements which are truly harbingers of the overlying Wolfcampian. There are several primitive species of Leptotriticites, a genus characteristic of the Early Wolfcampian. Similarly, Schubertella ex. gr. S. kingi become very abundant in the Nebraska City and Brownsville limestones. Schubertella kingi is a long-recognized "marker" of the Wolfcampian, and the Virgilian forerunners are very closely related indeed. It has been proposed that the Pennsylvanian--Permian boundary be lowered to accommodate these forms, but we disagree because it is a transitional sequence and more than one position for the boundary could be selected with equal justification. Here is a case where graphic correlation provides the only reasonable solution.

All in all, this is an excellent reference section for strengthening the Upper Pennsylvanian part of our Composite Standard. Control is continuous from pre-Virgilian into the Wolfcampian, fusulinid occurrences are frequent, ranges are restricted, and evolutionary changes can be discerned

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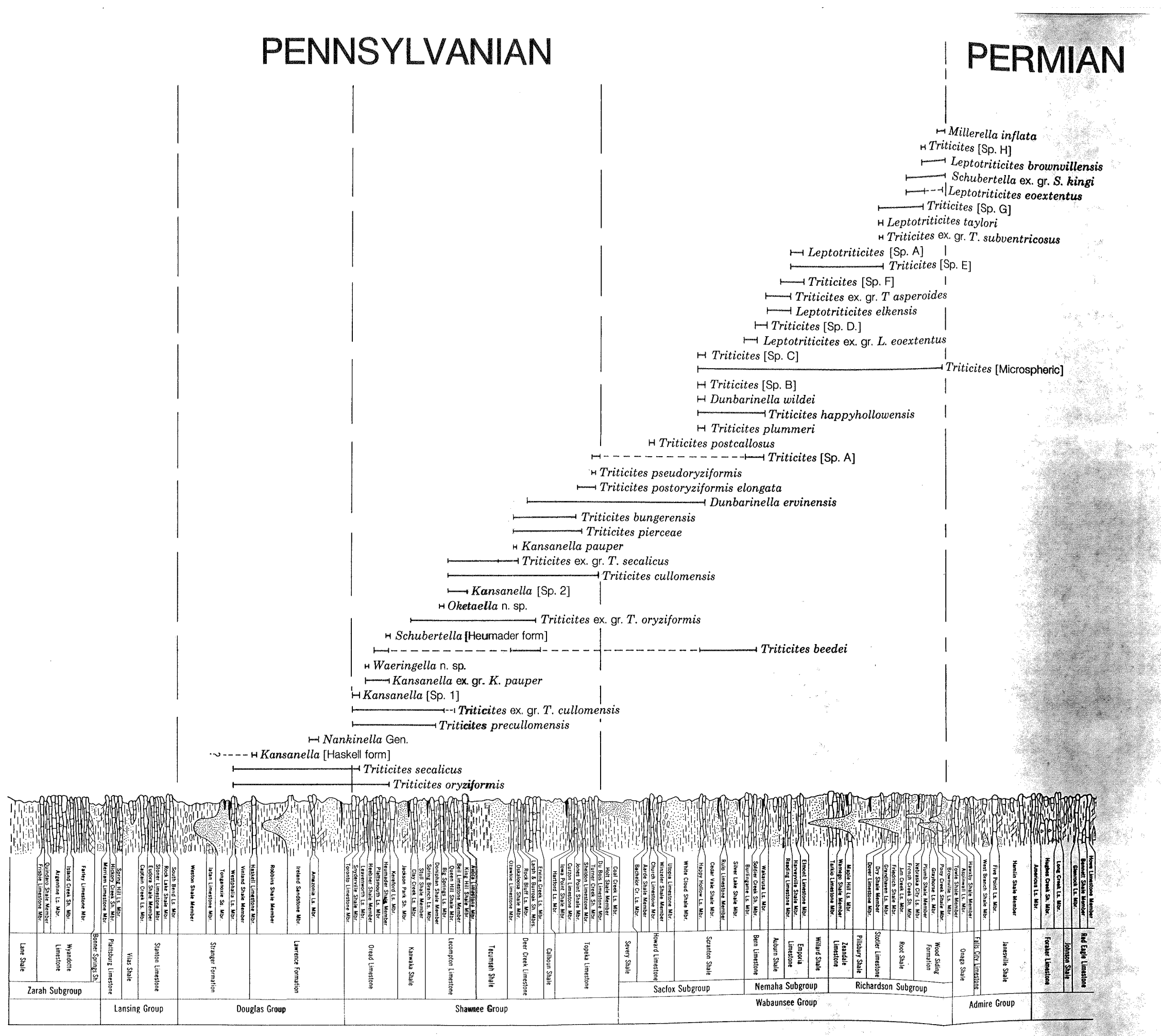
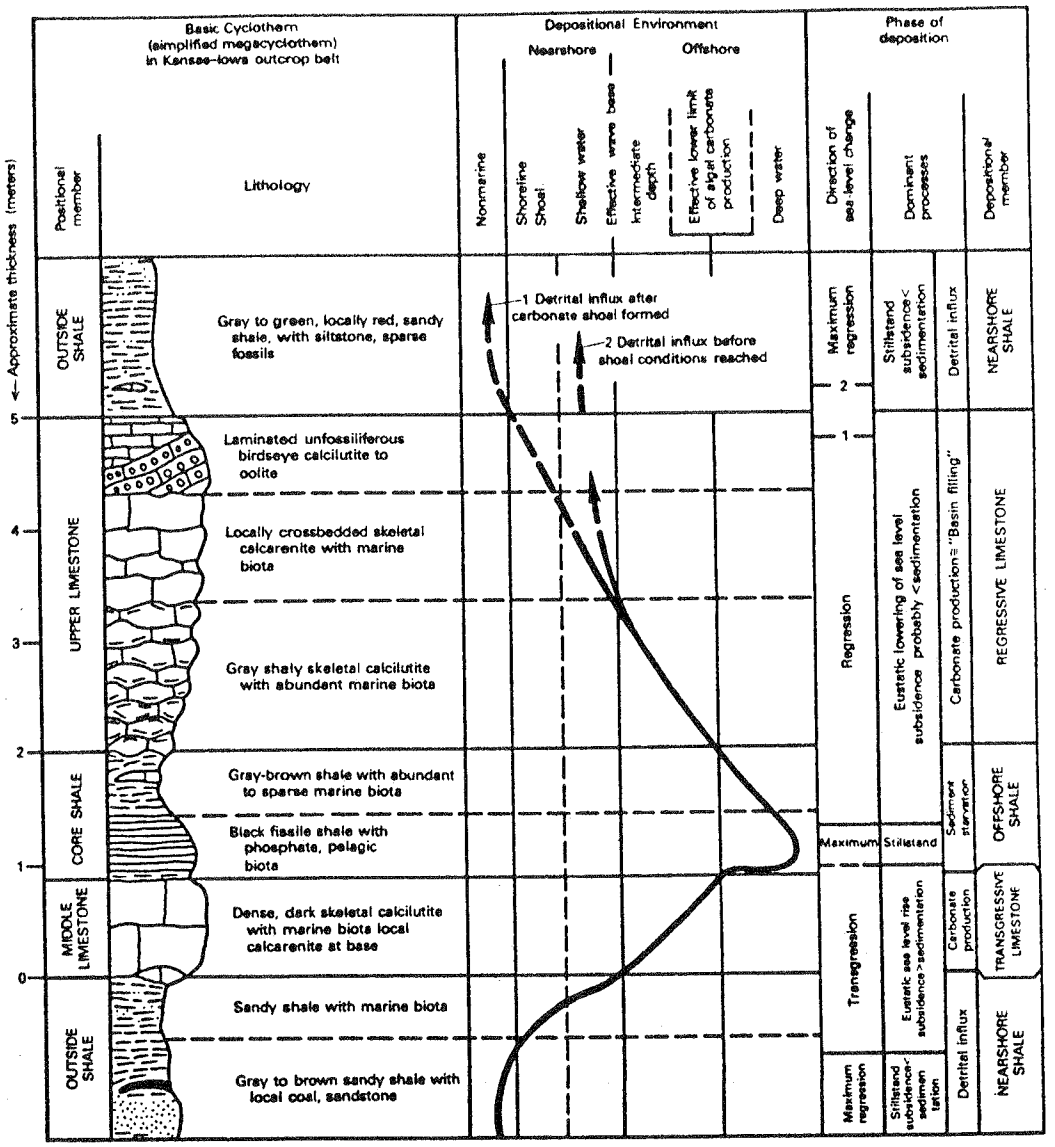


Figure 4. Stratigraphic Chart



(After Ebanks et al, 1979)

Figure 7. Representative Kansas Cyclothem

within fossil lineages. These data will be integrated with those from Arrow Canyon to provide a diversified standard of wide applicability.

Paleoecology

The question of Virgilian fusulinid paleoecology engenders both optimism and frustration--the former because we can readily demonstrate that environmental controls exist and the latter because we do not understand them as well as we would like to. Much of the difficulty lies in the fact that our material, collected many years ago, was not sampled with the study of ecology in mind. Further, many samples were processed to destruction in the past, and what has served admirably for stratigraphic study is found wanting for the broader objectives of today. Nevertheless, a number of facts have become apparent, and some relationships are hinted at in a tantalizing manner. They certainly will provide direction for more definitive efforts in the future.

First of all there are gross environmental constraints which are quite familiar. In an intracratonic setting in which sea level fluctuates and depositional environments shift in cyclical fashion, there are obvious parts of the regimen which are totally unsuited to the fusulinids--the coals and nonmarine sediments, for example. Even within the marine portions of the cyclothem there are differences in lithology, bathymetry, turbidity, etc. which affect fusulinid distribution. In the so-called "Representative Kansas Cyclothem" (Fig. 7), fusulinids are generally attributed to the Middle Limestone or the offshore limestone at (or near, depending upon one's interpretation of the black, fissile shales) maximum transgression. The regressive or Upper Limestone is usually characterized as algal and perhaps oolitic at the top. Actually, fusulinids can be found in both transgressive and regressive shales and limestones, although the open marine conditions are most attractive. The salient questions are first, whether the same fusulinids inhabit all the marine portions of a given cycle, and second, whether they are laterally consistent in their distribution. The answer to both appears to be negative.

The most conclusive evidence comes from study of lateral distribution, and there are several examples of faunal variability within the same stratigraphic unit. On a fairly large scale, it can be seen that the Plattsmouth Limestone in southern Kansas contains large, inflated Triticites of beedei - plummeri - cullomensis type, whereas in Nebraska the same unit is the type level for T. secalicus, a very different species. This suggests either a miscorrelation or a change in biofacies. Fortunately, we have similar, well-documented data from other horizons, including an earlier detailed investigation in which the Toronto Limestone was traced through Kansas and found to exhibit clear cut distribution patterns for species of Triticites and Kansanella (Fig. 8). Unfortunately, there seems at present to be no simple relationship to lithology or to some quantifiable parameter. Nevertheless, lateral changes are a fact and will have to be dealt with in the future.

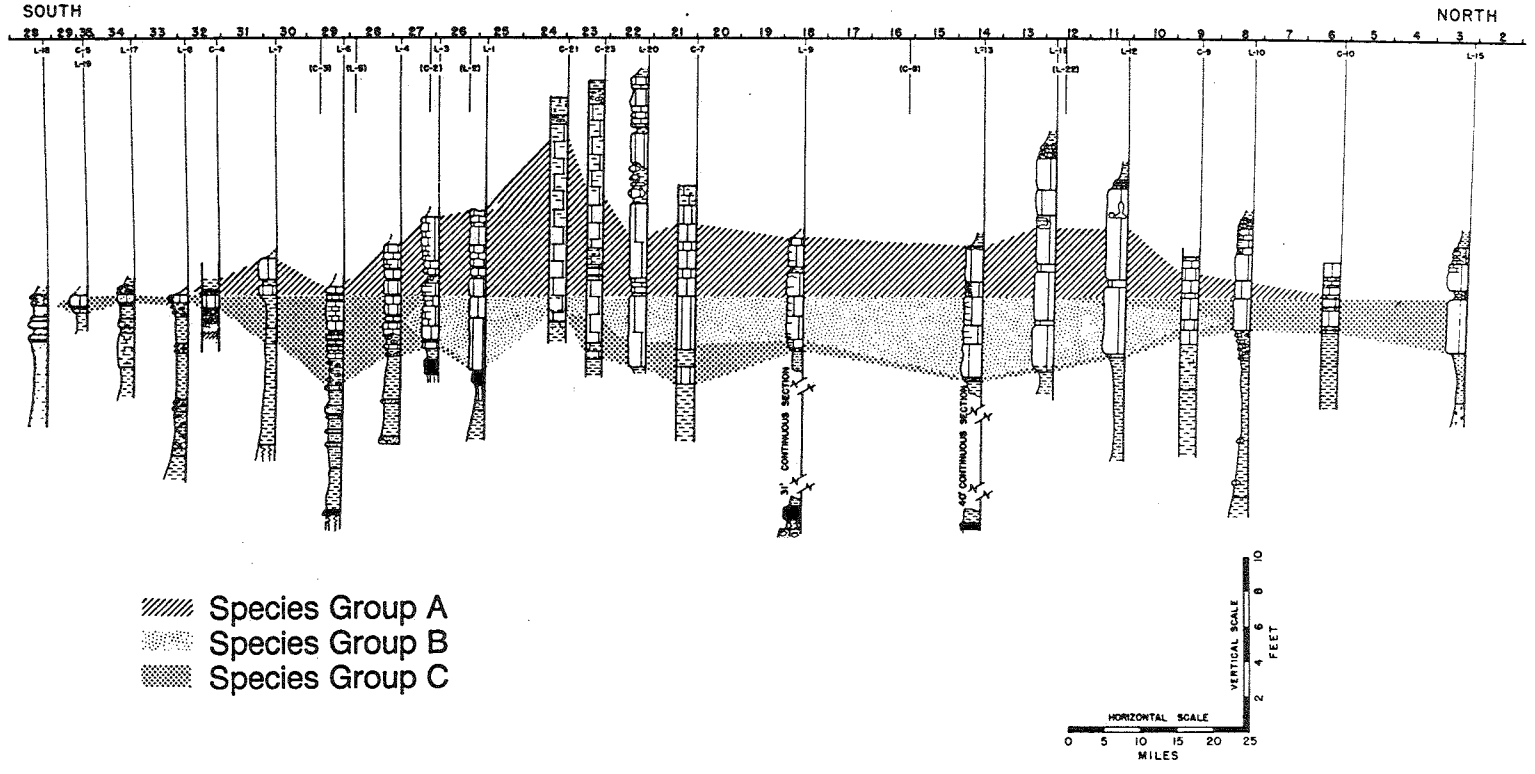


Figure 8. Toronto Fusulinid Distribution

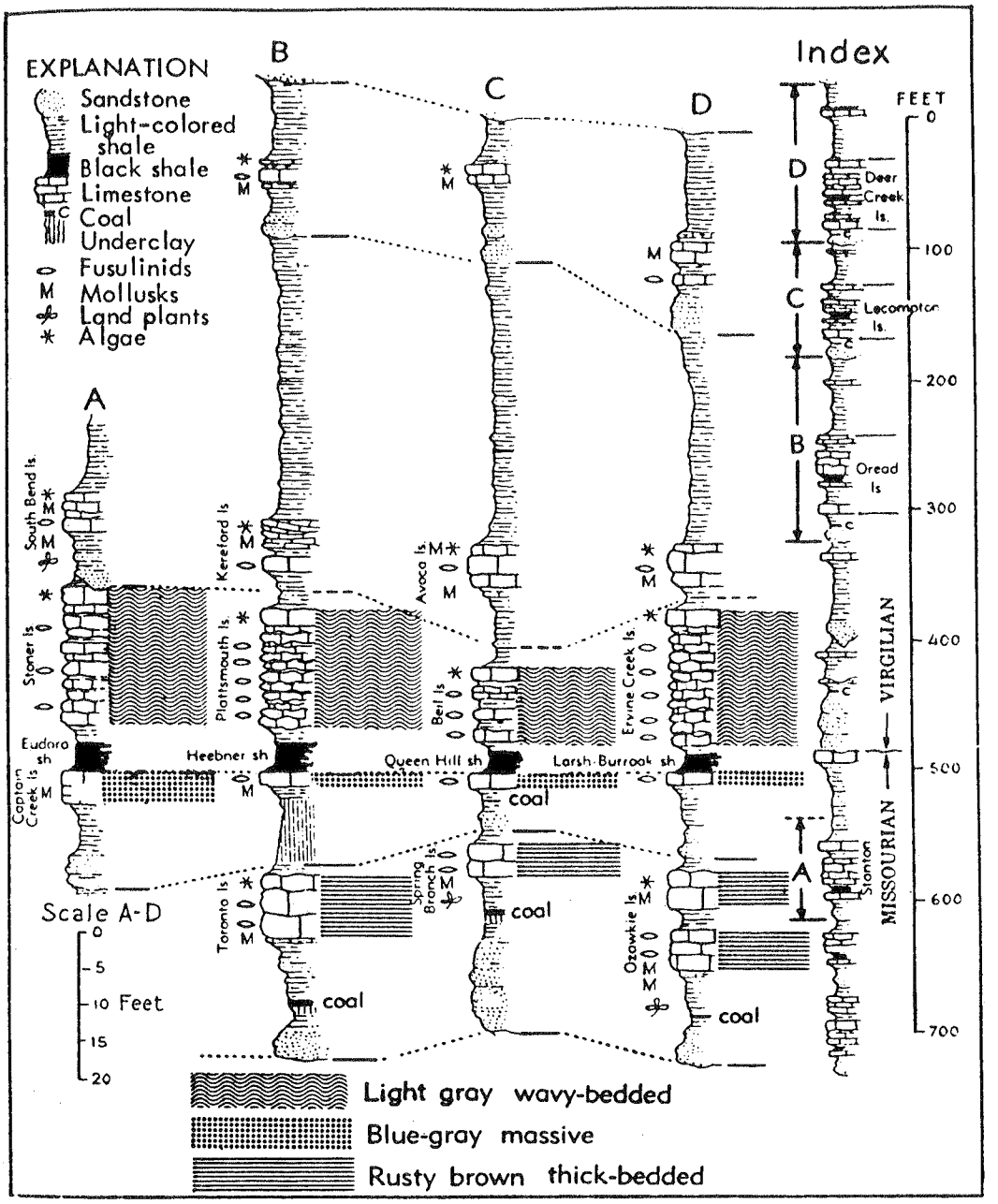
In the vertical or stratigraphic sense we also have evidence of fusulinid succession within the sedimentary cycle, but its significance is not clear because we do not know if the physical sequence in our examples represents a smooth continuum or whether it embraces minor fluctuations. Thus, it is not certain if the Kansanella which overlie the inflated Triticites in a Middle Limestone such as the Toronto represent deeper water or a slight regression before maximum transgression is achieved. As indicated above, corroborative information is lacking in our material.

Several of our distinctive morphotypes are recurrent in the Virgil, just as are the physical units comprising the cyclothems. Bearing in mind the concept of functional morphology, we plotted the stratigraphic distribution of these morphotypes regardless of taxonomic identification. The three morphologic groups recognized are first; the fusiform to cyclindrical, lightly fluted species of Triticites including T. secalicus, T. oryziformis, T. postoryziformis, and T. pseudoryziformis; second, the inflated, robust, moderately fluted species of Triticites including T. beedei, T. plummeri, T. bungerensis, T. postcallosus, T. happyhollowensis, and T. subventricosus; and, finally, the thin-walled, highly fluted forms with axial filling referable to various species of Kansanella, Dunbarinella, Leptotriticites, and possibly Triticites sp. D. These are, of course, different taxa, but they exhibit basic similarities in gross morphology and presumably they may have lived in similar environments.

Comparison of the distribution patterns reveals a strong, although not perfect, tendency toward mutual exclusion, suggesting a significant ecological bias. Also, since we did not differentiate samples within members of formations, the exceptions may prove to be more apparent than real. In any case, ecologic patterns appear to be emerging, however poorly they may be understood.

There has been much discussion of megocyclothems and the apparent correspondence of individual cycles in successive units. Placing the Oread, Lecompton and Deer Creek megacyclothems side by side (Fig. 9) illustrates the comparable nature of the various units, such as the correspondence of the Plattsmouth, Beil and Ervine Creek limestones. Since our fusulinid morphotypes also exhibit well-defined recurrent patterns, we attempted to correlate their distribution with that of the corresponding lithic units. In short, if the Plattsmouth, Beil and Ervine Creek are ecologically comparable units, they should contain similar morphotypes, if not the same species. Unfortunately, no definitive correlation is evident, suggesting either that the units are not truly comparable in our samples, or that the fusulinids do not respond to the same controls.

The fact that the fusulinids are so widespread and evolve so rapidly tends to obscure their ecologic sensitivity, which can become a significant predictive tool once understood. The factors controlling fusulinid



(After Moore, 1964)

Figure 9. Comparison of Megacyclothems

distribution are evidently complex, and sophisticated techniques may be required to unravel them. That remains the challenge to permit maximum utilization of the fusulinids.

G. A. Sanderson

G. J. Verville

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APPENDIX

PLATES

PLATE 1

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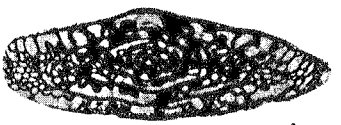

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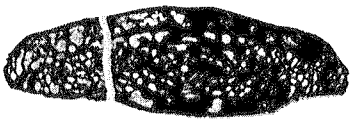

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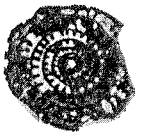

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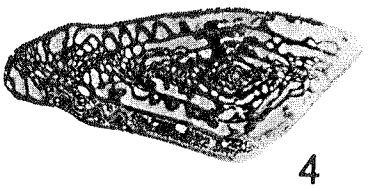

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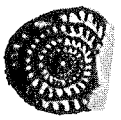

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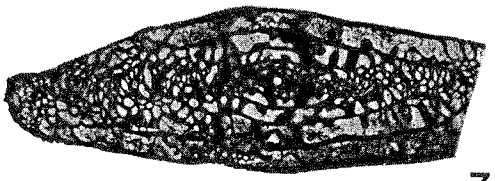

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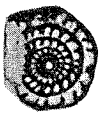

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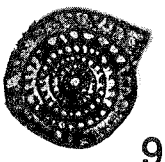

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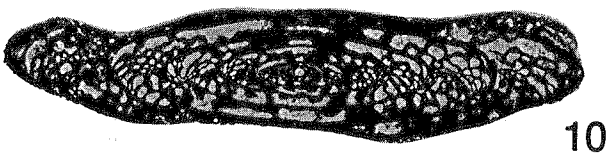

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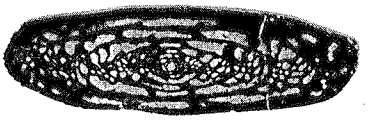

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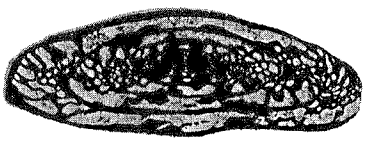

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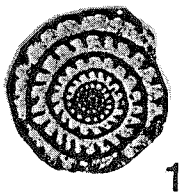

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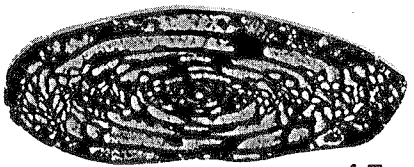

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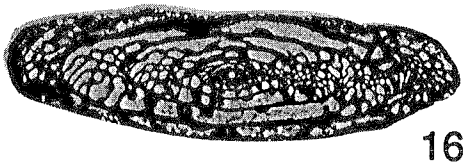

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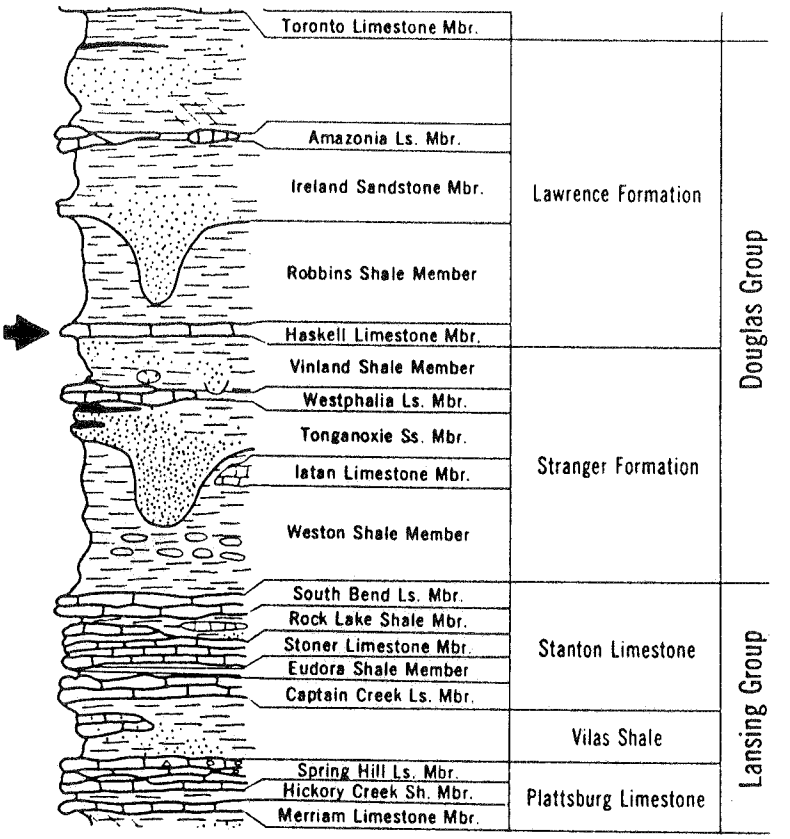
PLATE 2

HASKELL



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-11 26482 Kansanella n.sp. [Haskell form]

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PLATE 2 HASKELL

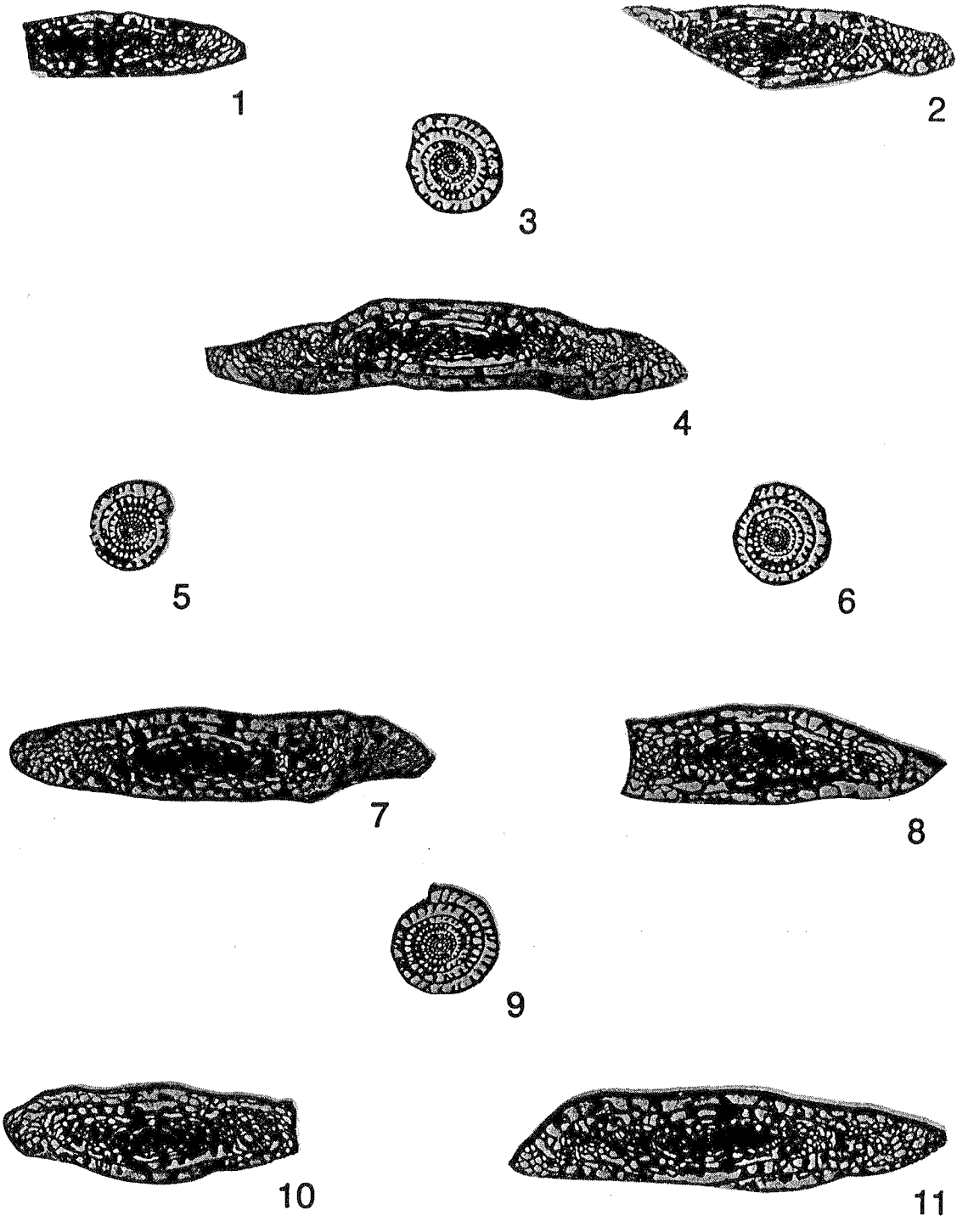

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PLATE 3 AMAZONIA

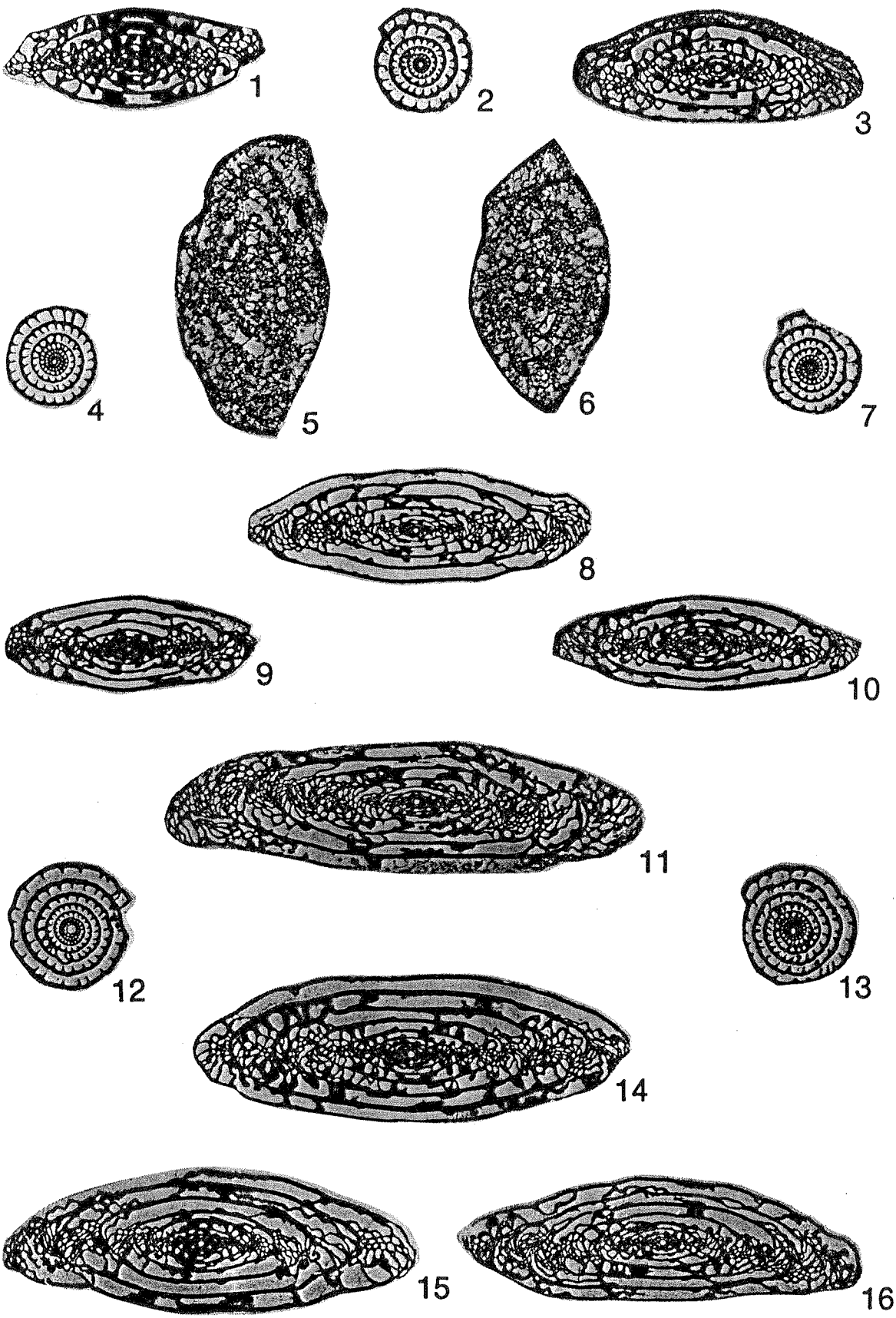

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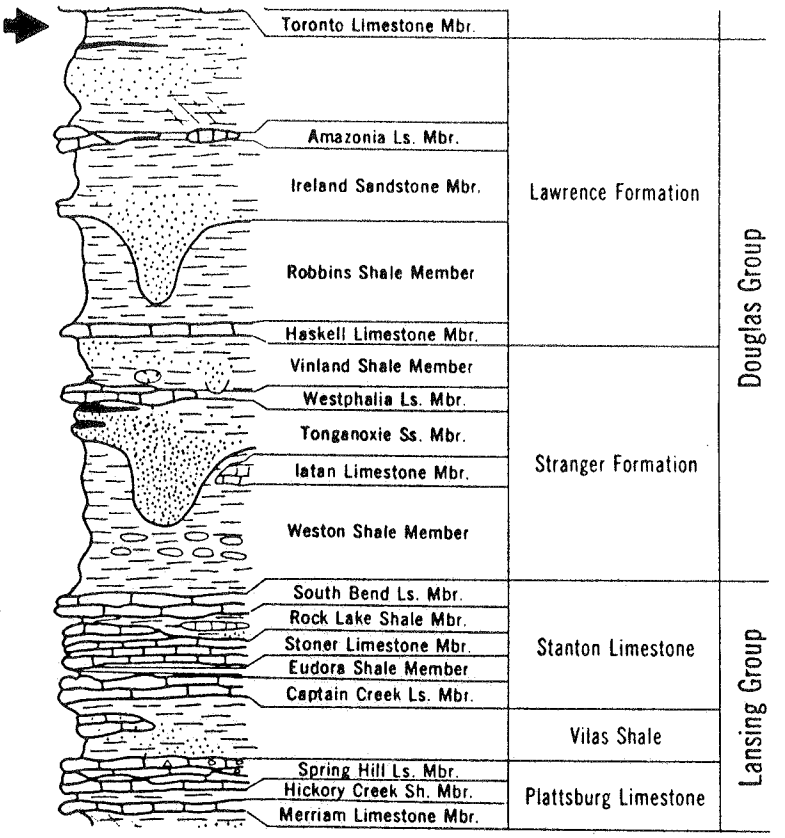
PLATE 4 SHALE BELOW TORONTO



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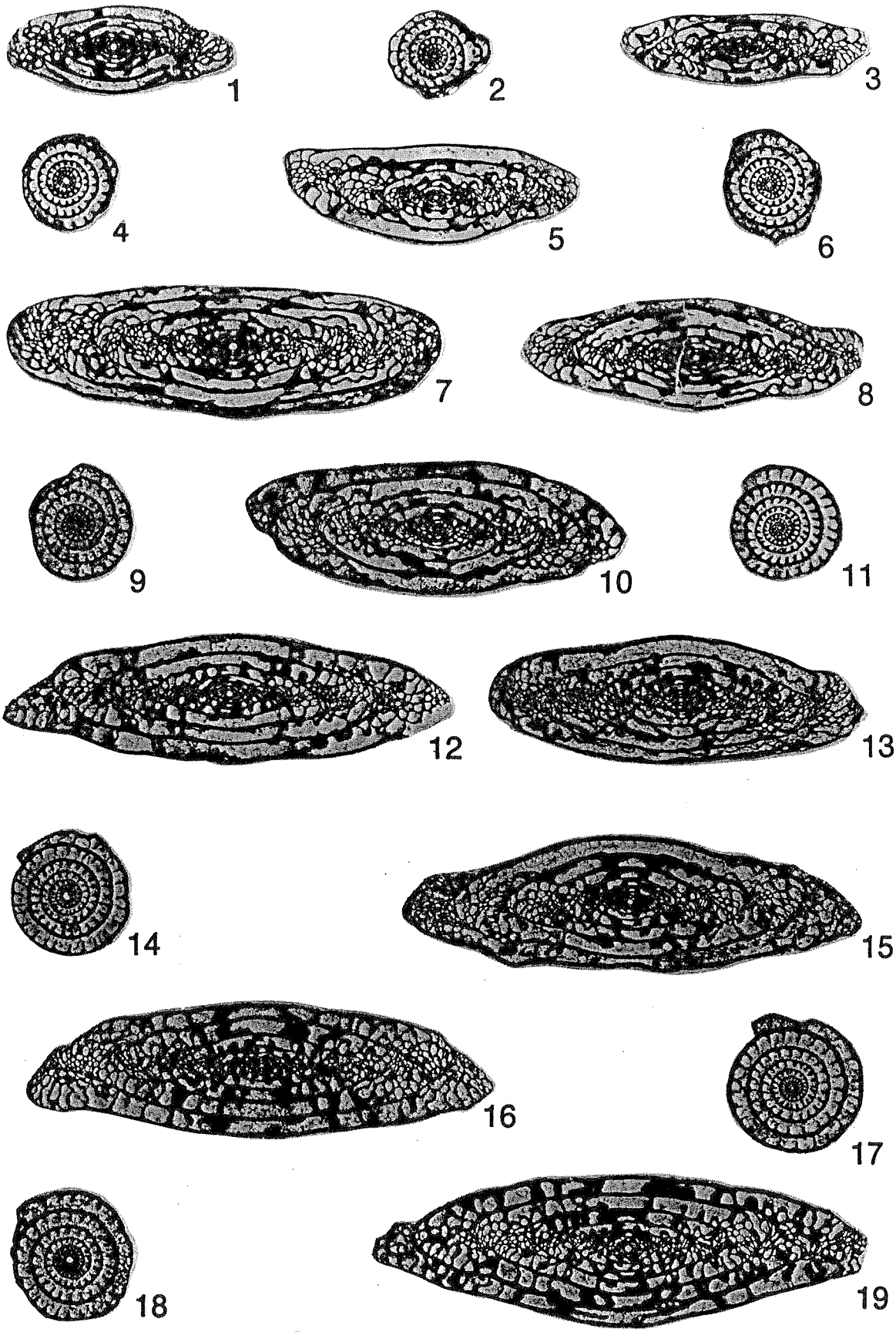
Figs. 1-11 26496 Triticites oryziformis Newell, 1934

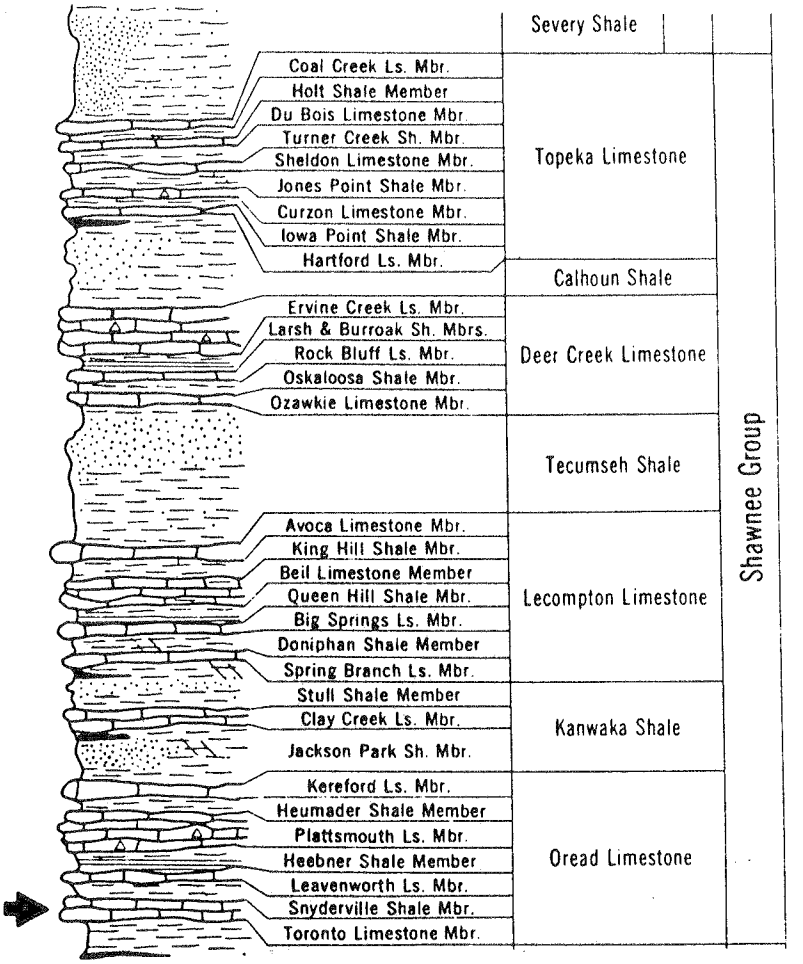
Figs. 12-19 26498 Triticites secalicus (Say, 1823) sensu Douglass, 19

PLATE 4 SHALE BELOW TORONTO



10993–5

PLATE 5 LOWER TORONTO

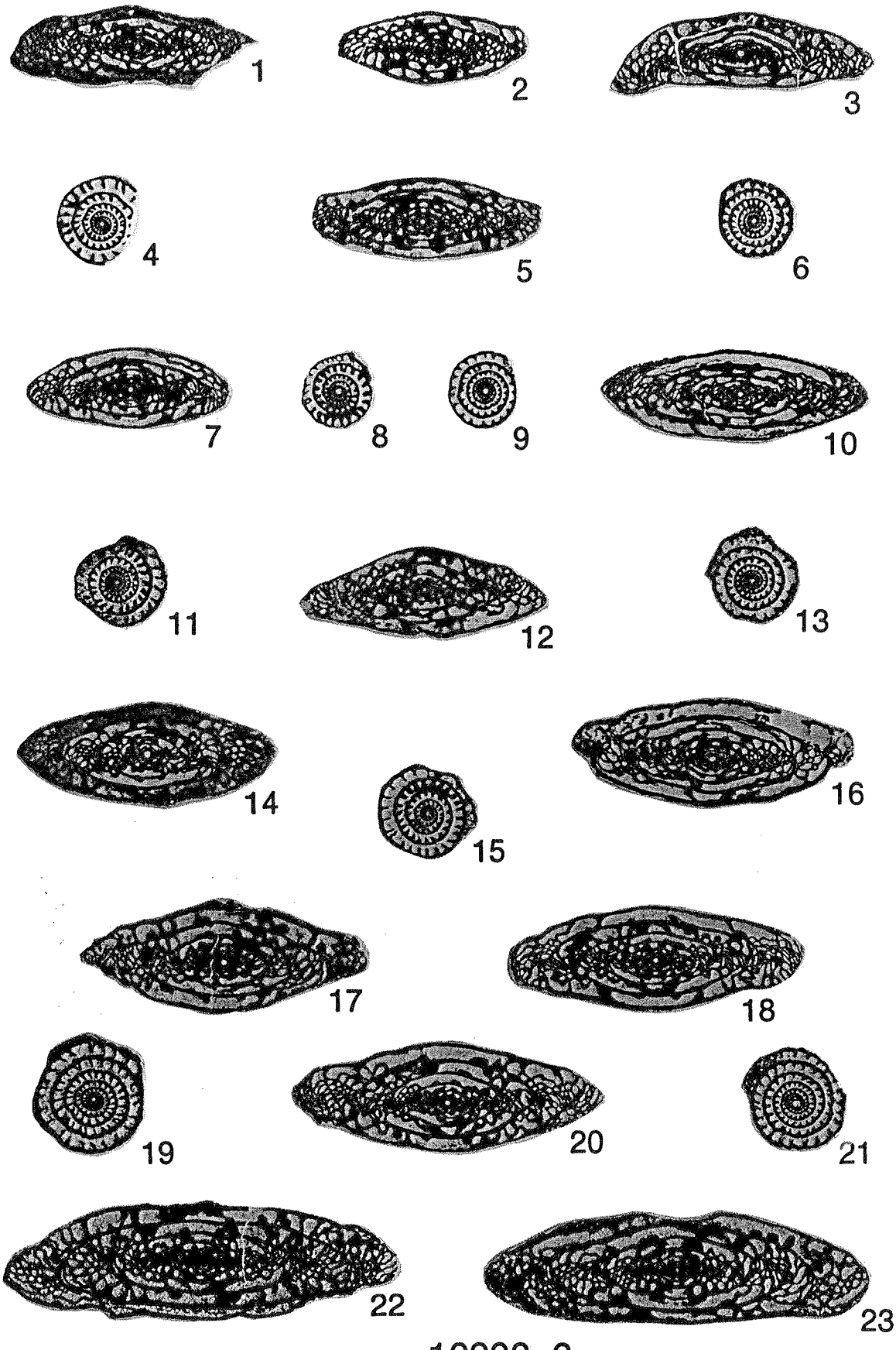


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-21 26502 Triticites precullomensis n.sp.

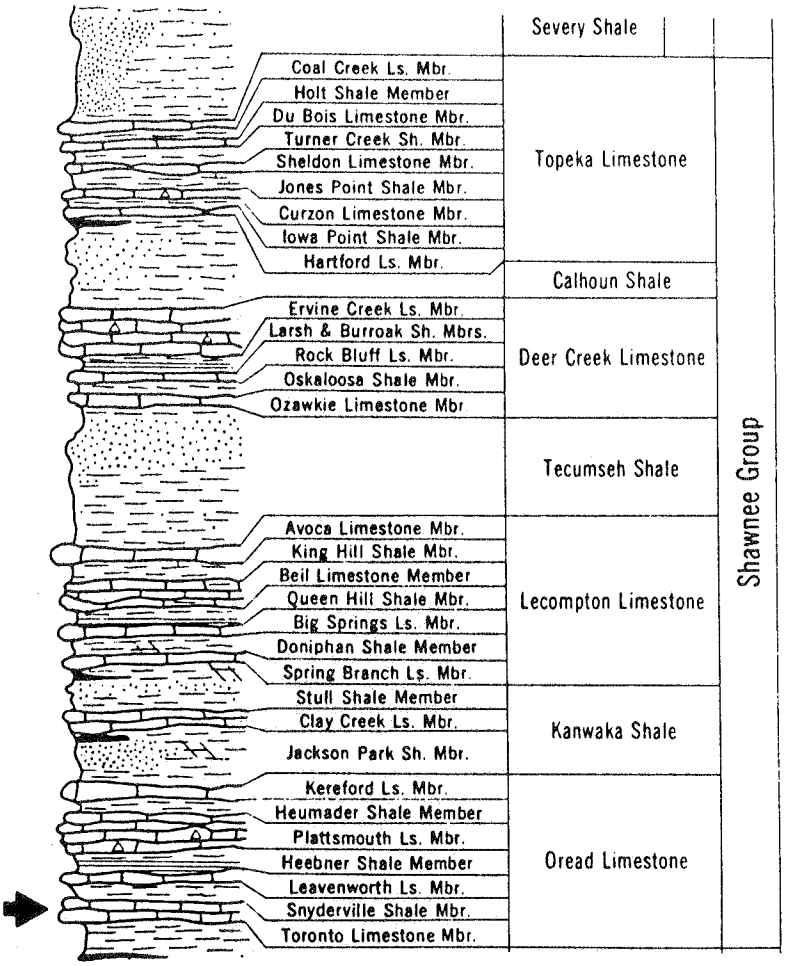
Figs. 22,23 26498 Triticites secalicus (Say, 1823) sensu Douglass, 1966

PLATE 5 LOWER TORONTO



10993–6

PLATE 6 MIDDLE TORONTO



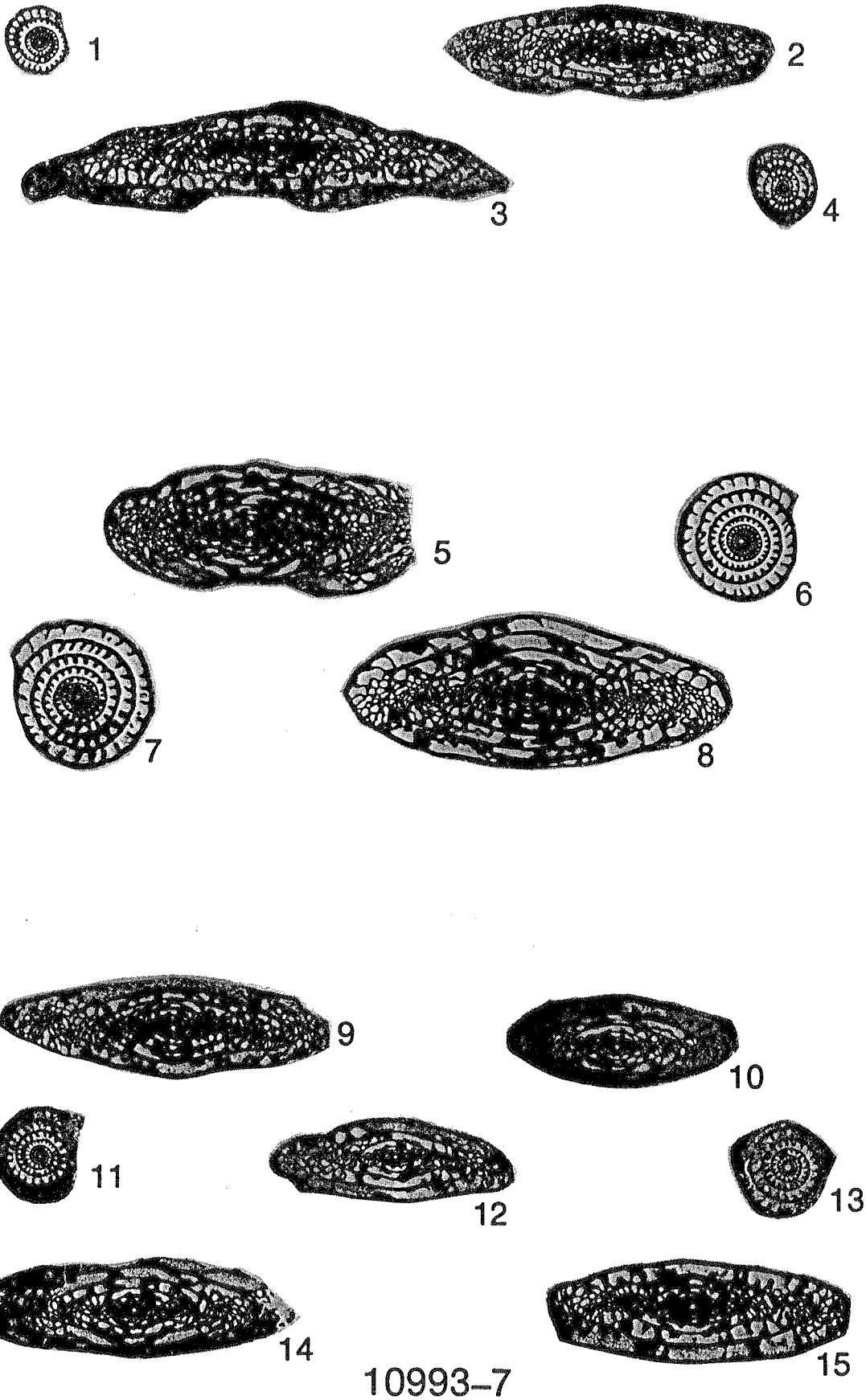
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-4 26615 Kansanella n.sp. [SP. 1]

Figs. 5-8 26501 Triticites ex. gr. T. cullomensis Dunbar & Condra, 19

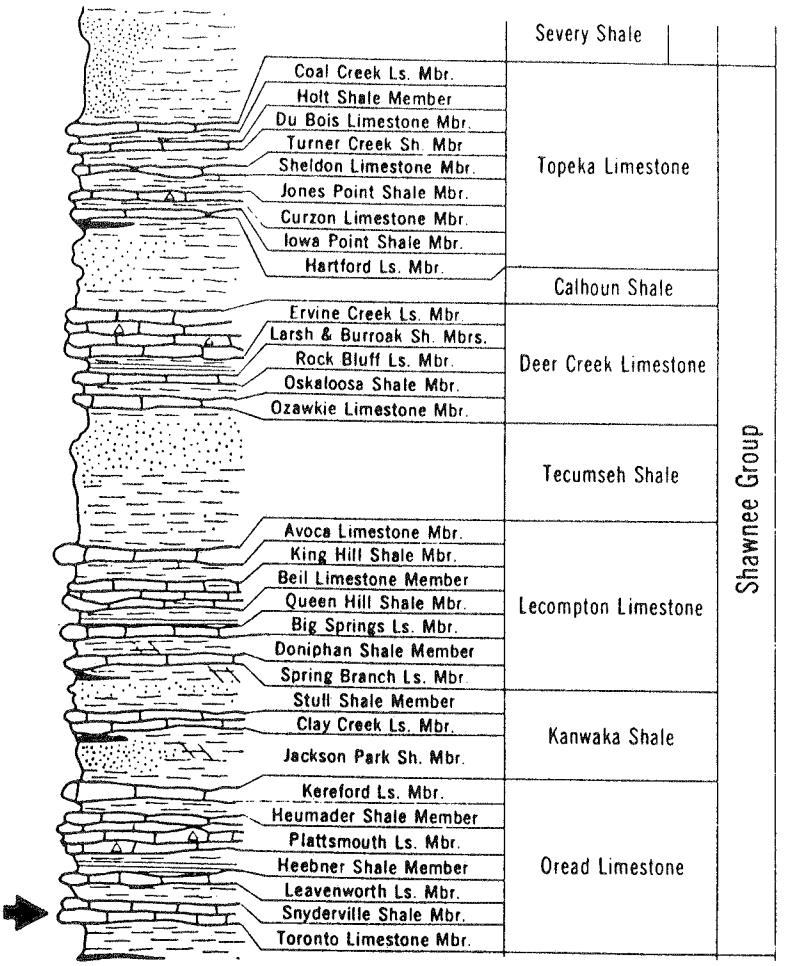
Figs. 9-15 26502 Triticites precullomensis n.sp.

PLATE 6 MIDDLE TORONTO



10993–7

PLATE 7 UPPER TORONTO



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-10 26615 Kansanella n.sp. [SP. 1]

PLATE 7 UPPER TORONTO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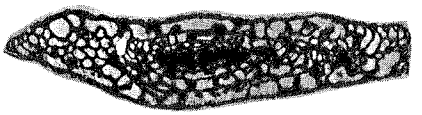
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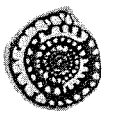
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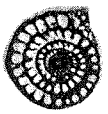
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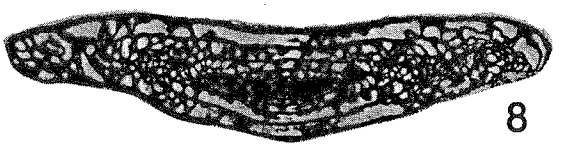
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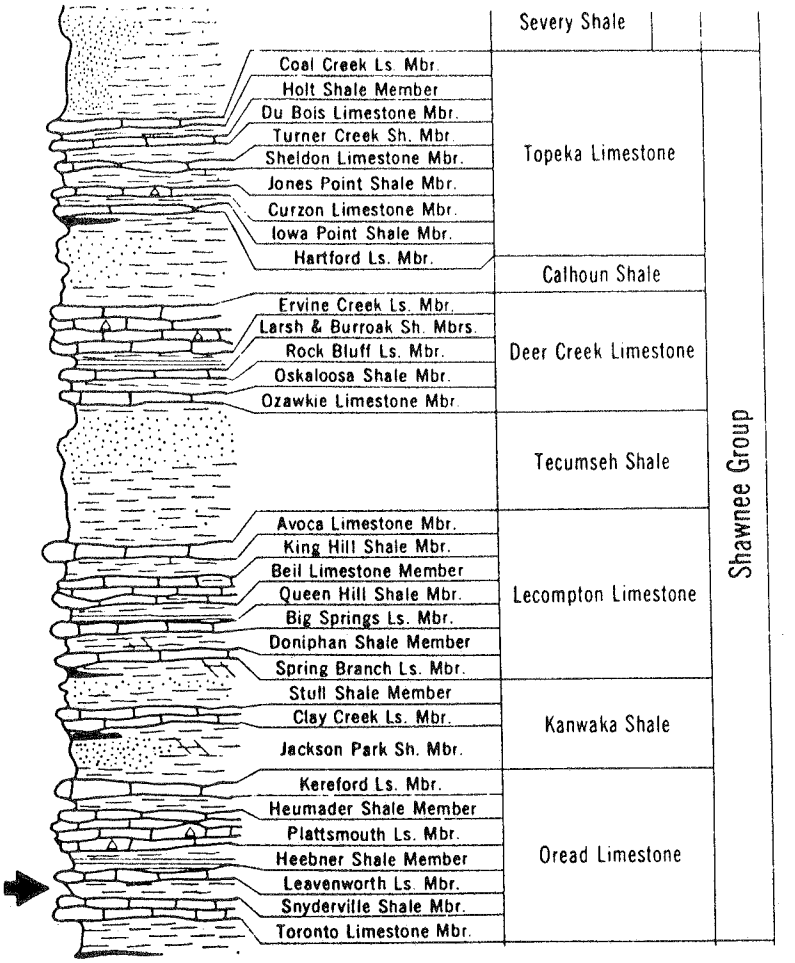
10993–8

PLATE 8 UPPER SNYDERVILLE

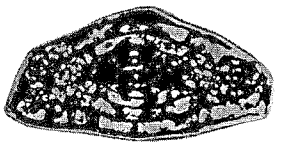


All Magnifications x10 Unless Otherwise Indicated

Fig. 1 26502 Triticites precullomensis n.sp.

PLATE 8

UPPER SNYDERVILLE



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10993–10

PLATE 9

LEAVENWORTH

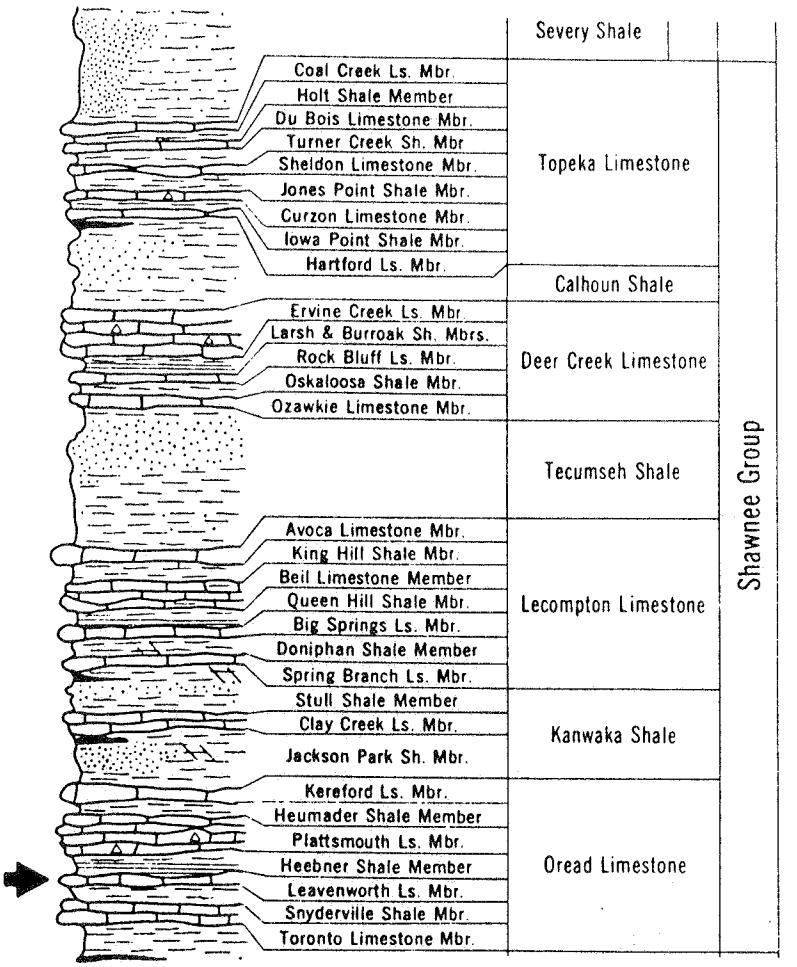


PLATE 9 All Magnifications x10 Unless Otherwise Indicated

Figs. 1-7 26481 Kansanella ex. gr. K. pauper (Dunbar & Henbest, 1942)

Fig. 8 26489 Millerella Gen. [x100]

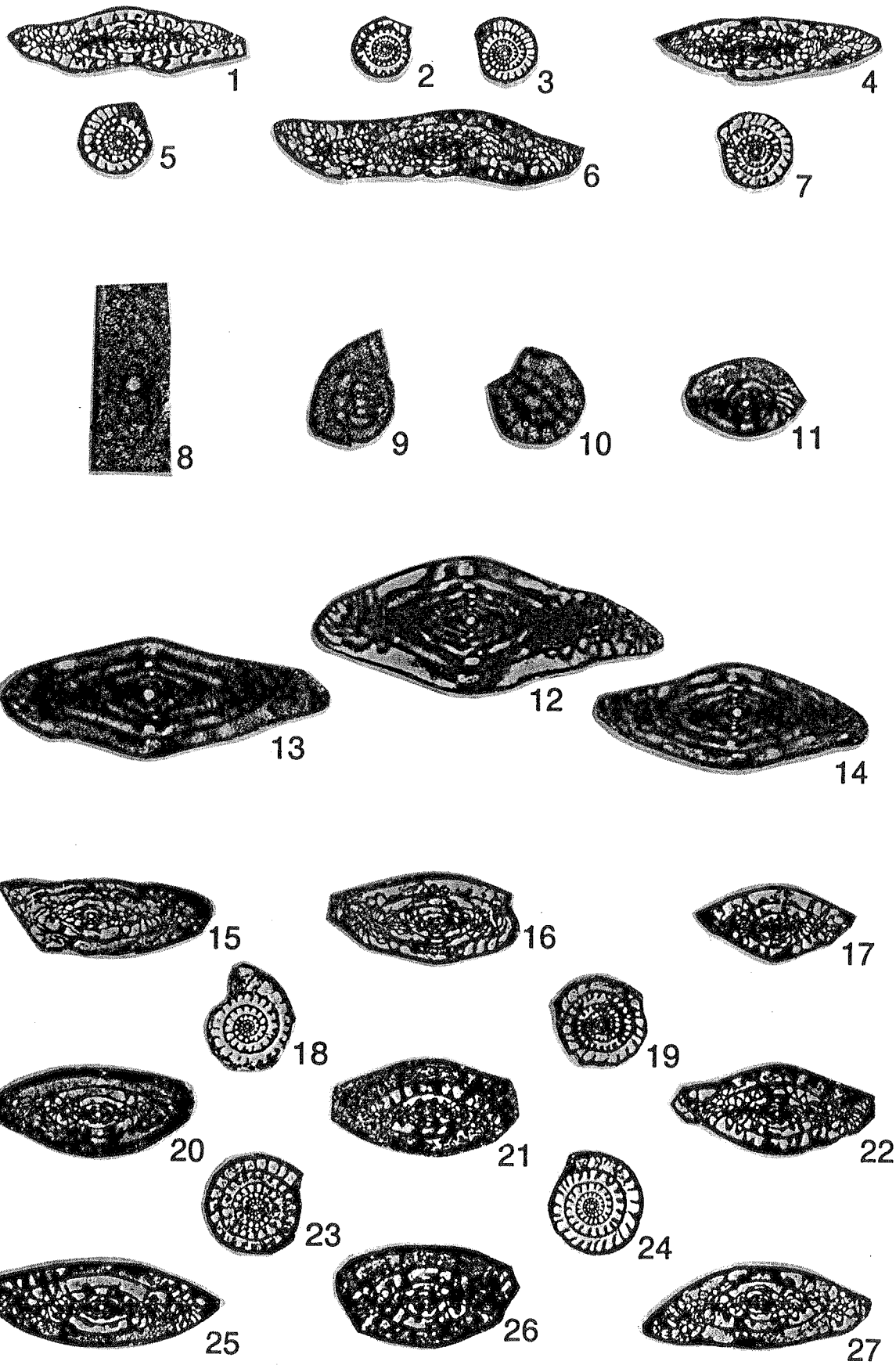
Figs. 9-11 26493 Schubertella Gen. [9-10=x100; 11=x40]

Figs. 12-14 26523 Waeringella n.sp. [x25]

Figs. 15-27 26502 Triticites precullomensis n.sp.

PLATE 9

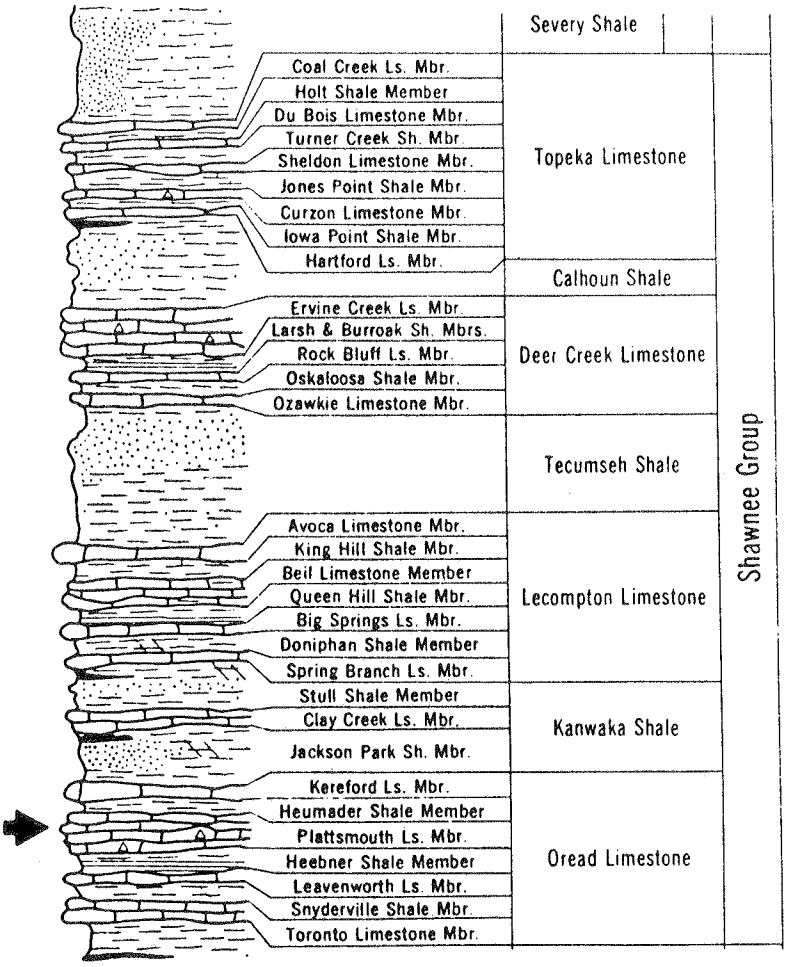
LEAVENWORTH



10993–11

PLATE 10

PLATTSMOUTH

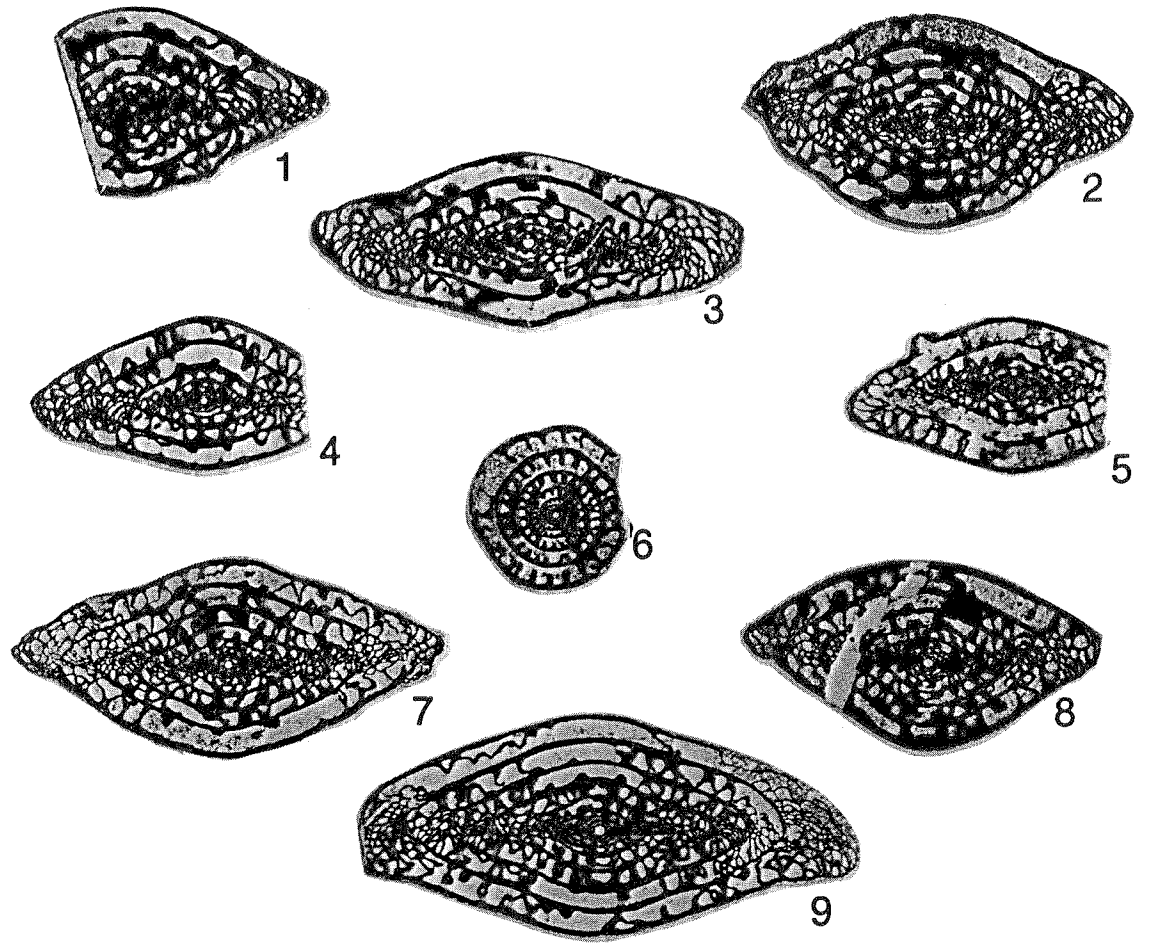


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-16 26504 Triticites beedei Dunbar & Condra, 1927

PLATE 10

PLATTSMOUTH



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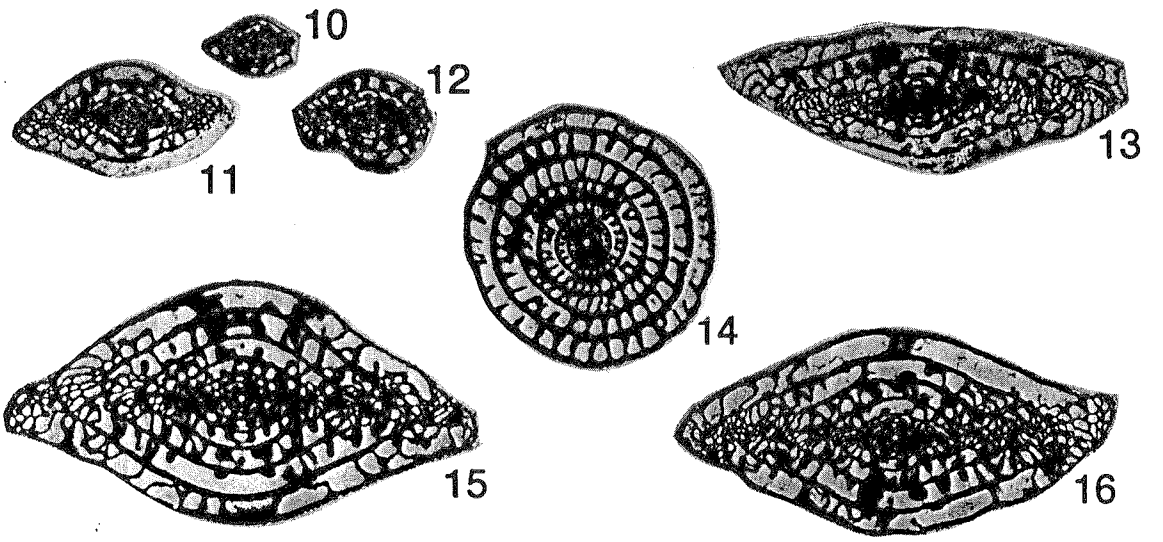

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PLATE 11

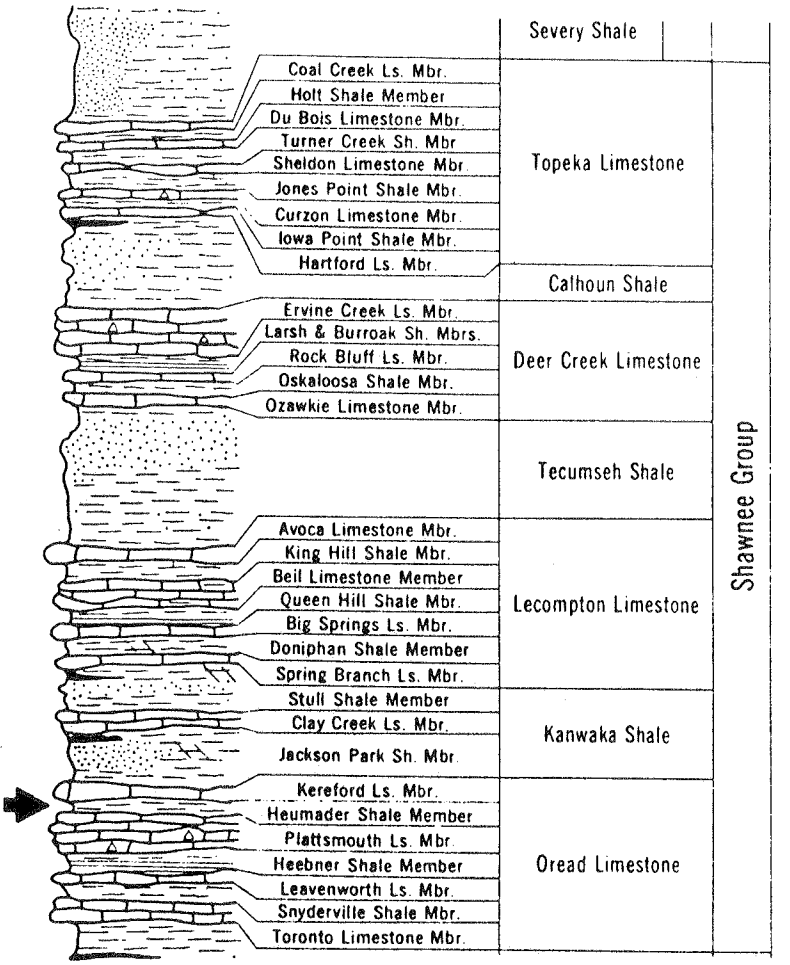


PLATE 11 All Magnifications x10 Unless Otherwise Indicated

Figs. 1-4, 7-13 26496 Triticites oryziformis Newell, 1934

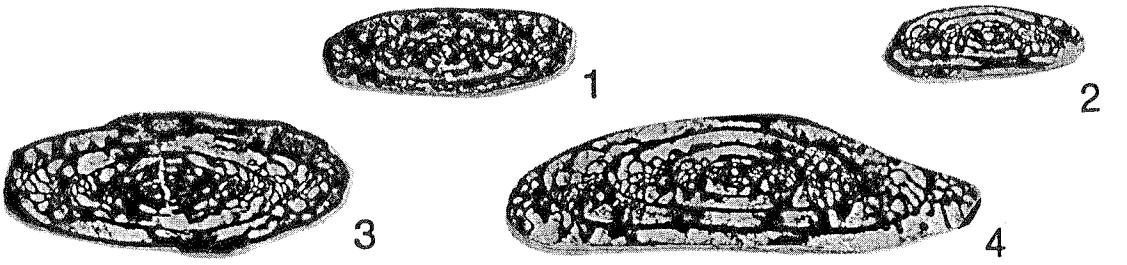
Figs. 5,6 26494 Schubertella n.sp. [Heumader form] [x10 & x40]

Figs. 14-16 ?26481 Kansanella ex.gr. K. pauper (Dunbar & Henbest, 194

Figs. 17-20 26504 Triticites beedei Dunbar & Condra, 1927

PLATE 11

HEUMADER



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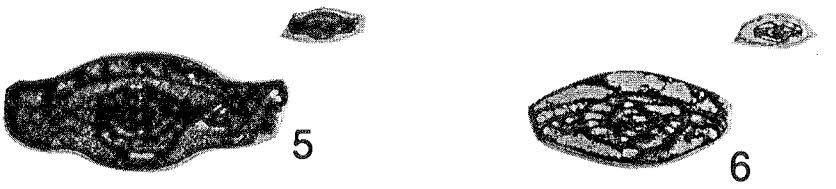

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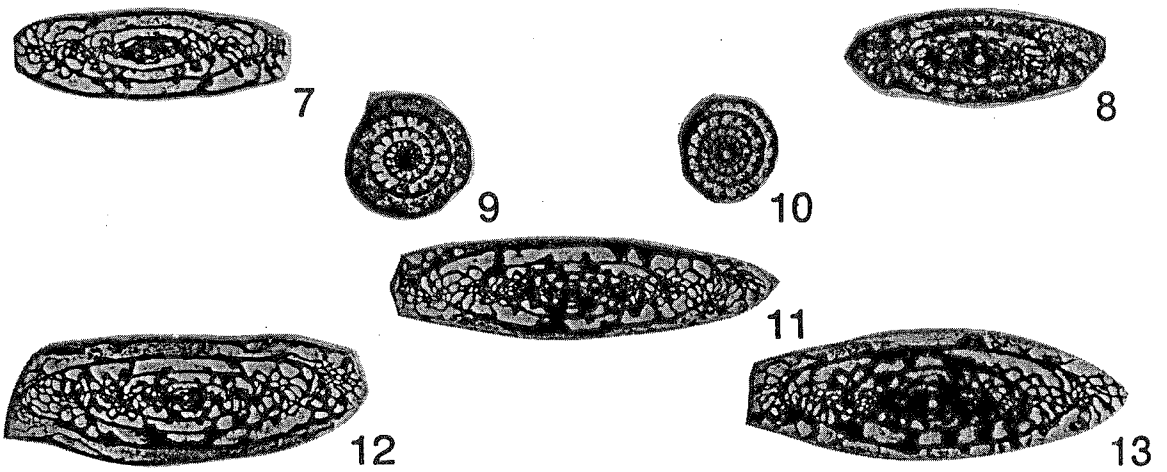

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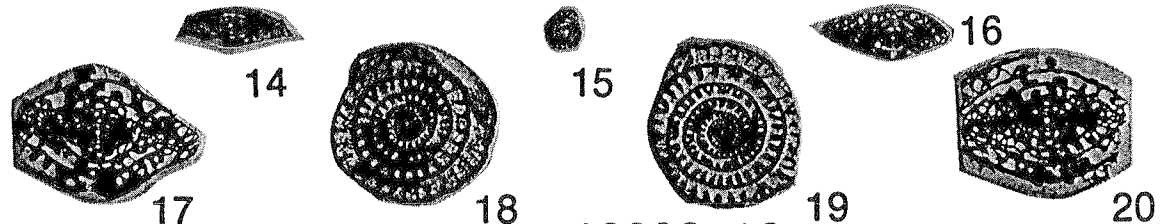
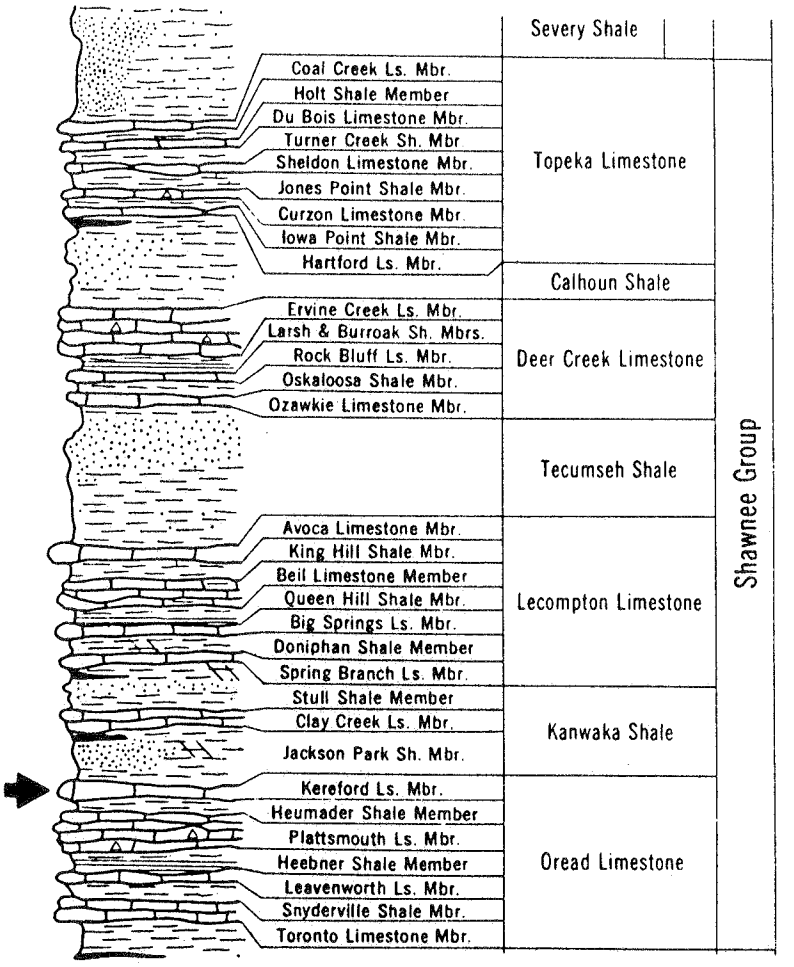


10993–16

PLATE 12

KEREFORD

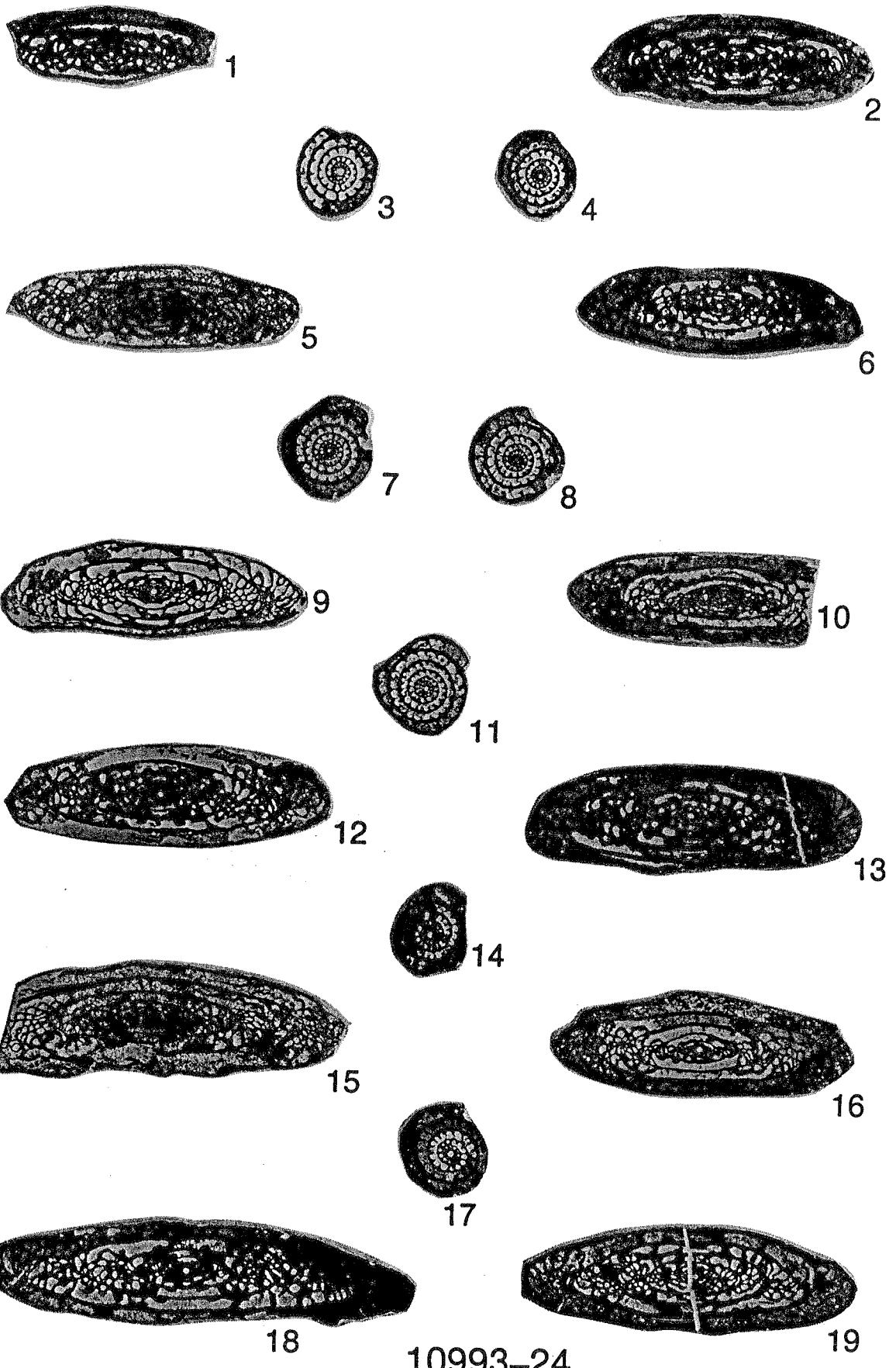


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-19 26497 Triticites ex.gr. T. oryziformis Newell, 1934

PLATE 12

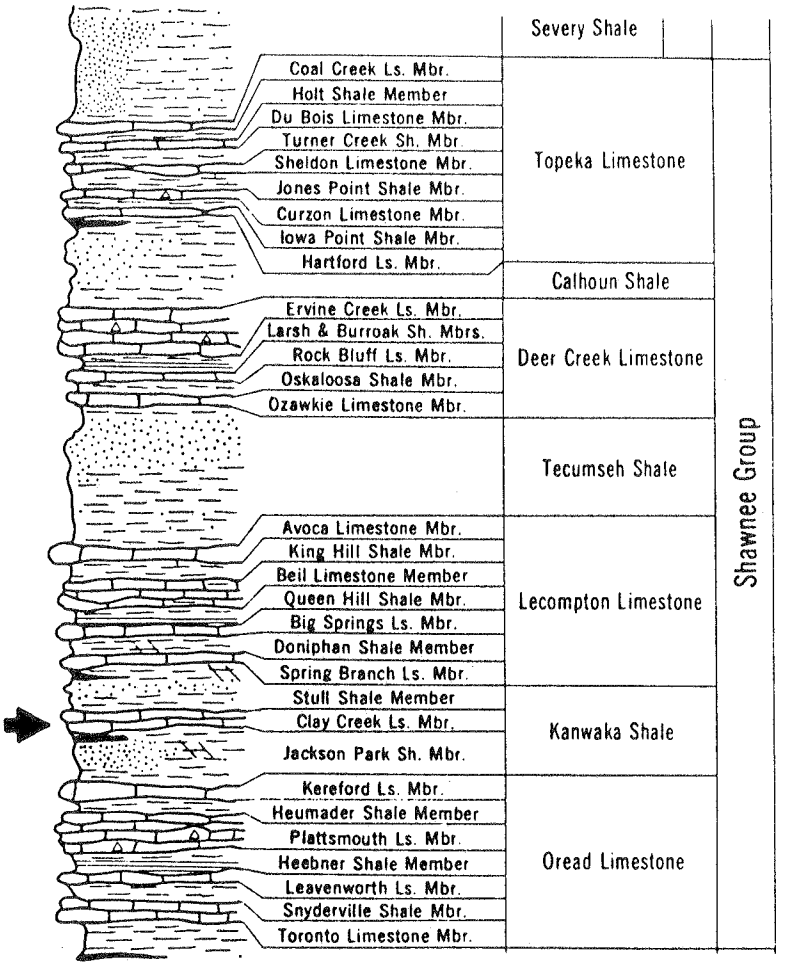
KEREFORD



10993–24

PLATE 13

CLAY CRE

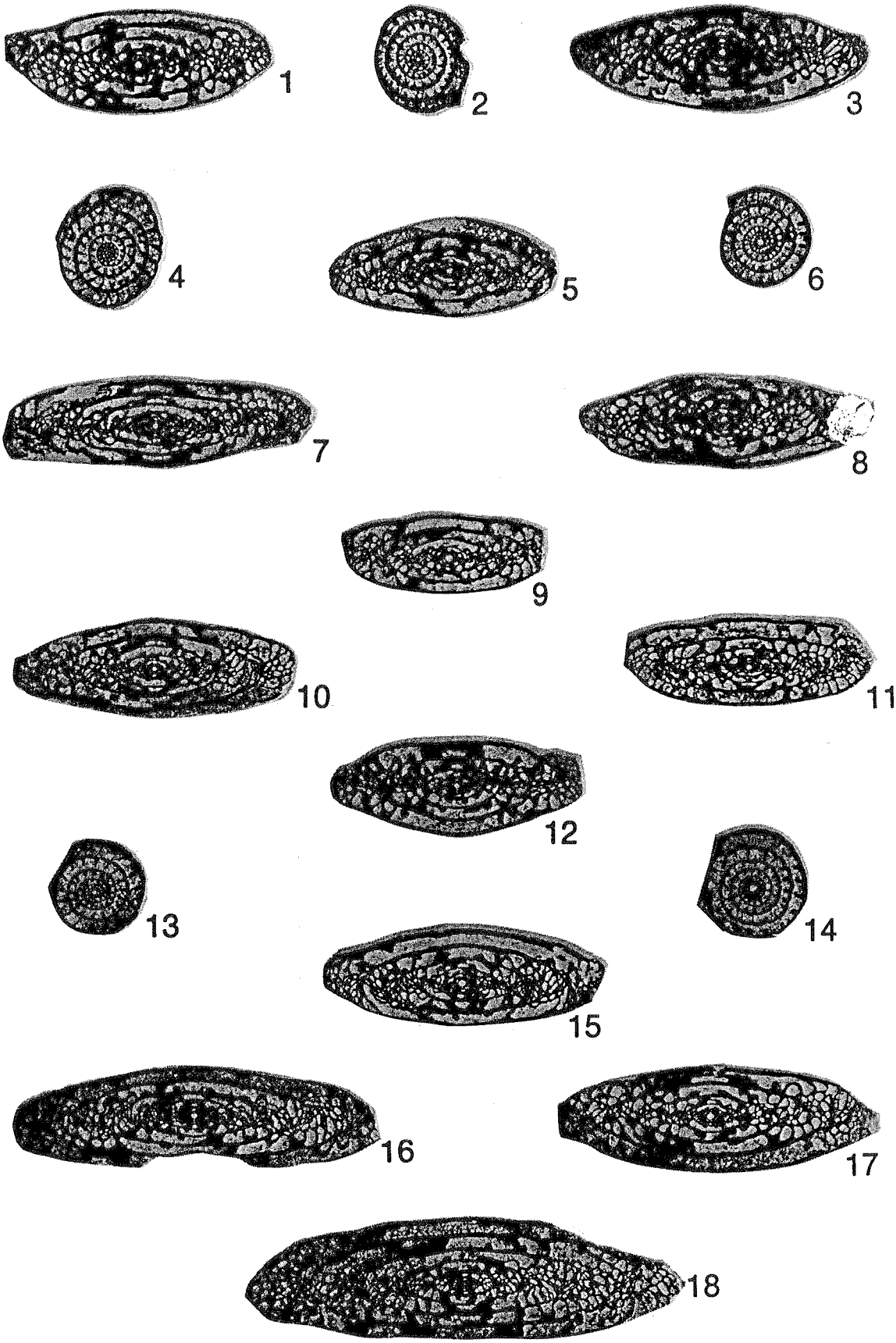


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-18 26497 Triticites ex.gr. T. oryziformis Newell, 1934

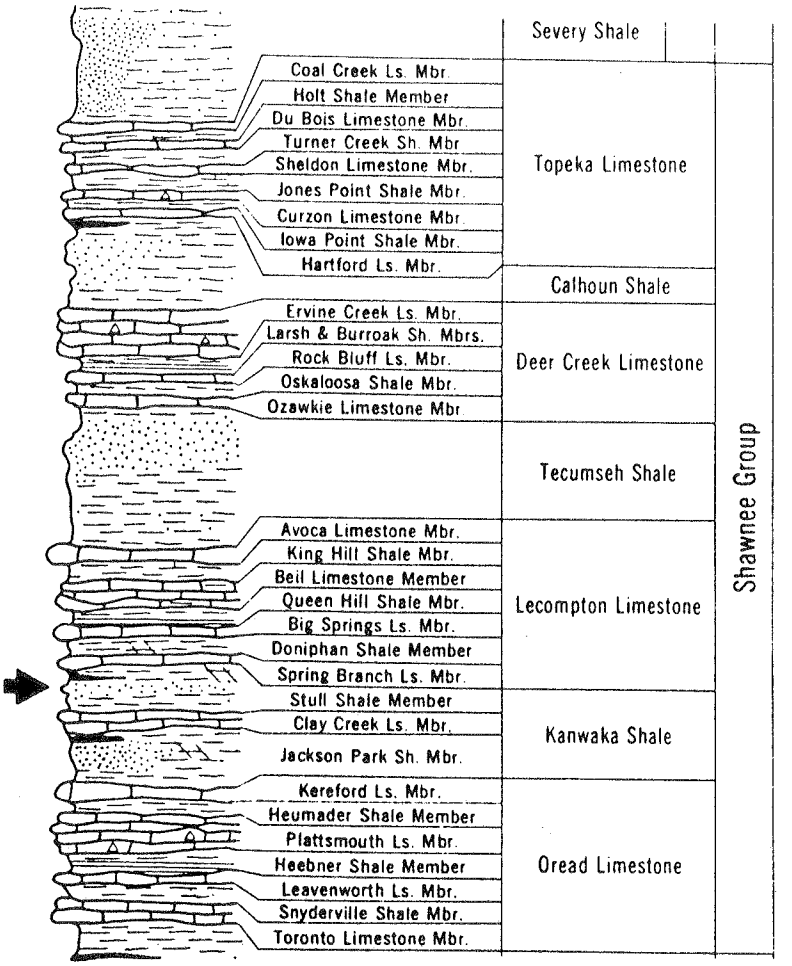
PLATE 13

CLAY CREEK



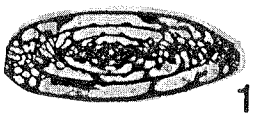
10993–25

PLATE 14



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-16 26502 Triticites precullomensis n.sp.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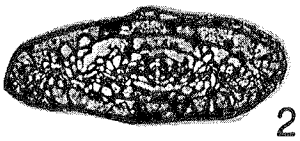
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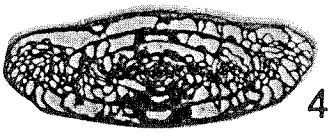
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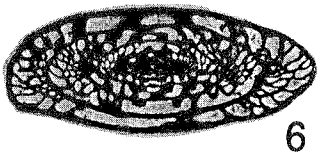
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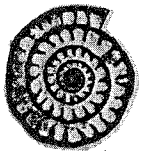
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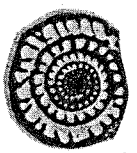
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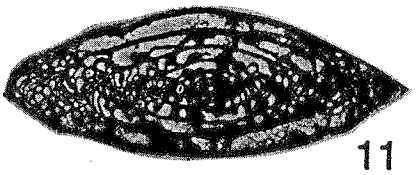
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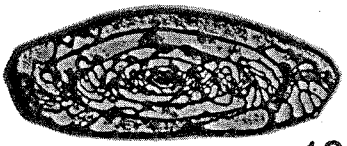
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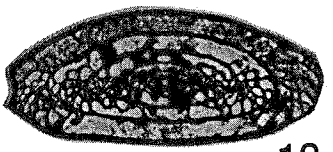
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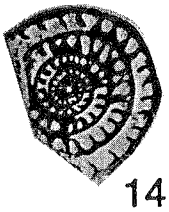
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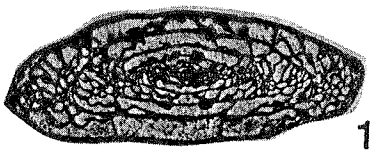
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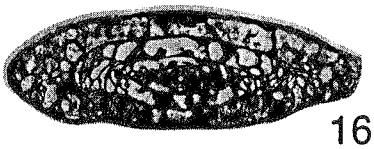
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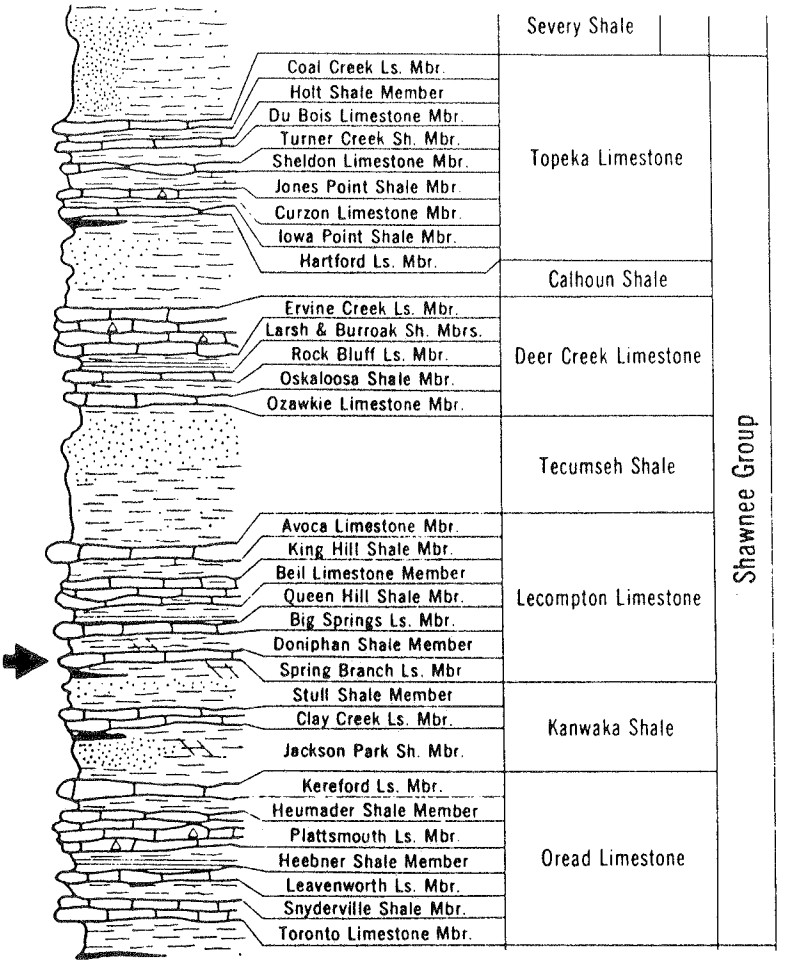
PLATE 15

SPRING BRANCH



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-11 26502 Triticites precullomensis n.sp.

Figs. 13-18,20 26497 Triticites ex.gr. T. oryziformis Newell, 1934

Fig. 19 26501 Triticites ex.gr. T. cullomensis Dunbar & Condra, 1927

PLATE 15

SPRING BRANCH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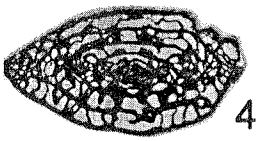
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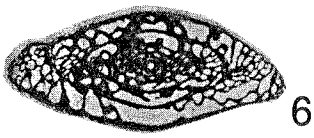
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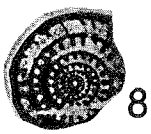
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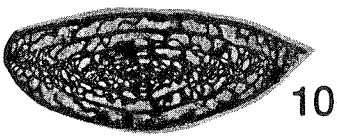
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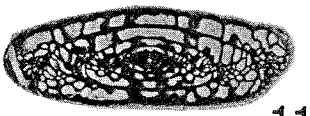
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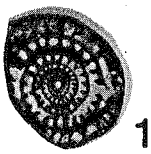
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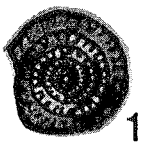
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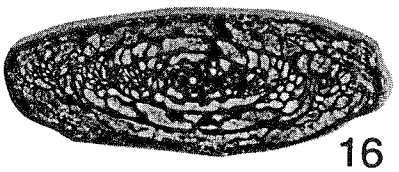
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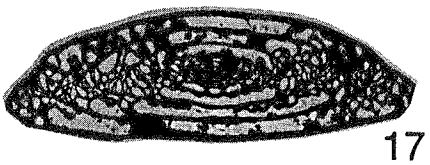
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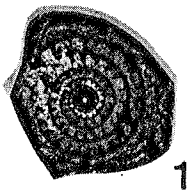
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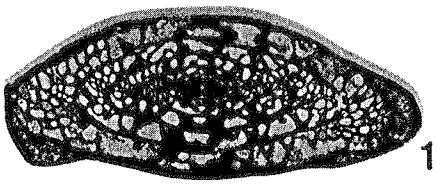
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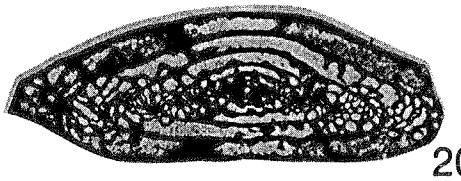
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10993–27

PLATE 16

BIG SPRINGS

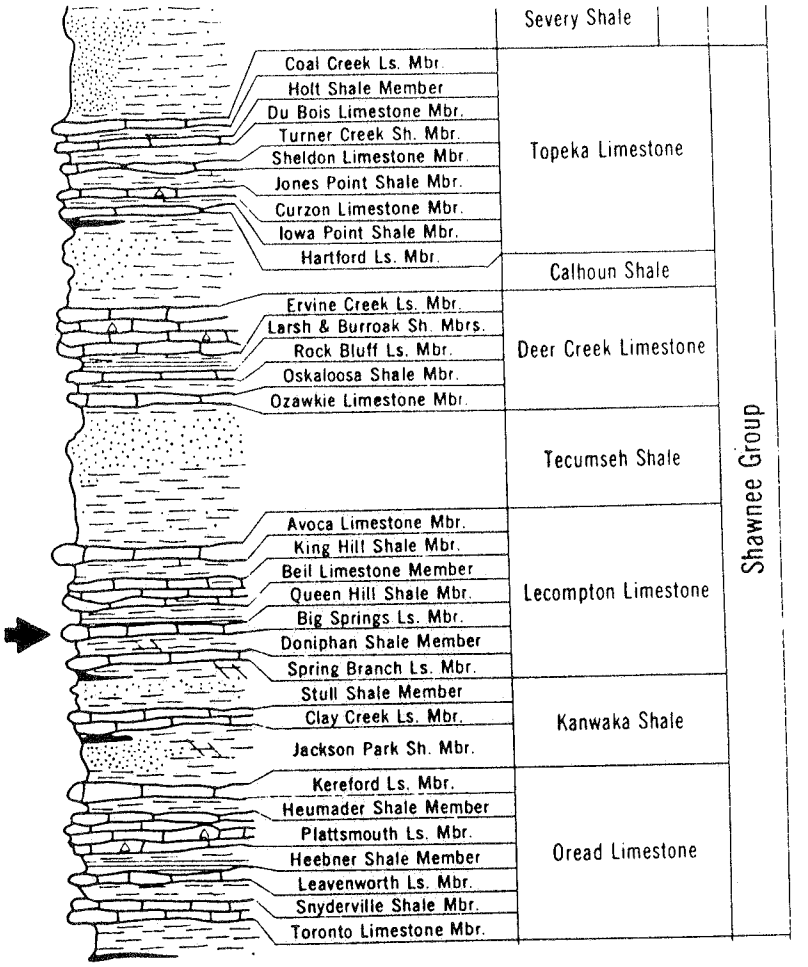


PLATE 16 All Magnifications x10 Unless Otherwise Indicated

Figs. 1-17 26497 Triticites ex.gr. T. oryziformis Newell, 1934

Figs. 18,20 26492 Oketaella n.sp. [SP. A] [x40]

Fig. 19 26493 Schubertella Gen. [x100]

Figs. 21-23 26501 Triticites ex.gr. T. cullomensis Dunbar & Condra, 1927

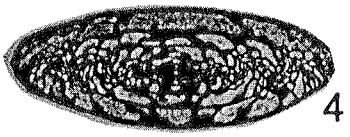
PLATE 16

BIG SPRINGS


1


2


3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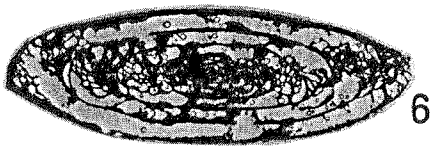
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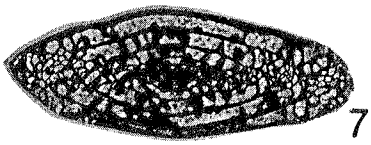
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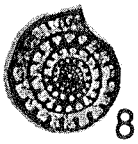
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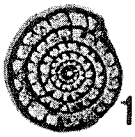
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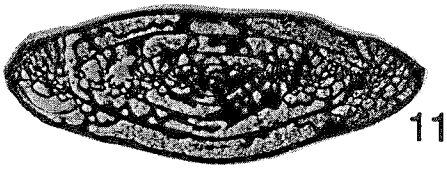
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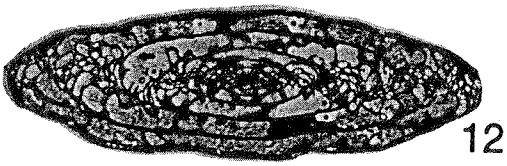
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10993–30


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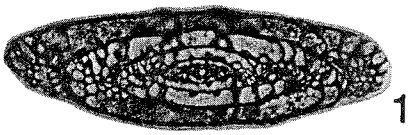
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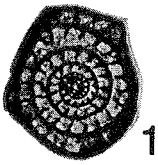
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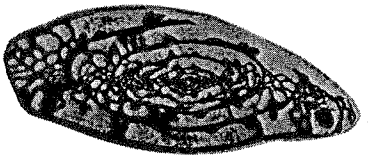
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10993–29


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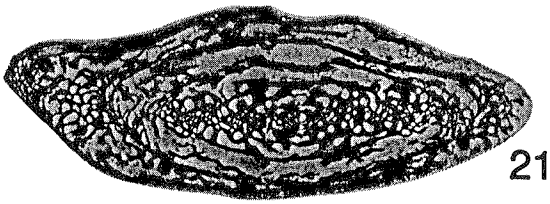
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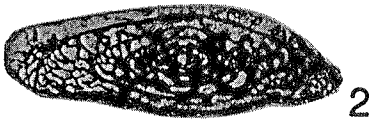
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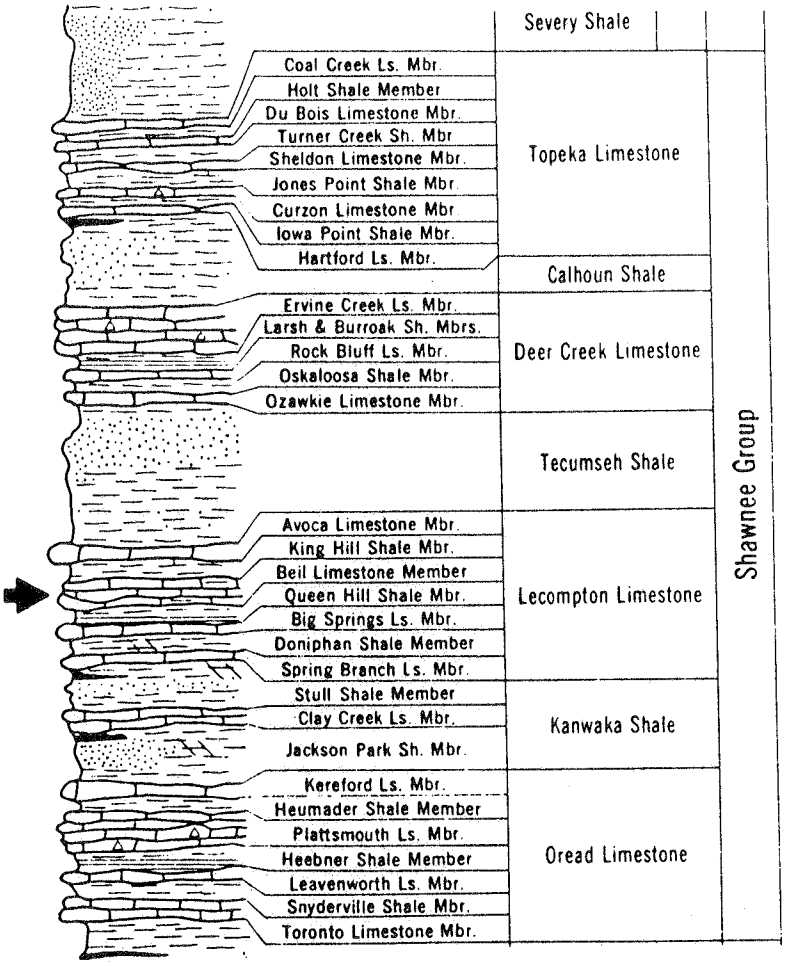
10993–28

PLATE 17

LOWER BEIL



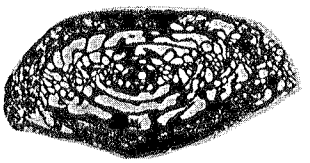
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-9 26500 Triticites cullomensis Dunbar & Condra, 1927

Figs. 10-18 26616 Kansanella n.sp. [SP. 2]

PLATE 17

LOWER BEIL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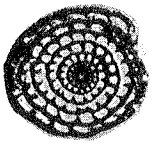
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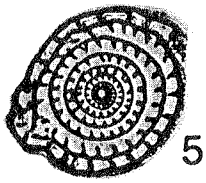
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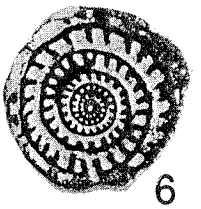
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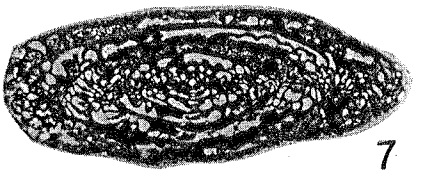
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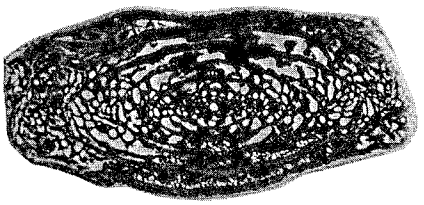
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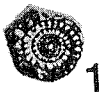
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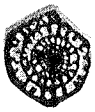
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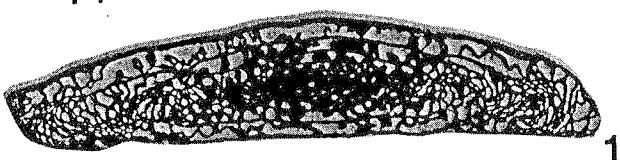
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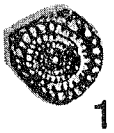
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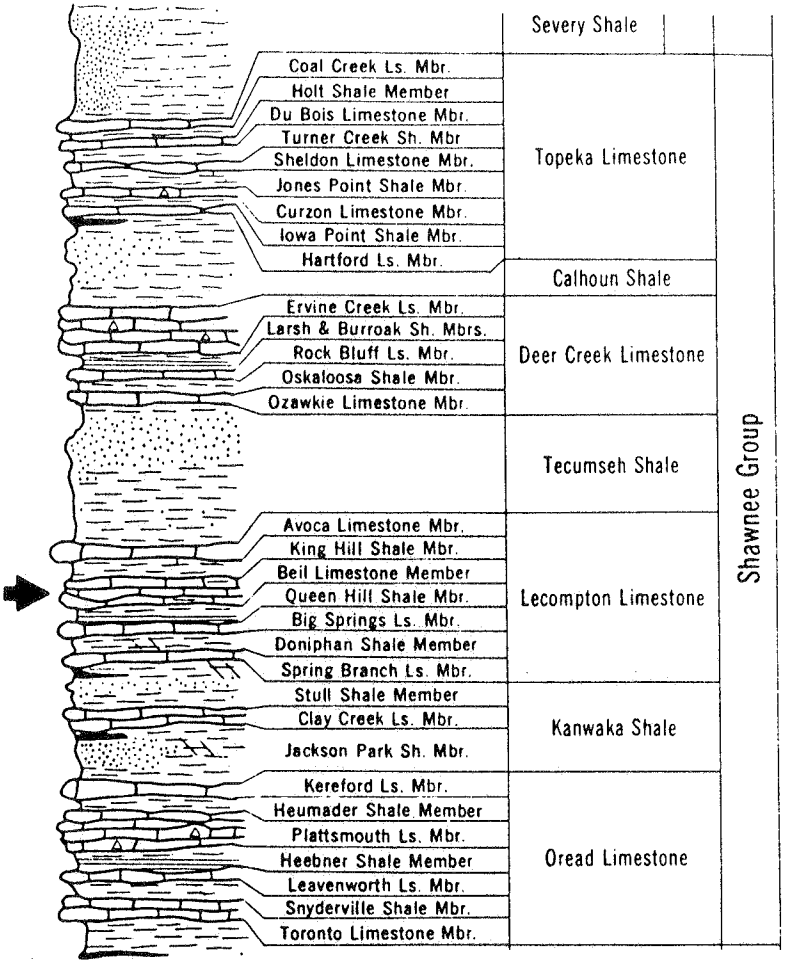
10993–31

PLATE 18

UPPER BE



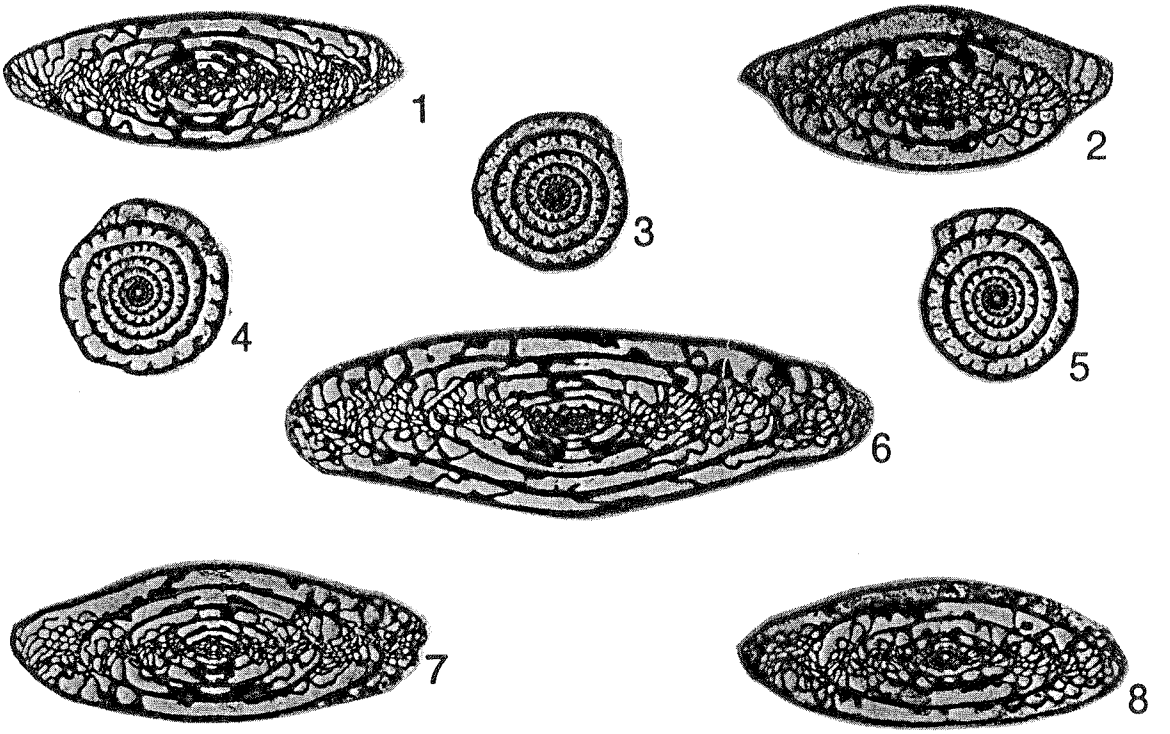
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-15,17,18 26499 Triticites ex.gr. T. sealicus (Say) sensu Douglass,

Fig. 16 26501 Triticites ex.gr. T. cullomensis Dunbar & Condra, 19

PLATE 18

UPPER BEIL



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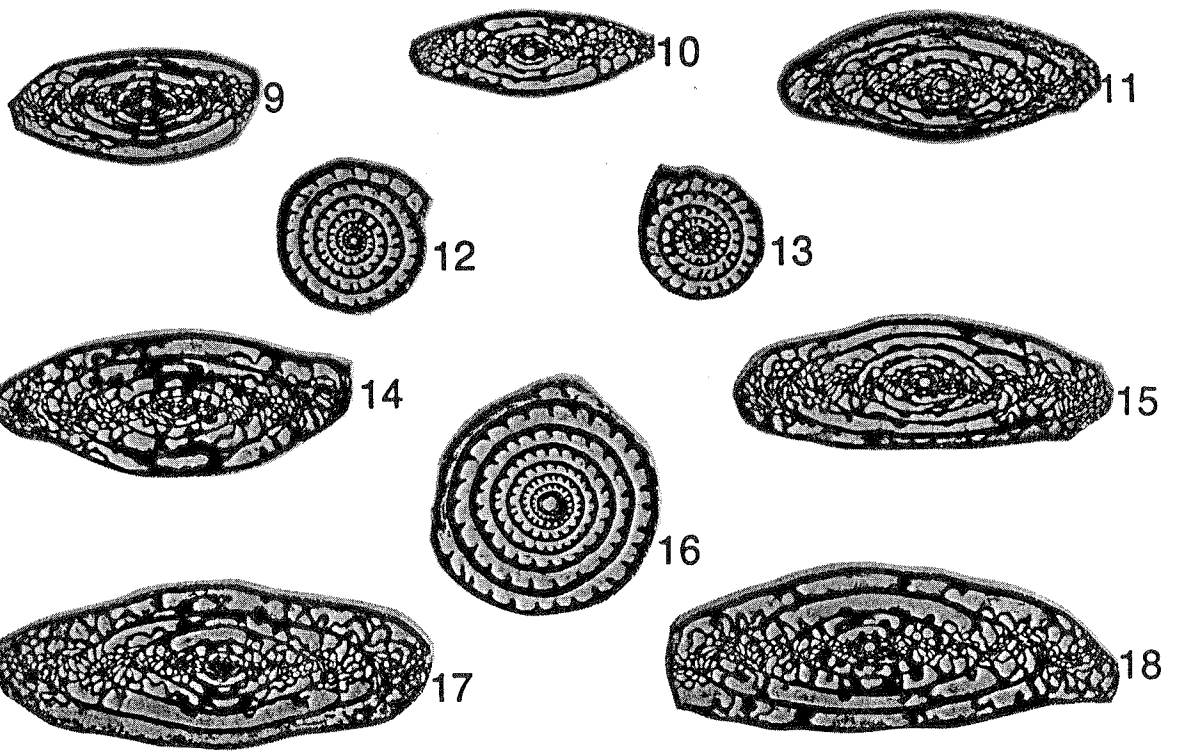


10993–33

PLATE 19

LOWER AVOCA

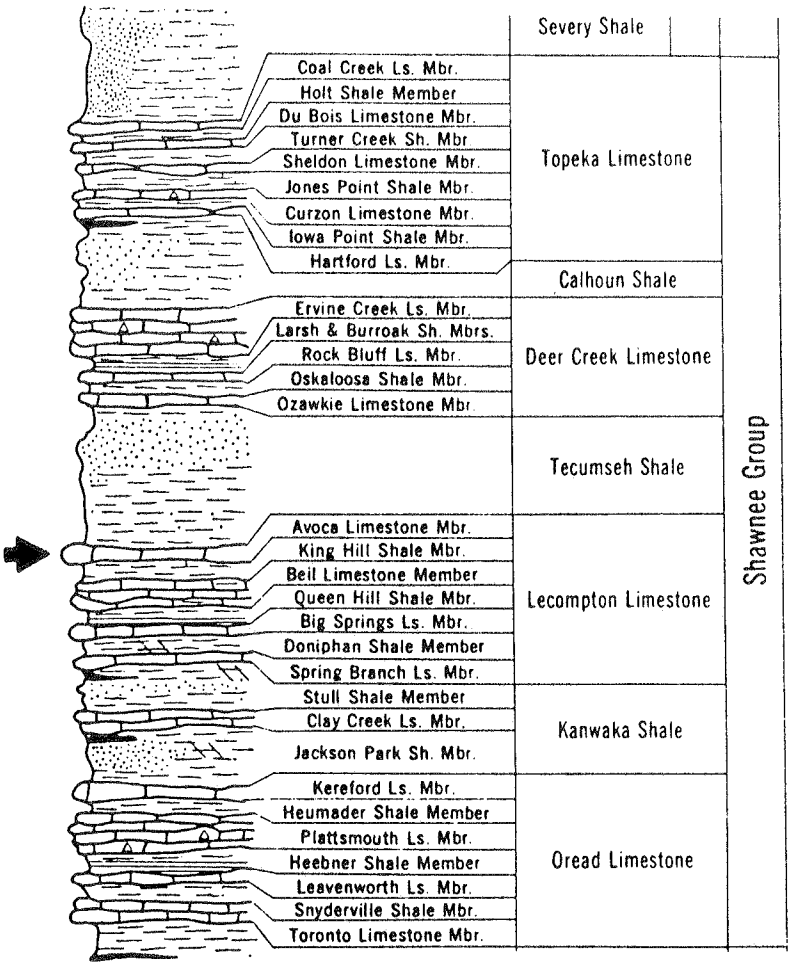


PLATE 19 — All Magnifications x10 Unless Otherwise Indicated

Figs. 1,3 — Microspheric forms. *Triticites* sp.

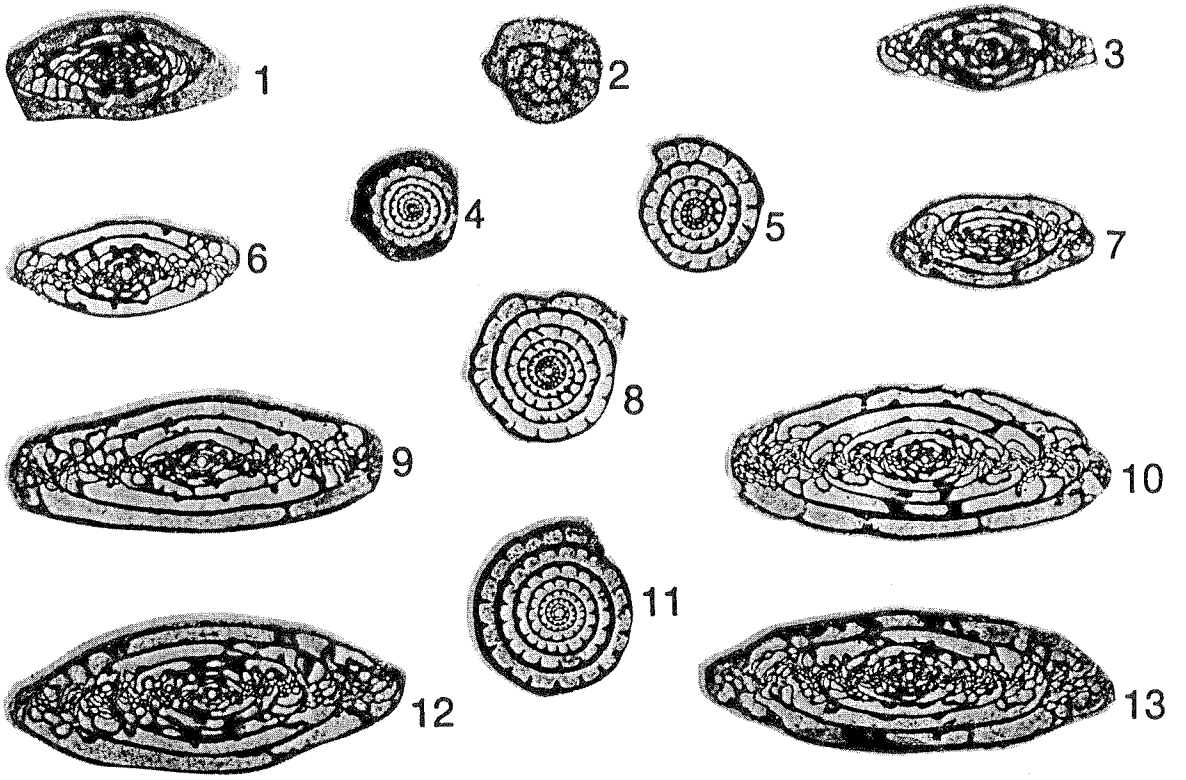
Fig. 2 — 26493 *Schubertella* Gen. [x100]

Figs. 4-13 — 26497 *Triticites* ex.gr. *T. oryziformis* Newell, 1934

Figs. 14-22 — 26499 *Triticites* ex.gr. *T. secalicus* (Say) sensu Douglass, 1966

PLATE 19

LOWER AVOCA



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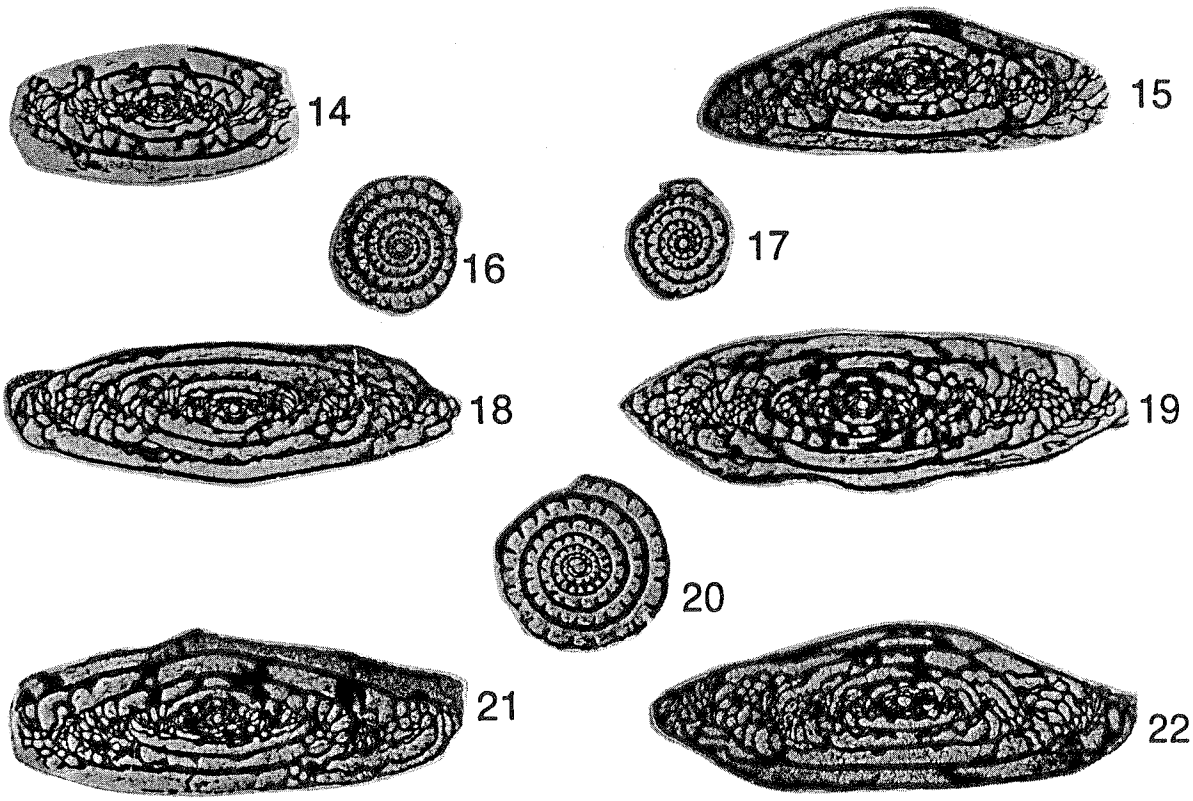
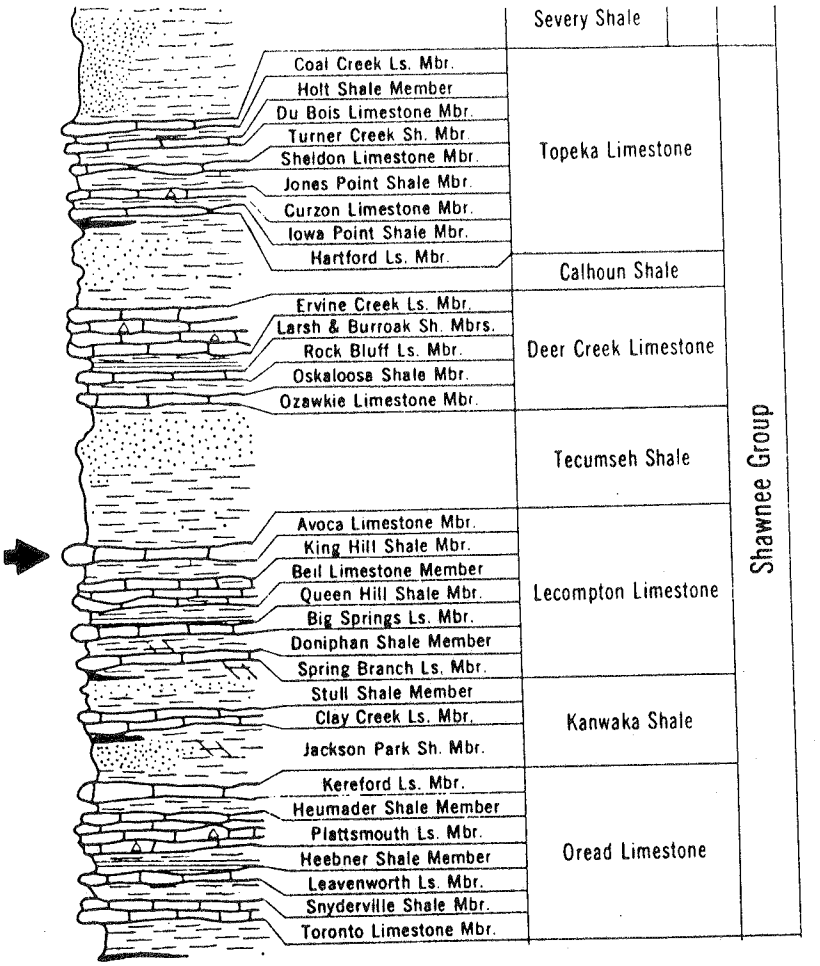


10993–35

PLATE 20

MIDDLE AVO

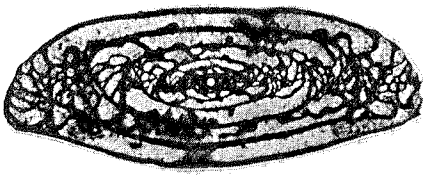


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-18 26497 Tricites ex.gr. T. oryziformis Newell, 1934.

PLATE 20

MIDDLE AVOCA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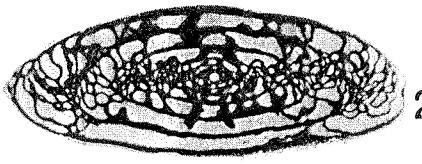
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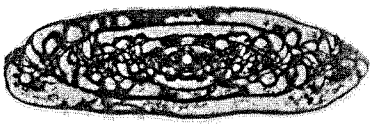
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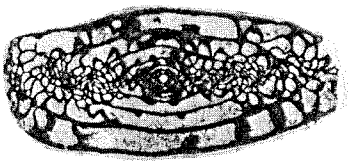
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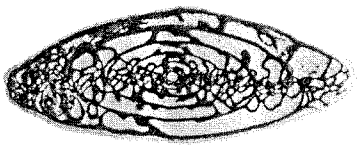
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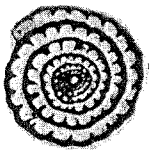
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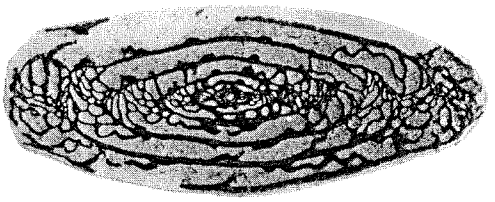
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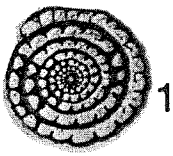
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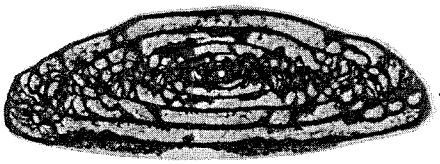
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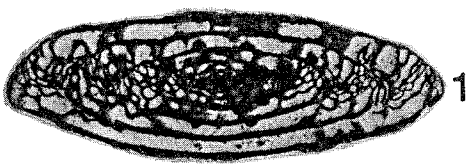
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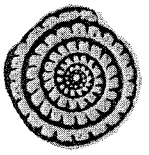
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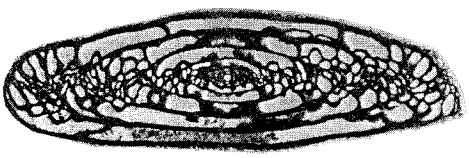
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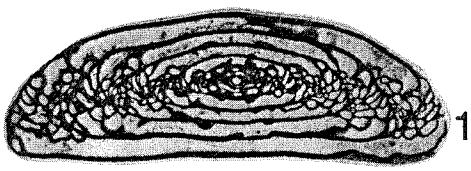
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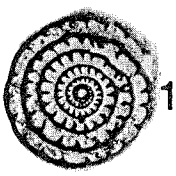
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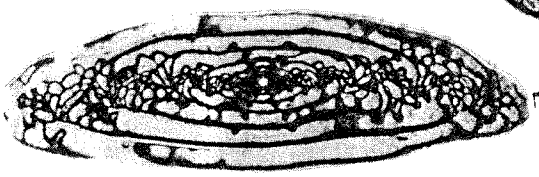
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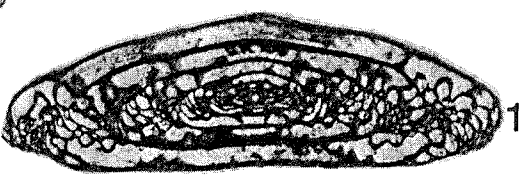
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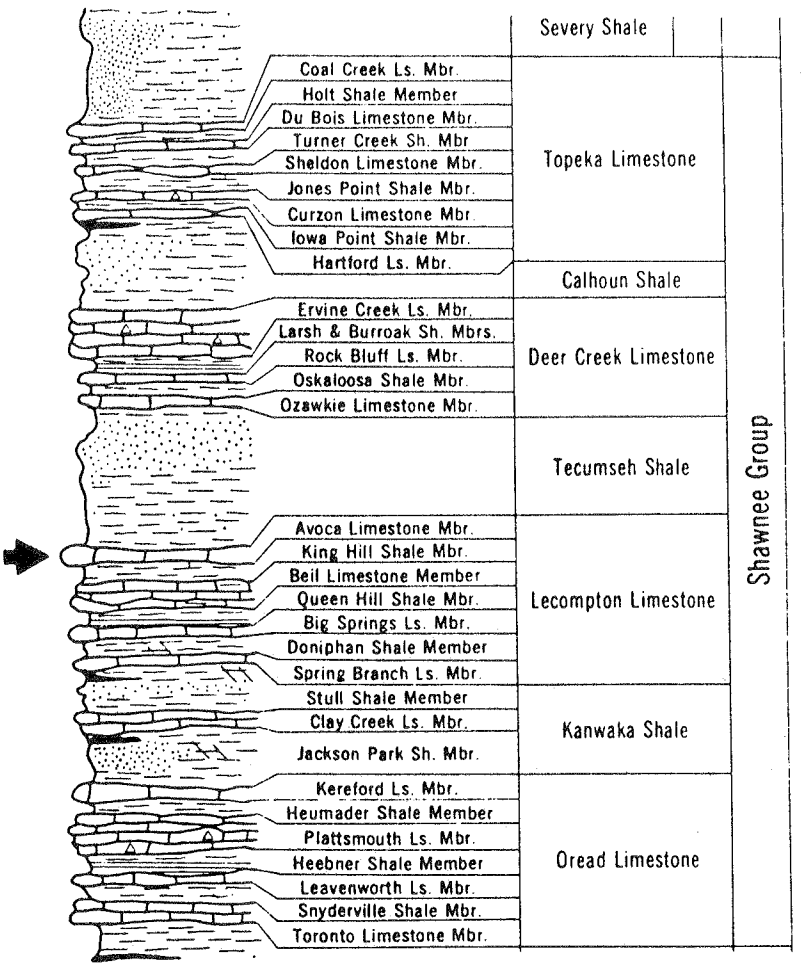
PLATE 21

UPPER AVOC



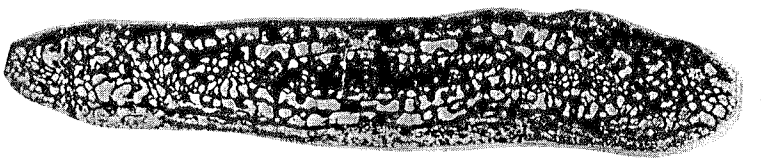
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-11 26616 Kansanella n.sp. [SP. 2]

Figs. 12-17 26497 Triticites ex. gr. T. oryziformis Newell, 1934

PLATE 21

UPPER AVOCA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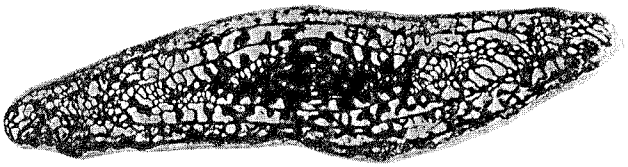
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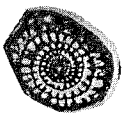
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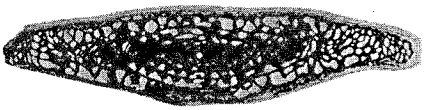
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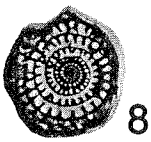
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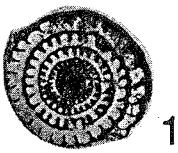
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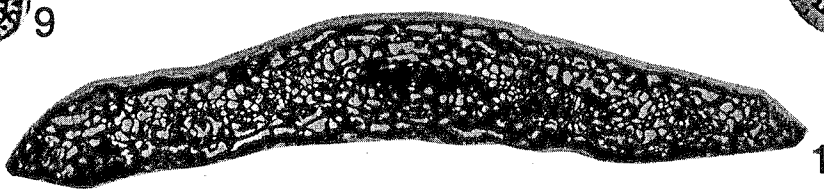
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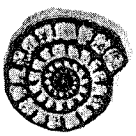
10993–41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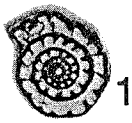
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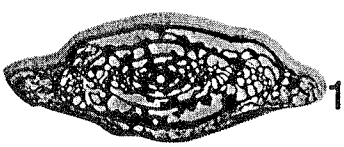
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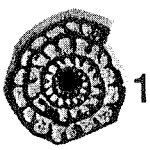
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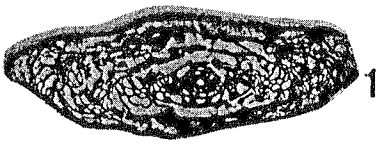
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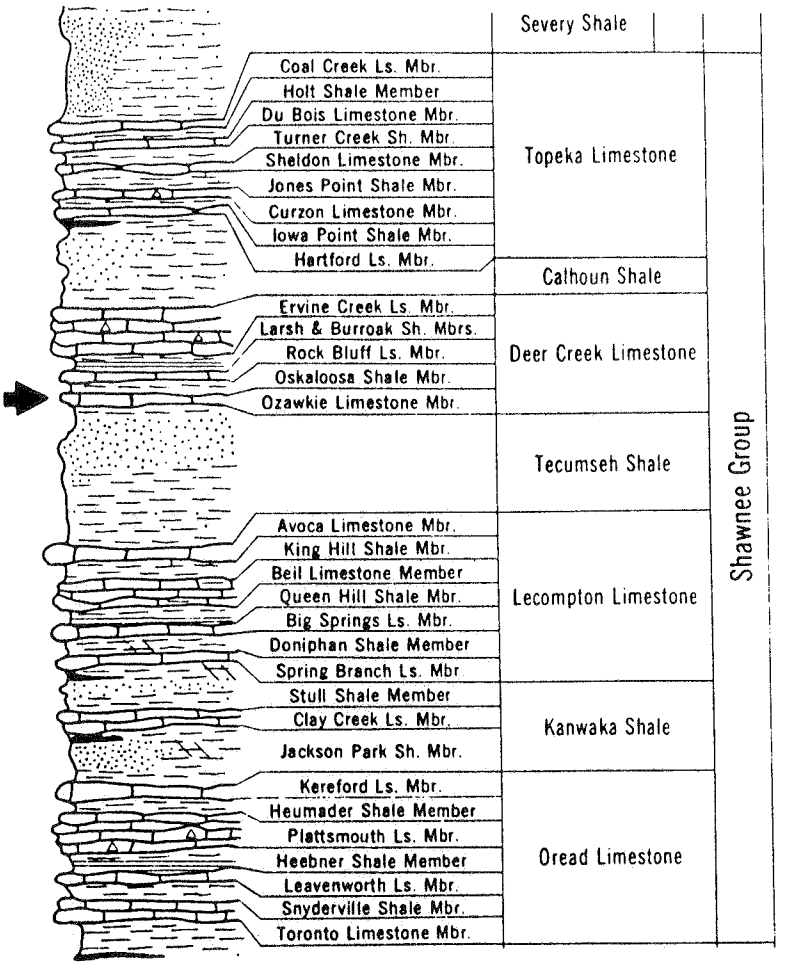
10993–38

PLATE 22

OZAWKIE



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-19 26505 Triticites pierceae Kauffman & Roth, 1966

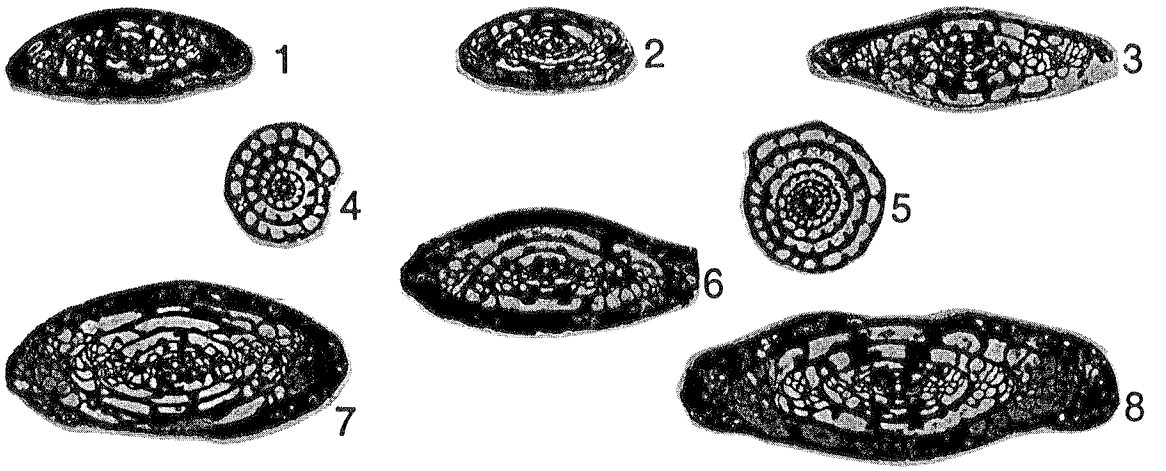
Fig. 20 26480 Kansanella pauper (Dunbar & Henbest, 1942)

Fig. 21 26495 Triticites Gen.

Figs. 22-26 26504 Triticites beedei (Dunbar & Condra, 1927)

PLATE 22

OZAWKIE



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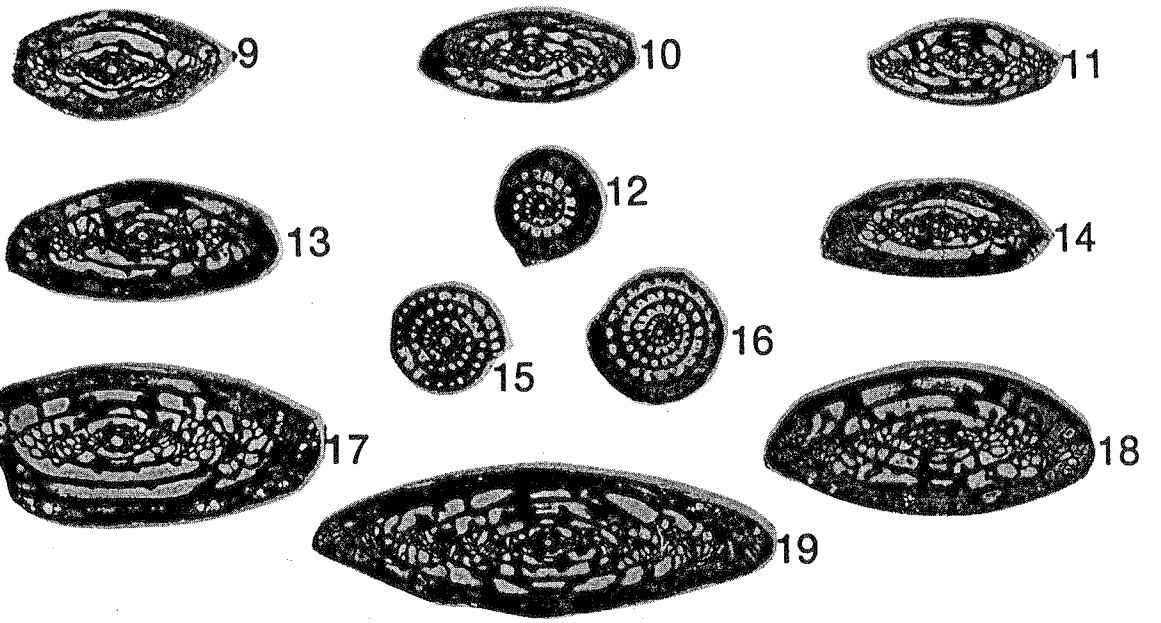

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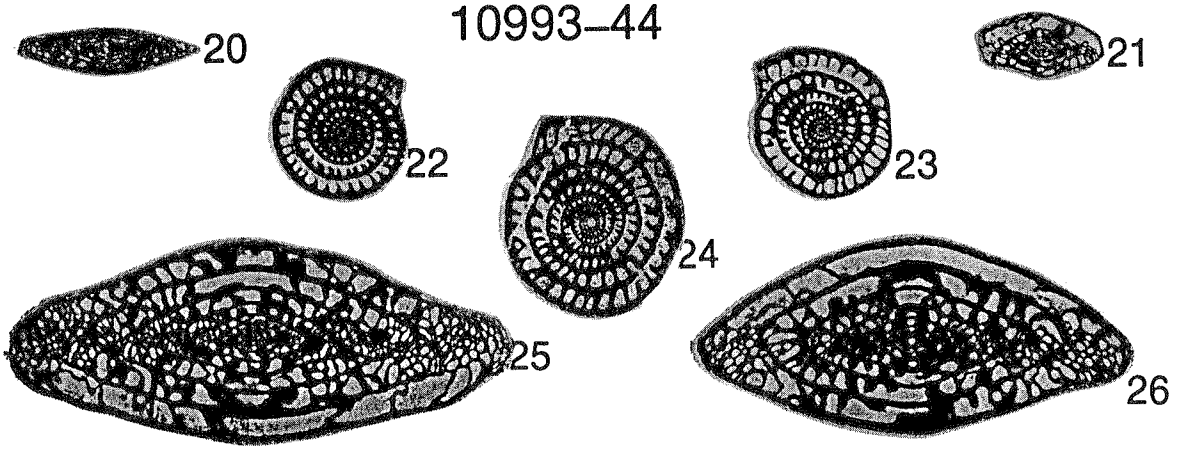
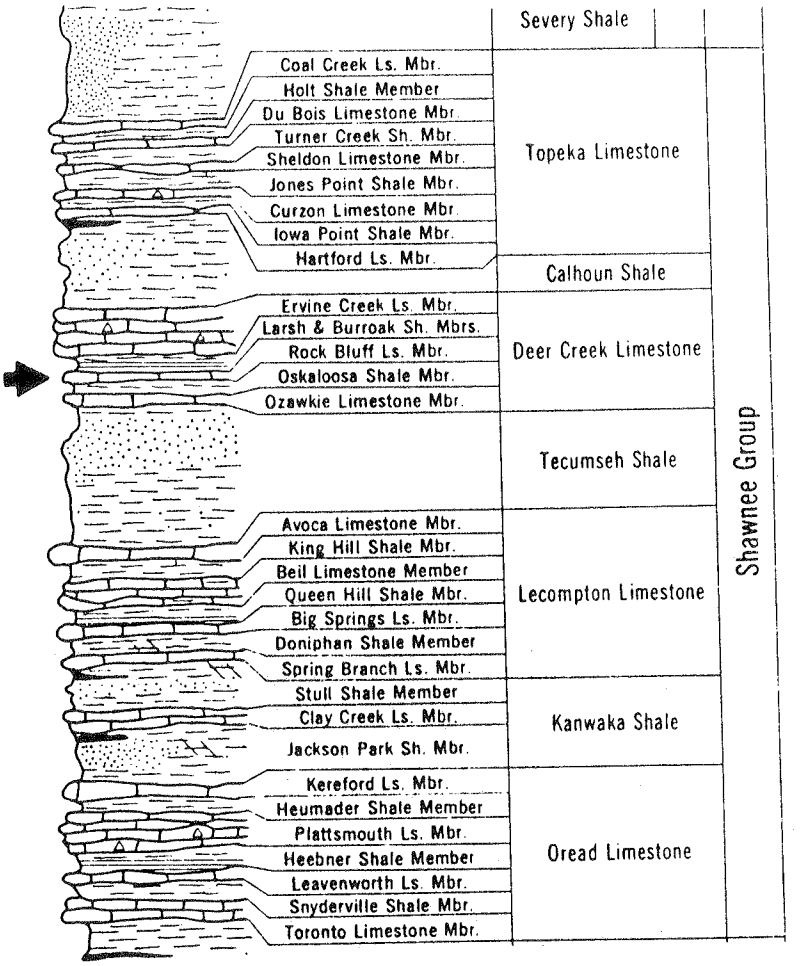


10993–43

PLATE 23

ROCK BLUFF



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-4 26478 Kansanella Gen. [primitive and/or juvenile]

Fig. 5 26495 Triticites Gen. [juvenile form]

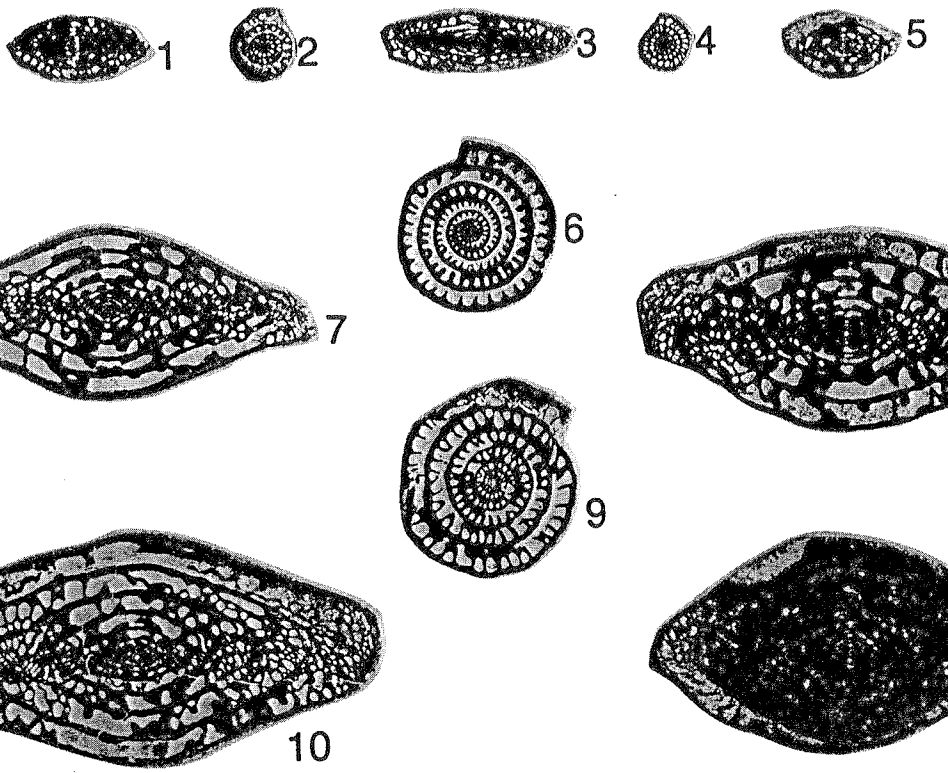
Figs. 6-11,17 26504 Triticites beedei Dunbar & Condra, 1927

Figs. 12-14 26499 Triticites ex. gr. T. secalicus (Say) sensu Douglass,

Figs. 15-16 26506 Triticites bungerensis Kauffman & Roth, 1966

PLATE 23

ROCK BLUFF



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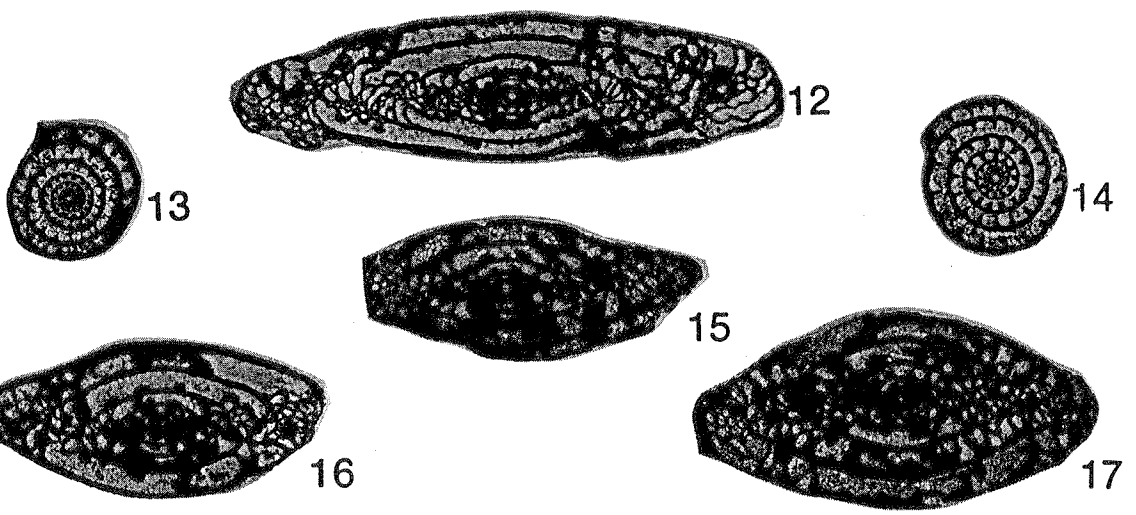
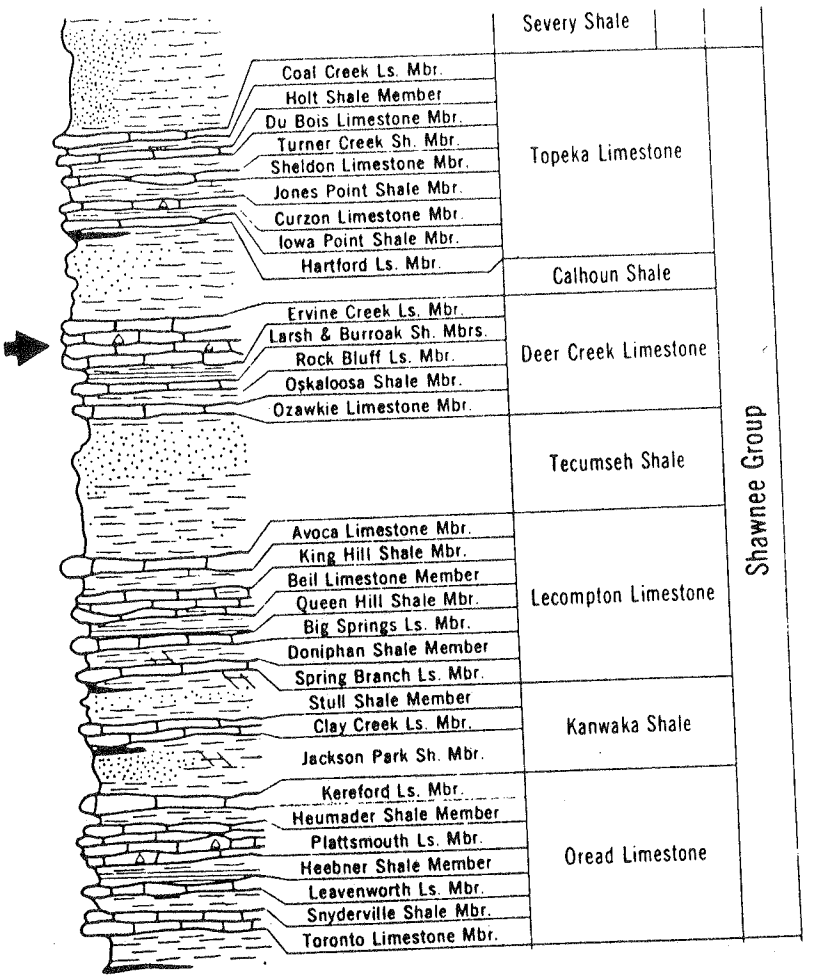


10993–46

PLATE 24

LOWER ERVINE CREEK



All Magnifications x10 Unless Otherwise Indicated

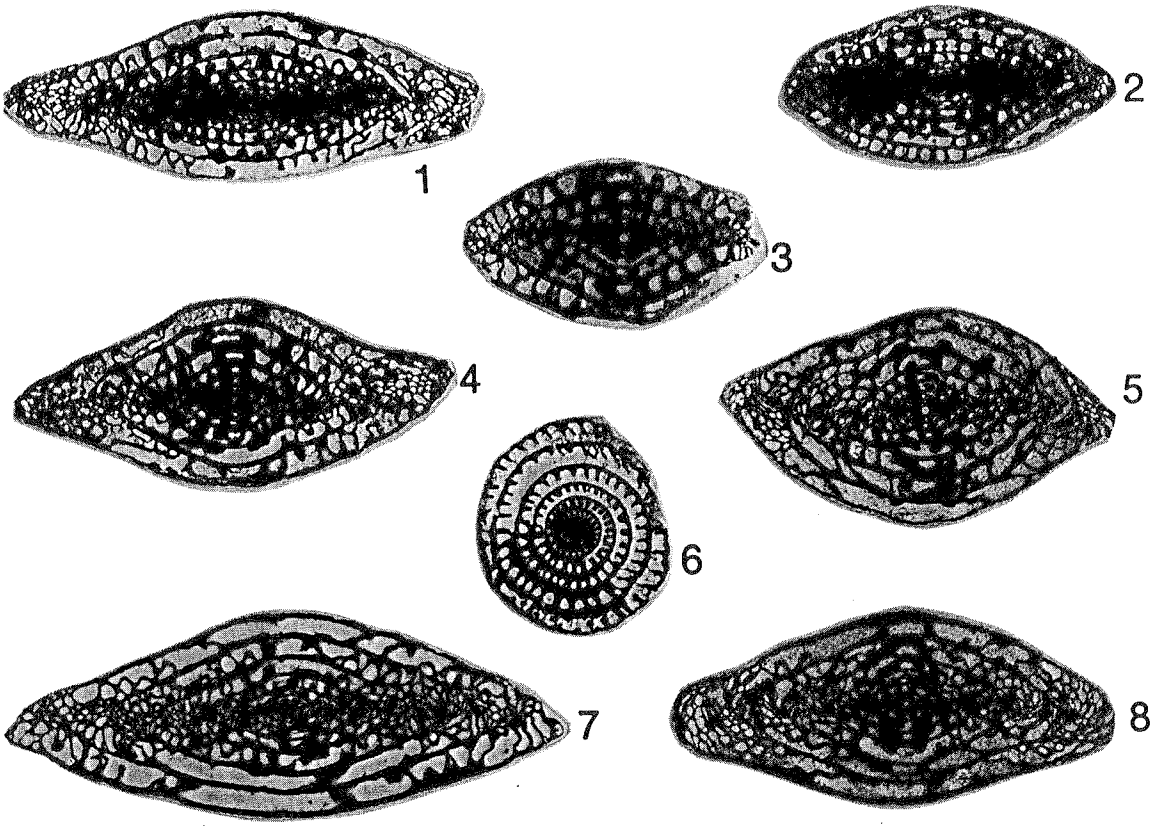
Figs. 1-2 22321 Dunbarinella ervinensis Thompson, 1942

Figs. 3-13,15 26504 Triticites beedei Dunbar & Condra, 1927

Fig. 14 26478 Kansanella Gen.

PLATE 24

LOWER ERVINE CREEK



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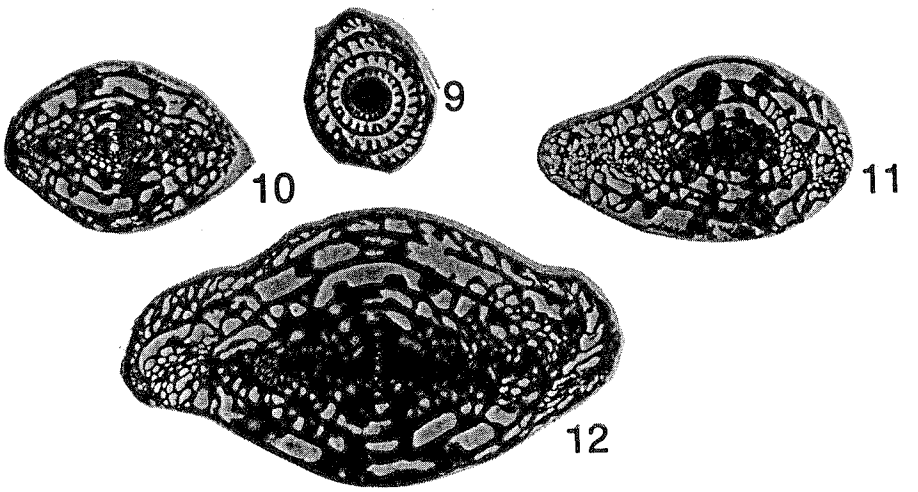

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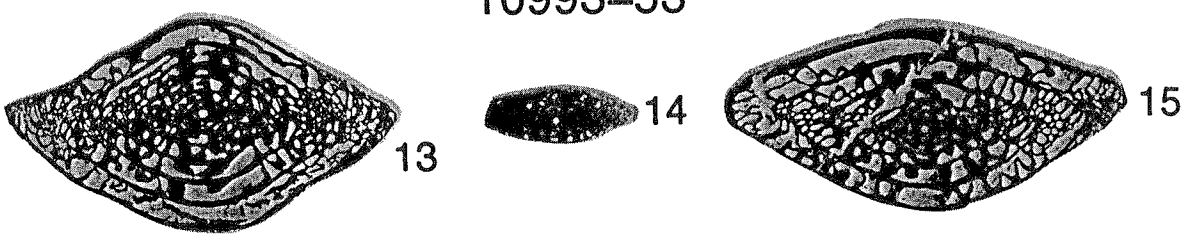
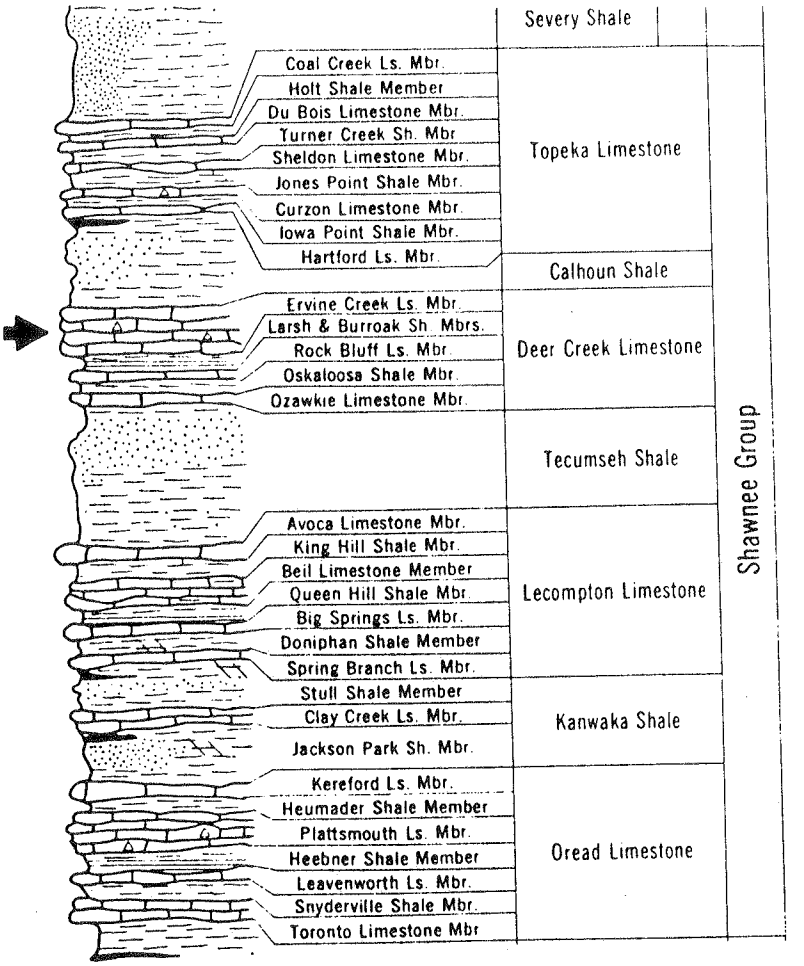


10993–51

PLATE 25 UPPER ERVINE CREEK



All Magnifications x10 Unless Otherwise Indicated

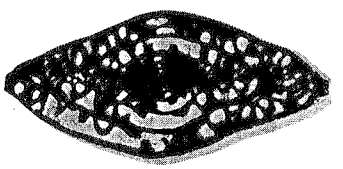
Figs. 1-5, 13-17 26504 Triticites beedei Dunbar & Condra, 1927

Figs. 6-7 26497 Triticites ex. gr. T. oryziformis Newell, 1934

Figs. 8-12 26506 Triticites bungerensis Kauffman & Roth, 1966

PLATE 25

UPPER ERVINE CREEK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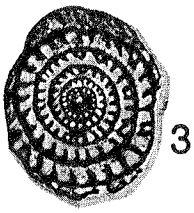
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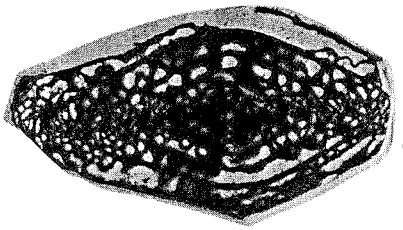
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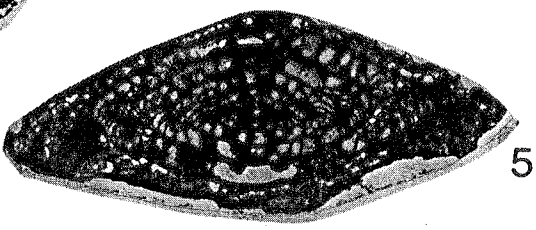
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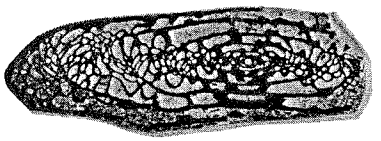
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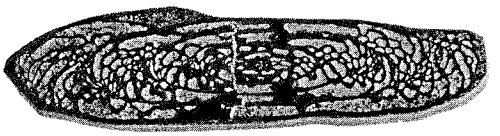
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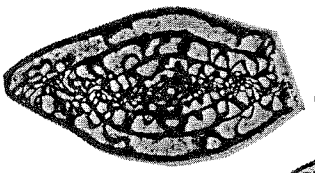
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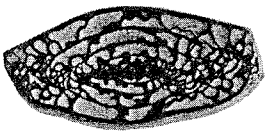
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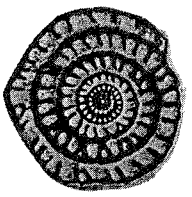
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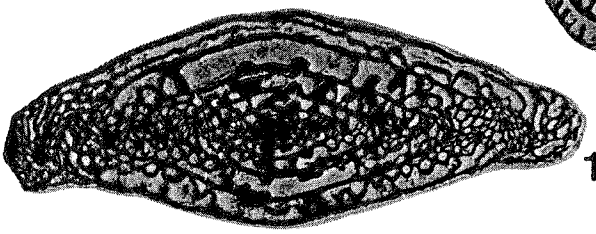
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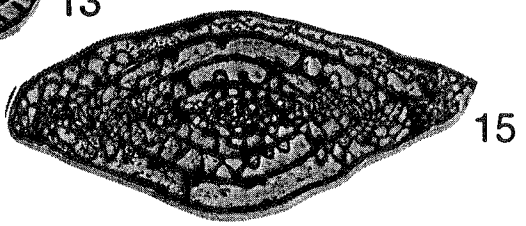
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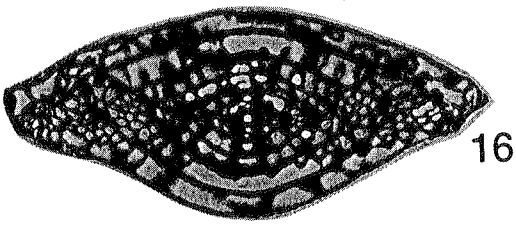
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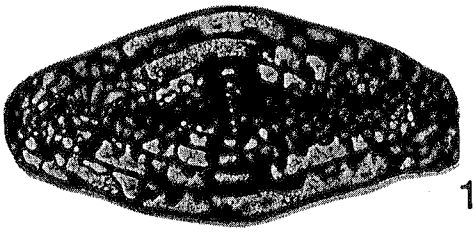
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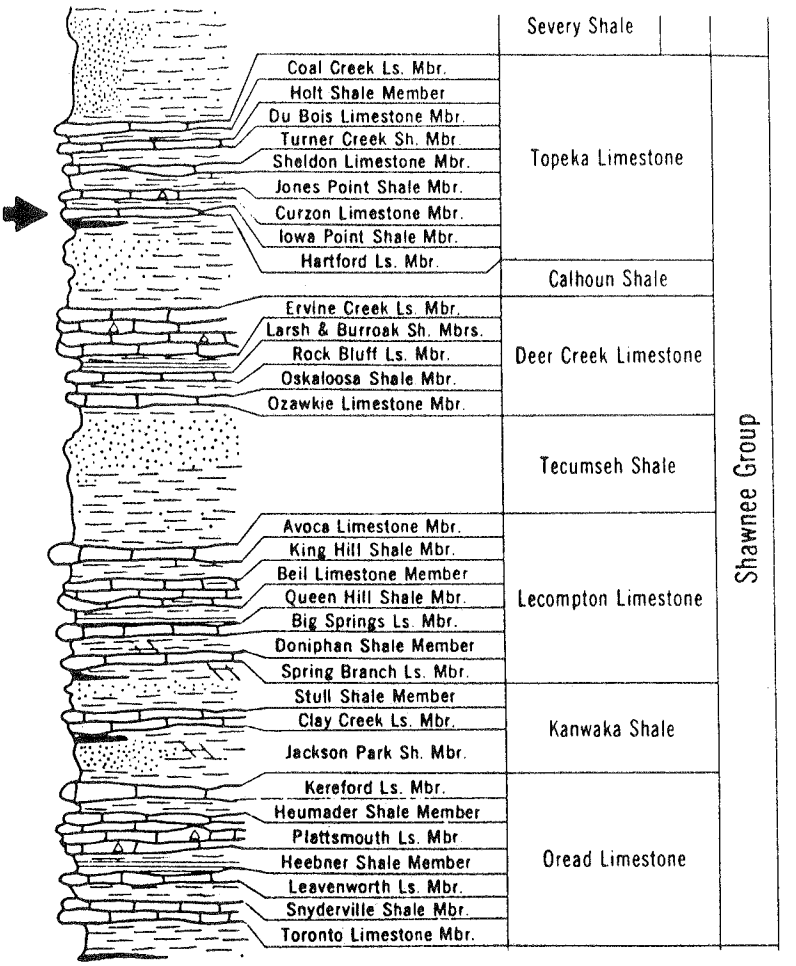
10993–56

PLATE 26

HARTFORD

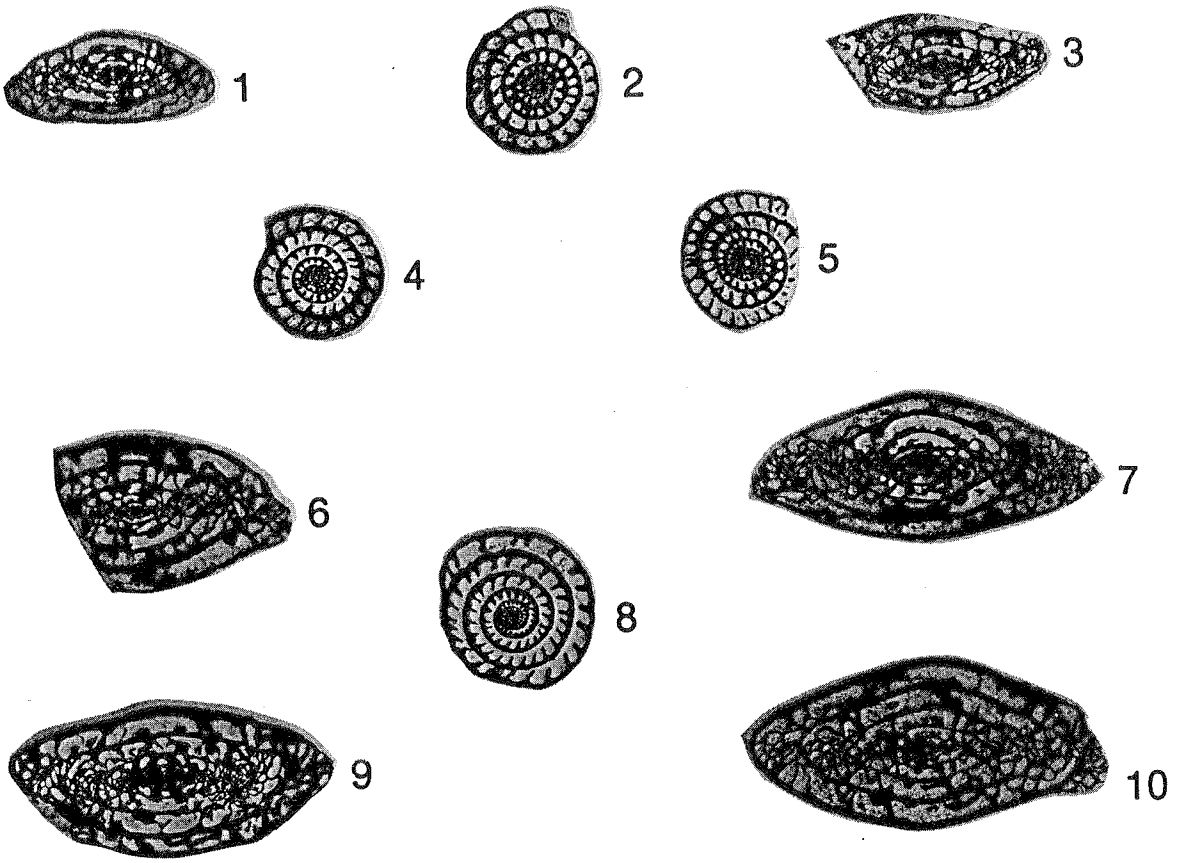


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-10 26506 Triticites bungerensis Kauffman & Roth, 1966

PLATE 26

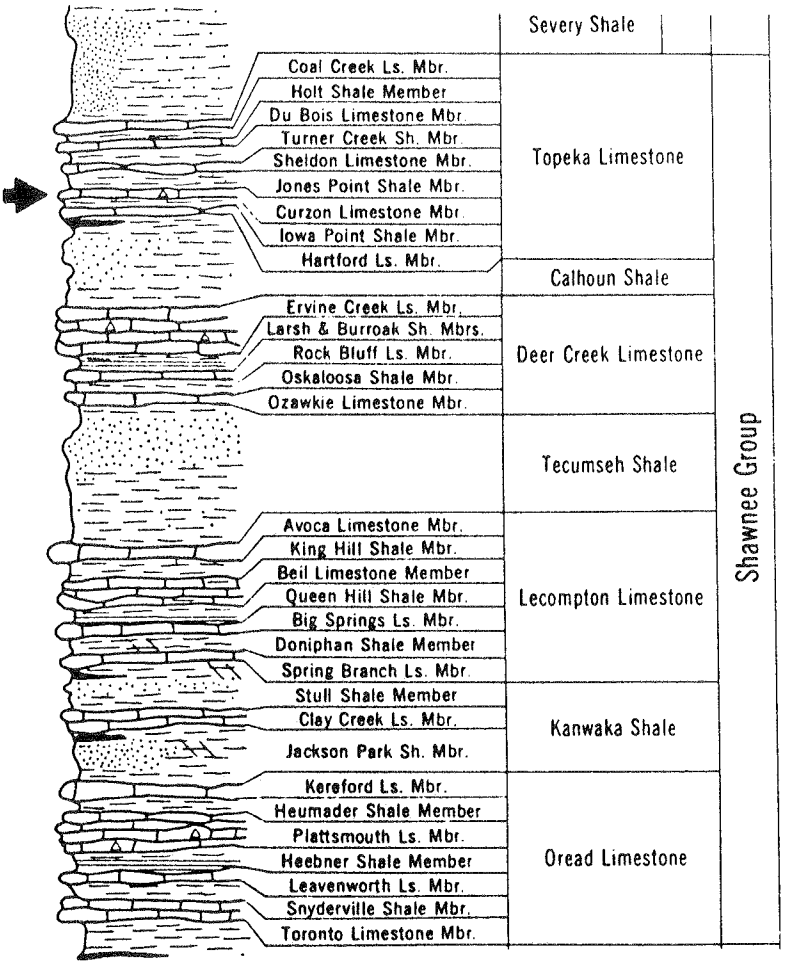
HARTFORD



10993–61

PLATE 27

CURZO



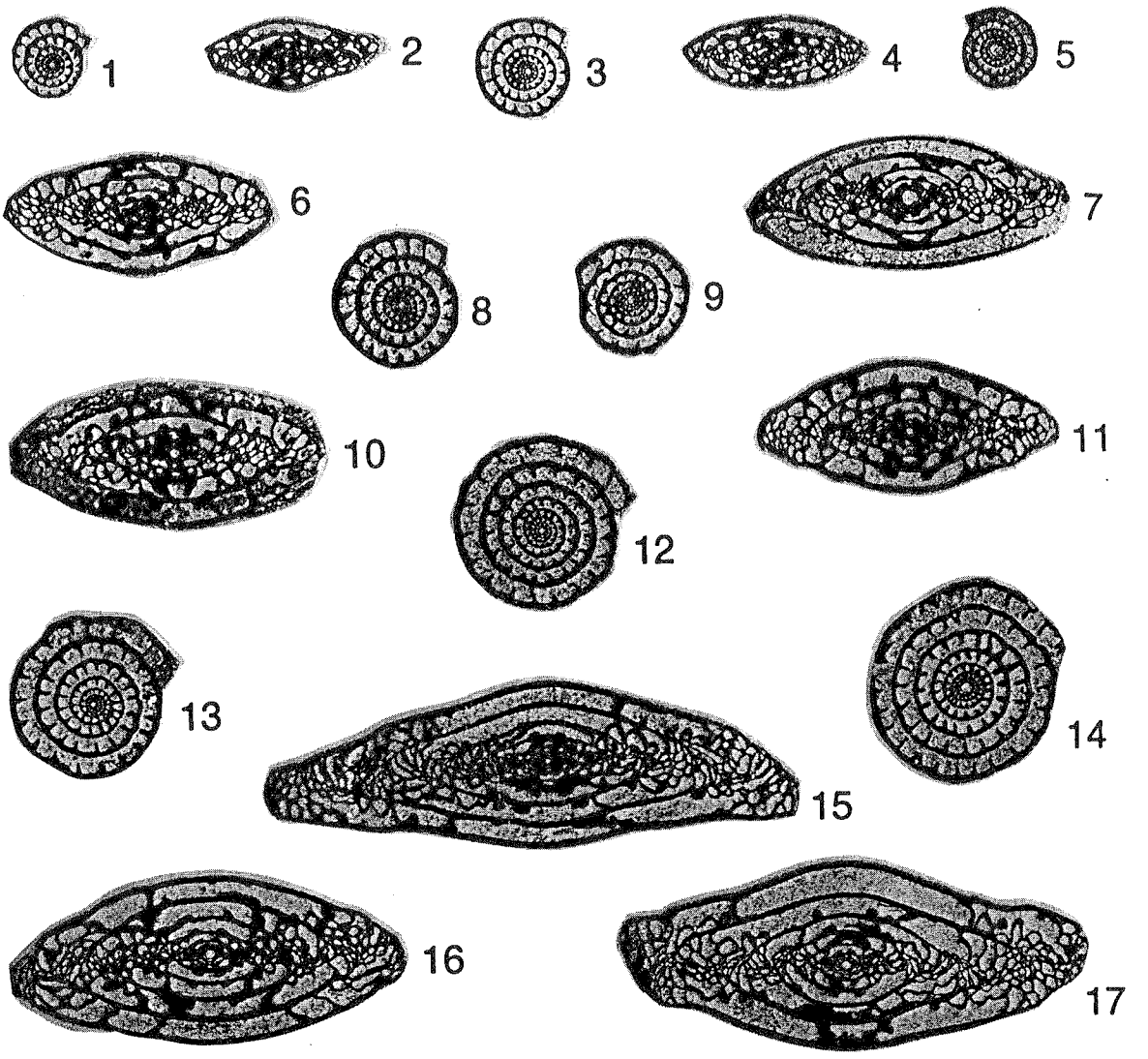
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-6, 8-11 26506 Triticites bungerensis Kauffman & Roth, 1966

Figs. 7, 12-23 26505 Triticites pierceae Kauffman & Roth, 1966

PLATE 27

CURZON



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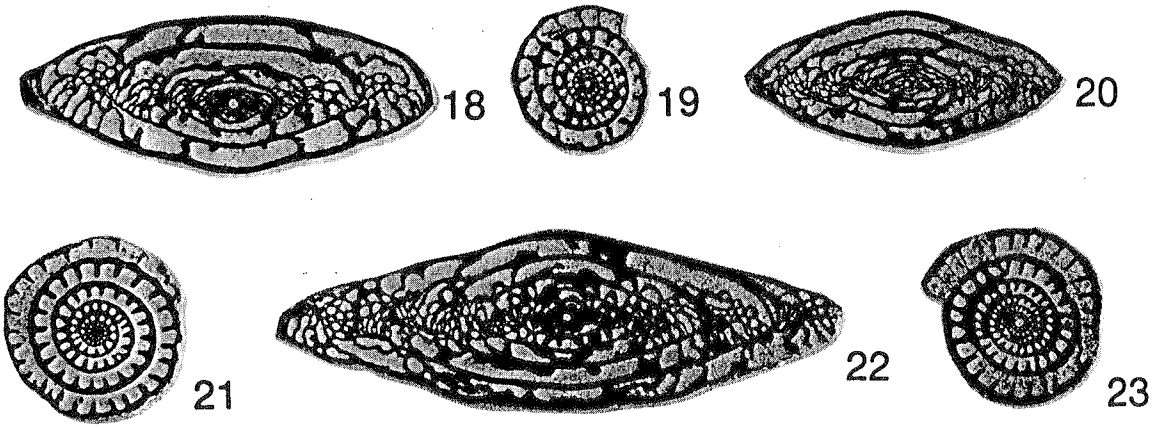
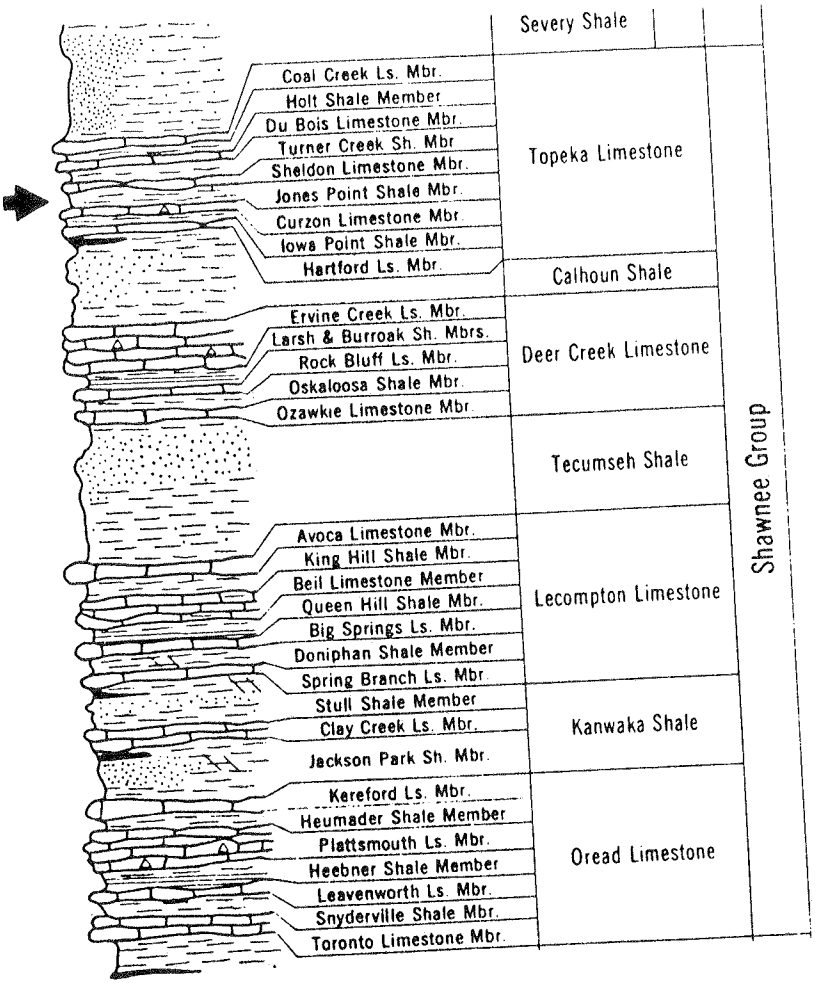


10993–62

PLATE 28

JONES POINT



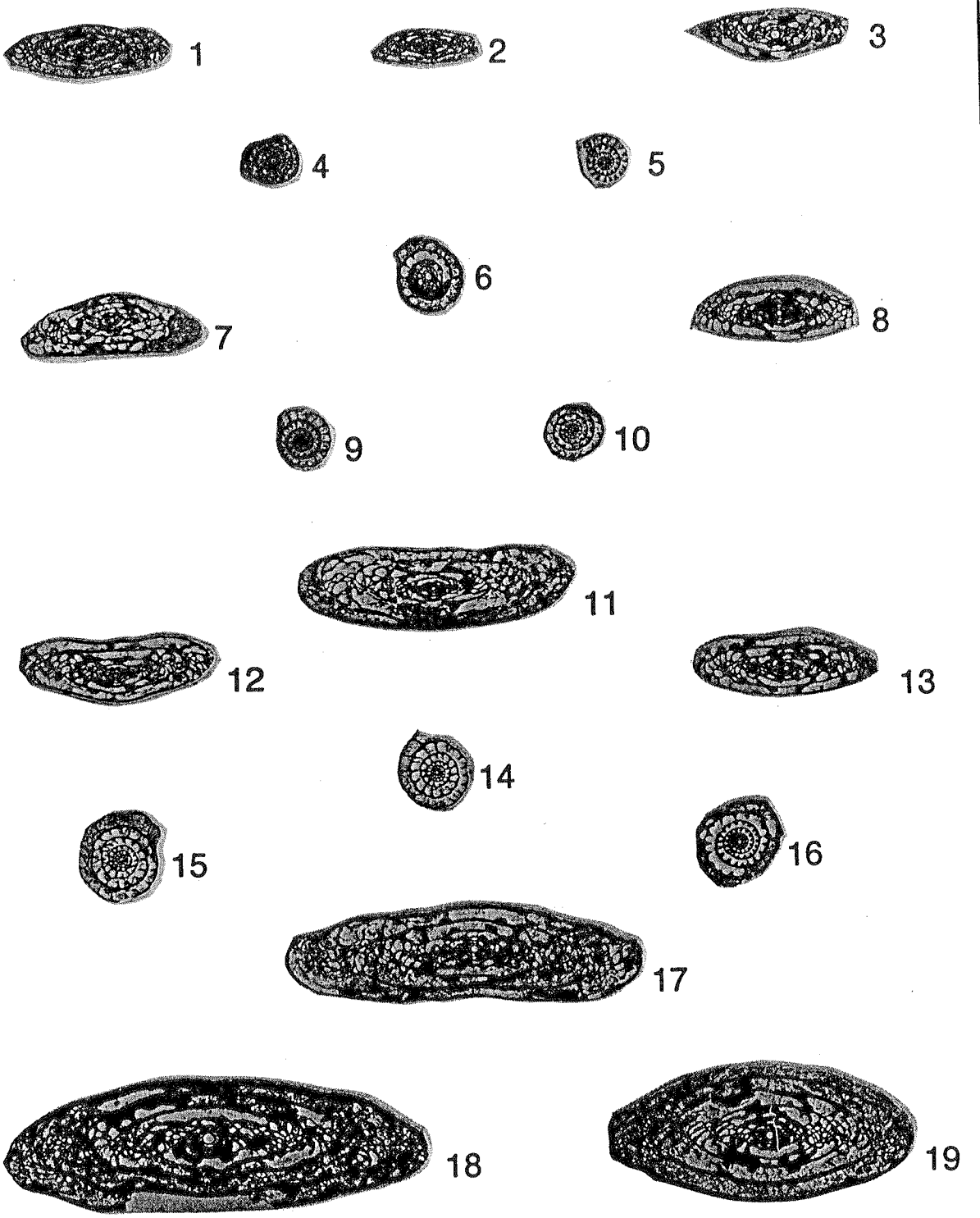
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-17 26508 Triticites postoryziformis elongata n.sp. n.var.

Figs. 18-19 26505 Triticites pierceae Kauffman & Roth, 1966

PLATE 28

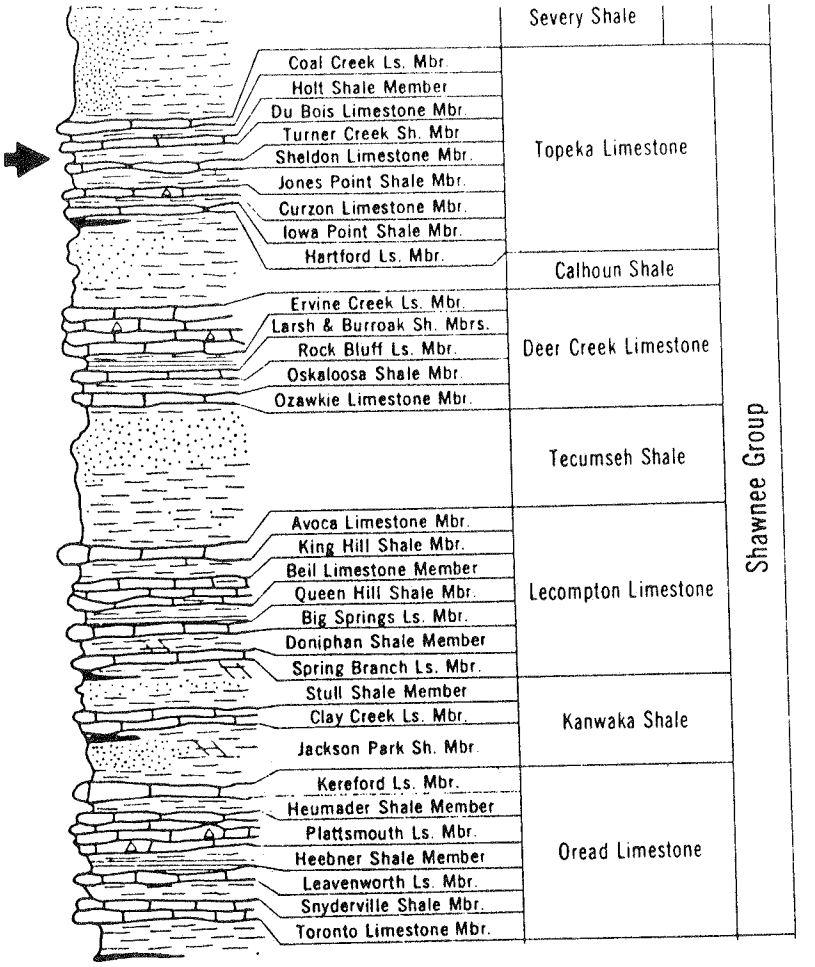
JONES POINT



10993–64

PLATE 29

TURNER CREEK

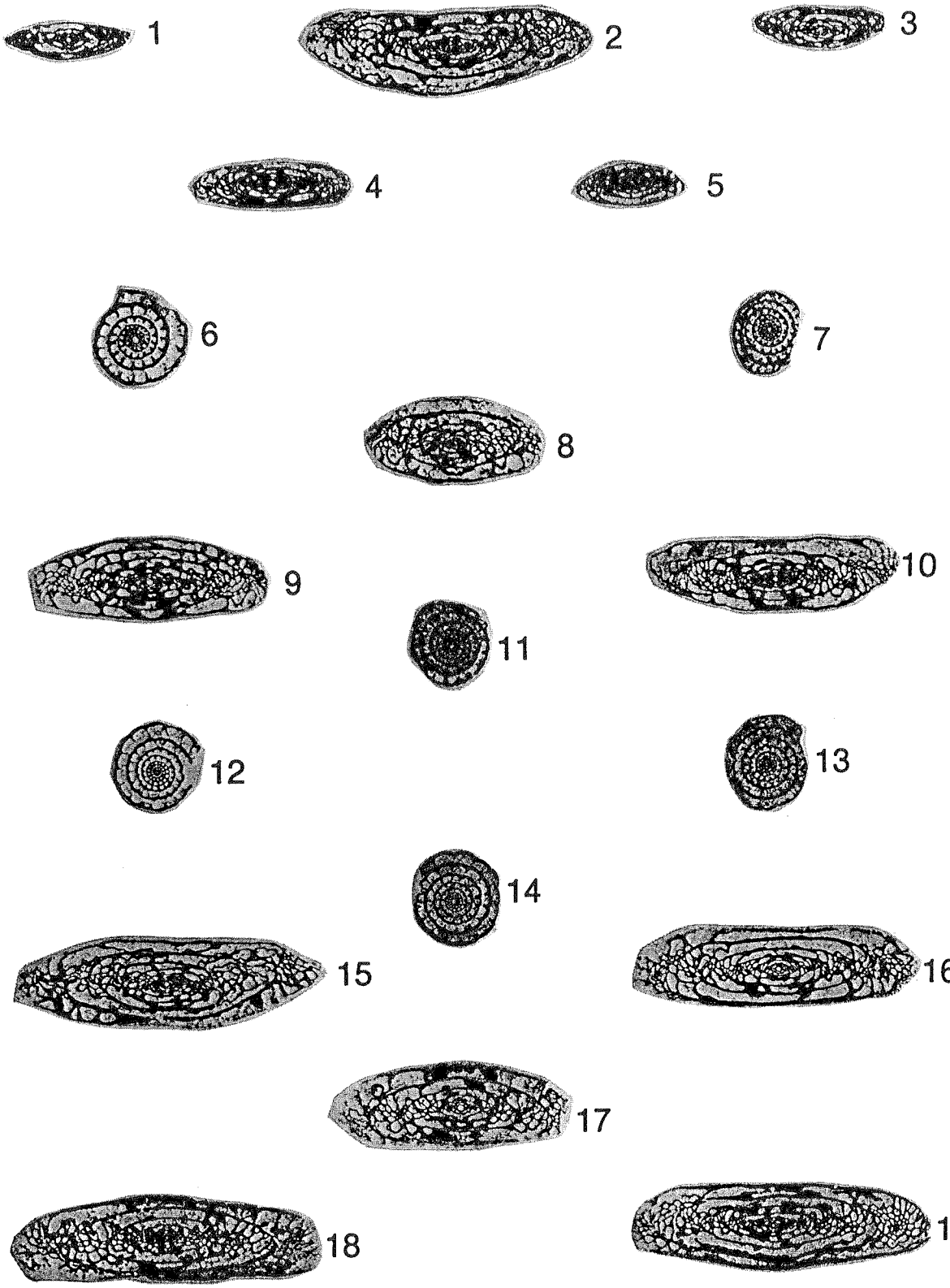


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-19 26508 Triticites postoryziformis elongata n.sp., n.var.

PLATE 29

TURNER CREEK



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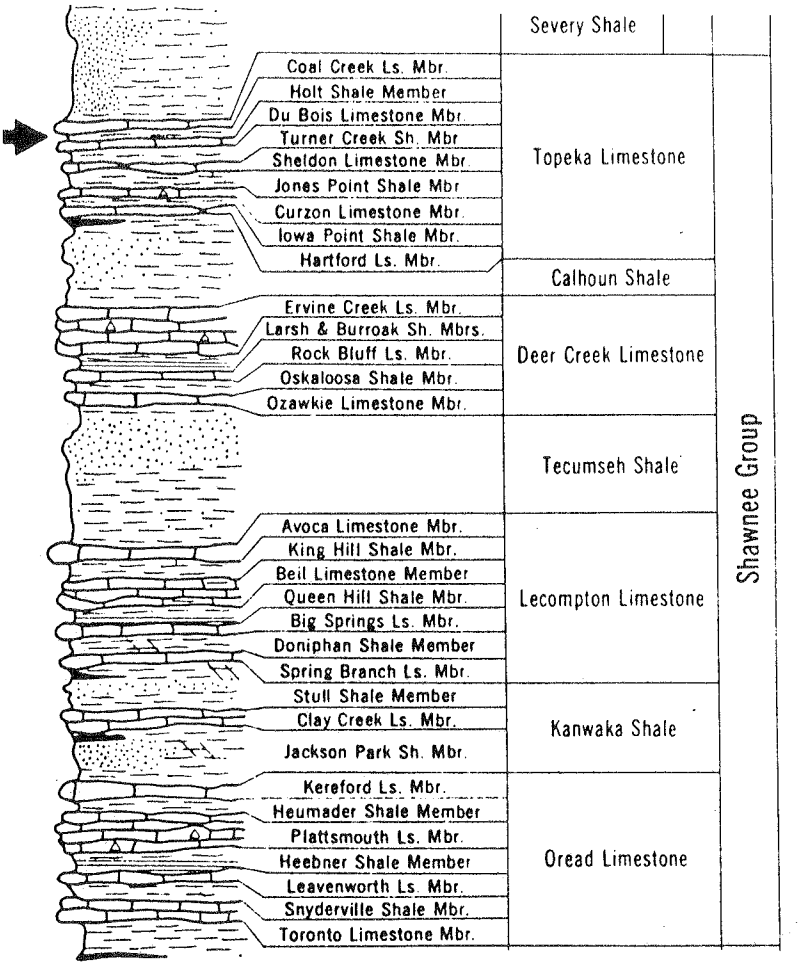
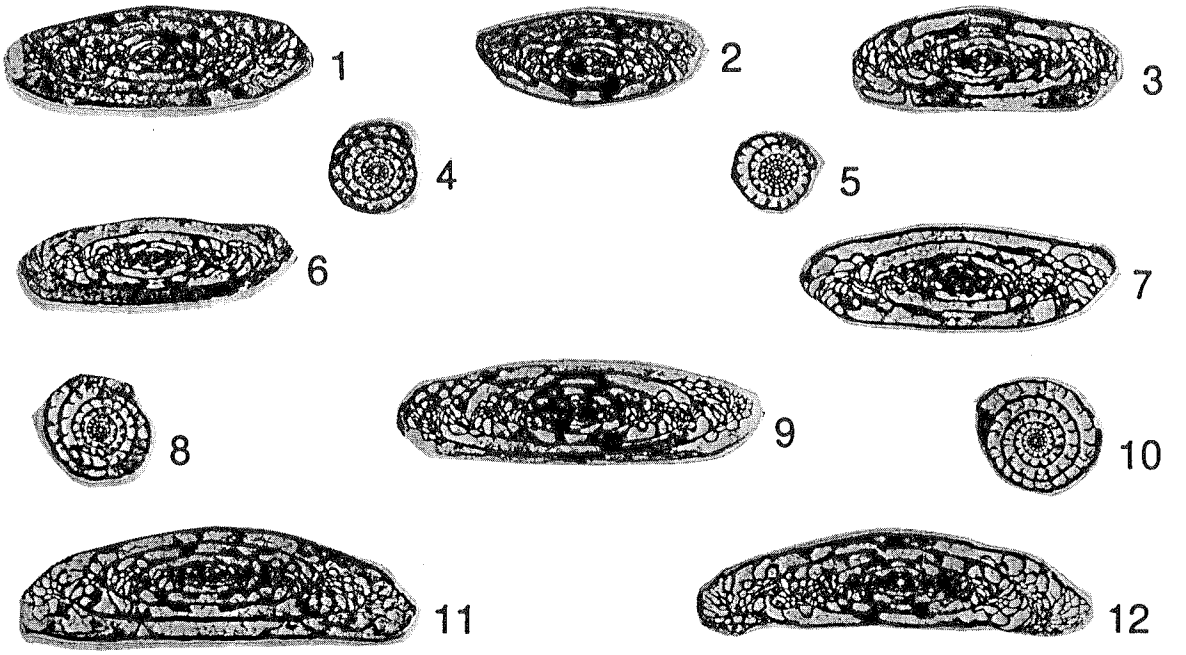


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-23 26508 Triticites postoryziformis elongata n.sp., n.var.

PLATE 30

HOLT



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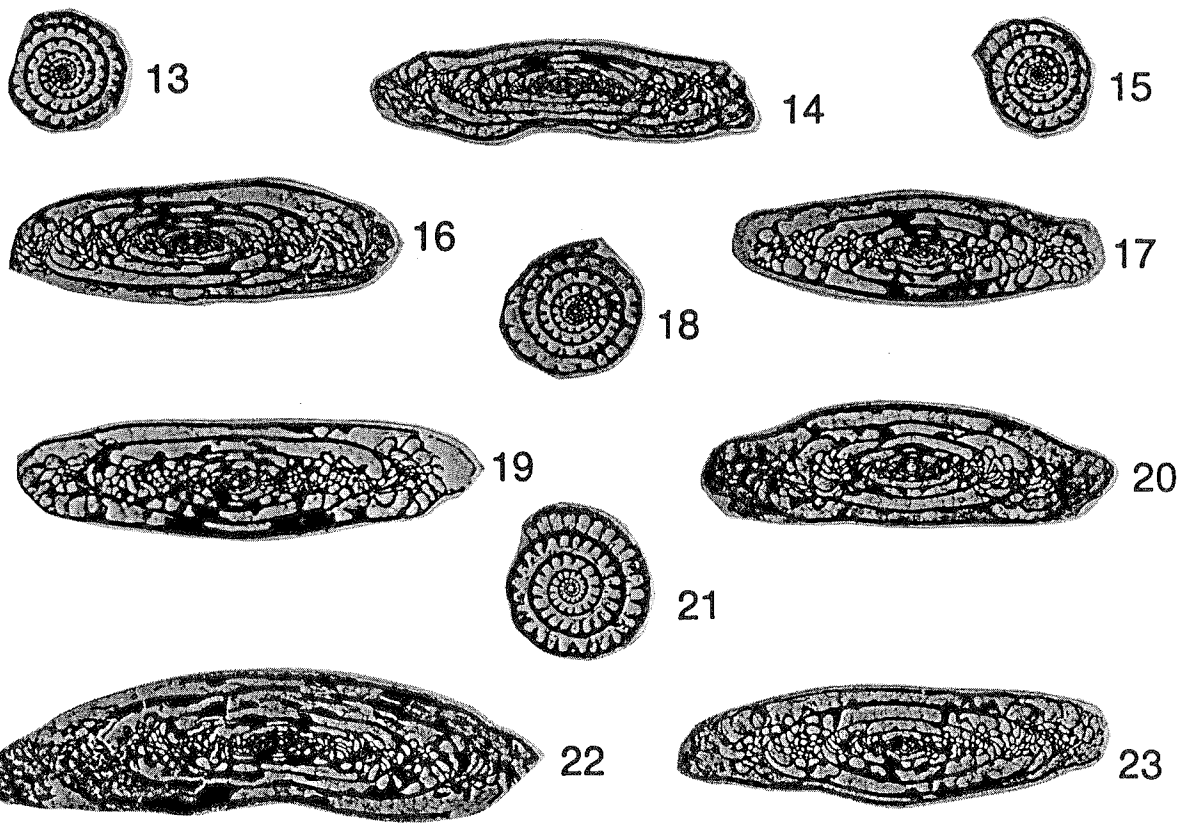
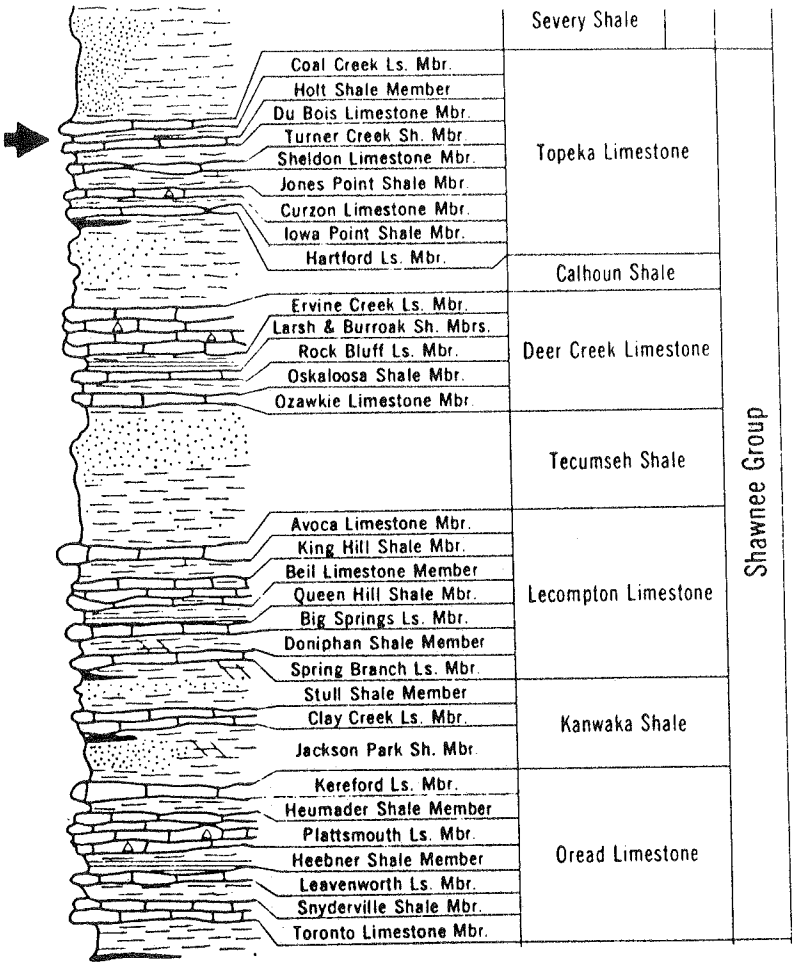


10993–72

PLATE 31



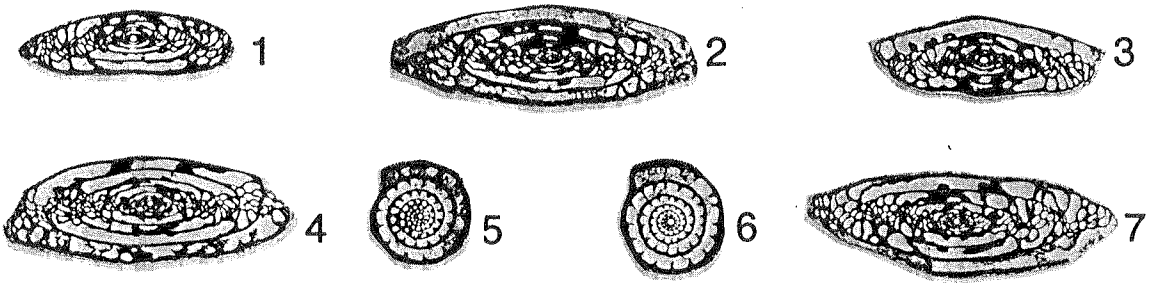
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-15 26508 Triticites postoryziformis elongata n.sp., n.var.

Figs. 16-25 26509 Triticites pseudoryziformis n.sp.

PLATE 31

HOLT



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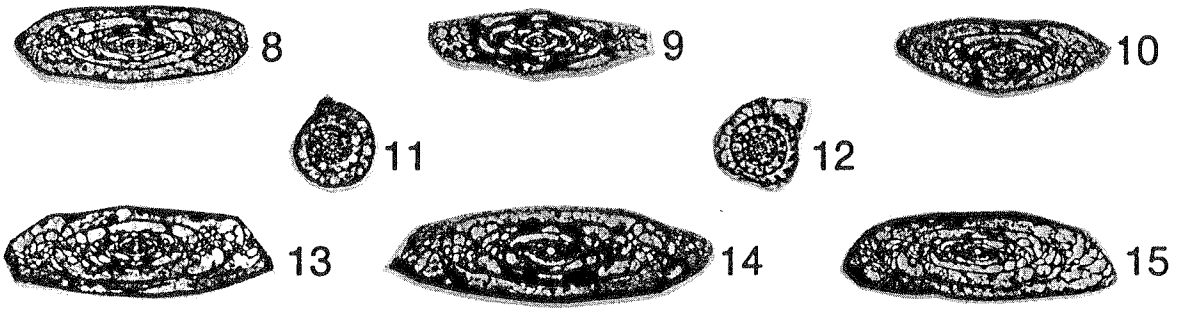

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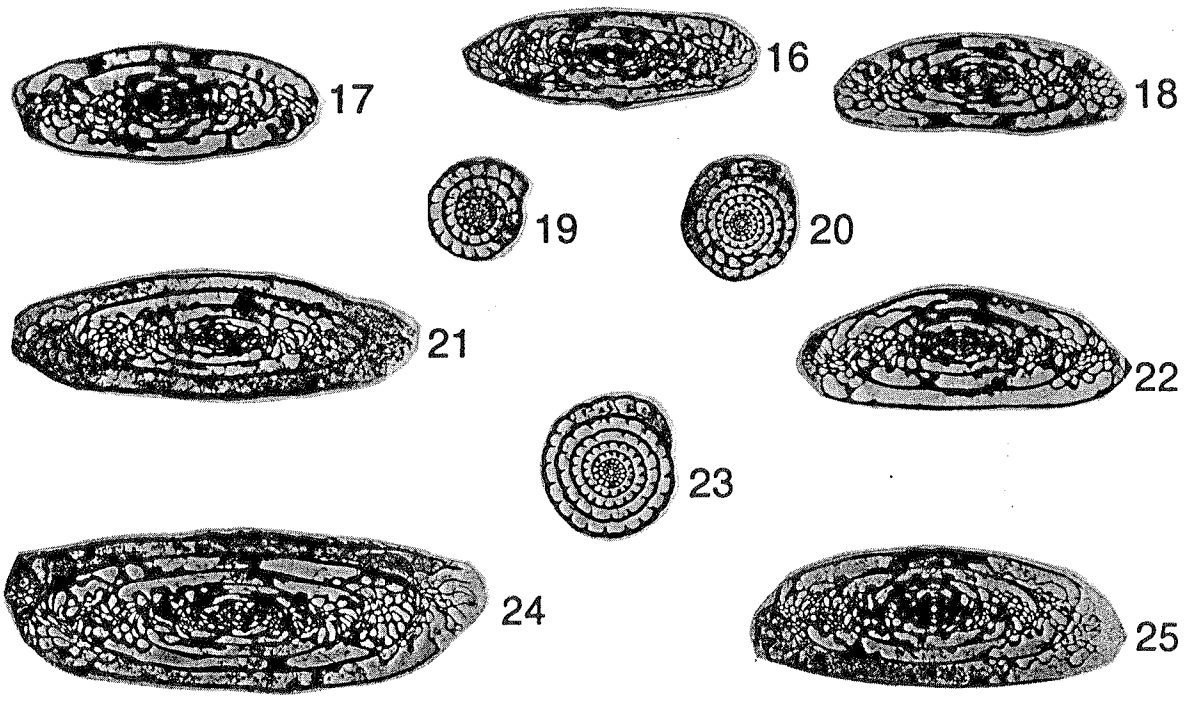
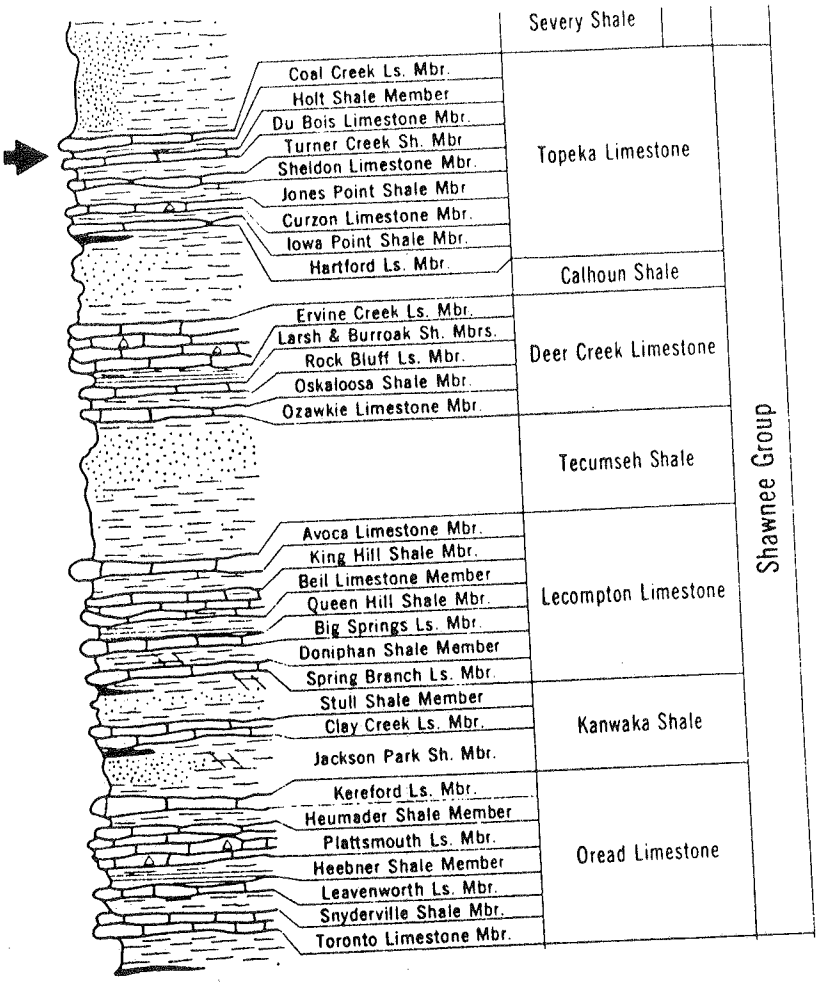


10993 74

PLATE 32



All Magnifications x10 Unless Otherwise Indicated

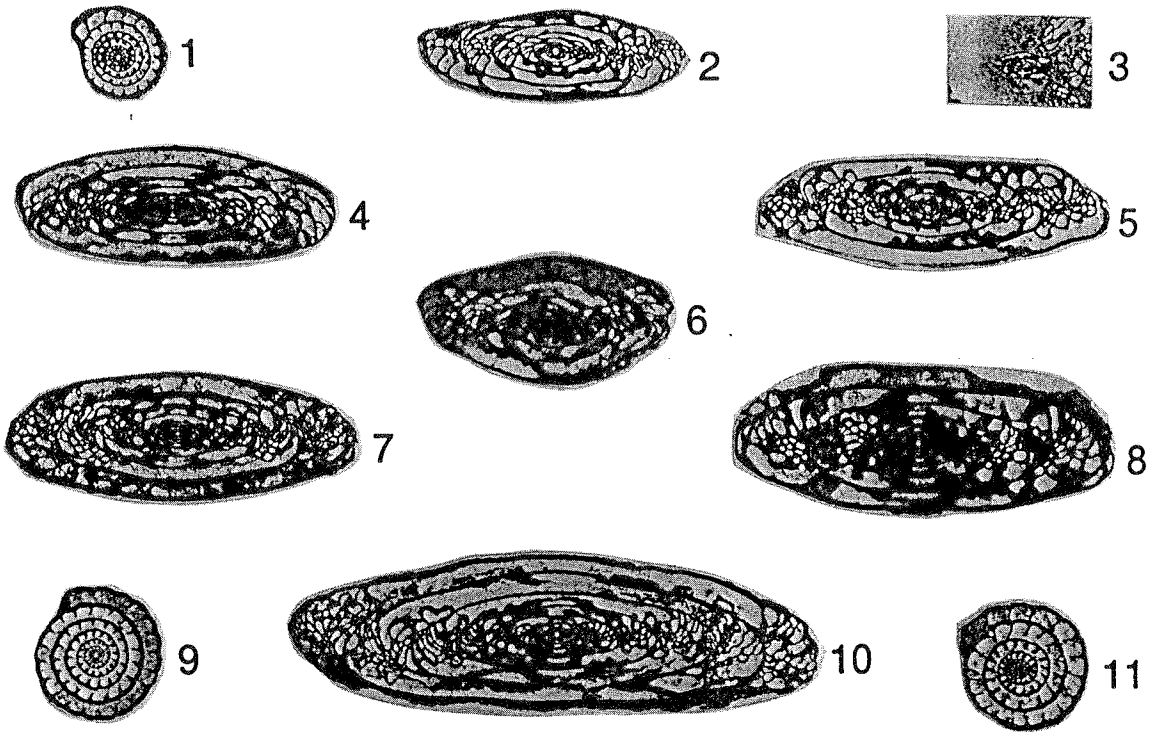
Figs. 1,2,4,5,12,14 26508 Triticites postoryziformis elongata n.sp., n.var.

Fig. 3 Microspheric juvenile Triticites

Figs. 6,13 26514 Triticites n.sp. [SP.A]

Figs. 7-11, 15-22 26509 Triticites pseudoryziformis n.sp.

PLATE 32



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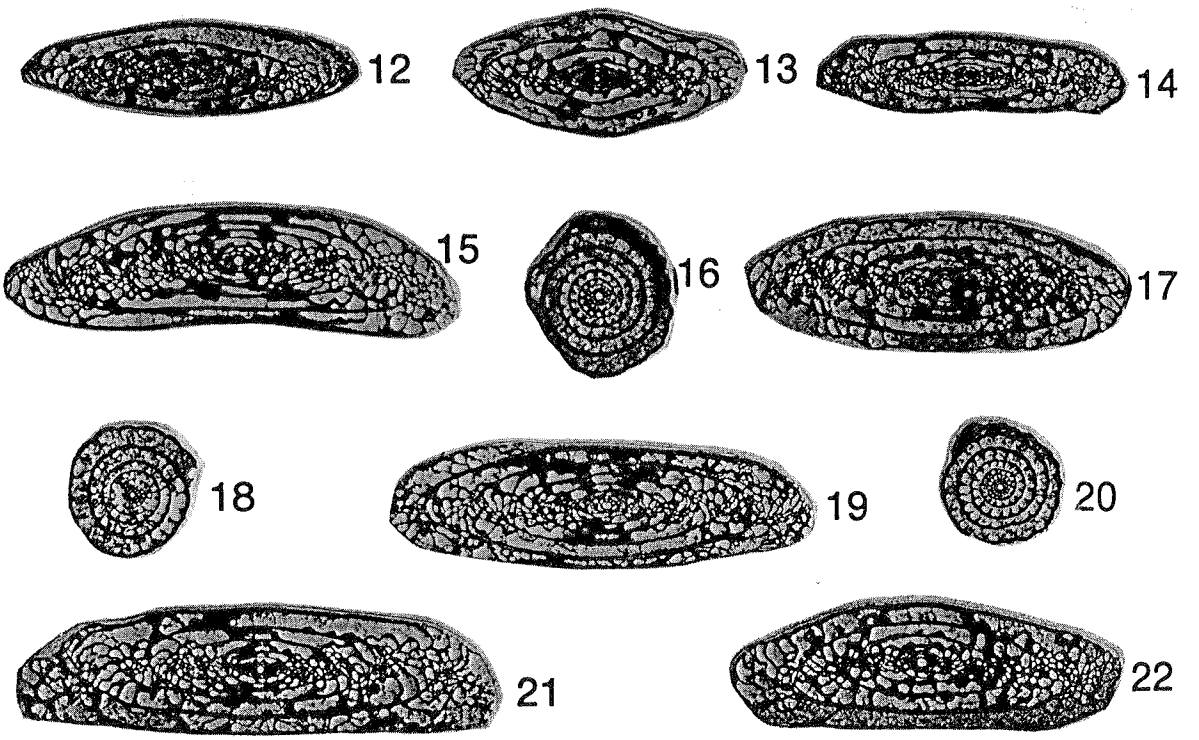
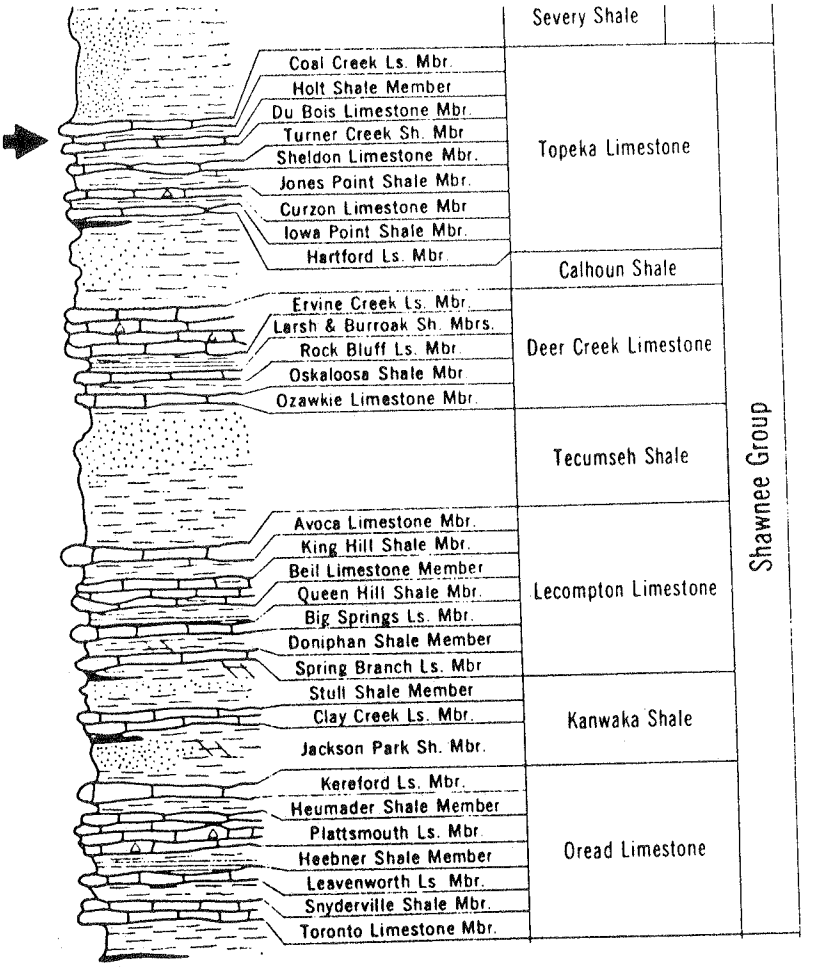


10993–77

PLATE 33



All Magnifications x10 Unless Otherwise Indicated

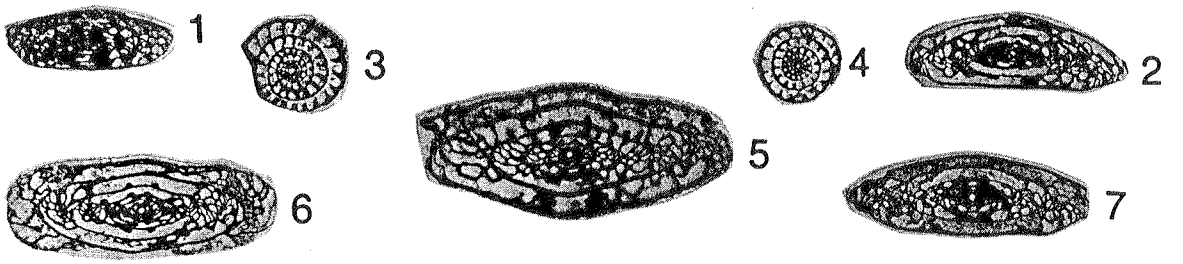
Figs. 1-4, 6,7,16,17,19,20 26508 Triticites postoryziformis elongata n.sp., n.var.

Figs. 5,13,18 26514 Triticites n.sp. [SP.A]

Figs. 8-12,14,15, 21-23 26509 Triticites pseudoryziformis n.sp.

PLATE 33

HOLT



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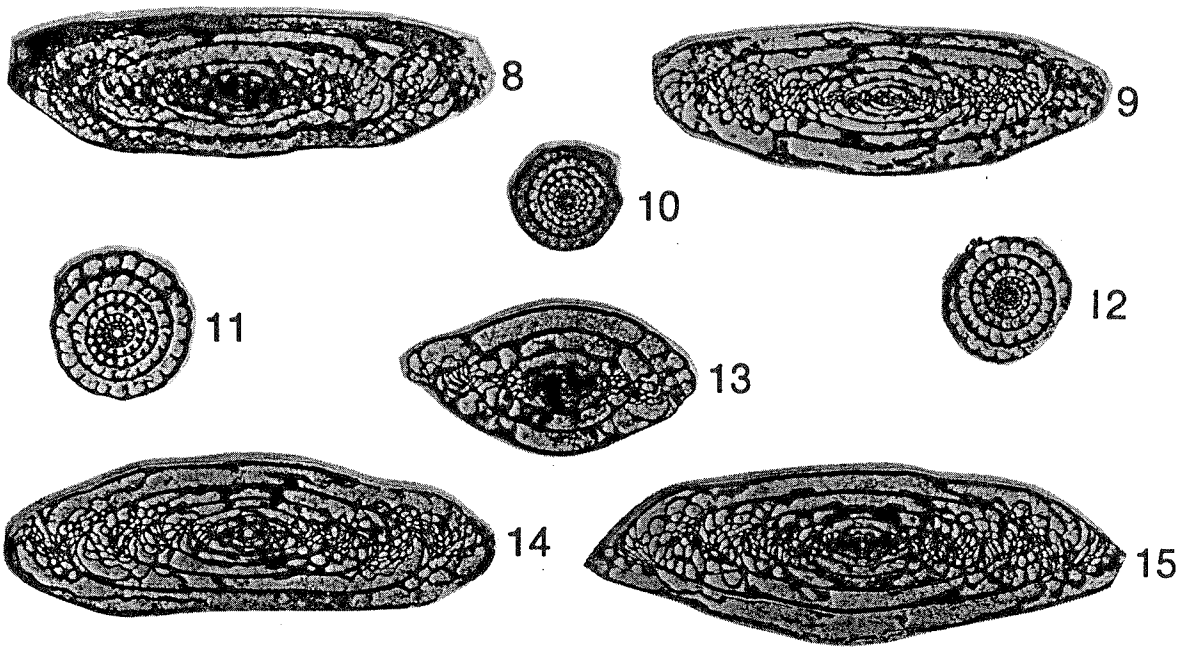
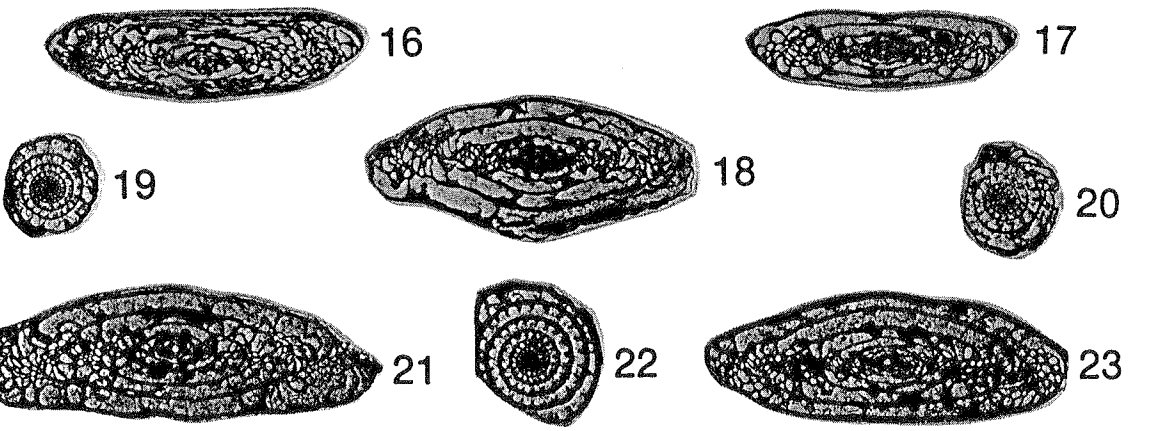


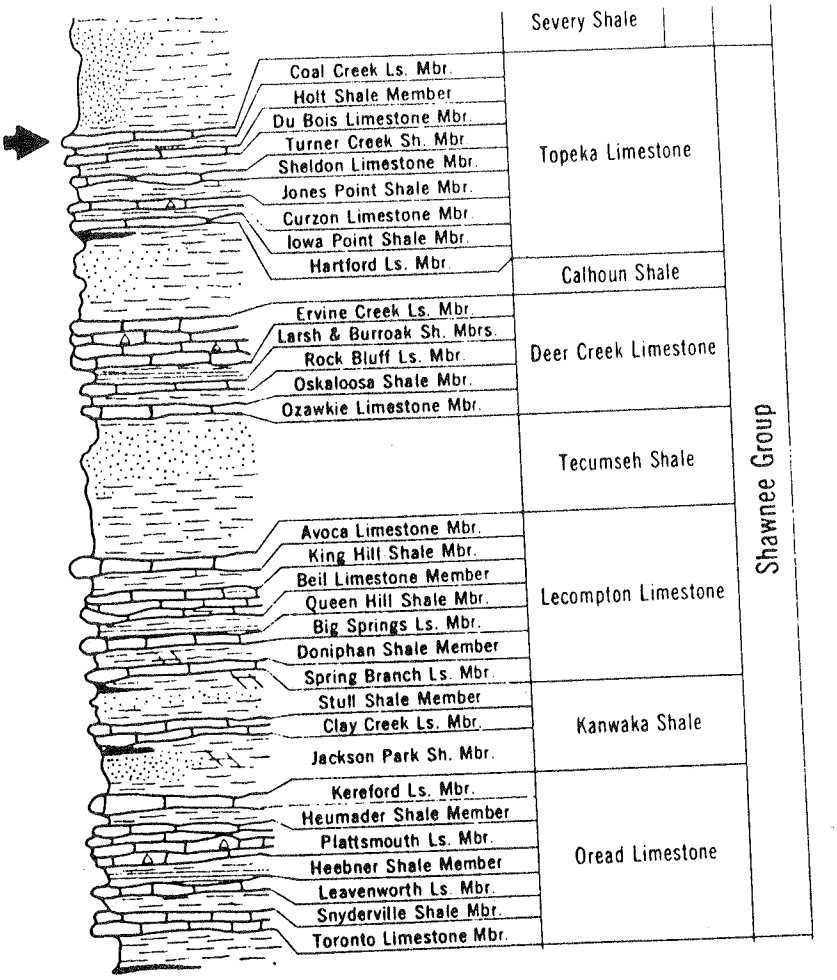
10993–80



10993–79

PLATE 34

COAL CREEK



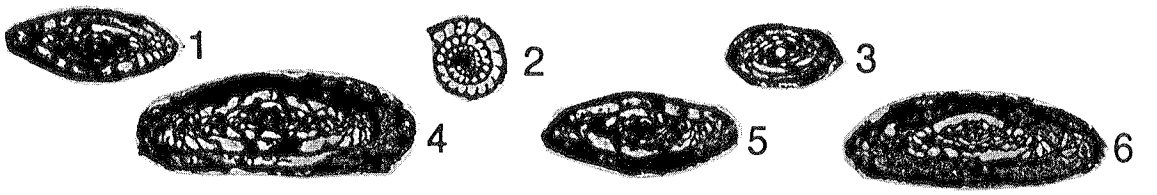
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-6, 16,17,19 26514 Triticites n.sp. [SP.A]

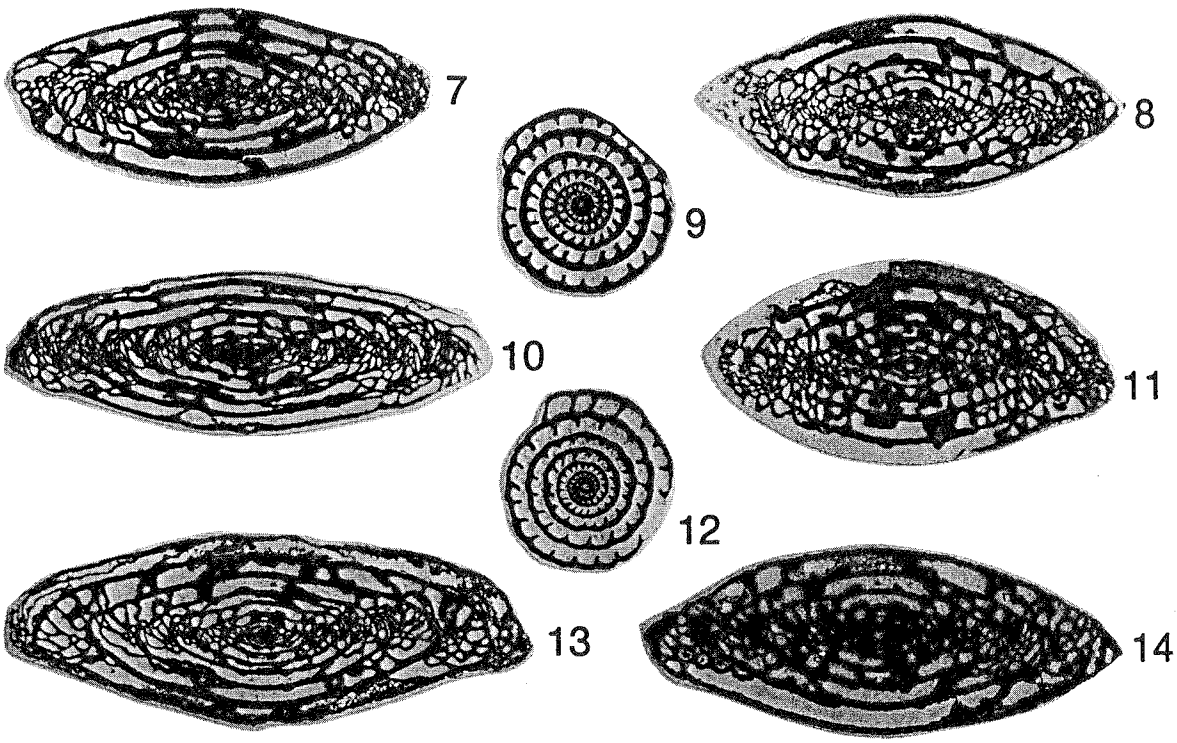
Figs. 7-15, 18,20 26500 Triticites cullomensis Dunbar & Condra, 1927

PLATE 34

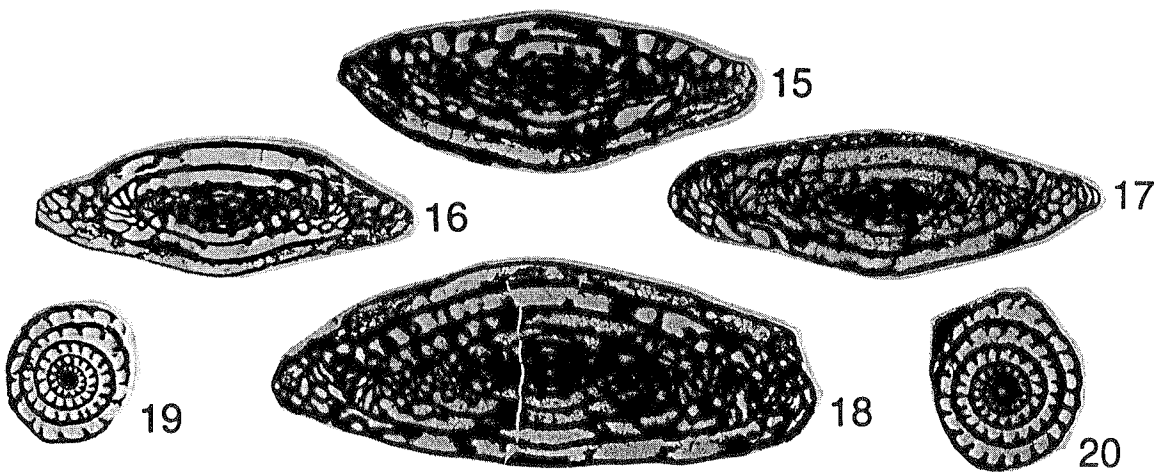
COAL CREEK



10993–85



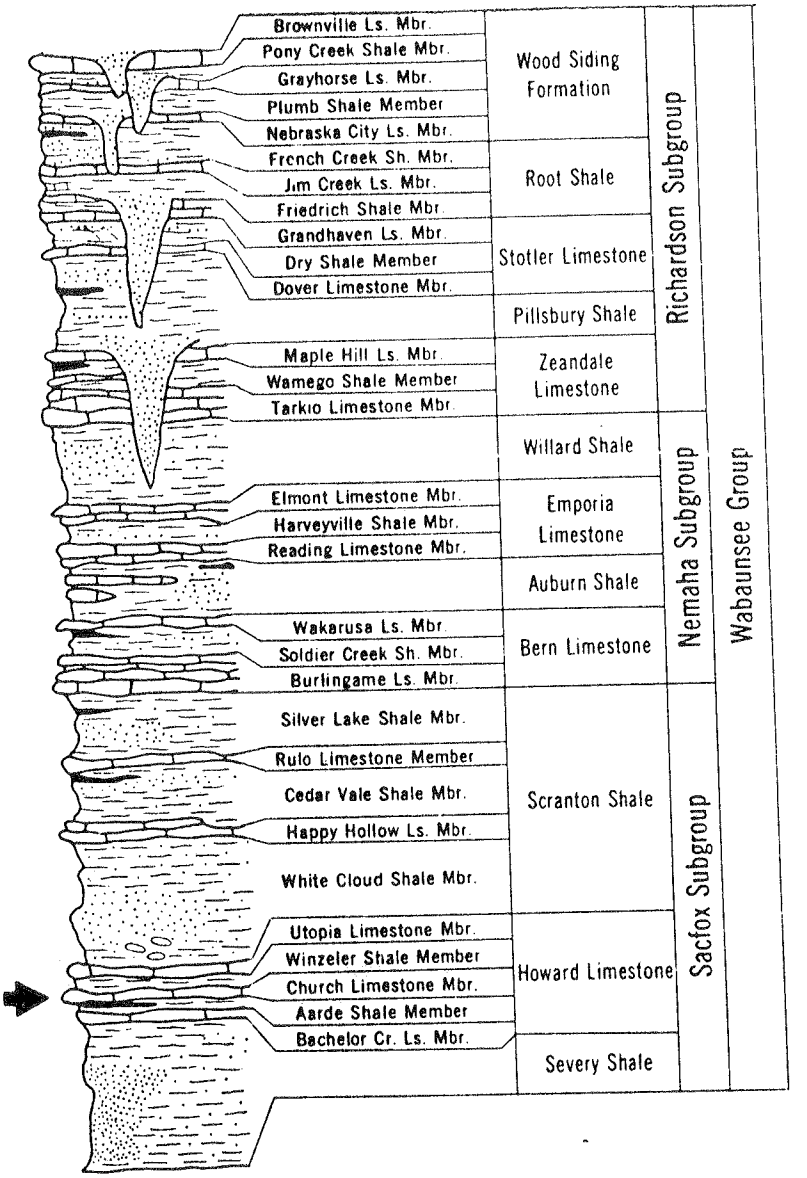
10993–84



10993–83

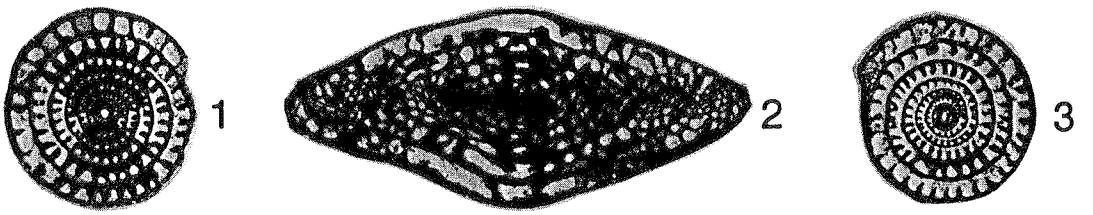
PLATE 35

CHURCH

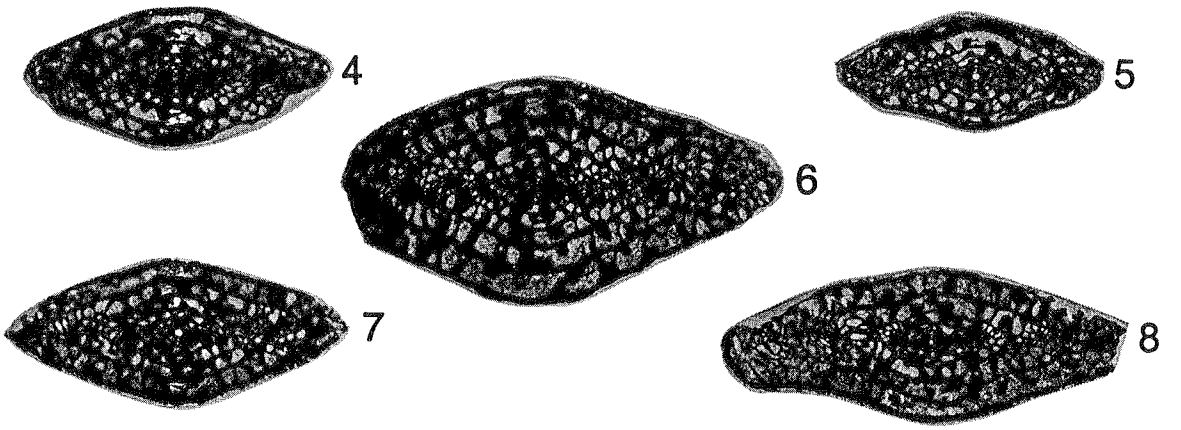


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-8 26511 Triticites postcallosus n.sp.

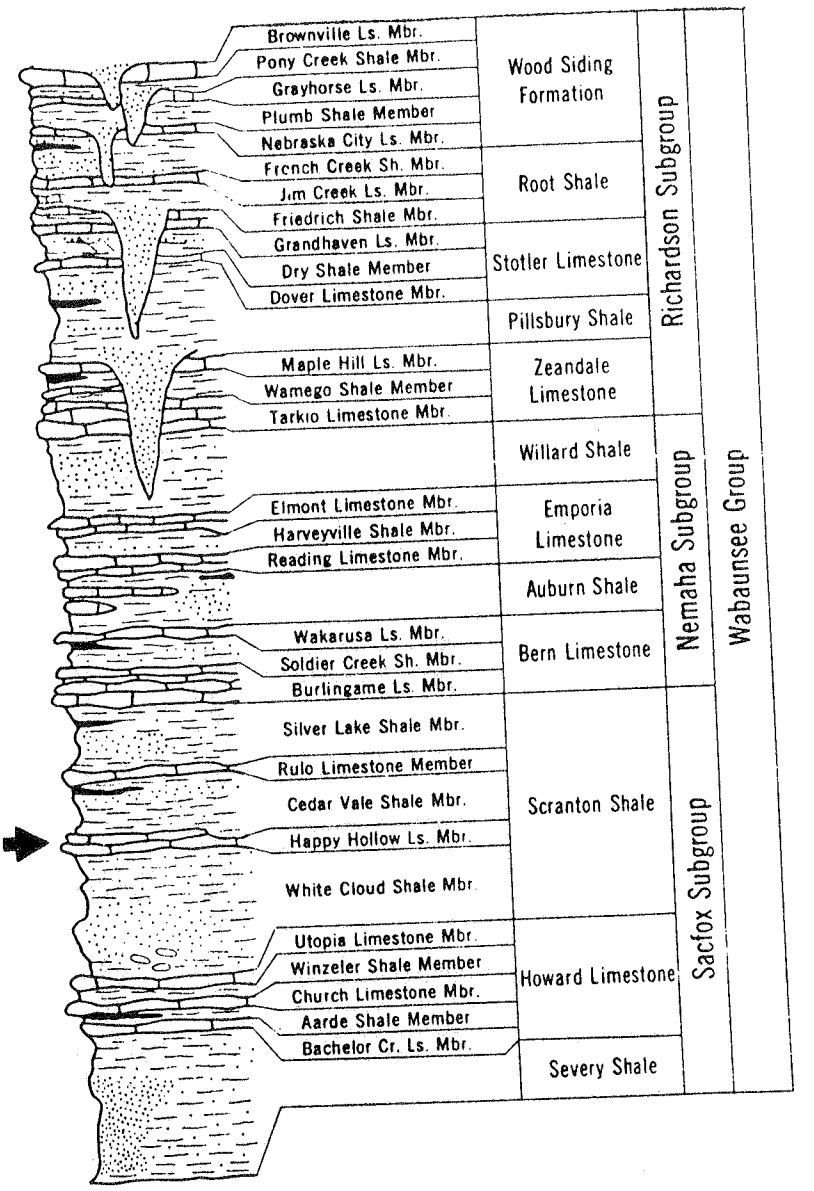


10993–90



10993–89

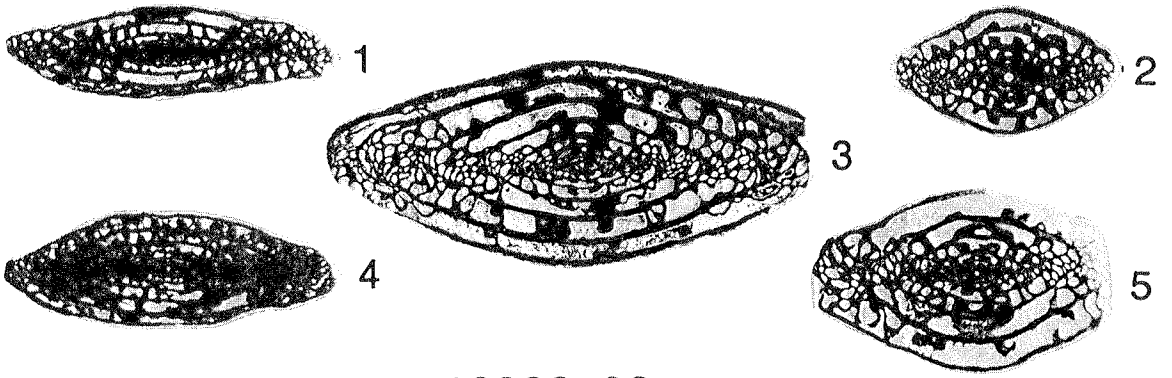
PLATE 36 LOWER HAPPY HOLLOW



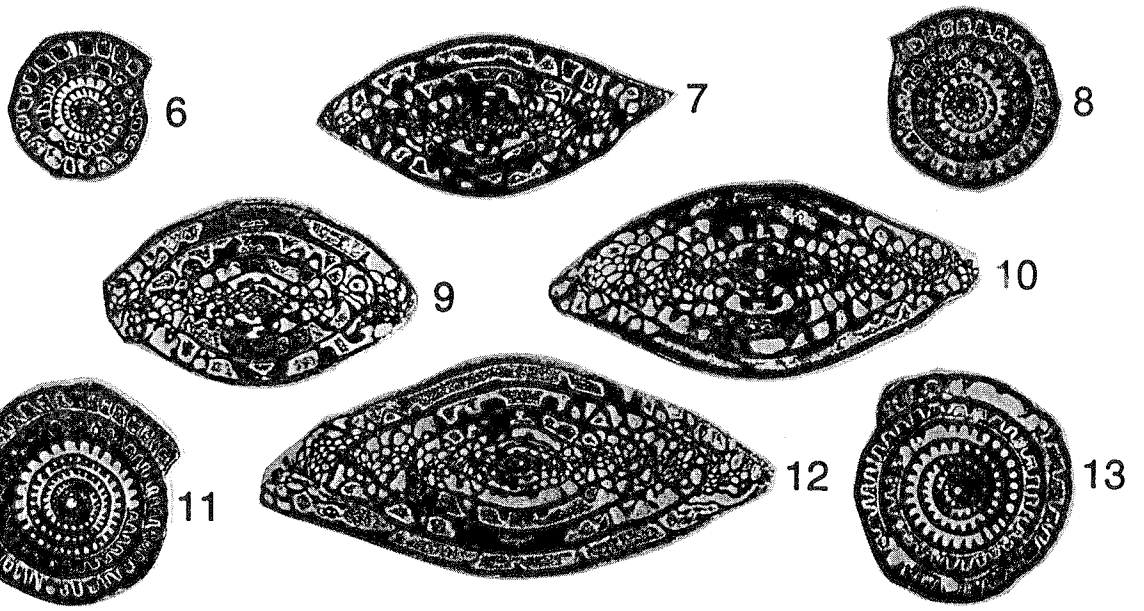
All Magnifications x10 Unless Otherwise Indicated

Fig. 1	26476	Dunbarinella wildei Kauffman & Roth, 1966
Fig. 2	26513	Triticites happyhollowensis n.sp. [immature]
Fig. 3	26515	Triticites n.sp. [SP.B]
Figs. 4,14,16	22321	Dunbarinella ervinensis Thompson, 1942
Fig. 5	26504	Triticites beedei Dunbar & Condra, 1927
Fig. 6,9	26512	Triticites plummeri Dunbar & Condra, 1927
Fig. 7,8,12,13,15,17	26504	Triticites beedei Dunbar & Condra, 1927
Fig. 10,11	26513	Triticites happyhollowensis n.sp.

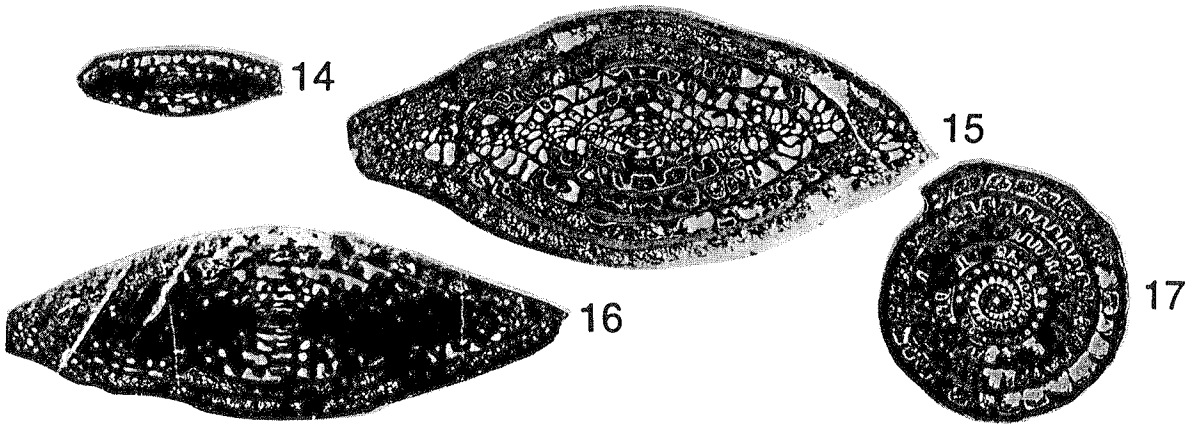
PLATE 36 LOWER HAPPY HOLLOW



10993–98



10993–97



10993–96

PLATE 37 UPPER HAPPY HOLLOW

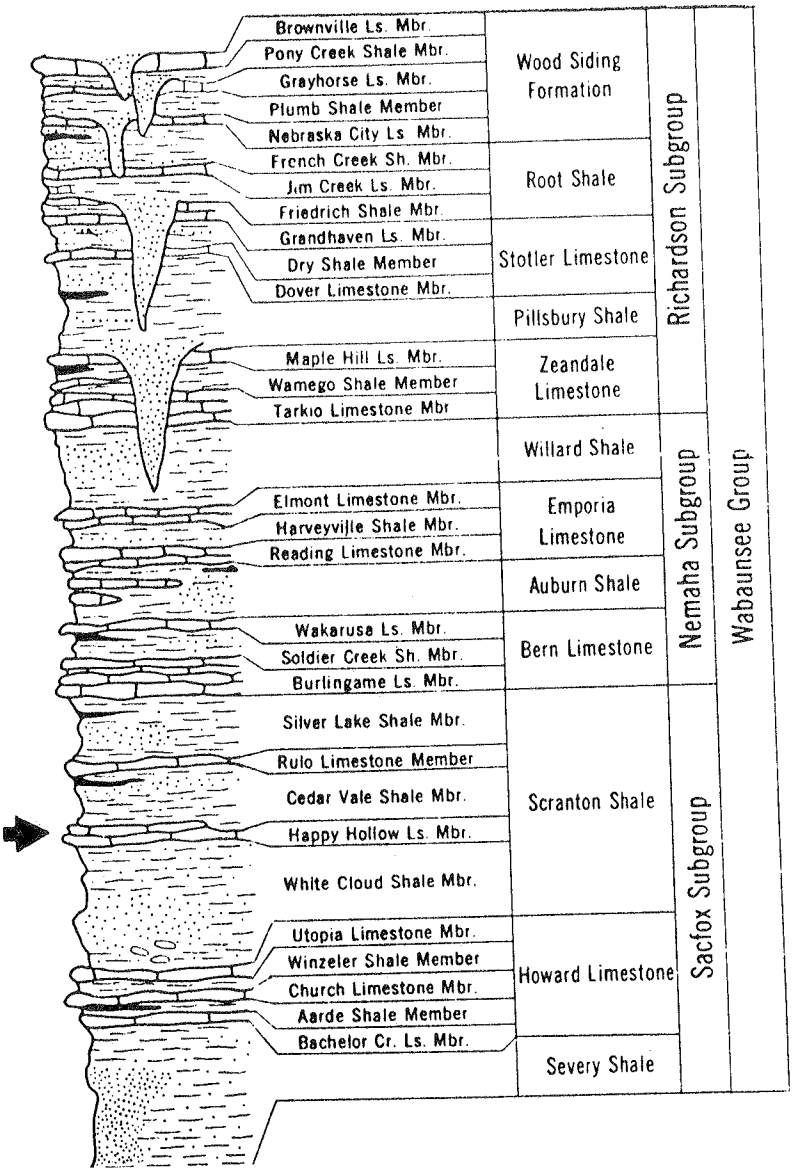


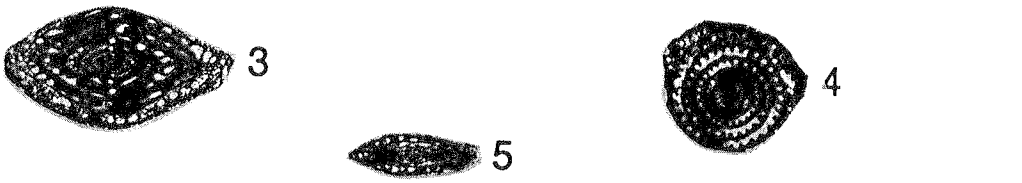
PLATE 37 All Magnifications x10 Unless Otherwise Indicated

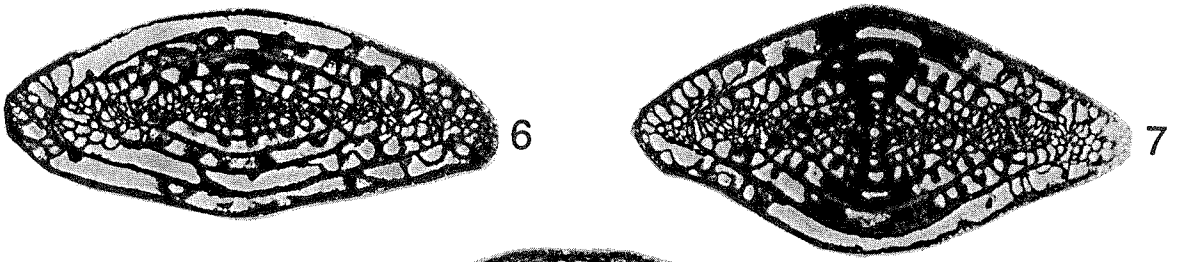
Figs. 1,2	26516	Triticites n.sp. [SP.C]
Figs. 3,4	26617	Triticites [microspheric form]
Fig. 5	26477	Dunbarinella [immature specimen]
Fig. 6	26515	Triticites n.sp. [SP.B]
Figs. 7-10, 12,13	26513	Triticites happyhollowensis n.sp.
Fig. 11	26512	Triticites plummeri Dunbar & Condra, 1927

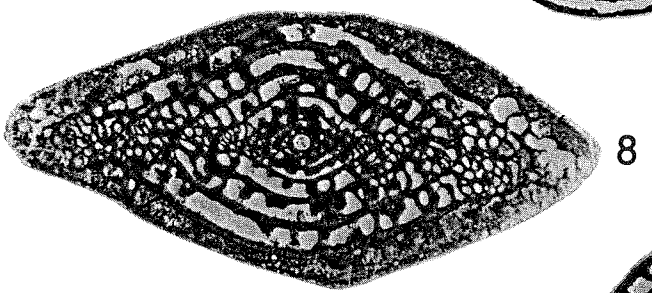
PLATE 37

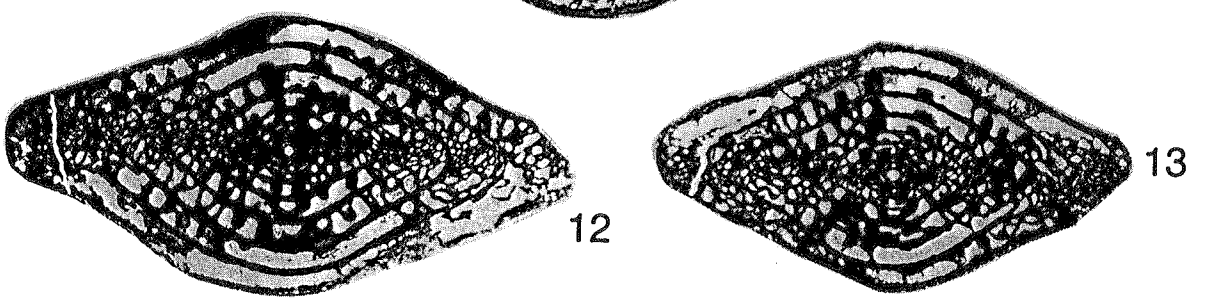
UPPER HAPPY HOLLOW

10993–100

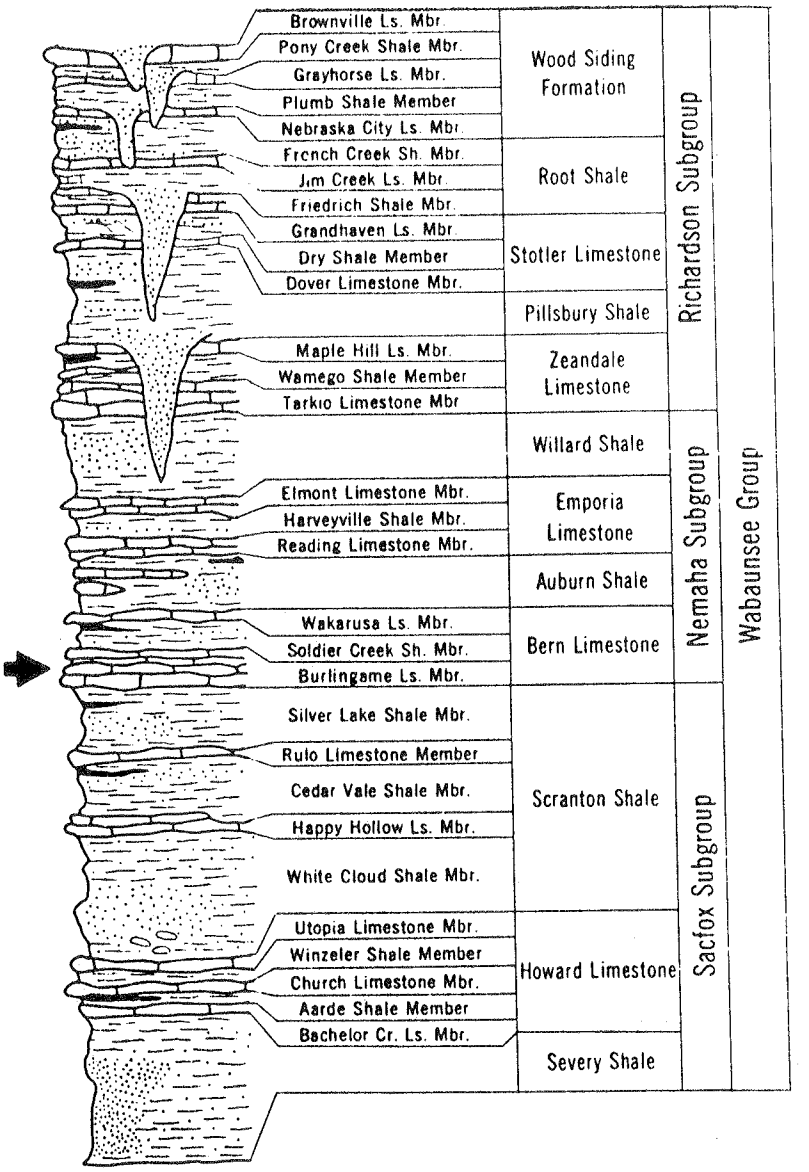








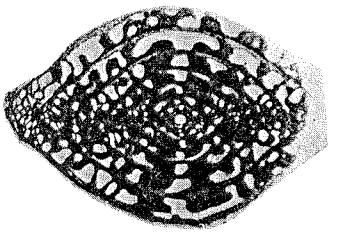
10993–99



All Magnifications x10 Unless Otherwise Indicated

Figs. 1, 3-10 26513 Triticites happyhollowensis n.sp.

Figs. 2,4 26617 Triticites [microspheric form]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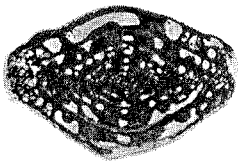
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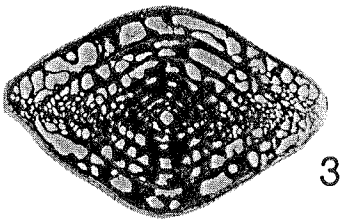
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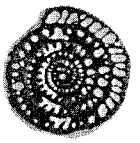
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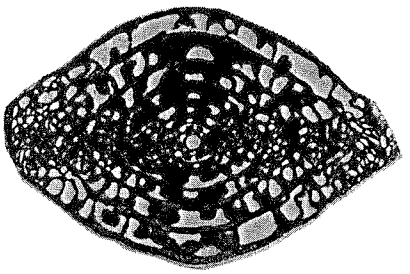
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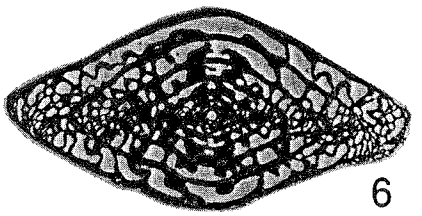
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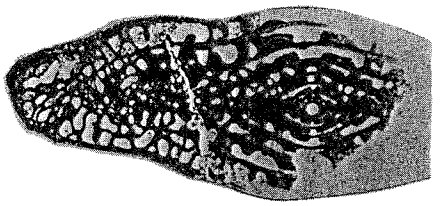
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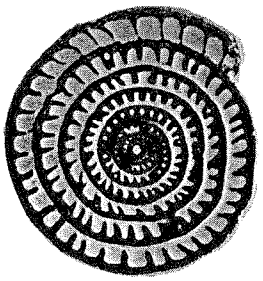
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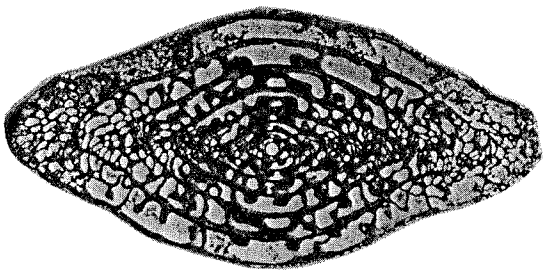
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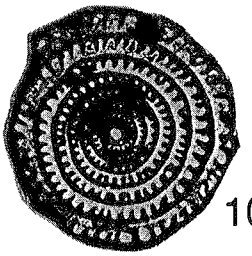
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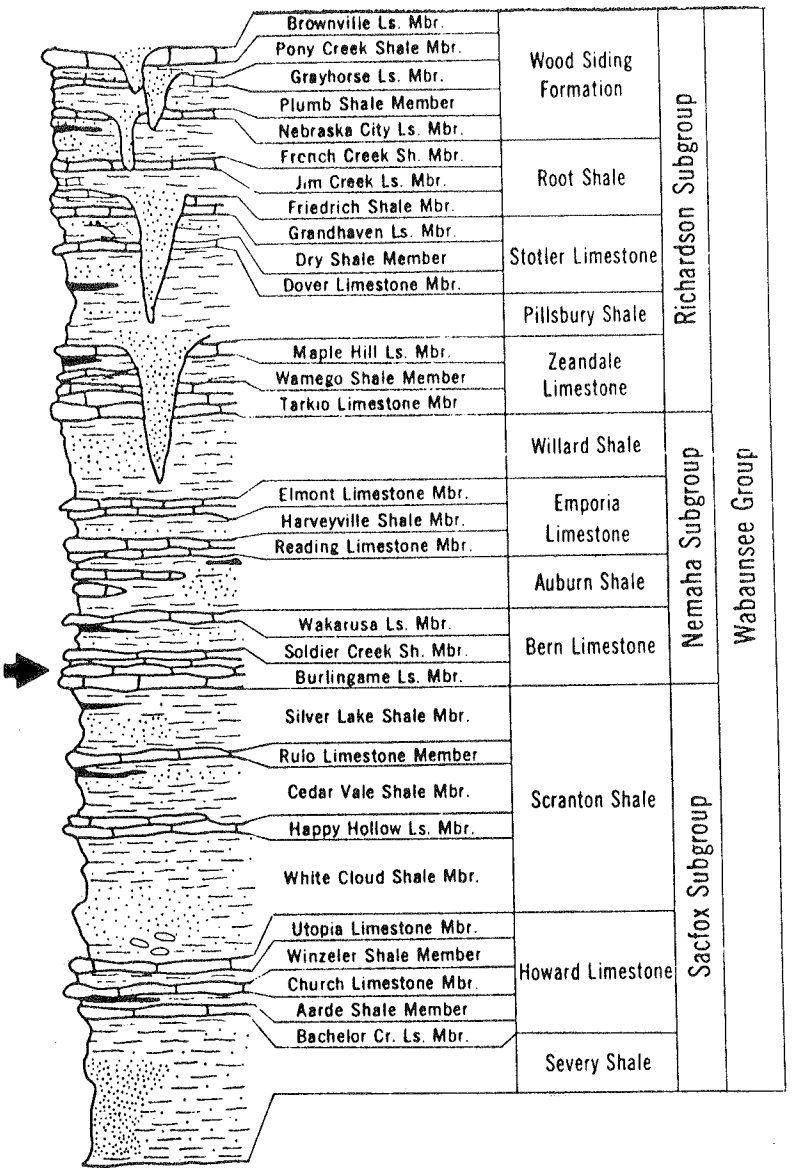
PLATE 38B

BURLINGAME



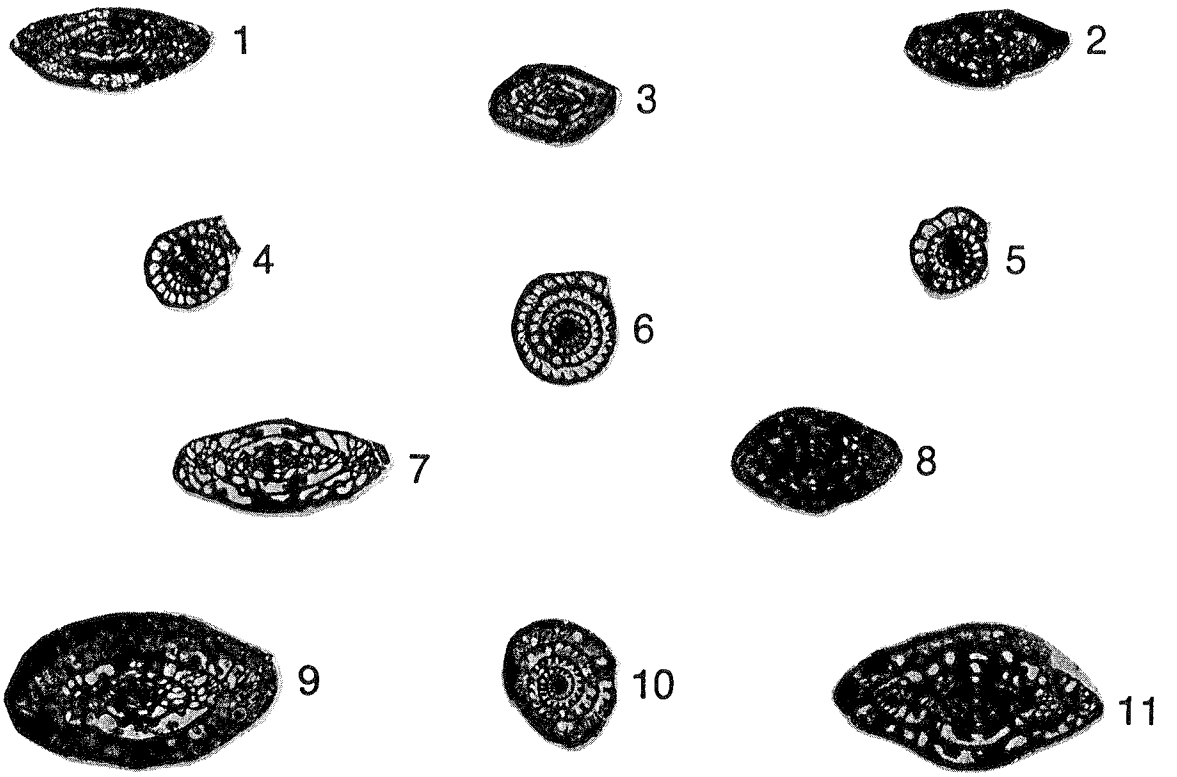
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-7, 10, 12-14,16,17 26514 Triticites n.sp. [SP.A]

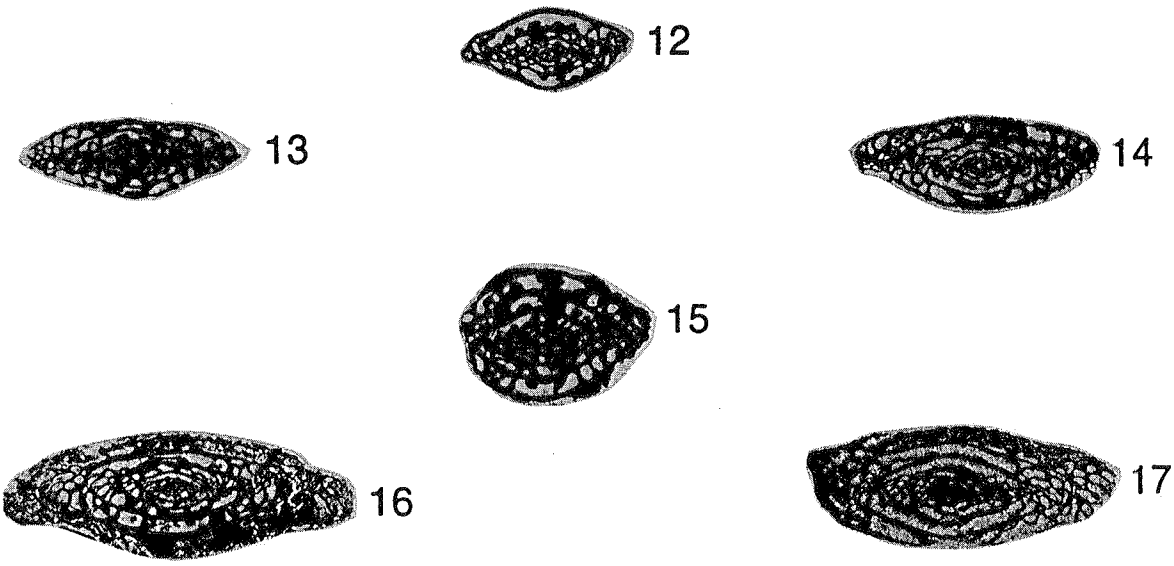
Fig. 8 26617 Triticites [microspheric form]

Figs. 9,11,15 26504 Triticites beedei Dunbar & Condra, 1927

PLATE 38B BURLINGAME



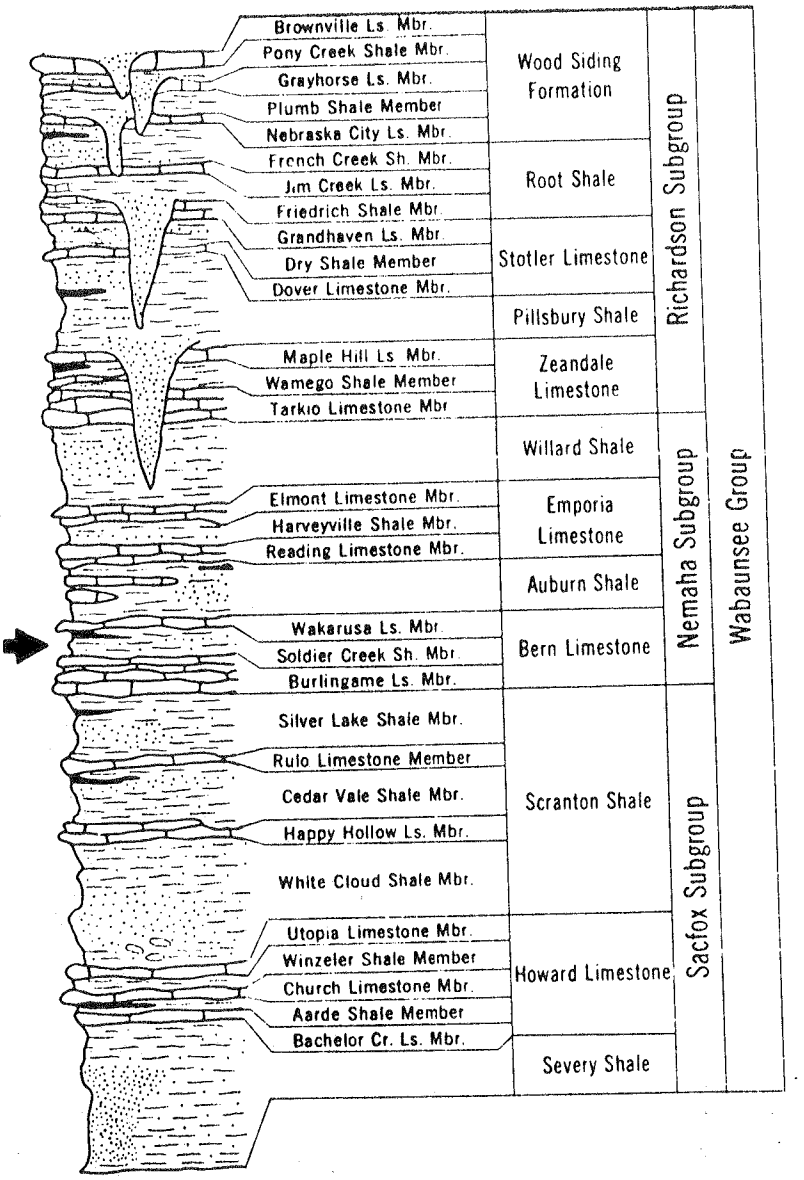
10993–111



10993–110

PLATE 39

SOLDIERS CREEK



All Magnifications x10 Unless Otherwise Indicated

Figs. 1,2, 4-6 26514 Triticites n.sp. [SP.A]

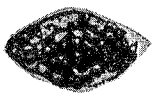
Fig. 3 26617 Triticites [microspheric form]

Figs. 7,8 26517 Triticites n.sp. [SP.D]

PLATE 39

SOLDIERS CREEK

1



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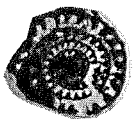

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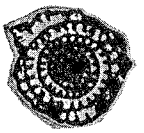


5

6

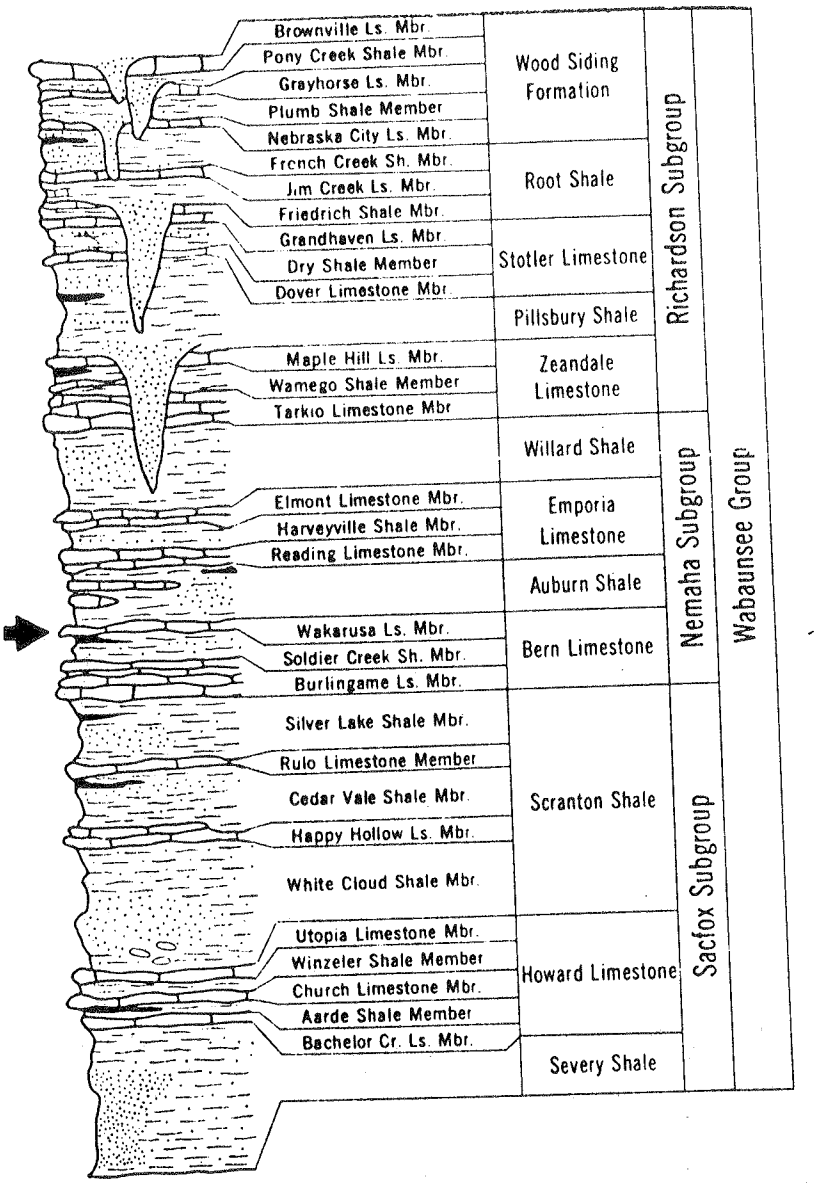
7

8

10993–115

PLATE 40

WAKARUSA



All Magnifications x10 Unless Otherwise Indicated

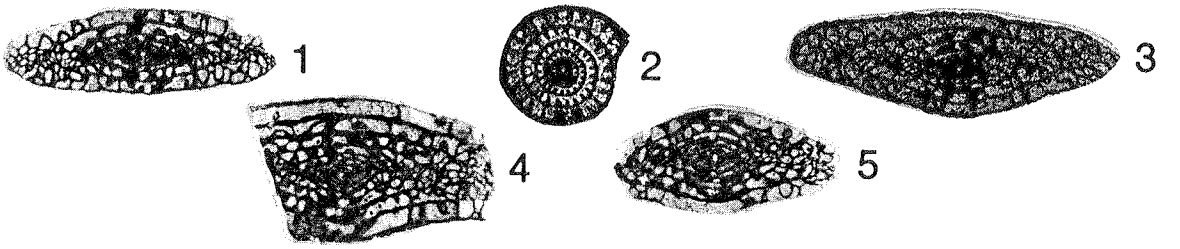
Figs. 1-7, 13 26517 Triticites n.sp. [SP.D]

Figs. 8-12,15,16 26486 Leptotriticites elkensis n.sp.

Figs. 14, 17-19 26513 Triticites happyhollowensis n.sp.

PLATE 40

WAKARUSA



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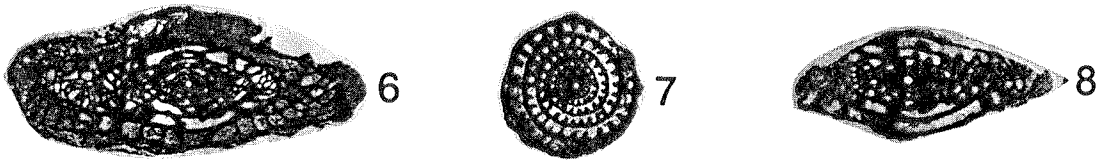
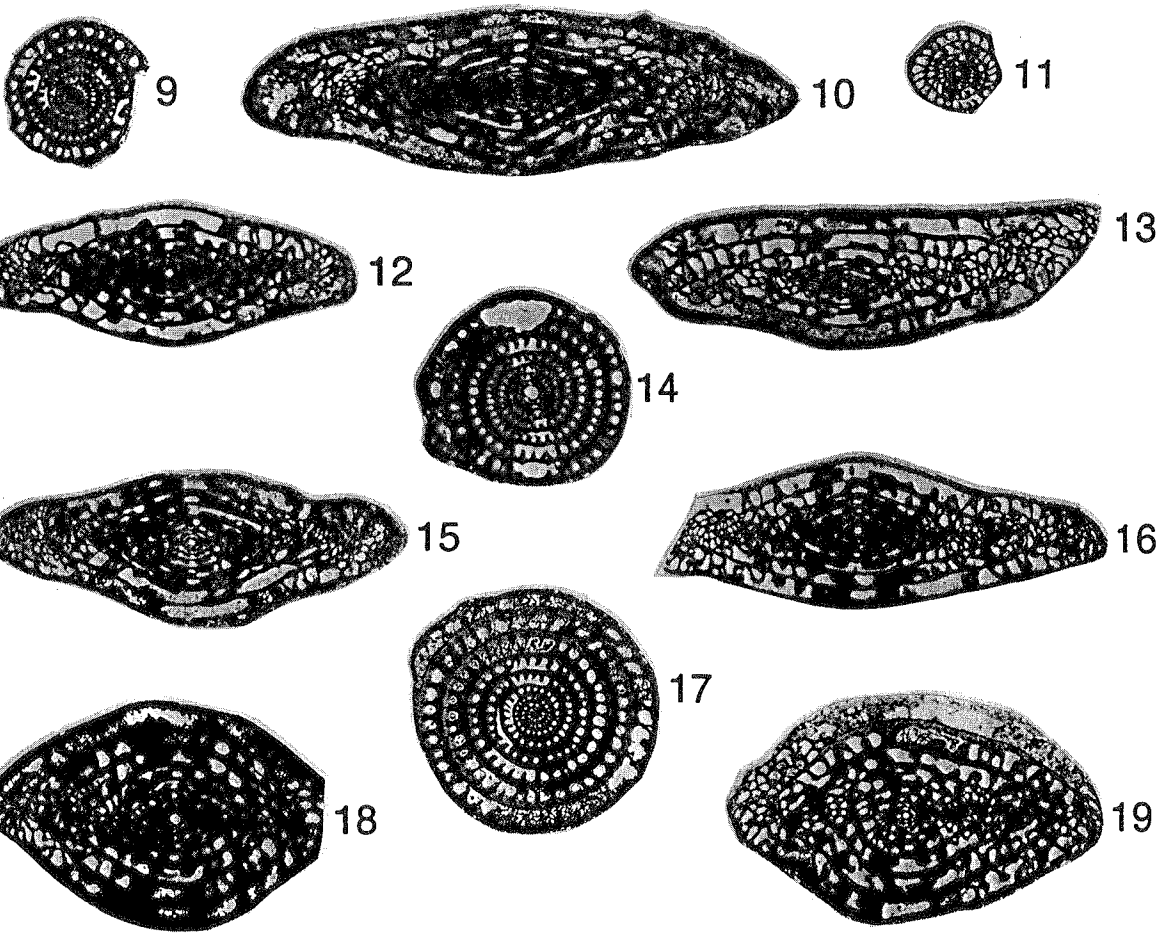


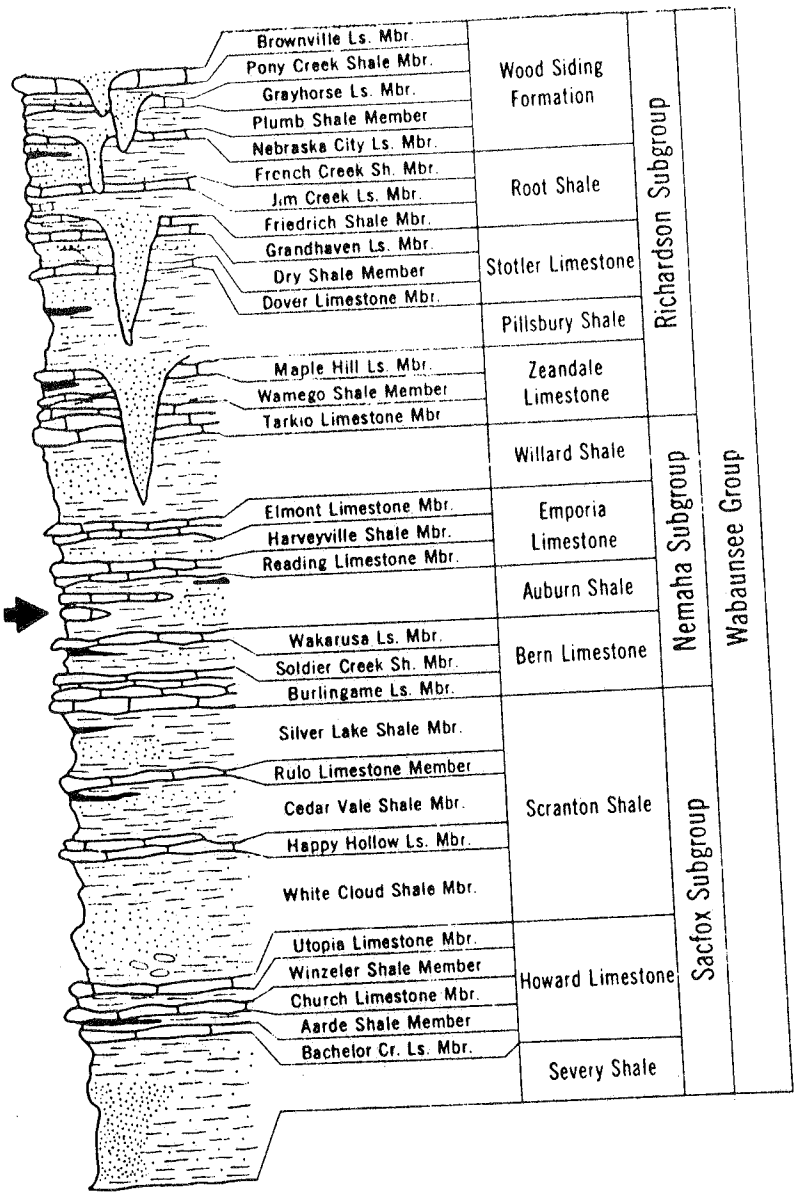
10993 118



10993–116

PLATE 41

AUBURN

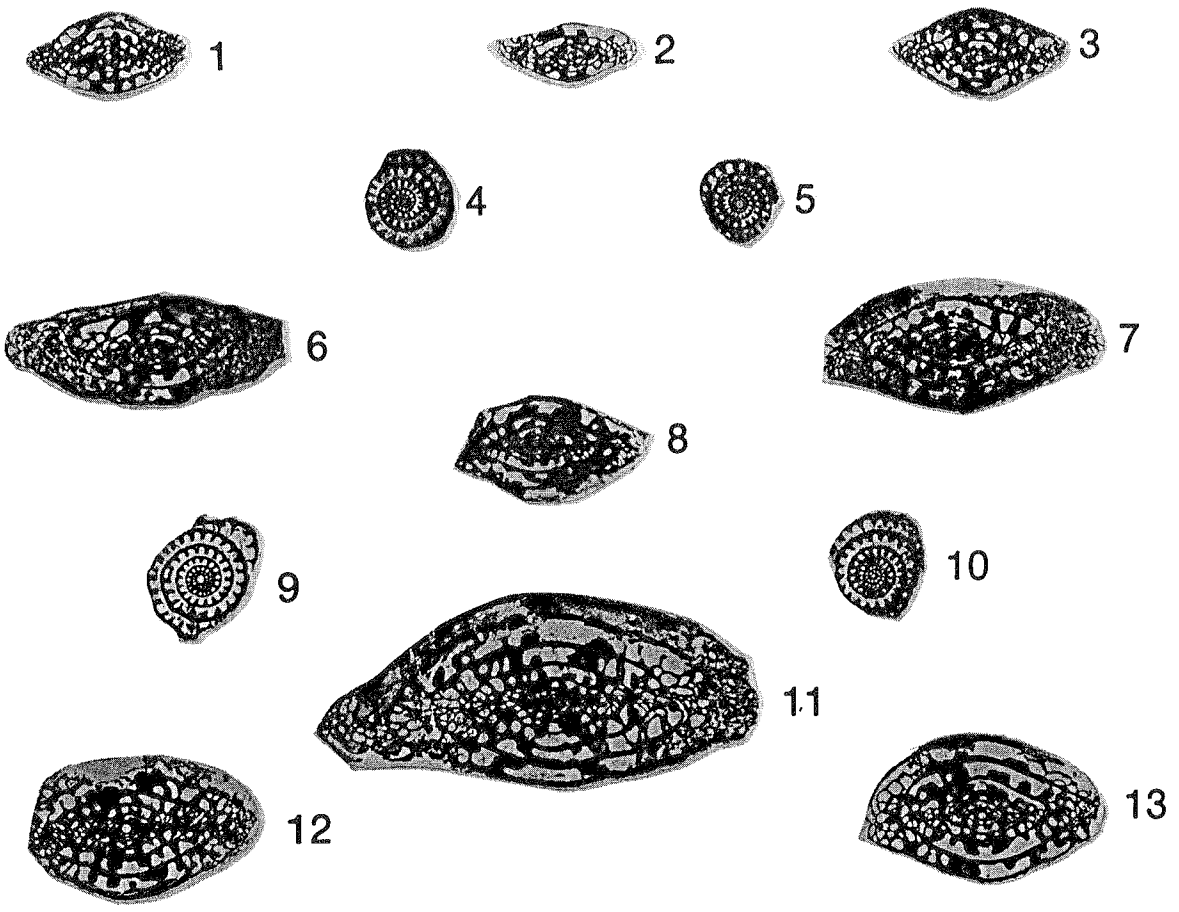


All Magnifications x10 Unless Otherwise Indicated

Fig. 1-13 26618 Triticites ex. gr. T. asperoides Ross, 1965

PLATE 41

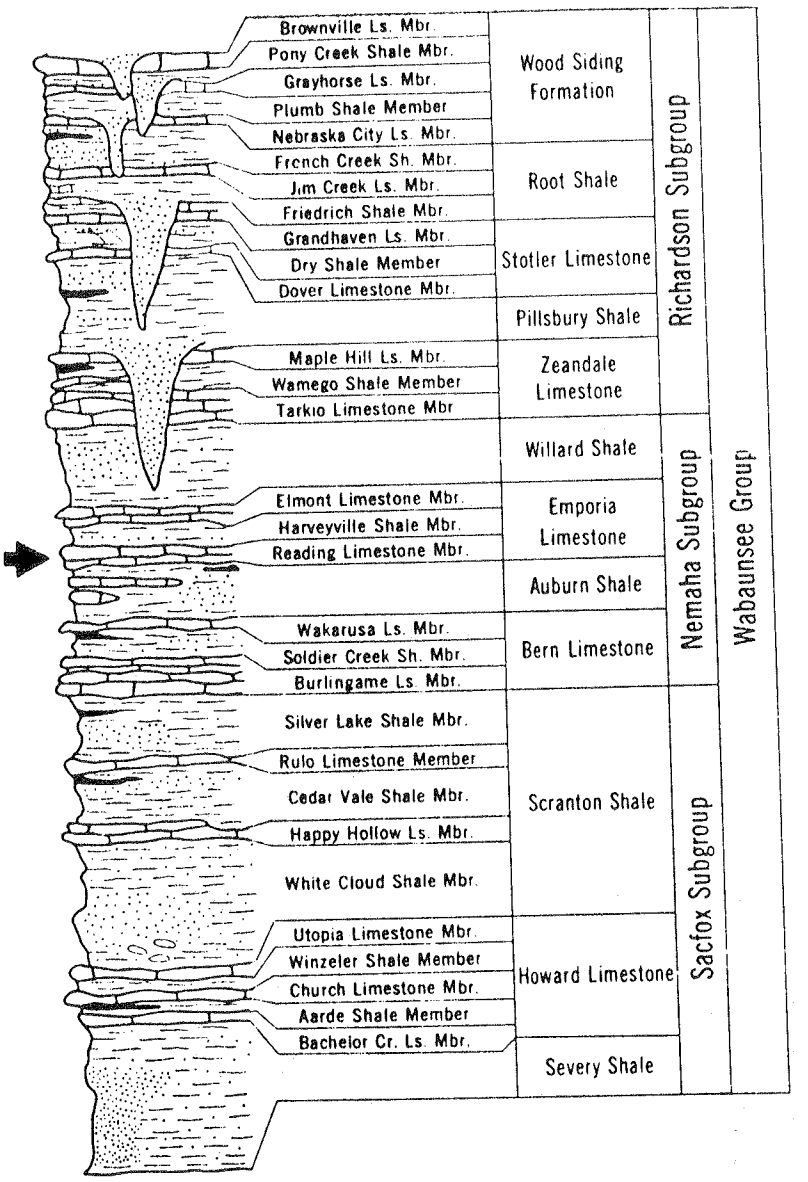
AUBURN



10993–122

PLATE 42

LOWER READING



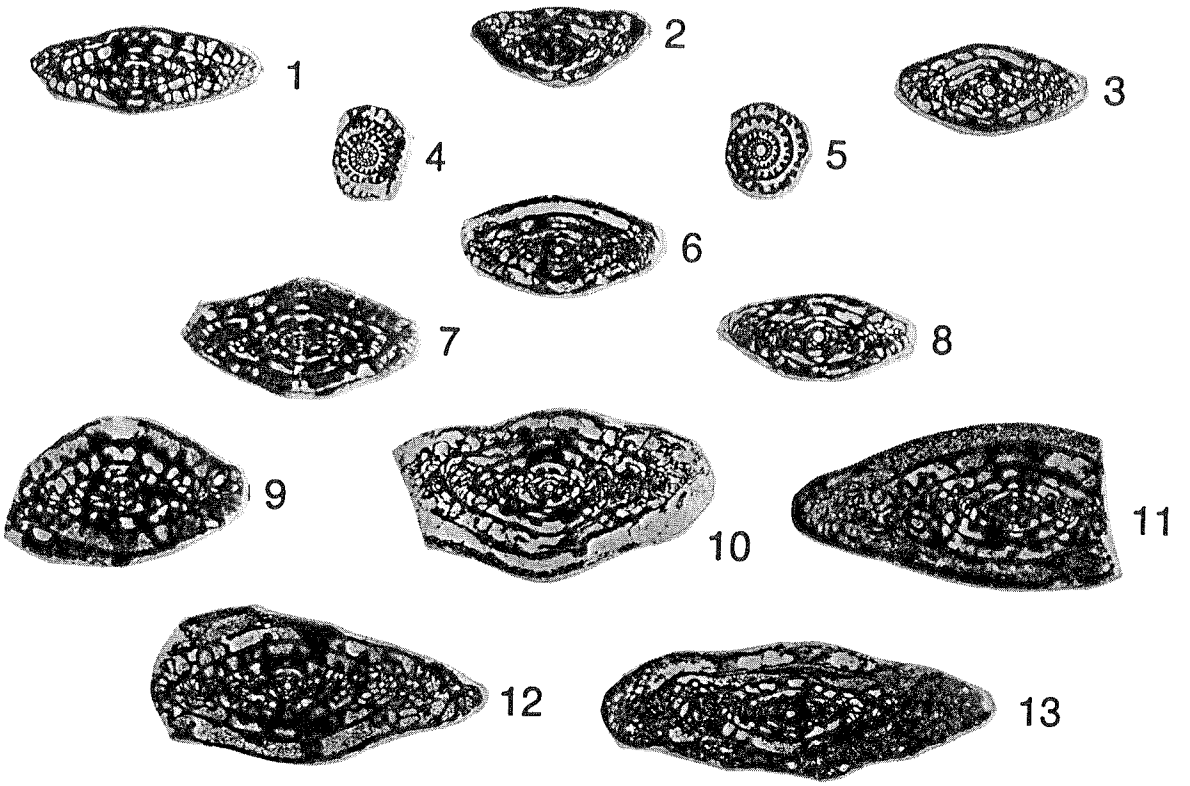
All Magnifications x10 Unless Otherwise Indicated

Figs. 1-6, 8-15, 17-23 26618 Triticites ex. gr. T. asperoides Ross, 1965

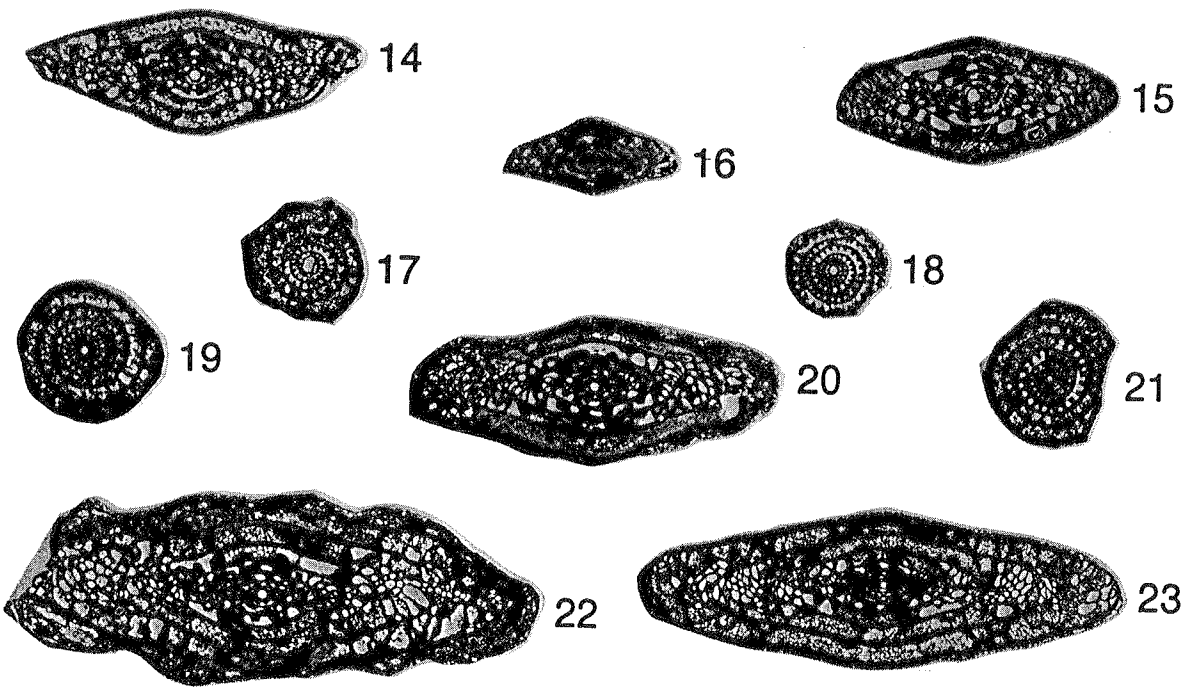
Figs. 7,16 26617 Triticites [microspheric form]

PLATE 42

LOWER READING



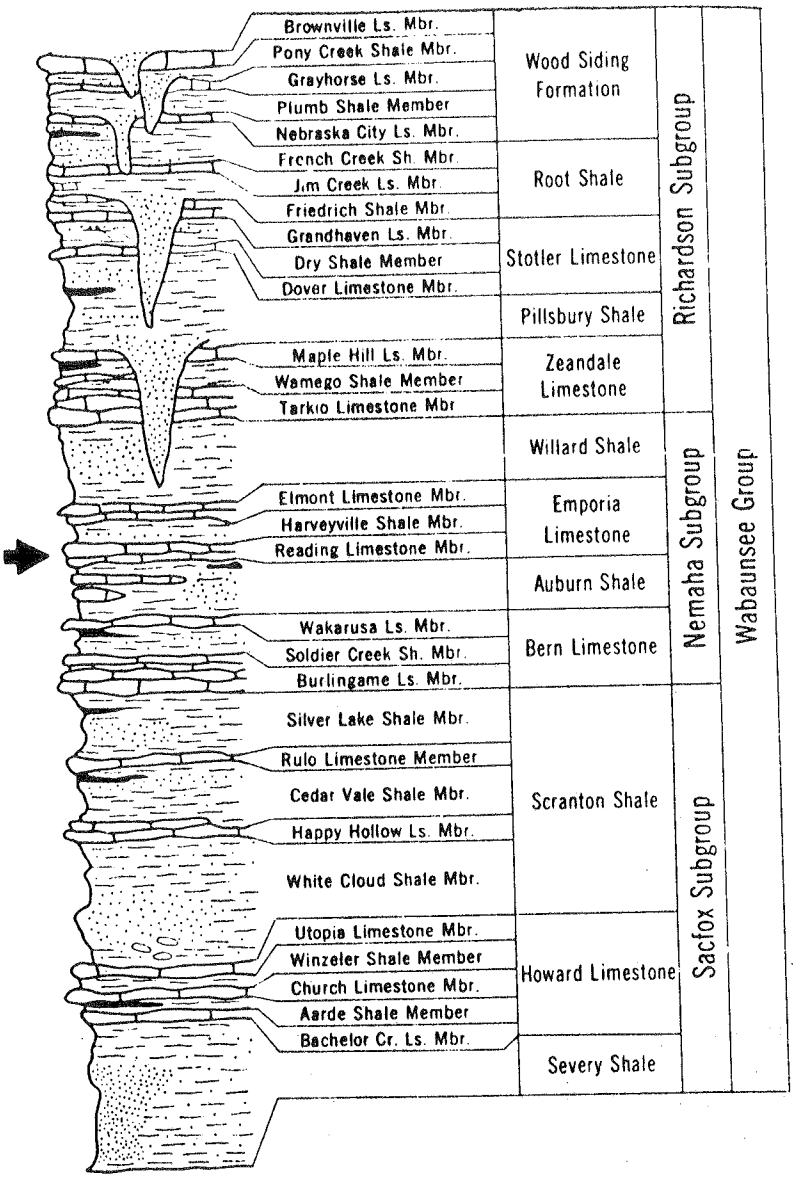
10993–124



10993–123

PLATE 43

UPPER READING



All Magnifications x10 Unless Otherwise Indicated

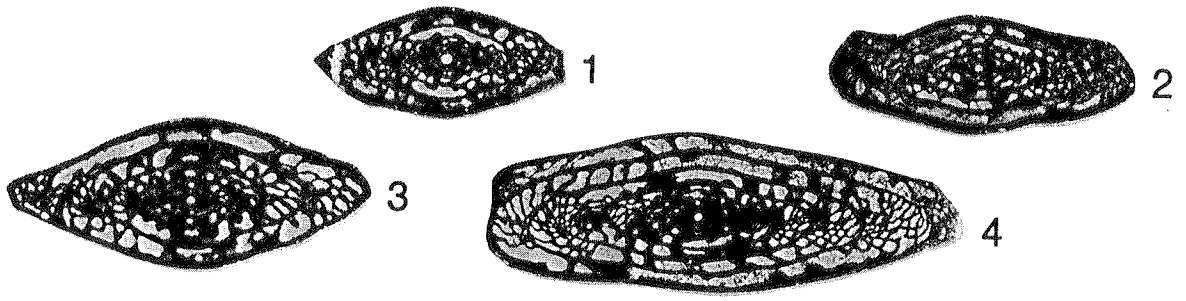
Figs. 1-4 26519 Triticites n.sp. [SP.F]

Figs. 5-13, 16 26486 Leptotriticites elkensis n.sp.

Figs. 14,15,17,18 26618 Triticites ex.gr. T. asperoides Ross, 1965

PLATE 43

UPPER READING



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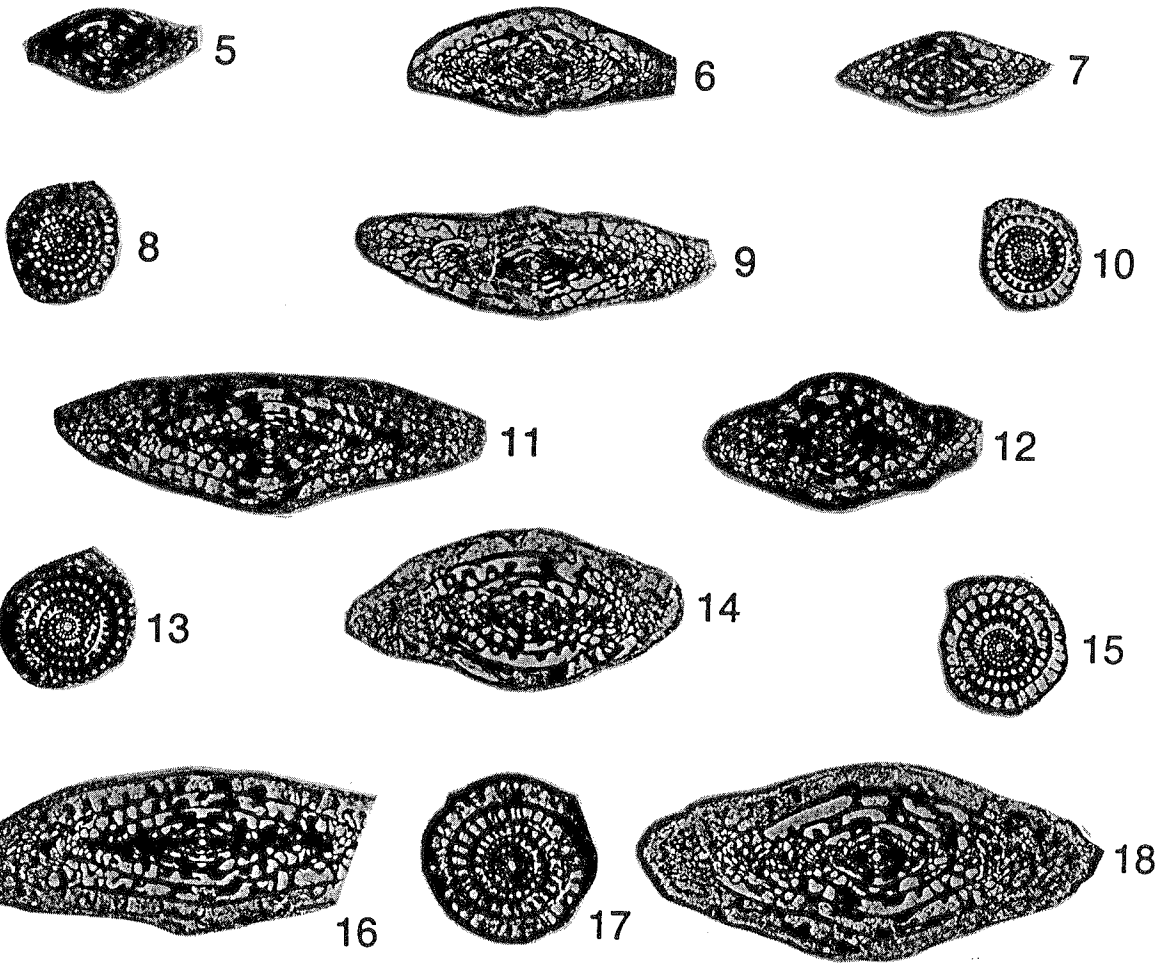
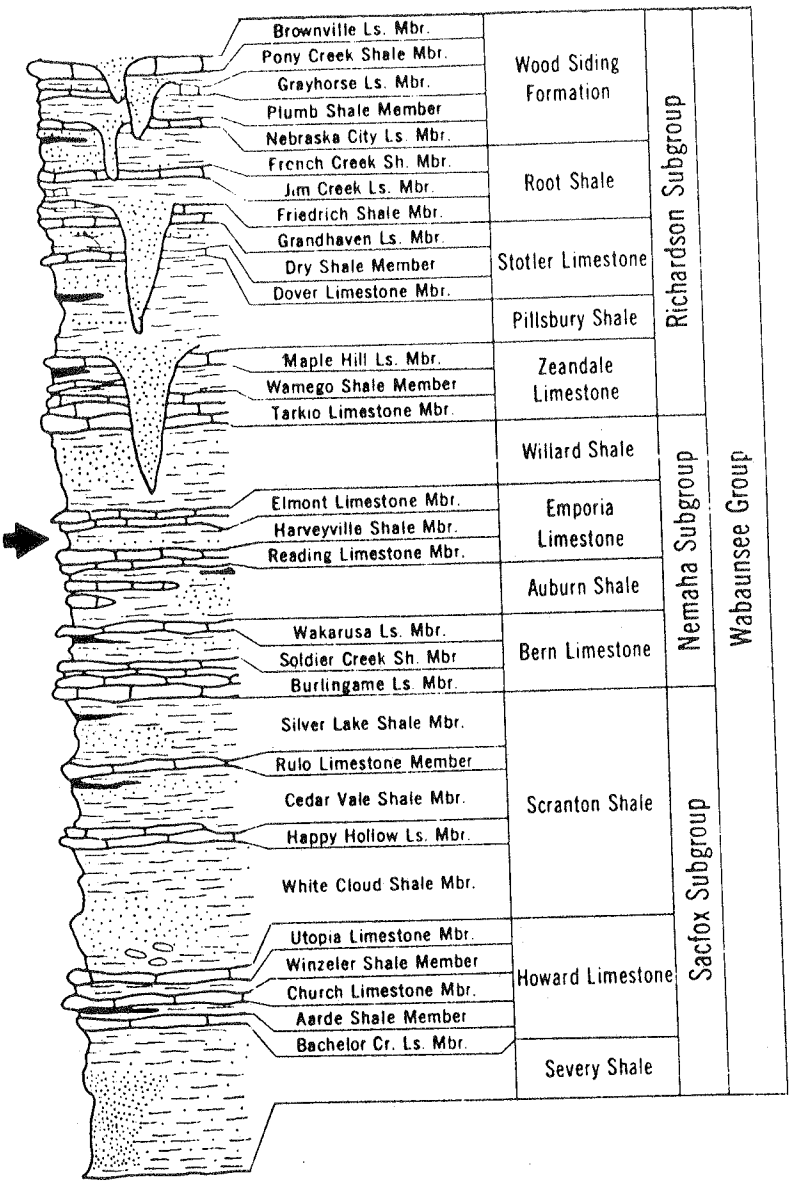


10993–125

PLATE 44

HARVEYVILLE

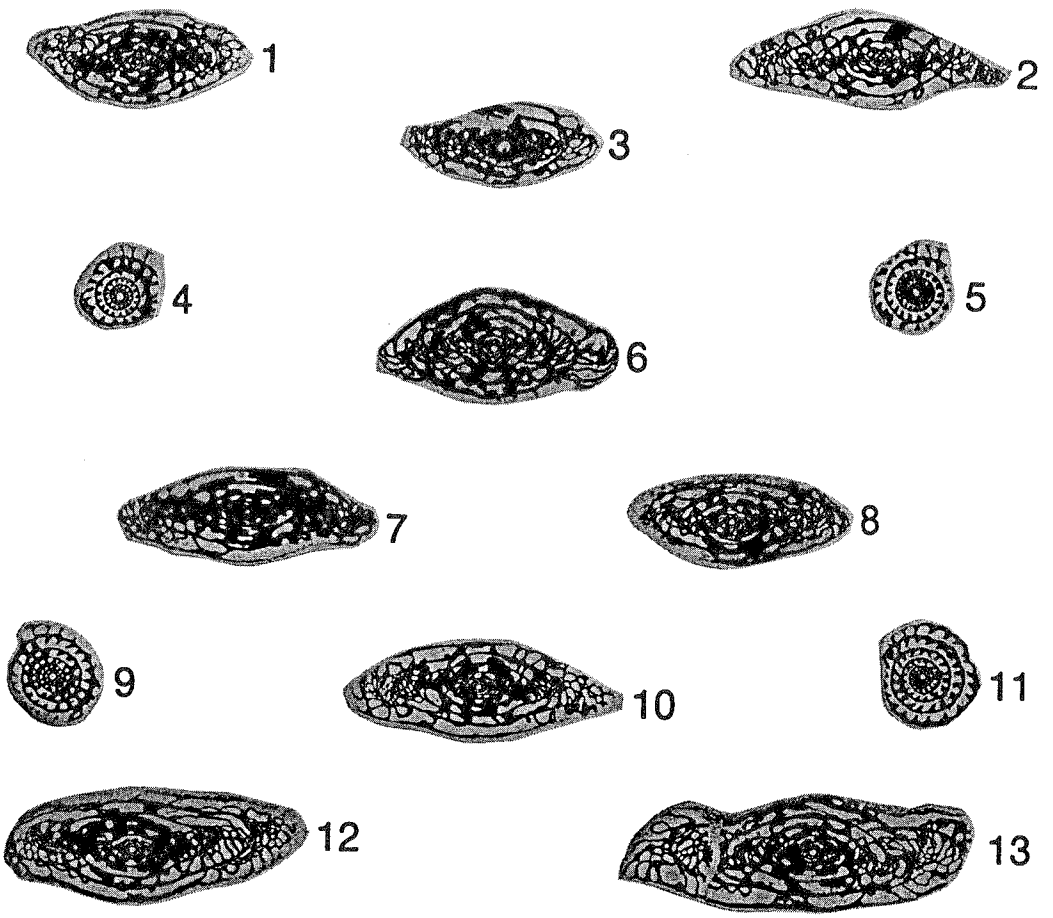


All Magnifications x10 Unless Otherwise Indicated

Figs. 1-13 26518 Triticites n.sp. [SP.E]

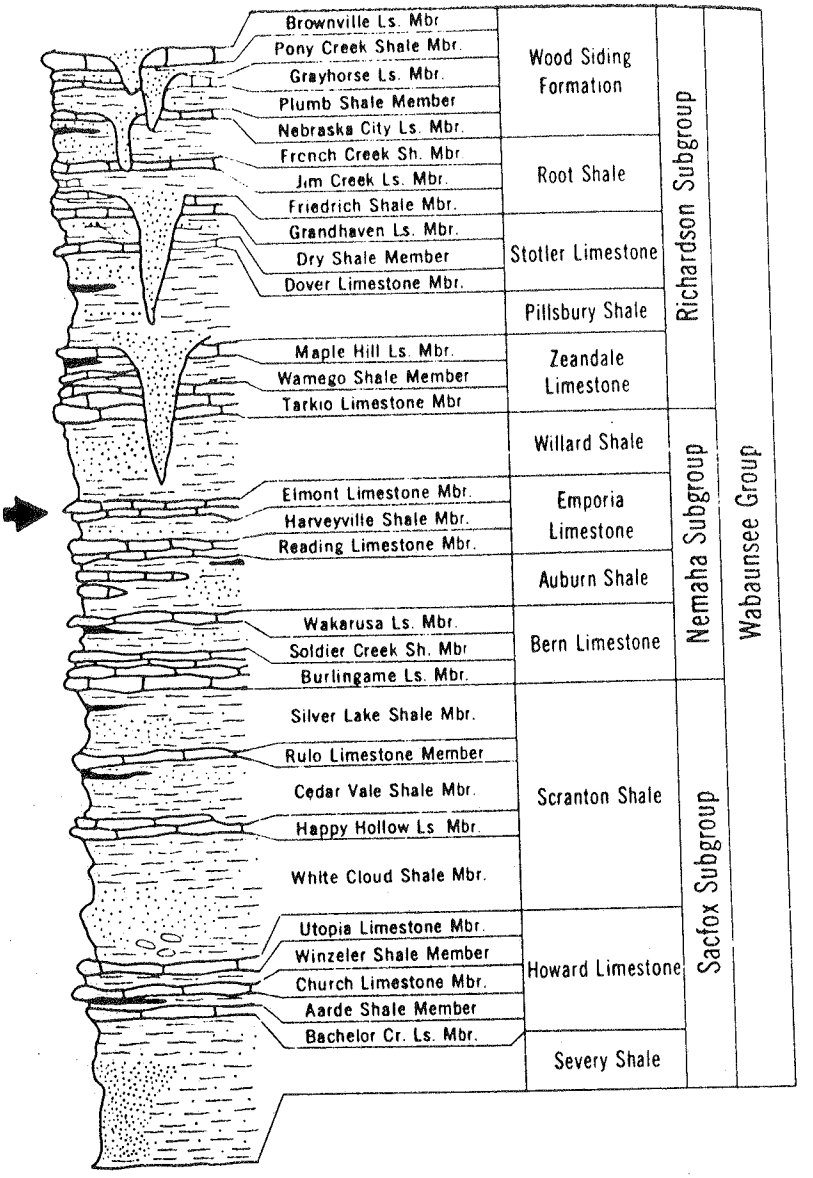
PLATE 44

HARVEYVILLE



10993–129

PLATE 45



All Magnifications x10 Unless Otherwise Indicated

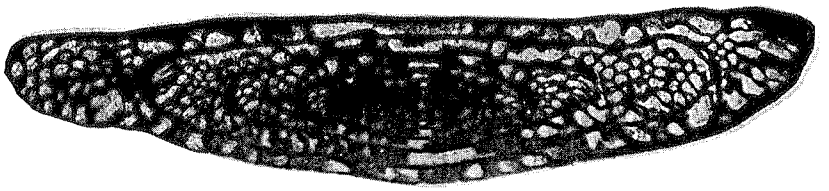
Figs. 1,3 26488 Leptotriticites n.sp. [SP.A]

Figs. 2, 7-18 26519 Triticites n.sp. [SP.F]

Figs. 4-6 26518 Triticites n.sp. [SP.E]

PLATE 45

ELMONT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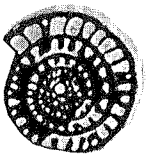
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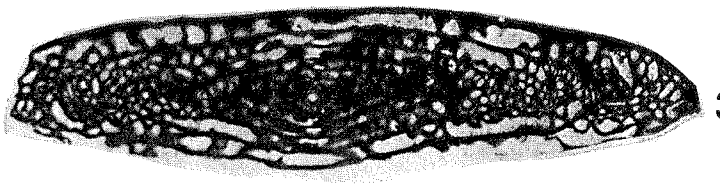
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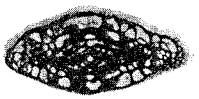
4


5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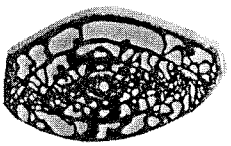
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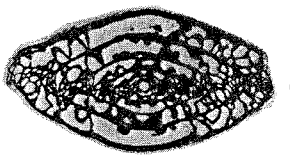
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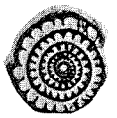
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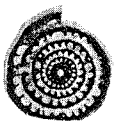
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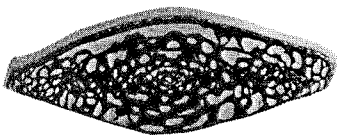
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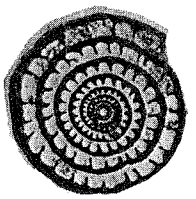
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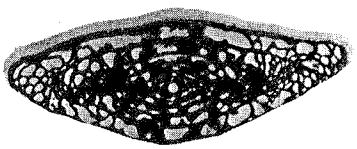
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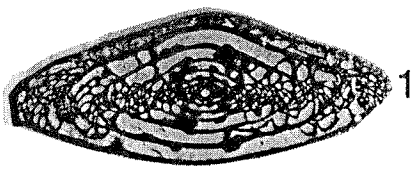
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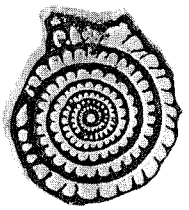
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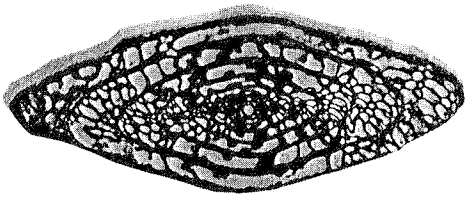
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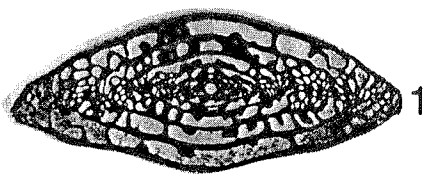
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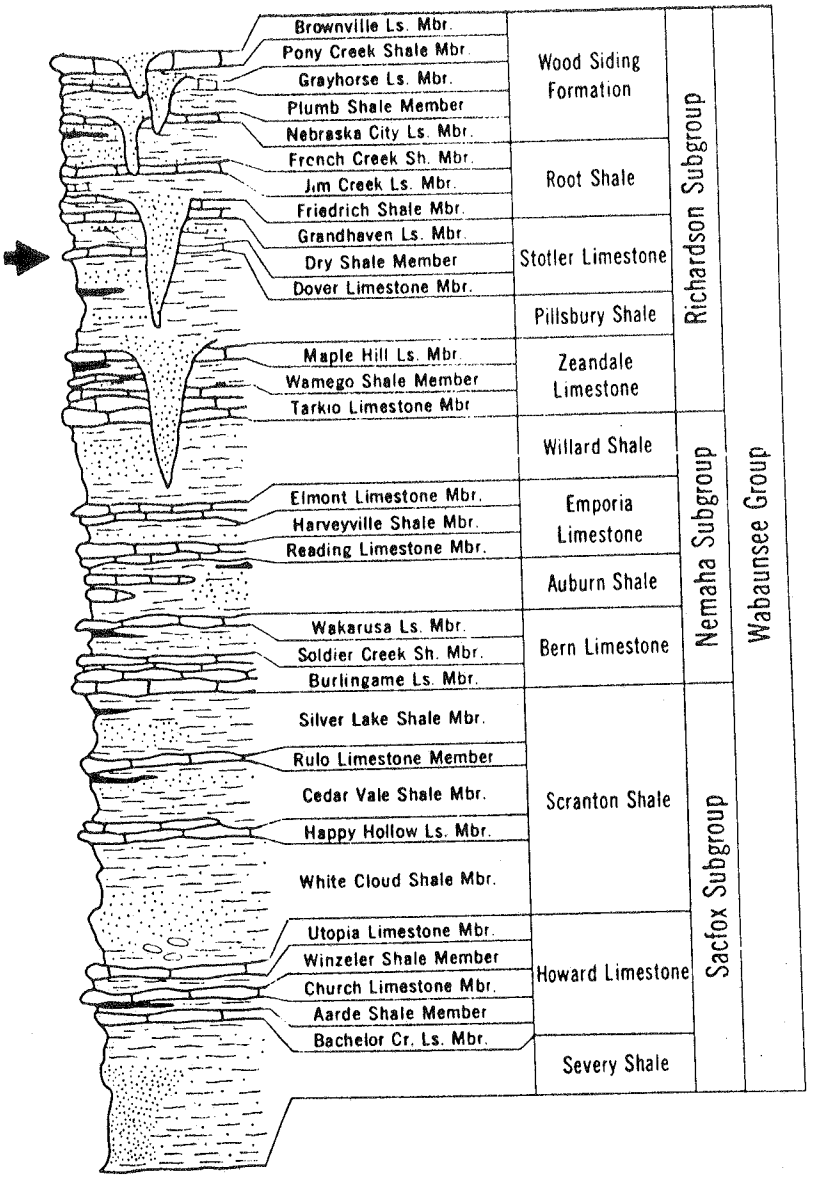
10993–130

PLATE 46

LOWER DOVER



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-8 26487 Leptotriticites taylori n.sp.

Fig. 9 26518 Triticites n.sp. [SP.E]

Fig. 10 26493 Schubertella Gen.

Figs. 11,12 26521 Triticites ex.gr. T. subventricosus Dunbar & Skinner, 1937

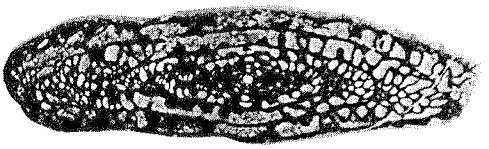
PLATE 46

LOWER DOVER


1


2


3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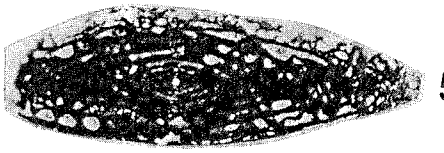
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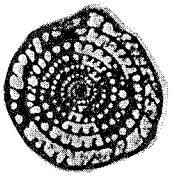
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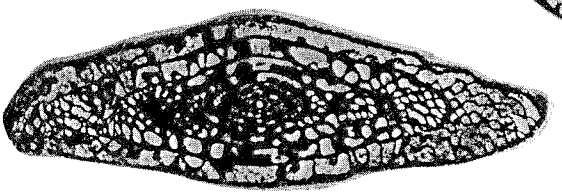
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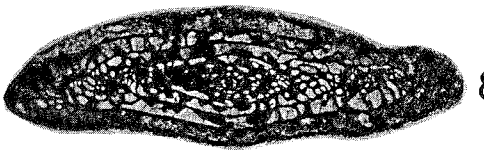
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10993–140


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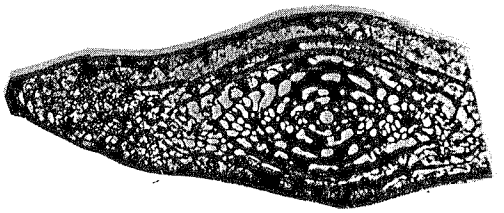
10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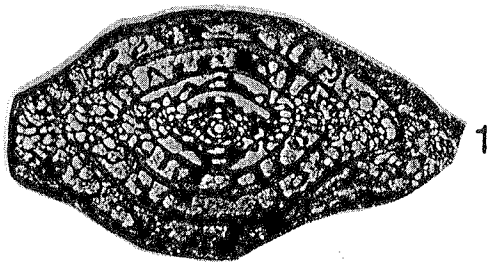
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10993–138

PLATE 47

UPPER DOVER

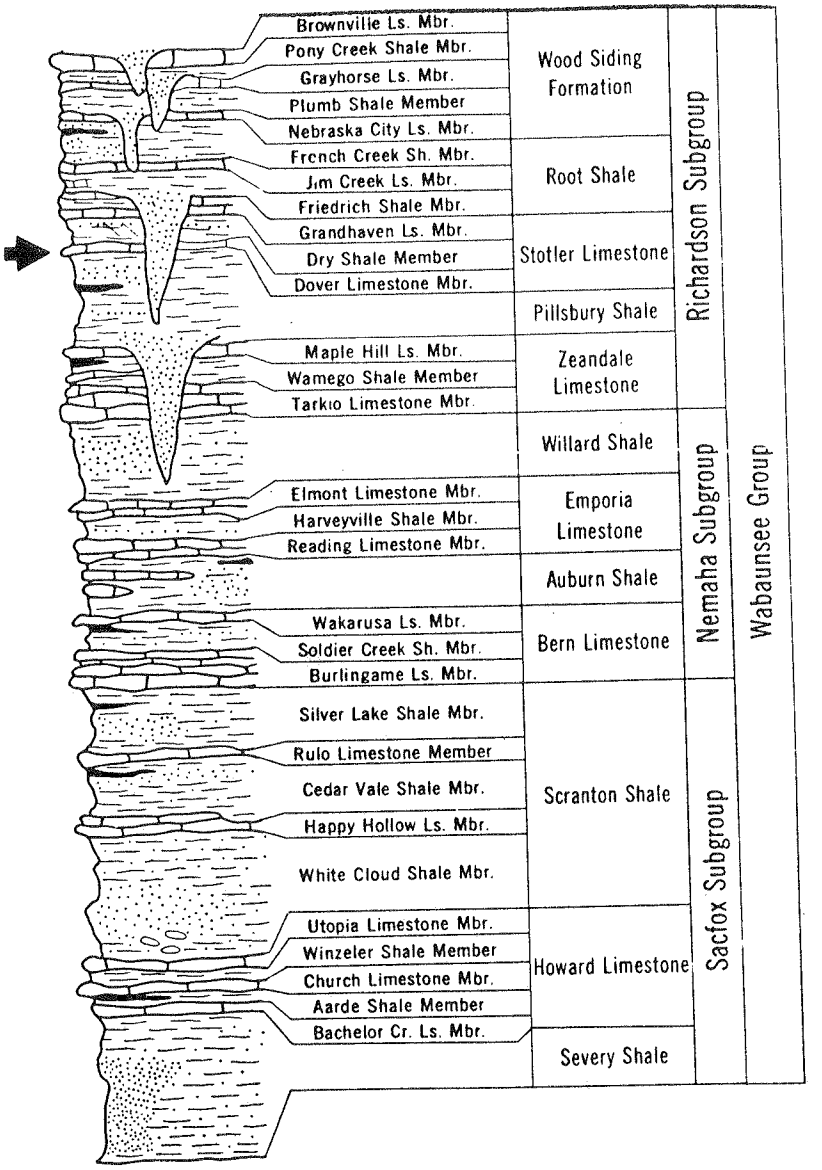
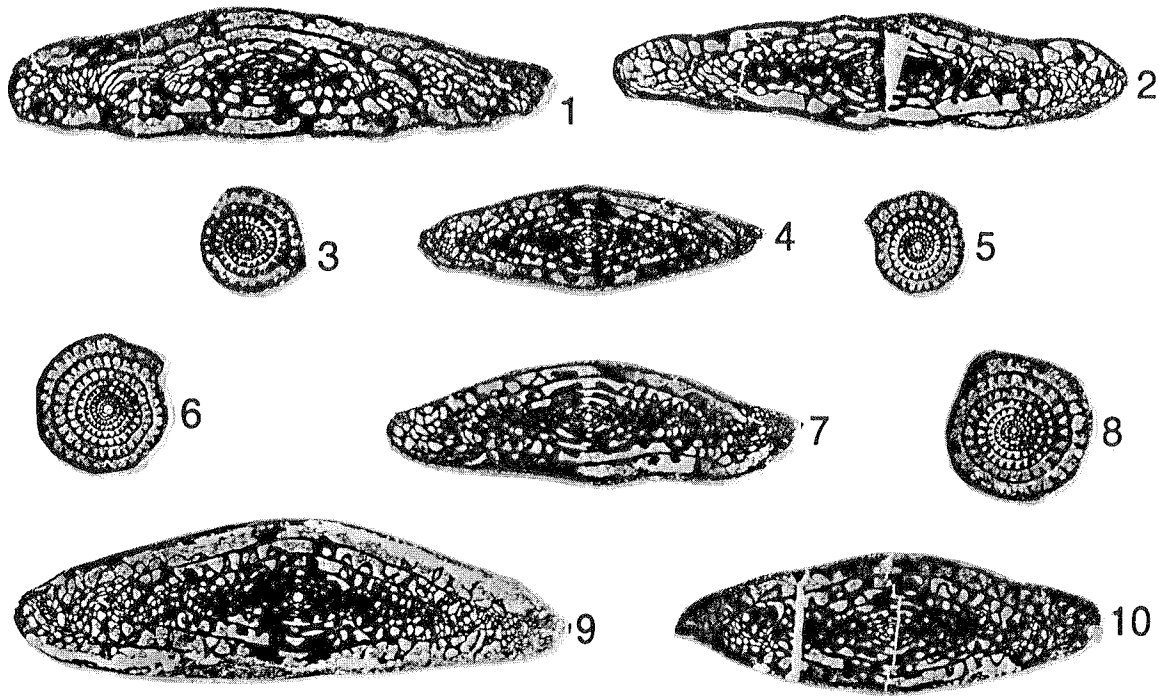


PLATE 47 All Magnifications x10 Unless Otherwise Indicated

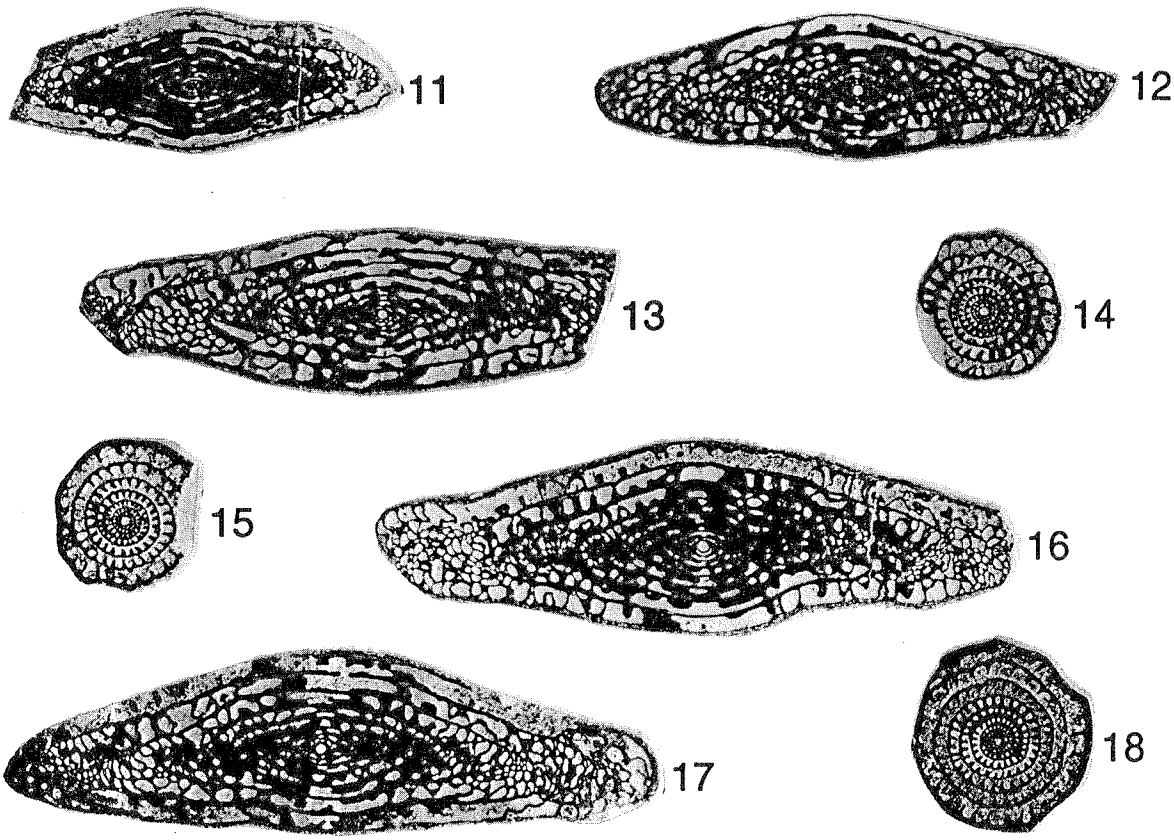
Figs. 1,2 26520 Triticites n.sp [SP.G]

Figs. 3-18 26487 Leptotriticites taylori n.sp.

PLATE 47 UPPER DOVER



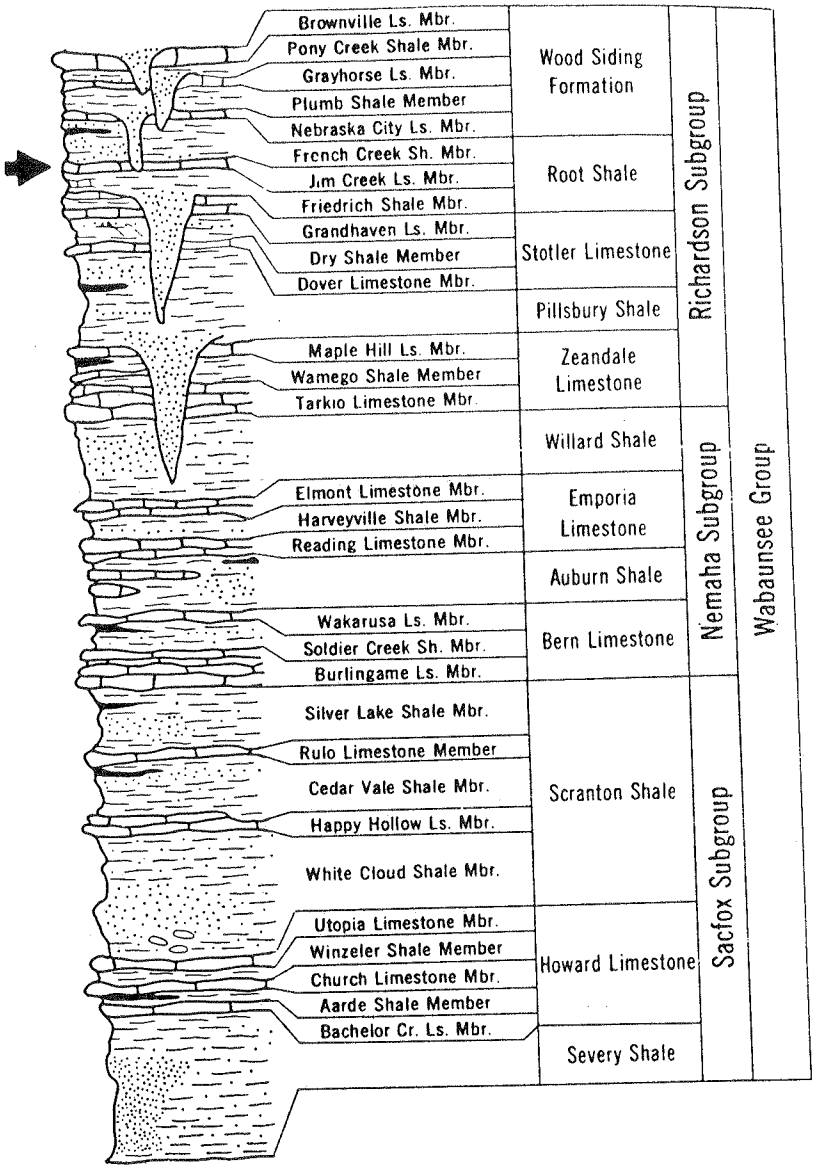
10993–143



10993–142

PLATE 48

JIM CR



All Magnifications x10 Unless Otherwise Indicated

Figs. 1-3

PLATE 48 All Magnifications x10 Unless Otherwise Indicated

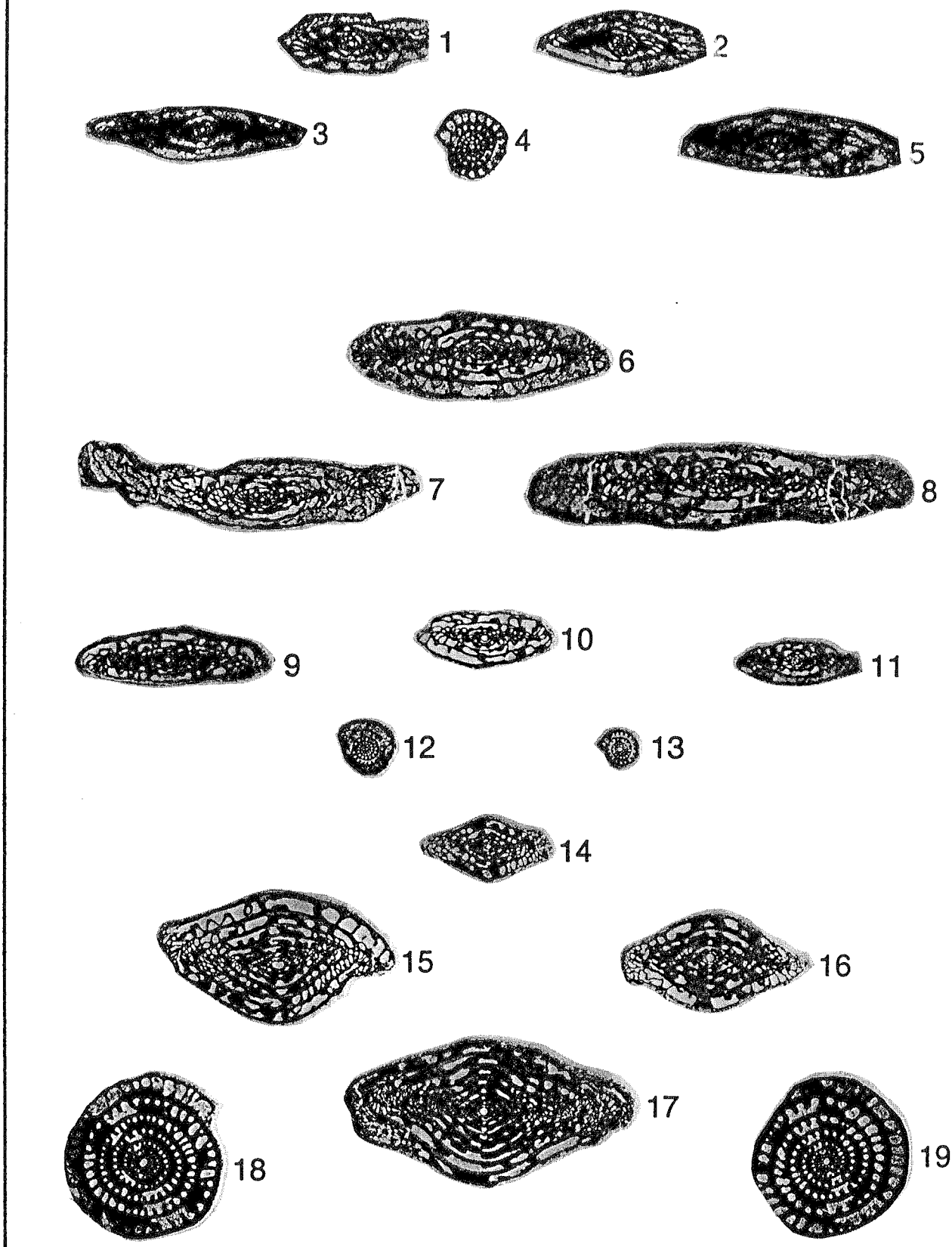
Figs. 1-5 26619 Schubertella ex.gr. S. kingi Dunbar & Skinner, 1937 [x40]

Figs. 6-13 26520 Triticites n.sp. [SP.G]

Figs. 14-19 23196 Leptotriticites eoextentus (Thompson, 1954)

PLATE 48

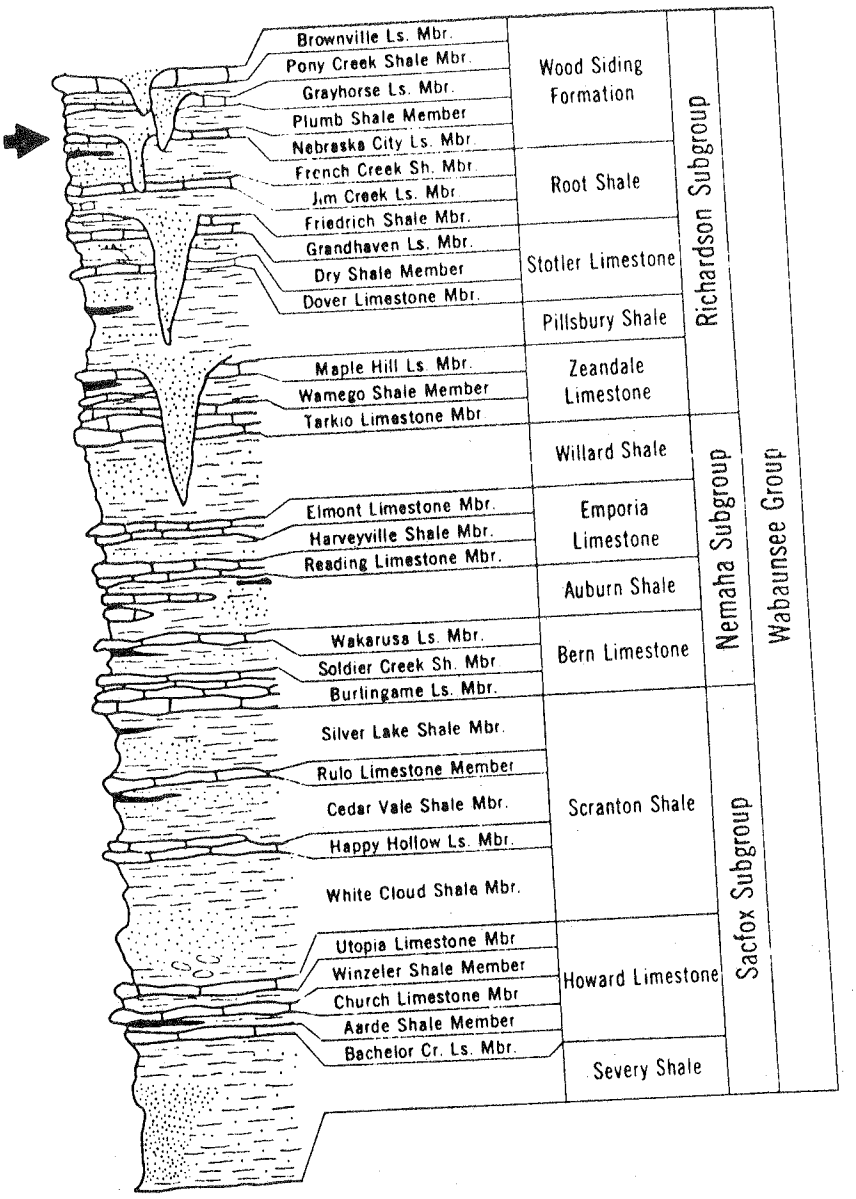
JIM CREEK



10993–153

PLATE 49

NEBRASKA CITY



All Magnifications x10 Unless Otherwise Indicated

PLATE 49

Figs. 1-3 — 26619 Schubertella ex.gr. S. kingi Dunbar & Skinner, 1937 [x40]

Figs. 4-7 — 26520 Triticites n.sp. [SP.G.]

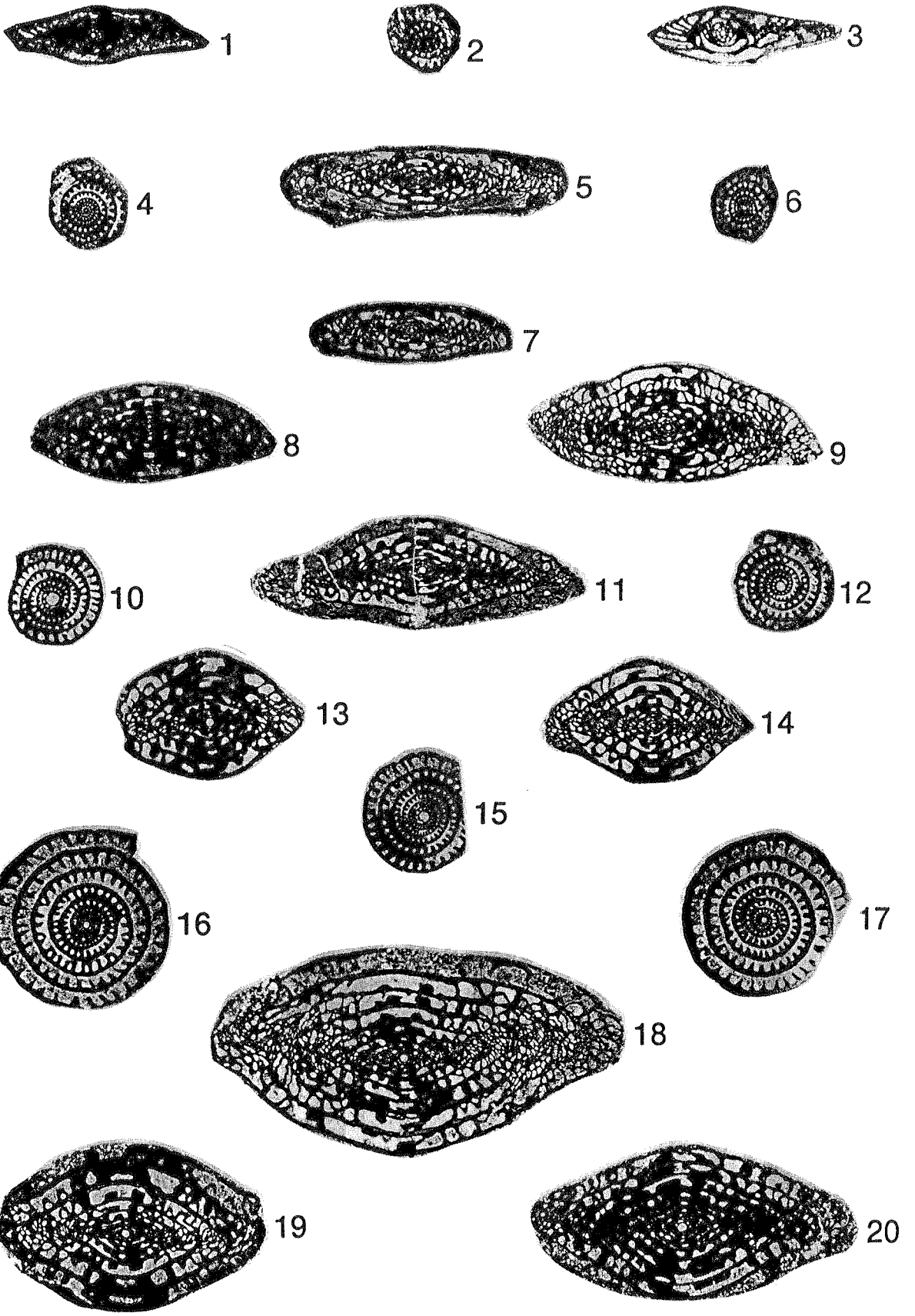
Figs. 8,9,11, 16,18 — 26484 Leptotriticites brownvillensis Douglass, 1962

Fig. 20 — 23196 Leptotriticites eoextentus (Thompson, 1954)

Figs. 10, 12-15, 17,19 — 26620 Triticites n.sp. [SP.H]

PLATE 49

NEBRASKA CITY



10993–159

PLATE 50

BROWNVILLE

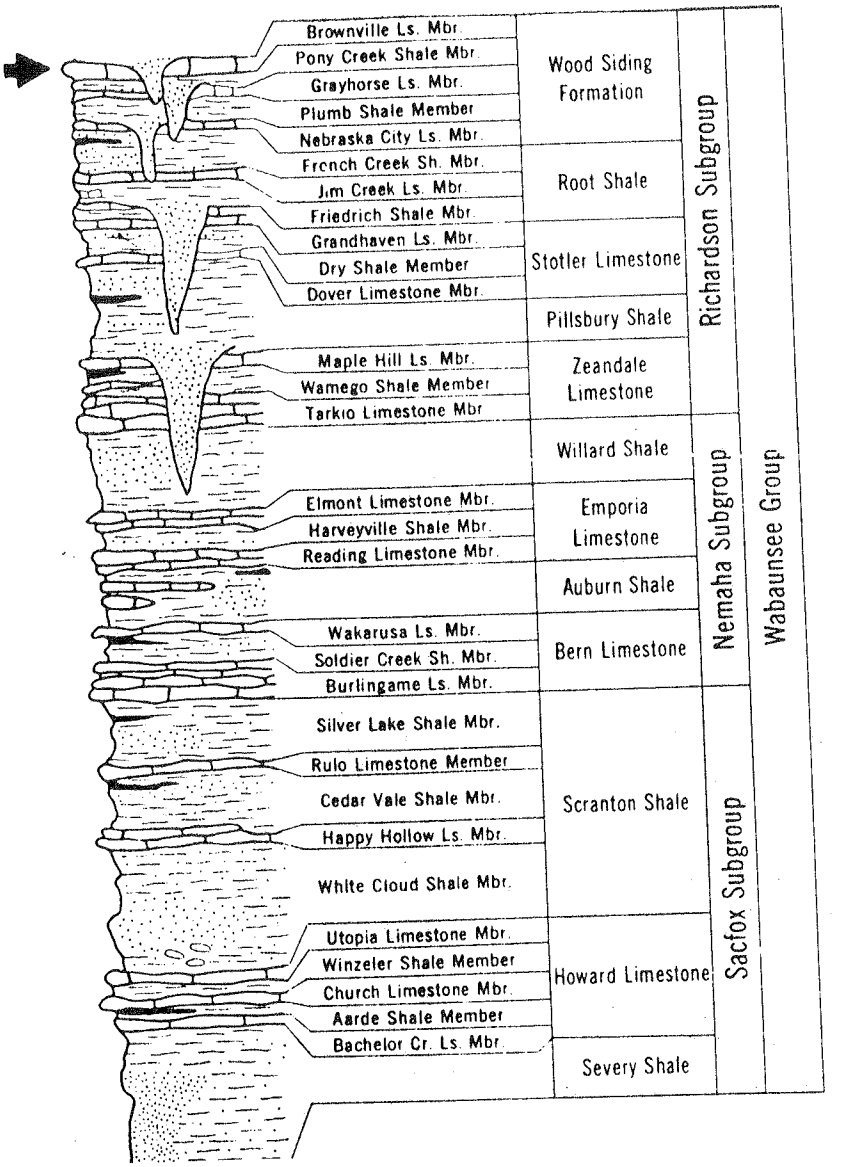


PLATE 50 All Magnifications x10 Unless Otherwise Indicated

Figs. 1,3,5 6-9, 12, 14-20 26484 Leptotriticites brownvillensis Douglass, 1951

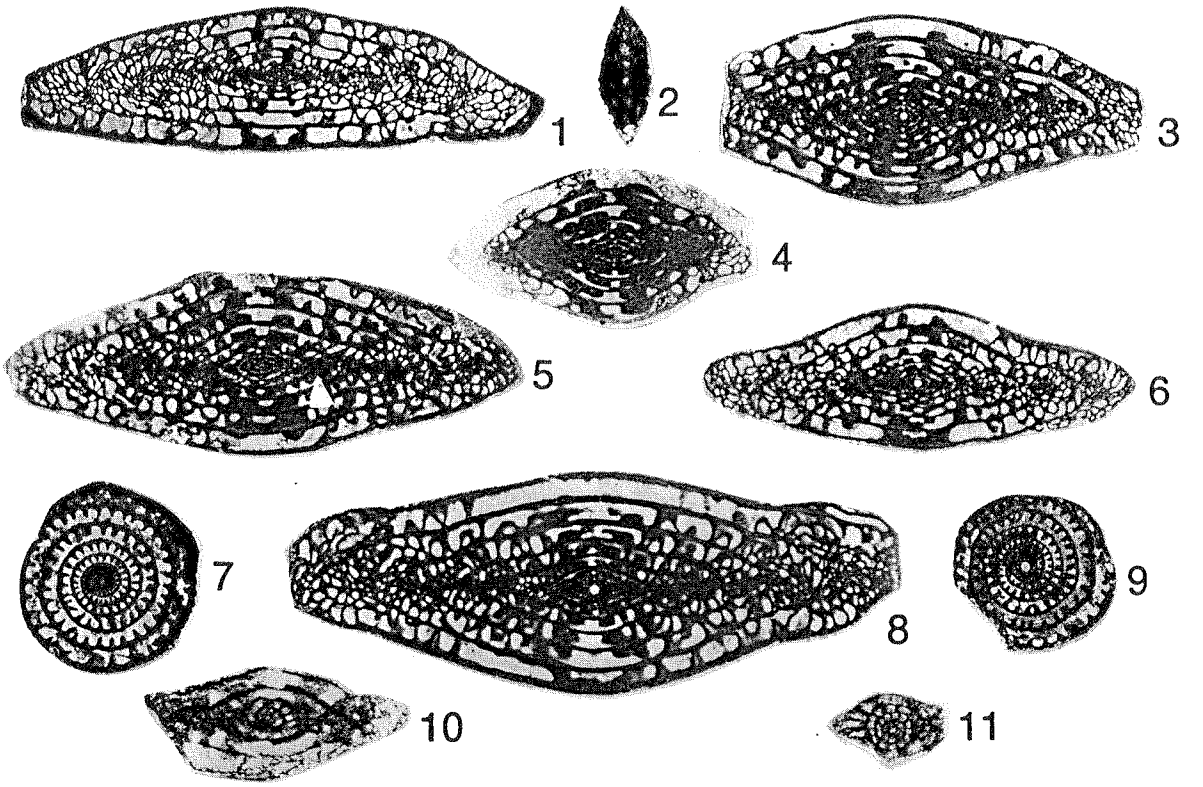
Fig. 2 01942 Millerella inflata (Thompson, 1954) [x40]

Figs. 4,13 26617 Triticites [microspheric form]

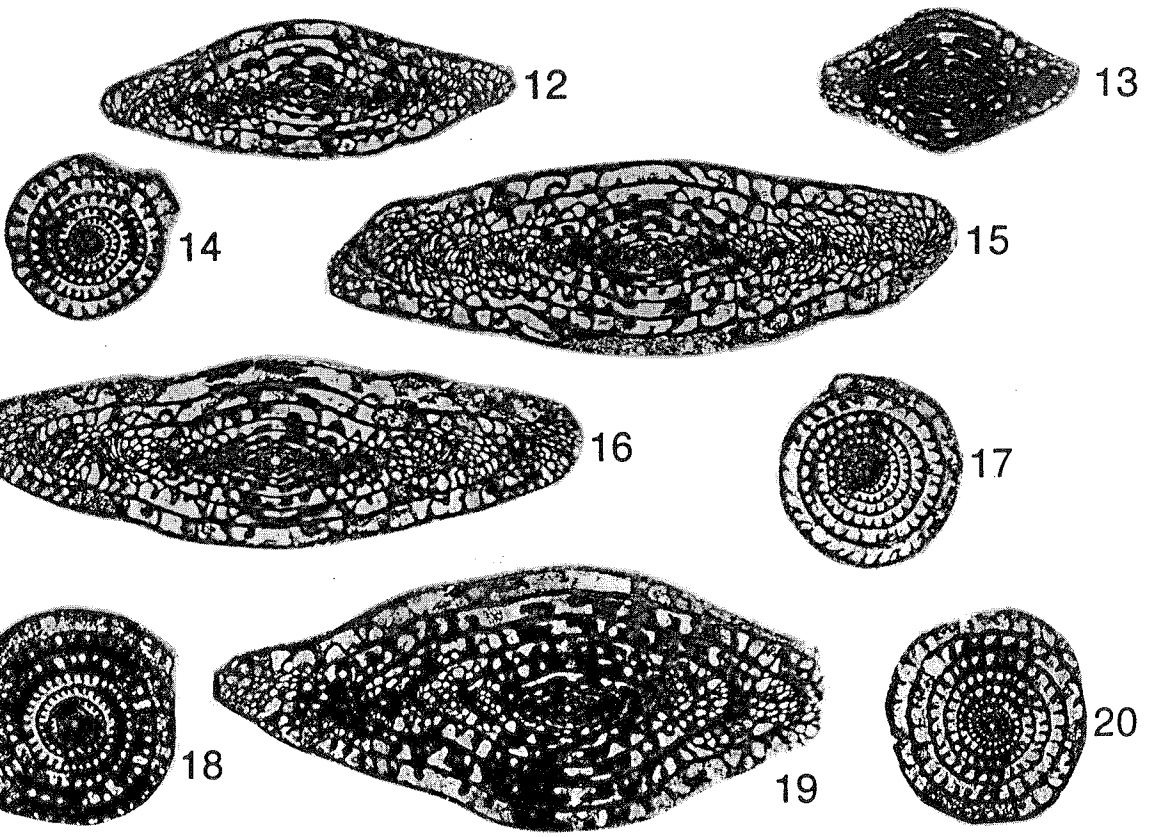
Figs. 10,11 26619 Schubertella ex.gr. S. kingi Dunbar & Skinner, 1937 [x40]

PLATE 50

BROWNVILLE



10993–164



10993–163

AMOCO PRODUCTION COMPANY
Tulsa, Oklahoma
September 17, 1981

81260ART0014

TO: Chief Geologist - Amoco Canada
Division Geologists
Regional Geologists
Managers, Geology - APC (USA and Int'l), Chicago

SUBJECT: Transmittal of Geological Research Department Report M81-G-11 Entitled "Upper Pennsylvanian (Virgilian) Fusulinid Biozonation - Preliminary Report

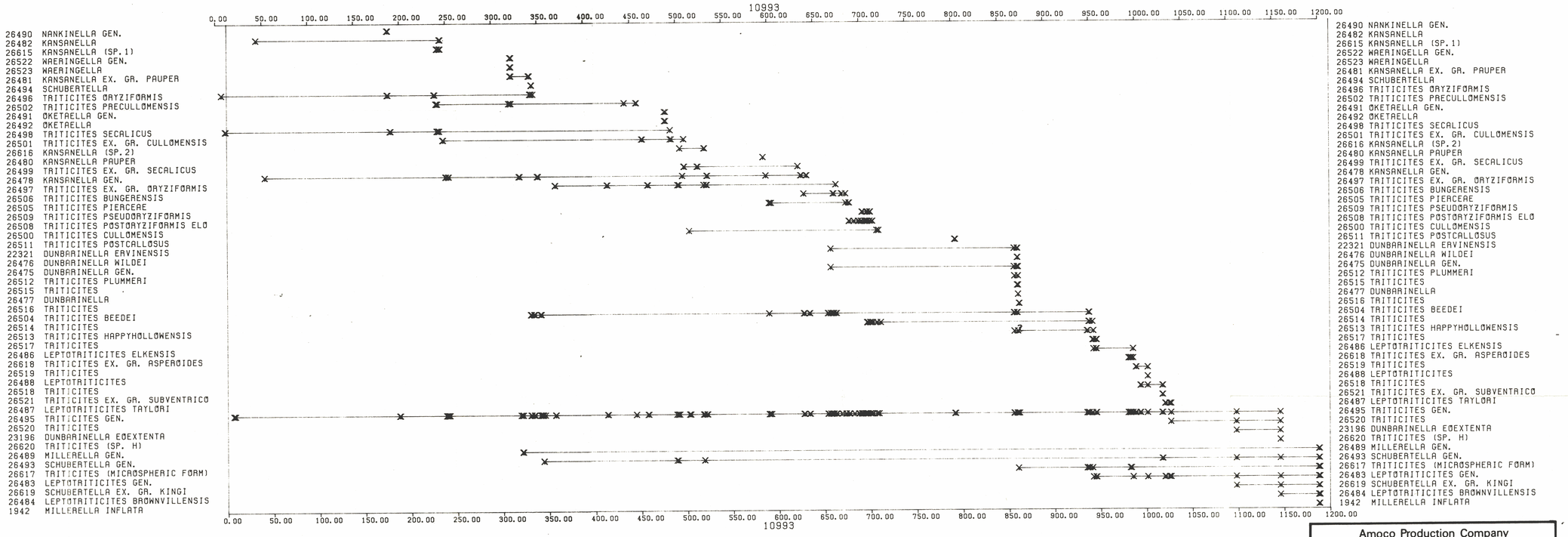
The subject report documents a continuous stratigraphic succession which forms the basis for biostratigraphic zonation of the Kansas Virgilian. Fusulinids from the Kansas Virgilian are being studied to provide diversely existing biotic coverage in the relevant portion of the U Composite Standard. Sample processing is completed and interpretive study of the fusulinids, which will require a quantitative approach, has begun. This is a preliminary report for Research Proposal 80-3.

Eric R. Michaelis

Eric R. Michaelis

ARO:srb
Attachment

cc: Regional Exploration Libraries
Exploration Systems Manager, Tulsa Data Center



Amoco Production Company

Research Center–Geological Research Division

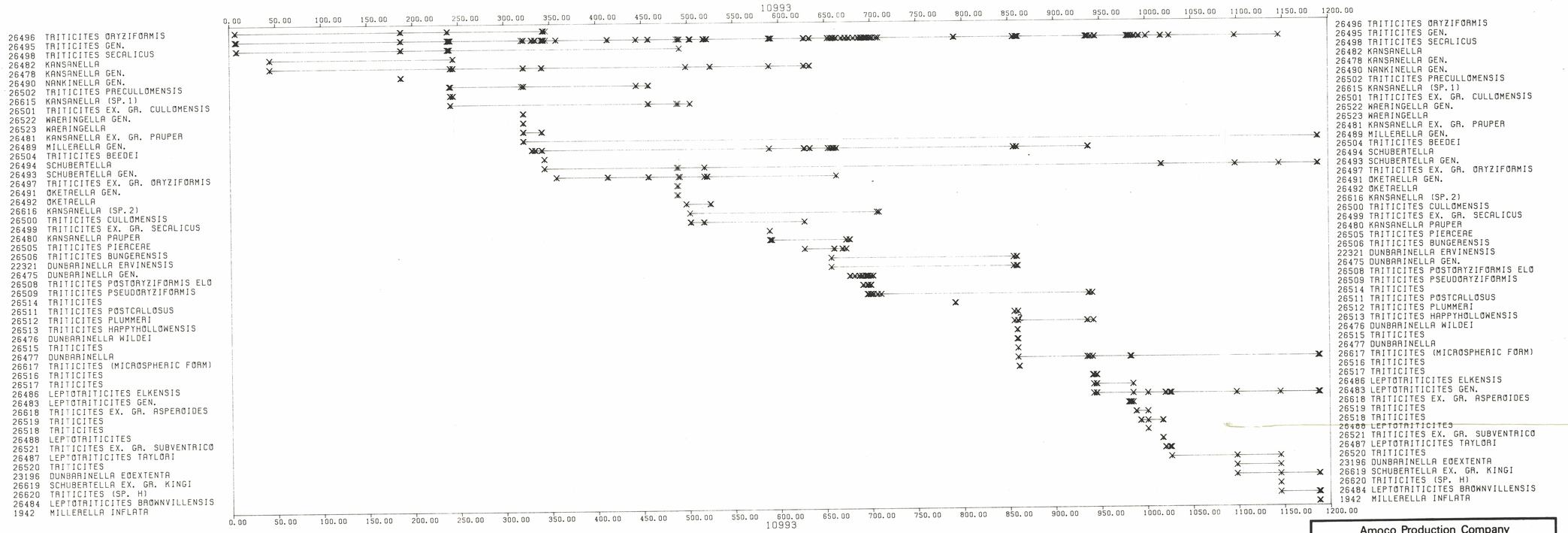
FUSULINID RANGE PLOT (TOPS)

INTERPRETATION BY: G. A. Sanderson & G. J. Verville

LOCALITY FILE (NO)S.: 10993

REPORT NO.: F83–G–18

FIGURE 5



26496 TRITICITES ORYZIFORMIS
26495 TRITICITES GEN.
26498 TRITICITES SECALICUS
26482 KANSANELLA
26478 KANSANELLA GEN.
26490 NANKINELLA GEN.
26502 TRITICITES PRECULLOMENSIS
26615 KANSANELLA (SP.1)
26501 TRITICITES EX. GR. CULLOMENSIS
26522 WAERINGELLA GEN.
26523 WAERINGELLA
26481 KANSANELLA EX. GR. PAUPER
26489 MILLERELLA GEN.
26504 TRITICITES BEEDEI
26494 SCHUBERTELLA
26493 SCHUBERTELLA GEN.
26497 TRITICITES EX. GR. ORYZIFORMIS
26491 OKETAELLA GEN.
26492 OKETAELLA
26616 KANSANELLA (SP.2)
26500 TRITICITES CULLOMENSIS
26499 TRITICITES EX. GR. SECALICUS
26480 KANSANELLA PAUPER
26505 TRITICITES PIERCEAE
26506 TRITICITES BUNGERENSIS
22321 DUNBARINELLA ERVINENSIS
26475 DUNBARINELLA GEN.
26508 TRITICITES POSTORYZIFORMIS ELO
26509 TRITICITES PSEUDORYZIFORMIS
26514 TRITICITES
26511 TRITICITES POSTCALLOSUS
26512 TRITICITES PLUMMERI
26513 TRITICITES HAPPYHOLLOWENSIS
26476 DUNBARINELLA WILDEI
26515 TRITICITES
26477 DUNBARINELLA
26617 TRITICITES (MICROSPHERIC FORM)
26516 TRITICITES
26517 TRITICITES
26486 LEPTOTRITICITES ELKENSIS
26483 LEPTOTRITICITES GEN.
26618 TRITICITES EX. GR. ASPEROIDES
26519 TRITICITES
26518 TRITICITES
26488 LEPTOTRITICITES
26521 TRITICITES EX. GR. SUBVENTRICO
26487 LEPTOTRITICITES TAYLORI
26520 TRITICITES
23196 DUNBARINELLA EOEXTENTA
26619 SCHUBERTELLA EX. GR. KINGI
26620 TRITICITES (SP. H)
26484 LEPTOTRITICITES BROWNVILLENSIS
1942 MILLERELLA INFLATA

Amoco Production Company
Research Center–Geological Research Division

FUSULINID RANGE PLOT (BASES)

INTERPRETATION BY: G. A. Sanderson & G. J. Verville

LOCALITY FILE (NO)S.: 10993

REPORT NO.: F83–G–18
FIGURE 6