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Stratigraphy and Ostracoda of the Ripley Formation of Western Georgia.

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Stratigraphy and Ostracoda of the Ripley Formation of Western Georgia

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ABSTRACT

The Ripley formation (Gulfian) and its bounding formations in western Georgia were studied stratigraphically from the Chattahoochee River on the west to the Ocmulgee River on the east. Surface exposures were measured and described in detail and ostracod samples and rocks for thin sections were collected for study. An outcrop map of the Ripley formation with the geographic location of the measured sections and a stratigraphic cross section with the position of all ostracod samples and rock thin sections are enclosed in the pocket.

The Ripley extends eastward into Georgia from Alabama and crops out from the Chattahoochee River to the Flint River where it is overlapped by the more northerly striking Providence sand. In western Georgia, the Ripley is composed of a nearshore marl that predominates updip and an offshore fine marine sand and clay that predominates downdip. The offshore sand and clay extend eastward to the Flint River with very little facies change but thin from approximately 150 feet in the Chattahoochee River valley to approximately 50 feet in the area of the Flint River.

East of the Flint River, the Providence sand overlaps the Ripley and lies unconformably upon the Cusseta sand. In Twiggs County, evidence suggests that the commercial kaolin is in beds of Cusseta and Providence ages where the Tertiary has overlapped both formations.

A total of 37 species of Ostracoda have been found in the Ripley as a result of this investigation. Twenty-seven of these species have been reported previously. Of the remaining 10 species, four are de-

scribed as new in this dissertation. On the basis of the ostracods, the Ripley of Georgia can be correlated with the Saratoga formation of Arkansas and the Peedee formation of North Carolina.

INTRODUCTION

This stratigraphic study of the Ripley formation developed from an attempt to solve the age and relationships of the pre-Jacksonian sediments east of the Ocmulgee River in central Georgia. These sediments have been mostly mapped as Tuscaloosa, but this writer agrees with Eargle (1955) that they represent the entire Upper Cretaceous Series of western Georgia. Because of the difficulty of finding traceable beds and the seemingly uniform lithology of the sediments east of the Ocmulgee River, it is extremely difficult to correlate with the formations west of the Ocmulgee. Additional detailed work is needed on the more easily mappable units of western Georgia before their eastern correlatives can be readily differentiated. D. Hoye Eargle (personal communication) kindly suggested at the beginning of this study that the Ripley formation might be a possible key to the problem.

The Ripley formation and its bounding contacts were traced from the Chattahoochee River, where the Ripley can be readily identified both paleontologically and lithologically, to the east bank of the Flint River. In the absence of topographic map coverage in most of the area, county road maps were used as base maps and field data were located thereupon. In addition, the altitudes of all measured sections were recorded with the aid of an altimeter, and were tied in to U. S. G. S. bench marks or other surveyed elevations. The field work for this study was done between September 1956 and February 1957 and between June and September 1957.

Topography plays an important role in controlling the stratigraphic and paleontologic study of the Ripley of Georgia. The steep bluffs of the rejuvenated Chattahoochee River and adjacent highlands afford the only outcrops with fossil animal remains suitable for faunal study. East of Buena Vista, Marion County, in an area of more subdued relief, the sediments have been weathered. The weathering has masked the true lithology and dissolved the shells in the upper beds.

Plate I shows the outcrop of the Ripley formation and the Providence sand and the location of the measured sections. The outcrop pattern west of the Flint River is after Eargle, 1955 and the outcrop pattern east of the Flint River is modified after Eargle, 1955 as a result of the field work for this dissertation. Plate II shows the stratigraphic cross section and location and stratigraphic position of the ostracod samples and rock thin sections.

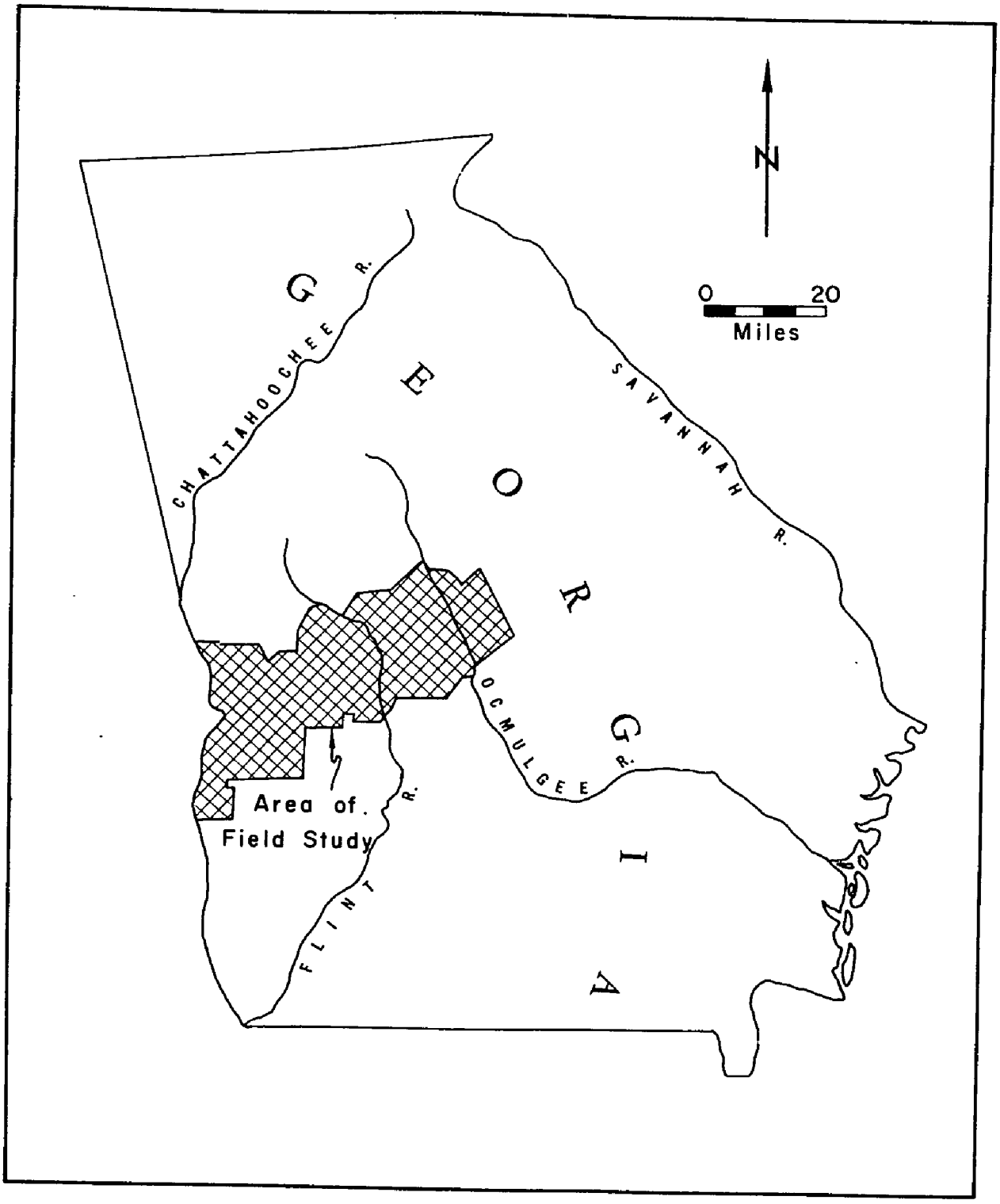

N
0
20
Miles
GEORGIA
CHATTAHOOCHEE R.
SAVANNAH R.
OCMULGEE R.
FLINT R.
Area of
Field Study

Fig. 1

STRATIGRAPHY

GULFIAN

General Features

The Gulfian sediments of the Chattahoochee River valley of Georgia are divided into six formations:

Providence sand

Ripley formation

Cusseta sand

Blufftown formation

Eutaw formation

Tuscaloosa formation

Langdon (1890, p. 605) in a general section along the Chattahoochee River divided the Cretaceous rocks of the region into Tuscaloosa, Eutaw, and Ripley, from oldest to youngest. Veatch (1909) recognized these same three divisions of the Cretaceous in Georgia and subdivided the Ripley formation into the Lower (Blufftown) marl, Middle (Cusseta) sand, Upper (Renfroes) marl, and Upper sand (Providence). Subsequent investigation resulted in the Blufftown, Cusseta, and Providence being elevated to formational rank.

In 1939, the Georgia Division of Mines, Mining and Geology in cooperation with the United States Geologic Survey published the Geologic Map of Georgia. The part of that map dealing with the Coastal Plain was based upon data from a manuscript prepared by C. Wythe Cooke. Cooke's manuscript, "Geology of the Coastal Plain of Georgia," was not published

until 1943. The Geologic Map of Georgia shows the Tuscaloosa cropping out from the Chattahoochee River on the west to the Savannah River on the east, the Eutaw and Blufftown formations extending from the Chattahoochee to Marion County, the Cusseta sand to the Ocmulgee River, the Ripley formation to Macon County, and Providence sand to the Ocmulgee River. Eargle (1955) extended the Eutaw and Blufftown formations to the Flint River and the Ripley formation to the Ocmulgee River; mapped the Eutaw, Blufftown, and Cusseta as undifferentiated between the Flint and Ocmulgee Rivers; mapped all Cretaceous sediments in Georgia east of the Ocmulgee as, "Rocks of Tuscaloosa to Providence age, undifferentiated." In making these changes and extensions, Eargle emphasized the cyclic nature of deposition of the Cretaceous rocks. These cycles or units of these cycles helped him map contacts in the nonmarine facies of Georgia east of the marine facies in the Chattahoochee River valley.

Eargle (1955, p. 5) described the Cretaceous rocks of the Coastal Plain as cyclic deposits most of which begin with coarse sand or gravel, progress upward through fine sand and clay and even chalky clay or chalk, and end with the beginning of another deposit of coarse sediment. A formation may consist of a complete cycle or one or more units of a cycle. With the exception of the Tuscaloosa, which is nonmarine, all the Upper Cretaceous formations in the Chattahoochee River valley are fossiliferous in the upper beds. Toward the east, each of the formations, with the exception of the Ripley, grade laterally into nearly similar beds of unfossiliferous, coarse sand and clay. The Ripley formation maintains the same general lithology eastward and fossil molds occur at the Flint River where the Ripley is overlapped by the coarse, crossbedded sand of the Providence.

RIPLEY FORMATION

General Features

The Ripley formation was first described by Hilgard (1860, p. 87) from localities near Ripley, Tippah County, Mississippi. Hilgard (1860) designated the Ripley as the sandy marls and limestones separating the underlying Cretaceous unit, the Rotten Limestone, from the overlying Northern Lignitic, which is Tertiary in age. Harris (1896) identified the top few feet of Hilgard's Ripley section as Tertiary (Midwayan).

The Ripley formation crops out in a narrow belt from the Chattahoochee River to the Flint River. East of the Flint River it is concealed by overlapping coarse, crossbedded sand of the Providence formation which is in turn overlapped by the more northerly striking Tertiary beds. The Ripley thins from approximately 150 feet in the Chattahoochee River valley to approximately 50 feet in the Flint River area.

In extreme western Georgia, the Ripley formation strikes N 77° E and dipssouthward 24 feet to the mile (data based on three points on an easily recognizable horizon). Toward the east the strike swings more northward and in the vicinity of Schley and Marion Counties the strike is N 60° E and the dip is southward at approximately 30 feet to the mile. In the area of the Flint River, the Ripley strikes N 55° E and dips southward approximately 30 feet to the mile.

The Ripley of western Georgia is composed of a nearshore facies of yellowish gray, sandy, calcareous clay (marl) with sandy limestone ledges and an offshore facies of dark gray, carbonaceous, micaceous, clayey fine sand and sandy clay with limestone ledges. The nearshore facies (marl)

predominates in an updip direction and thins downdip where the offshore facies (clayey fine sand) predominates.

The offshore facies of the Ripley is best exposed in the bluffs along the Chattahoochee River where it borders Quitman County and in deep gullies of southern Stewart County. These beds are fossiliferous, but many outcrops have the fossil shells leached away in the top few feet and only molds remain. Eastward in Schley County, the downdip Ripley is a dark gray, carbonaceous clay and light gray, clayey, fine sand with fossil molds. This lithology persists eastward to the Flint River. The nearshore facies is exposed in northern Stewart County, southern Chattahoochee County, and western and central Marion County. These beds are very fossiliferous and provide the most prolific ostracod fauna in the Ripley. The nearshore facies wedges out downdip and the contact between these beds is well exposed in an outcrop south of Frog Bottom Creek in central Stewart County (page 16, RWS locality 11).

In northern Quitman County, the Ripley rests on fine sand and fossiliferous, fissile dark gray clay of the Cusseta. Northeast of this region, in Chattahoochee and Marion Counties, the Cusseta is fine to coarse, crossbedded sand with beds of laminated clay. Near Butler, Taylor County, Georgia commercial kaolin has been mined from a lenticular clay bed in coarse, crossbedded, kaolinitic sand.

The Providence sand, which overlies the Ripley, is fossiliferous downdip in the Chattahoochee River valley and in outcrops along Pataula Creek in Clay county. In this region, the Providence is a light gray, fine to coarse, calcareous sand with calcareous sandstone ledges. The updip Providence, which is unfossiliferous, is well exposed at the type locality, Providence Canyons near Providence Church, Stewart County,

Georgia (page 10, RWS locality 10). Here, the basal part of the Providence is distinctly different from the upper part. The basal part is gray, very micaceous, clayey, carbonaceous fine sand which is in part distinctly stratified. Eargle (1955, p. 10) correlated these beds with the Perote member of the Providence sand of Alabama (Eargle, 1950) which merges with the Providence in the area of the Flint River. The upper part of the Providence sand is coarse, crossbedded, kaolinitic sand containing kaolin cobbles, pebbles, and partings. In Peach and Houston Counties, there are several localities where the coarse, crossbedded sand of the Providence contains stained, sandy kaolin lenses five to ten feet thick.

In summarizing the gross lithology of the three youngest Cretaceous formations (the Ripley and its bounding formations), the writer wishes to point out the marked similarity between the coarse, crossbedded, kaolinitic sand of the Cusseta in west central Georgia, and the coarse crossbedded sand of the Providence in the same area. In this area, these formations are separated by the fine marine sands and clays of the Ripley formation. It is the author's opinion that east of the Flint River, the Providence sand overlaps the Ripley and rests unconformably on the Cusseta sand. (see, AREA BETWEEN FLINT AND OCMULGEE RIVERS in this report).

Detailed Lithology

The outcrop area of the Ripley formation of Georgia is divided into four areas for the purpose of a detailed lithologic description:

(1) The fossiliferous offshore facies exposed along the Chattahoochee River and tributary streams in Quitman County and southern Stewart County;

(2) The very fossiliferous nearshore facies cropping out in northern Stewart County, southern Chattahoochee County, and southern Marion County;

(3) The belt of outcrops extending east-west across Stewart County that show the relationship between the nearshore and offshore facies;

(4) The offshore facies exposed eastward in northern Schley County, southern Taylor County, and northern Macon County. The Ripley outcrops of this area are, for the most part, exposed in the valleys of Buck Creek, Whitewater Creek, Toteover Creek, and the Flint River. In this area, the fossil shells in the fine sands and clays of the Ripley have been leached away and only molds remain.

Quitman and Southern Stewart Counties

The offshore facies of the Ripley crops out along the banks of the Chattahoochee River for most of the distance along the western boundary of Quitman County. One of the best known exposures of the Ripley and overlying Perote member of the Providence sand is near Georgetown, Quitman County:

RWS Locality 1

Location: West bank of Chattahoochee River, 500 yards below bridge on U. S. Highway 82; 1.5 miles west of Georgetown, Quitman County, Georgia; eastern city limits of Eufaula, Barbour County, Alabama.

	Feet
Terrace.	18

Providence sand:

Perote member:

	Feet
3. Sand, fine, grayish orange; very micaceous; contains kaolin grains; loose	2
2. Sand, fine, dark gray, clayey, carbonaceous; very micaceous; thinly bedded	29

Ripley formation: Elevation at top of formation = 233'

1. Sand, fine, dark gray, very clayey, micaceous, calcareous; fossiliferous; 2 sandy limestone ledges about 10 feet apart in upper half; 1 fine grained limestone ledge with borings near top. Most of lower one-third covered by slump. Exposed to normal water level of river	77

This same contact is found along Tobannee Creek, two miles southwest of the above locality, where the following section is exposed:

RWS Locality 2

Location: Left bank of Tobannee Creek at bridge of north-south trending county road; 1 mile south of Georgetown, Quitman County, Georgia. Section continued in ditch east of road up hill to the south

Providence sand:

Perote member:

2. Clay, dark gray, silty, carbonaceous; very thinly bedded.	9

Ripley formation: Elevation at top of formation = 203'

1. Clay, dark gray, silty, carbonaceous, calcareous; fossiliferous. 13

Stephenson (1911) and Cooke (1943) placed the entire section, below the terrace deposit, at Eufaula, Alabama in the Ripley formation, and placed the entire section at Tobannee Creek (Stephenson's Mercers Mill Creek locality) in the Ripley. Eargle (1955) correlated the very micaceous, thinly bedded sand at the top of the Eufaula section (page 8, RWS locality 1) and its stratigraphic equivalent on Tobannee Creek (page 9, RWS locality 2) with the Perote member of Providence sand at its type locality near Perote, Bullock County, Alabama (Eargle, 1950). The Perote, as mapped by Eargle, is a distinct lithologic unit and can be mapped as far east as Schley County. The Perote at Eufaula contains 42 percent mica (see Table I), is distinctly layered, and possesses a silvery sheen and a characteristic spongy feel that aid in distinguishing it from the underlying dark gray, very clayey, micaceous, fine marine sand of the Ripley.

In the Providence Canyons, at the type locality of the Providence sand, seven miles west of Lumpkin, southern Stewart County, the Perote-Ripley contact is exposed below 100 feet of coarse, crossbedded, kaolinitic sand of the Providence sand. This section is the same stratigraphic level as the Eufaula and Tobannee Creek sections, but it is approximately eight miles updip and 245 feet higher in elevation than the contact at Eufaula. The Providence Canyons section is:

RWS Locality 10

Location: Providence Canyons, 7 miles west of Lumpkin, Stewart County, Georgia; 100 yards south of

Providence Church and westernmost of the two canyons south of east-west trending county road

Feet

Tertiary (residuum of the Clayton formation)

6. Clay, sandy, weathers reddish brown. 37

Unconformity

Providence sand:

Upper member:

5. Sand, coarse, crossbedded; kaolinitic; variegated with yellow, orange, white, red, purple, and pink; contains kaolin balls up to 3 inches in diameter; loose 100

Perote member:

4. Sand, fine, grayish orange; very micaceous; contains kaolin grains; loose. Clay stringers in upper half 13

3. Sand, fine, dark gray, clayey, carbonaceous; very micaceous; thinly bedded 10

2. Sand, very fine, light gray, micaceous. 7

Ripley formation: Elevation at top of formation = 478'

1. Sand, fine, dark gray, clayey, micaceous; firm; fossil molds 14

Stephenson (1911) placed beds 1, 2, and 3, of the preceding section in the Ripley, but Cooke (1943, p. 38) placed beds 1 to 5 inclusive in the Providence with the following reservations: "The lower fossiliferous part of this section may belong to the Ripley formation, but no certain evidence of an unconformity separating it from the overlying Providence

sand was observed." Eargle (1955) placed the Ripley-Providence contact between beds 1 and 2 of the preceding section with an "Unconformity (?)" separating the two formations.

I failed to find evidence of an unconformity within the Cretaceous in any of the three preceding sections, and all formational contacts appear to be transitional.

The offshore Ripley of Eufaula and Tobannee Creek contains an abundant ostracod fauna as well as many thin shelled mollusks, but the Ripley of Providence Canyons is so leached by ground water that only molds remain.

Northern Stewart, Southern Chattahoochee, and Southern Marion Counties

The nearshore facies of the Ripley crops out along the steep frontal slope of a cuesta trending northeast across northern Stewart, southern Chattahoochee and central Marion Counties. This cuesta is formed by the more resistant Providence sand and Ripley formation which overlie the easily eroded Cuessata sand. One of the best exposures of the nearshore yellowish gray, sandy, calcareous clay is found just north of the Chattahoochee-Stewart county line at Renfroe, Georgia (type locality of Veatch's (1909) "Renfroe Marl"). It consists of:

RWS Locality 13

Location: U. S. Highway 280, beginning .5 mile north of Chattahoochee-Stewart County line at Renfroe, Georgia and continuing north down hill

Feet

Providence Sand:

Perote member:

4. Sand, fine to coarse, micaceous; weathers red . . 4

Ripley formation: Elevation at top of formation = 611'

		Feet
3.	Sand, fine, yellowish gray, calcareous, micaceous, very clayey	6
	Not exposed	26
2.	Clay, yellowish gray, sandy, micaceous, calcareous; contains white lime nodules; very fossiliferous; (marl); 4 to 6 inch sandy limestone ledges every 4 to 6 feet	22
	Not exposed.	37
1.	Sand, very find, medium gray, micaceous; very clayey	32

Three and one-half miles north-northeast of the above locality, in the southwest corner of Chattahoochee County, the following section is exposed:

RWS Locality 14

Location: Northwest trending county road 2.5 miles northwest of the Chattahoochee-Marion County line; outcrop on north side of road, 2 miles airline northwest of Liberty Hill Church and 1.3 miles airline east of Gobblers Hill School

Ripley formation: Elevation at top of outcrop = 627'

		Feet
3.	Sand, fine, light gray, micaceous; weathers yellowish orange.	12
2.	Clay, yellowish gray, silty, micaceous, calcareous; fossil molds	10
1.	Clay, yellowish gray, micaceous, calcareous;	

Feet

contains white calcareous nodules; very fossilferous; (marl). 2

The nearshore marl contains the most fossiliferous beds known in the Ripley formation. A prolific ostracod fauna was collected and is described in this report. The beds abound with well preserved mollusks and Stephenson (1911) has a complete list of the fossils collected at Renfroe, Georgia.

Fourteen miles east of the section at Renfroe, on a steeply sloping hillside, one and one-half miles northeast of Buena Vista, Marion County, both bounding contacts of the Ripley are exposed. Here, the Cusseta is a loose, crossbedded, coarse sand. This far east the Perote is coarser and has apparently merged with the upper member of the Providence sand. Downdip, the Perote can be traced as far east as Schley County. At Buena Vista, weathering has masked the true lithology and leached all fossil shells. The following section was measured:

RWS Locality 16

Location: State Highway 137, 1.5 miles northeast of Buena Vista, Marion County, Georgia

Feet

Providence sand:

5. Sand, medium to coarse, micaceous, weathers red. . . 8

Ripley formation: Elevation at top of formation = 615'

4. Sand, fine, very clayey; weathers light red. 26

3. Clay, yellowish gray, very silty, micaceous, hackly; weathers reddish brown; fossil molds 10

Not exposed. 75

2. Sand, fine to medium, very clayey; weathers reddish brown 4

Cusseta sand:

1. Sand, coarse, light brown; crossbedded, loose 6

Central Stewart County

The nearshore marl facies thins from approximately 90 feet at Renfroe to 18 feet at the Roods Creek locality (RWS locality 8) and apparently wedges out completely farther down dip.

At Renfroe, the marl immediately underlies the Perote although intense leaching has reduced the clay and lime content in the top few feet. At Frog Bottom Creek (RWS locality 11), 11 miles south-southwest of Renfroe, the top of the marl is 35 feet below the Perote-Ripley contact and is overlain by dark gray, clayey, fine sand of the downdip Ripley. At Roods Creek (RWS locality 8), 21 miles southwest of Renfroe, the top of the marl is 75 feet below the Perote-Ripley contact. At Soapstone Creek, 8 miles southwest of Roods Creek, dark gray, fossiliferous, fine sand overlies medium to coarse sand at the base of the Ripley with no trace of the nearshore marl.

The Roods Creek section exposes both bounding contacts of the Ripley and the boundary between the nearshore and offshore facies. The Frog Bottom Creek section shows the facies contact and the Perote-Ripley contact:

RWS Locality 8

Location: East-west unimproved road into valley of Roods Creek, beginning 1 mile north of Templeton cemetery and extending into valley bottom; 3 miles west of Oak Grove Church, Stewart County, Georgia

Feet

Providence sand:

Upper Member: Feet

7. Sand, coarse, weathers red; leached. Ironstone ledge at base. 15

Perote member:

6. Sand, fine, grayish orange; very micaceous; contains kaolin grains, 2 feet of bedded, pale yellowish orange clay in lower part of bed; ironstone ledge at base 33

Ripley formation: Elevation at top of formation = 440'

5. Sand, fine, light gray, clayey; weathers reddish-brown. Five feet of silty clay near base. Only upper 5 feet and lower 13 feet exposed. 75

4. Clay, yellowish gray, sandy, micaceous blocky, calcareous; very fossiliferous; (marl). 18

3. Sand, fine, clayey, very coarse sand at base; weathers dark yellowish orange; leached 42

Cusseta sand:

2. Clay, light gray, sandy; weathers light brown . . . 4

1. Sand, fine to medium; weathers light brown. 14

RWS Locality 11

Location: U. S. Highway 27, 3.7 miles north of Lumpkin, Stewart County, Georgia; road cut in hill south of Frog Bottom Creek

Feet

Providence sand:

Upper member:

4. Sand, coarse, crossbedded; weathers red; contains clay pebbles; undulating contact with

	Feet
bed below.	20
Perote member:	
3. Sand, fine, grayish orange; very micaceous; trace of bedding; loose; more clayey and firm in lower 6 feet.	26
Ripley formation: Elevation at top of formation = 455'	
2. Sand, fine, dark gray, clayey, micaceous; becomes calcareous and more clayey toward bottom; 1 foot sandy limestone ledge in middle; fossiliferous. . .	35
1. Clay, yellowish gray, sandy, calcareous; contains white lime nodules; very fossiliferous; (marl). . .	6

Cooke (1943, p. 32) and Eargle (1945, p. 60) placed the contact of the Providence-Ripley between beds 3 and 4 of the preceding section. However, in my opinion, the very micaceous, fine sand (bed 3) at Frog Bottom Creek is the stratigraphic equivalent of the Perote at Eufaula, Tobannee Creek, Roods Creek, and Providence Canyons. If this is the case, the contact between the Providence sand (Perote member) and the underlying Ripley formation should be placed between beds 2 and 3. Both Cooke and Eargle recognized an unconformity between beds 3 and 4. However, I was unable to trace this unconformity to any of the aforementioned localities and as a result believe the undulating contact is local in nature. This contact could well be the result of offshore currents depositing the coarse, crossbedded sand of bed 4 and need not necessarily be an unconformity separating the Providence from the Ripley.

Northern Schley, Southern Taylor and Northern Macon Counties

In this area, the offshore facies of the Ripley-light-gray, clayey,

fine marine sand and sandy clay—is exposed in the valleys of Buck, Whitewater, and Toteover Creeks and along the east bank of the Flint River. East of Marion County, only mollusk molds and a few areanaceous foraminifers were found during the course of this investigation. The foraminifers Haplophragmoides sp. and Ammobaculites sp. were identified from the dark gray, silty clay on Toteover Creek (RWS locality 20). Cooke (1943, p. 34) reports the presence of Veniella conradi, Cyprimera depressa, Etea? sp., and Turritella trilira from fossil prints which occur in an outcrop of Ripley on State Highway 127, 5 miles S. 70° W. of Marshallville. This is the Flint River ferry locality (RWS locality 23A) of this report. The following four sections are typical of the Ripley in this area:

RWS Locality 18

Location: South valley slope of Buck Creek, east side of north trending county road, 5.5 miles north-northwest of Ellaville, Schley County, Georgia; 4.5 airline miles north-northwest of Ellaville

Feet

Providence sand:

Coarse, kaolinitic, crossbedded Providence sand with basal conglomerate crops out near top of hill south of section below

Perote member:

3. Sand, medium, weathers light brown, contains clay partings; channels into bed below. 6

Unconformity:

Ripley formation: Elevation at top of formation = 396'

2. Sand, fine, clayey, micaceous; weathers yellowish

Feet

orange; 6 inches of brown clay at base. 1-6

1. Clay black, carbonaceous, interbedded sand stringers. Clayey sand toward base 10

RWS Locality 22A

Location: Cut on Atlantic Coast Line Railroad, 1 mile west of Ideal, Macon County, Georgia

Feet

Ripley formation: Elevation at top of outcrop = 371'

2. Sand, fine, light gray, clayey; weathers grayish orange. 9

1. Clay, dark gray, very silty, micaceous, carbonaceous; more silty and sandy toward top; fossil molds 21

RWS Locality 20

Location: Ditch 50 yards south of bridge of State Highway 128 over Toteover Creek, east side of highway; Macon County, Georgia

Feet

Ripley formation: Elevation at top of outcrop = 352'

2. Clay, dark gray, silty, micaceous, carbonaceous; brown clay in top 2 feet. 5

1. Clay, light gray, very silty, micaceous, becomes clayey fine sand in top 3 feet; fossil molds. . . . 7

RWS Locality 23A

Location: East bank of Flint River, 50 yards upstream from the ferry crossing on State Highway 127; 4.8 miles southwest of Marshallville, Macon County, Georgia

	Feet
Providence sand:	
3. Sand, coarse; weathers red.	5
Ripley formation: Elevation at top of formation = 314'	
2. Sand, find, brownish gray, very clayey, micaceous; fossil molds.	10
Not exposed	15
1. Clay, dark gray, silty, micaceous, carbonaceous; interbedded sand stringers; exposed to normal water level of river.	5

The Ripley thins to approximately 50 feet in the Flint River area from a maximum of 150 feet in the offshore facies of the Chattahoochee River valley. The thinning is at least partly the result of erosion of the Ripley associated with overlap of that formation by the more northerly striking Providence. (See PROVIDENCE SAND in this report). The contact at the ferry crossing is poorly exposed so no erosional surface was seen.

There is little evidence of a facies change from west to east and the formation has the same gross lithologic appearance along the Flint River as along the Chattahoochee River. Although the mica percentage, in grains greater than 18 microns, decreases considerably in eastern Stewart County and is reduced to less than one percent east of Marion County, the limonite content of the matrix increases as the mica decreases (see Tables I and III). This increase may be due, in part, to intense weathering altering biotite to limonite.

PROVIDENCE SAND

Area Between Flint and Ocmulgee Rivers

The Flint River area is most important in understanding the stratigraphic relationship between the Ripley formation and the Providence sand in central Georgia. In order to avoid future misunderstandings concerning the age of strata exposed at the ferry on the Flint River (RWS locality 23A) and at the high bluff northeast of the ferry (RWS locality 24), a brief history of their previous age determinations is necessary.

Stephenson (1911, p. 165) wrote, "Strata belonging to the Cusseta sand member underlie the northern part of Macon County in an area embracing about one-third of the county. In a gully in the high scarp facing Flint River, five or six miles west of Marshallville, Ga., over 100 feet of materials are exposed, consisting of coarse to fine, more or less arkosic, crossbedded sand with occasional lenses of light drab clay. The sand contains small clay balls in places. About half way to the top of the section an indurated ironstone forms a projecting ledge, and just below this is a layer of large, mechanically included, clay balls. The sands above the indurated layer are more argillaceous than those below it. This whole section is believed referable to the Cusseta member.

"At Underwood Ferry, Flint River, one and one-half miles below the locality described, weathered marine sand, poorly exposed about 10 feet above water level, contains soft casts of Venericardia planicosta. It

is therefore of Eocene age. If the materials in the gully just described, one and one-half miles north of this place, are of Cretaceous age, as interpreted, there must be a profound unconformity separating the Cretaceous and Eocene deposits, for the difference in level between the Underwood Ferry exposure and the top of the section in the gully must be fully 150 feet. The fossilbearing sand at Underwood Ferry, however, is poorly exposed, and there is a possibility of its having slipped down from a higher level."

Cooke (1943, p. 34) states, "Early in 1943 A. D. Zapp discovered an outcrop of the Ripley formation east of Flint River on State Highway 127, 5 miles S. 70° W. of Marshallville. This extends the Ripley about 6 miles farther toward the northeast than is shown on the geologic map. The Ripley consists of 12 feet of soft gray micaceous, argillaceous sand containing many soft prints of fossils, among which L. W. Stephenson recognized Veniella conradi, Cyprimeria depressa, Etea? sp. and Turritella trilira. The bottom of the bed lies about 15 feet above the normal water level in the river. The bed is overlain by coarse red sand and sandstone supposed to be Providence."

The ferry at the crossing of State Highway 127 over the Flint River is Underwood Ferry (authority David Montfort, Reynolds, Georgia) 5 miles S. 70° W. of Marshallville. Thus, Stephenson's Underwood Ferry locality, Cooke's outcrop east of the Flint River on State Highway 127, and locality 23A of this report are all the same locality.

In addition to the fine marine sand of Stephenson and Cooke, 5 feet of dark gray, carbonaceous silty clay crops out in the east bank of the Flint River just upstream from the ferry (see page 20, RWS locality 23A). This clay is in place and leads me to believe the sand is

also in place. The entire section correlates with other Ripley sections at Toteover Creek, Buck Creek, and Ideal, Georgia. Therefore, the Flint River section is considered Ripley in this report.

Although locality 24 in this report is only 3 miles airline northwest of Marshallville, there is little doubt that it is the same stratigraphic interval, if not the same outcrop, that Stephenson believed referable to the Cusseta sand. The lithic sequence compares favorably with Stephenson's description and the top of the Cretaceous in locality 24 is 160 feet higher than the top of the marine sands at the ferry.

Eargle recognized the presence of Providence sand in the high bluff 3 miles northeast of Marshallville, but referred the lower part of the section to the Ripley. Eargle (1955, p. 81) states, "Three miles northwest of Marshallville, west of the county road, are large gullies that expose the wedge of Providence sand between Tertiary rocks and the Ripley formation. Here, deep-reddish brown clayey sand of the Tertiary overlies white to light-red coarse sand of the Providence. One thin lens of pale-red-purple massive clay about 2 feet thick lies about 20 feet below the contact of the Tertiary and Cretaceous. In the bottom of the gullies, fine sand of the Ripley is exposed, but the Providence and Ripley contact is obscured by colluvium. Large blocks of ferruginous conglomerate are scattered on slopes below the contact. In this area the Providence is about 30 feet thick."

The following section was measured in the high bluff facing the Flint River, 3 miles northwest of Marshallville:

RWS Locality 24

Location: Gully in the high bluff west of north trending county road, 2 miles airline south of Macon-

Peach County line; 3 miles airline northwest of Marshallville, Macon County, Georgia

	Feet
Tertiary:	
4. Sand, coarse, dark red, clayey; contains clay partings; indurated.	6
Unconformity	
Providence sand: Elevation at top of formation = 475'	
3. Sand, medium yellowish white; crossbedded; loose; interbedded with white clay stringers; coarse ferruginous sand stringers scattered throughout bed.	28
2. Sand, coarse, ferruginous, forms ironstone ledge . .	2
1. Sand, fine to medium, purplish white, micaceous; loose; interbedded with purple clay 1-8 inches thick. Clay predominated toward the top and the top 3-4 feet is a sandy, purple clay; exposed to bottom of gully.	27

The gross lithology of the high bluff section is the same as the Providence sand at its type locality; the elevation at the base of the lowest sand is approximately 70 feet above the top of the Ripley (projected from the Flint River ferry, 1.3 miles down dip); and the strata exposed on Toteover Creek, 6 miles southwest of the high bluff, are typical Ripley lithology and bear no resemblance to that exposed here. For these reasons, the entire section is assigned to the Providence.

In my opinion, determining the correct age of the section in the high bluff east of Marshallville is the key to mapping the younger

Cretaceous formations east of the Flint River. It is this stratigraphic unit that crops out at the margins of the overlying Fort Valley Plateau which is formed by the overlapping resistant Tertiary beds in northern Macon, southern Crawford, Peach and Houston Counties.

Roads and gullies cutting the western scarp of the Fort Valley Plateau fail to reveal any sign of the Ripley north of the Flint River ferry (RWS locality 23A), and it appears that the Providence sand has overlapped and cut out the Ripley to the north.

One-half mile north of Zenith, 7 miles northwest of Fort Valley and 13 miles north of the Flint River ferry, in cuts of the Southern Railroad, a 32-foot section of yellow, fine to medium, crossbedded sand with lenses of thinly bedded gray clay and sand underlies dark red, coarse, ferruginous sand of the Tertiary. Beneath the yellow sand is a gray, coarse, crossbedded sand with a 4-foot lens of white, iron stained kaolin. This is probably the contact between the Providence sand and the Cusseta sand with the Ripley formation having been cut out by the overlapping Providence. This contact is very difficult to correlate with other outcrops because of the lithologic similiarity and crossbedded structure of the Cusseta and Providence sands.

The contact of the Providence with the overlapping Tertiary is exposed one-half mile southwest of Powersville, Peach County. Here, the Providence contains a 2-foot lens of kaolin at the contact with the Tertiary. The Powersville section consists of:

RWS locality 26

Location: One-half mile southwest of Powersville, Peach County, Georgia on State Highway 49 in gully east of highway near top of hill

	Feet
Tertiary:	
2. Sand, coarse, dark red, intensely leached.	4
Unconformity	
Providence sand: Elevation at top of formation = 460'	
1. Sand, medium to coarse, red; crossbedded; loose; contains kaolin partings, balls, and stringers; 2-foot kaolin lens at top of bed	10

Two miles north of Byron and one-half mile south of Walton's Mill, red, fine to medium, crossbedded sand of the Providence underlies coarse clayey sand of the Tertiary. Near the bottom of the hill, 150 feet lower in the section, is a coarse sand with clay beds that probably belong in the Cusseta sand.

In this area, where the Providence overlaps onto the Cusseta and the fine marine sand of the Ripley is no longer present to separate the formations, it is virtually impossible to map the base of the Providence. Therefore, I believe the Providence sand east of the Flint River should be considered as part of the Cusseta sand, Blufftown and Eutaw formations undifferentiated of Eargle (1955). (See page 4 in this report.)

CRETACEOUS EAST OF THE OCMULGEE RIVER

Twiggs County

All Cretaceous beds east of the Ocmulgee River are presently mapped as Tuscaloosa. The age of these beds and of kaolin lenses that occur at the contact of the Cretaceous and overlying Tertiary is uncertain.

Regarding the Cretaceous deposits east of the Ocmulgee River, Eargle (1955, p. 83) states, "Most of the beds of the Cretaceous section east of the Ocmulgee River are so similar that it has not been possible to map separate formations. In earlier reports the Cretacecus strata east of the Ocmulgee River have been assigned to the Tuscaloosa formation, but it now appears that only the basal part of these beds in central Georgia, possibly a few tens of feet, can properly be assigned to the Tuscaloosa formation. Most of the Cretaceous formations of the Chattahoochee region may be represented in eastern Georgia, but if so, all look so much alike that they cannot be readily differentiated."

It is not the intent of this paper to assign an age to these deposits. However, while studying the Ripley and its bounding formations, data came to light that do have a bearing on the age of these sands and their kaolin lenses.

In Twiggs County, east of the Ocmulgee River, coarse crossbedded, kaolinitic sand, resembling the Cusseta and Providence west of the Ocmulgee, crops out below overlapping Tertiary beds. The elevation of these sands compares favorably with the elevation obtained by projecting the trend of the Cusseta and Providence, west of the Ocmulgee, into

Twiggs County. No trace of the Ripley, which is overlapped in the area of the Flint River, can be found at the surface in Twiggs County.

Some of the best quality kaolin occurs in northern and central Twiggs County in the coarse, crossbedded, kaolinitic sand just below the contact of the overlapping Tertiary formations. As stated previously, kaolin has been mined from the Cusseta sand near Butler, Taylor County and from the Providence in Peach and Houston Counties.

In view of the above data, it seems very likely that the kaolin in Twiggs County is mined from beds of Cusseta and Providence sand where the Tertiary has overlapped both formations.

SUMMARY

The Ripley formation represents the most extensive marine sequence in the Cretaceous of Georgia. The Ripley is very fossiliferous in the Chattahoochee River Valley and yields mollusk molds and arenaceous foraminifers as far east as the Flint River. The rejuvenated Chattahoochee River and its tributaries afford fresh exposures for stratigraphic study as well as an excellent ostracod and mollusk fauna. The lack of fossils east of Marion County suitable for precise identification is due to the intense leaching of the outcrops rather than to a change in depositional environment.

The Ripley of western Georgia is composed of a nearshore facies of yellowish gray, sandy, calcareous clay (marl) and an offshore facies of dark gray, carbonaceous, clayey, fine sand. The marl predominates in an updip direction and thins downdip where the gray, fine sands predominate. In west central Georgia, the Ripley is almost entirely gray, fine marine sand and dark gray, carbonaceous clay.

The underlying Cusseta sand and overlying Providence sand are fossiliferous and definitely marine downdip along the Chattahoochee River, but updip and eastward the Cusseta and Providence formations are represented by unfossiliferous, coarse, crossbedded sands and clays.

The gray, calcareous fine marine sands of the Ripley undergo very little facies change from the Chattahoochee River to the Flint River. East of the Flint River, the more northerly striking Providence overlaps the Ripley and rests unconformably on the Cusseta. In this area, it is virtually impossible to distinguish the Providence from the Cusseta

because of their gross lithologic similarity and the absence of the marine sands of the Ripley that separate these formations west of the Flint River.

The commercial kaolin of central Georgia occurs in coarse, cross-bedded, kaolinitic sands that crop out below the overlapping Tertiary formations. The kaolin and the sands in which it occurs are probably of Cusseta and Providence ages, although the formations are not differentiated in this area of seemingly uniform lithology.

SEDIMENTARY PETROGRAPHY

Twenty thin sections have been used to supplement and modify field descriptions, and the results have been included in the composition of the text. Plate I shows the geographic location and Plate II shows the stratigraphic position of the thin sections.

The mineral percentages of each thin section are based on a 100 point count (Chayes, 1949) of grains 18 microns (.018 mm) in diameter or larger. Grains smaller than 18 microns (fine silt to clay size particles) are grouped under the heading "Matrix" regardless of mineral composition. In these slides, the micas form a continuous series from coarse sand size muscovite and biotite, to sericite, to clays; and quartz grades from coarse sand size to clay size. Thus, matrix as used in this report is an arbitrary classification including both quartz and clay mica minerals. The minerals listed under the heading "Trace Minerals" are minerals that were identified in a survey of the thin sections but did not appear in the point count.

Petrographic data are given on Tables I, II, and III. Table I lists percentage of mineral component. Table II lists mean, standard deviation from the mean, and observed range of the quartz grain size in slides where the quartz exceeds 10 percent. Quartz grain size is based on measurements of the apparent long axis of the grain. Table III lists trace minerals and description of matrix.

TABLE I

PERCENTAGES OF MINERALS IDENTIFIED IN EACH THIN SECTION

Thin Section Number	Quartz	Green Biotite	Brown Biotite	Musco-vite	Carbonized Wood	Ortho-clase	Micro-cline	Kaolinite	Glauco-nite	Fossil Fragments	Matrix
1-1	44	4	2	2	1	1					46
1-8	41	4	4	4	8						39
1-13	28	18	12	12	4			1			25
2-2	9	5	5	9	26						46
2-6	10	15	12	12	10						41
3-2	47					2	1				50
3-4	75						2				23
8-4	24	5	2	3	1					5	60
9-2	40	1		1					5	5	48
10-3	23	9	12	17	9			10			20
10-5	59			3	2		2	2			31
11-1	74			2		2					22
11-3	69			2							29
11-7	39		1	3		1			1	4	51

TABLE I (cont'd.)

Thin Section Number	Quartz	Green Biotite	Brown Biotite	Musco-vite	Carbonized Wood	Ortho-clase	Micro-cline	Kaolinite	Glauco-nite	Fossil Fragments	Matrix
13-7	28		2	2						4	64
18-2	33										67
18-5	2										98
20-3	4										96
22A2	26						2		1		71
23A2	42										58

TABLE II

MEAN GRAIN SIZE, STANDARD DEVIATION FROM MEAN, AND OBSERVED RANGE OF QUARTZ GRAINS IN THIN SECTIONS WHERE QUARTZ EXCEEDS TEN PERCENT

Thin Section Number	Mean	Standard Deviation From the Mean	Observed Range
1-1	.144 mm	.0583	.04 to .27 mm
1-8	.137 mm	.0608	.02 to .27 mm
1-13	.128 mm	.0520	.04 to .27 mm
3-2	.215 mm	.0855	.07 to .46 mm
3-4	.197 mm	.0714	.02 to .38 mm
8-4	.108 mm	.0490	.04 to .23 mm
9-2	.371 mm	.2260	.02 to .92 mm
10-3	.069 mm	.0387	.02 to .12 mm
10-5	.153 mm	.0520	.03 to .32 mm
11-1	.205 mm	.0648	.07 to .38 mm
11-3	.187 mm	.0678	.03 to .38 mm
11-7	.132 mm	.0548	.02 to .23 mm
13-1	.094 mm	.0755	.02 to .32 mm
18-2	.234 mm	.0663	.12 to .38 mm
22A2	.075 mm	.0458	.02 to .19 mm
23A2	.122 mm	.0566	.02 to .27 mm

TABLE III

TRACE MINERALS AND MATRIX DESCRIPTION OF ALL THIN SECTIONS

Thin Section Number	Trace Minerals	Matrix
1-1	Pyrite, glauconite, microcline, plagioclase, pyroxene, fossil fragments	Approximately equal percent of quartz, mica and clay with small percent of carbonized wood fragments disseminated throughout matrix
1-8	Pyrite, glauconite, microcline, plagioclase, orthoclase, pyroxene, fragmental calcite, fossil fragments, kaolinite	Same as 1-1
1-13	Pyrite, collophane, microcline, orthoclase, pyroxene, kaolinite	Clay with small percent of mica and carbonized wood fragments disseminated throughout clay
2-2	Pyrite, microcline, pyroxene, fossil fragments	Clay and carbonized wood fragments with small percent of quartz and mica
2-6	Pyrite, collophane, microcline, orthoclase, pyroxene	Approximately equal percent of clay, mica, and carbonized wood fragments with small percent of quartz.
3-2	Pyrite, glauconite, green biotite, brown biotite, muscovite, pyroxene, phosphate, fossil fragments, carbonized wood fragments	Clay with small percent of limonite and quartz and a very small percent of mica
3-4	Green biotite, muscovite, plagioclase, pyroxene, garnet	Limonitic clay with small percent of mica and quartz
8-4	Glauconite, microcline, pyroxene carbonized wood fragments	Calcareous clay

TABLE III (cont'd.)

Thin Section Number	Trace Minerals	Matrix
9-2	Muscovite, green biotite, collophane, microcline, pyroxene, phosphate, zircon	Calcareous clay with small percent of quartz
10-3	Microcline, orthoclase	Same as 2-6
10-5	Glauconite, biotite, plagioclase, pyroxene, garnet	Limonitic clay with small percent of quartz, mica, and carbonized wood fragments
11-1	Biotite, pyroxene	Limonitic clay
11-3	Microcline, pyroxene	Limonitic clay with small percentage of quartz
11-7	Plagioclase, pyroxene, phosphate	Limonitic, calcareous clay with small percentage of quartz and very small percentage of mica
13-1	Glauconite, collophane, microline, phosphate	Calcareous clay with small percentage of quartz
18-2	Biotite, muscovite, orthoclase	Limonitic clay with small percentage of quartz and mica
18-5	Muscovite	Limonitic, carbonaceous clay with quartz and mica
20-3	Muscovite	Same as 18-5
22A2	Pyrite, biotite, muscovite, carbonized wood fragments	Same as 18-5
23A2	Glauconite, muscovite, microcline, carbonized wood fragments	Limonitic, carbonaceous clay with small percentage of quartz and mica

OSTRACODA

A total of 37 species of ostracods have been found in the Ripley formation as a result of this investigation. Thirty of the 37 species occur in the marly facies and 28 in the sandy facies. Although the number of species in each facies is about the same, the number of individual specimens per unit volume is far greater in the nearshore marl.

The following species are restricted to the nearshore marl facies:

Haplocytheridea ? rayburnensis Butler and Jones, 1957

Haplocytheridea ? monmouthensis (Berry), 1925

Cythereis costatana Israelsky, 1929

Krithe cushmani Alexander, 1929

Veenia ozanana (Israelsky), 1929

Cytherelloidea crafti Sexton, 1951

Cytherella sp. 2

Paracypris sp.

Argilloecia sp.

The following species are restricted to the offshore sand facies:

Cytherura ? saratogana Israelsky, 1929

Progonocythere ? sp.

Haplocytheridea n. sp.

Clithrocytheridea ? n. sp.

Haplocytheridea ? sarectaensis (Brown), 1957

Cythereis harardi Israelsky, 1929

Amphicytherura curta (Jennings), 1937

On the basis of the entire ostracod assemblage, the Ripley formation of Georgia can be correlated with the Saratoga formation of southwest Arkansas and the Peedee formation of North Carolina.

CHECK LIST OF OSTRACOD SPECIES

	1-1	1-3	1-5	1-6	1-7	1-8	1-10	1-11	2-1	2-2	2-3	3-2	8-4	9-2	11-5	11-7	11-9	13-1	13-3	13-5	14-2
Cytherelloidea crafti													x	x			x	x	x	x	x
Cytherella ovoidea	x	x	x	x	x			x	x					x		x	x		x	x	x
Cytherella cf. C. tuberculifera	x	x	x	x									x			x			x		
Cytherella sp. #1	x	x	x	x													x			x	
Cytherella sp. #2																			x		
Argilloecia sp.													x					x	x		x
Paracypris sp.																		x			
Bairdoppilata magna			x	x	x	x	x	x	x	x			x	x					x	x	x
Xestoleberis sp.				x	x		x						x	x		x	x	x	x	x	x
Loxoconcha cretacea							x		x	x	x		x		x		x	x	x	x	x
Cytheropteron n. sp.				x		x						x					x	x	x	x	x
Orthonotacythere hannai		x				x	x						x		x			x	x	x	x
Clithrocytheridea ? n. sp.	x	x	x	x		x		x	x												
Clithrocytheridea fabaformis	x	x	x	x	x	x				x	x	x			x	x			x	x	x
Haplocytheridea n. sp.	x	x	x																		
Haplocytheridea ? councilli		x	x	x	x	x	x	x	x	x		x		x	x	x	x			x	x
Haplocytheridea ? globosa	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x
Haplocytheridea micropunctata					x	x		x	x				x	x			x	x	x	x	x
Haplocytheridea ? monmouthensis																		x	x	x	x
Haplocytheridea ? plummeri	x	x	x	x		x	x	x		x			x	x	x		x	x	x	x	x
Haplocytheridea ? rayburnensis													x	x			x	x	x	x	x
Haplocytheridea sarectaensis	x	x													x	x					
Haplocytheridea ? ulrichi	x	x	x	x		x	x	x	x	x		x		x		x				x	
Krithe cushmani																	x	x	x		
Progonocythere ? n. sp.	x																				
Brachycythere ledaforma	x			x	x	x	x	x	x					x						x	
Brachycythere ovata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x
Brachycythere rhomboidalis	x	x	x	x	x	x	x		x			x	x	x	x	x	x	x	x	x	x
Ptergocythere saratogana				x	x	x			x				x	x			x	x	x		x
Cythereis costatana													x	x			x	x	x		
Cythereis communis			x	x	x	x	x	x	x	x			x	x	x		x	x	x	x	x
Cythereis hazardi		x														x					
Cythereis huntensis	x					x	x	x	x	x			x			x	x	x	x	x	x
Veenia ozanana													x				x				
Veenia arachoides	x	x	x	x	x	x	x	x	x	x		x			x	x		x	x	x	x
Amphicytherura ? curta			x													x					
Cytherura ? saratogana	x					x		x	x	x	x										

Fig. 2

DESCRIPTION OF GENERA AND SPECIES

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA

Suborder PLATYCOPA Sars, 1865

Family CYTHERELLIDAE Sars, 1866

Genus CYTHERELLOIDEA Alexander, 1929

CYTHERELLOIDEA CRAFTI Sexton, 1951

Plate IV, Fig. 7, 9

Cytherelloidea crafti Sexton 1951, p. 813, pl. 117, figs. 7-10.
Cytherelloidea sp. Butler and Jones 1957, p. 10, pl. 6, fig. 4.
Cytherelloidea greenensis Brown 1957, p. 9, pl. 1, figs. 22, 23, 26, 29.

DIAGNOSIS: A dimorphous species characterized by 3 longitudinal ridges. The dorsal and median ridge bends around a dorso-central muscle depression.

DESCRIPTION: Carapace oblong with broadly rounded anterior, truncated posterior, and straight dorsal outline. The ventral outline of the female is essentially straight, and the ventral outline of the male is concave. Marginal rim of female parallels the dorsal, ventral and anterior margin. Anterior rim is more raised and a little more removed from margin than the dorsal and ventral rim. Marginal rim of male like female, but also parallels posterior margin. Surface of carapace with 3 longitudinal ridges: dorsal, median, and ventral. Dorsal and ventral ridges begin near posterior margin and extend about three-fourths the length of valve. Median ridge begins just behind

small muscle pit and bends below it. Dorsal ridge bends above muscle pit. Dorsal and ventral ridges of female have large nodes at their posterior extremity. Median ridge of male not as well developed as female. Right valve larger than left and overlaps around entire periphrey. Hinge adont.

Dimensions: 0.70 x 0.44 mm. (female)

Localities: 8-4, 9-2, 11-9, 13-1, 13-3, 13-5, 14-2.

Genus CYTHERELLA Jones, 1849

CYTHERELLA OVOIDEA Alexander, 1929

Plate V, fig. 7

Cytherella ovoidea Alexander 1929, p. 54, pl. 1, figs. 11, 14.

Cytherella ovoidea Skinner 1956, p. 182, pl. 1, figs. 1a-d.

Cytherella ovoidea Howe and Laurencich 1958, p. 252, fig.

DIAGNOSIS: A species with strong centro-dorsal and centro-ventral overlap and thick posterior.

DESCRIPTION: Carapace in side view, oblong-ovate; highest at center. Anterior and posterior broadly rounded; dorsal outline evenly arched; ventral outline convex. Right valve larger than left and overlaps the entire periphery with strong centro-dorsal and centro-ventral overlap. In dorsal view, thickest near posterior. Surface smooth. Hinge adont.

Dimensions: 0.77 x 0.54 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 2-1, 2-2, 9-2, 11-7, 11-9, 13-3, 13-5, 14-2.

CYTHERELLA cf. C. TUBERCULIFERA Alexander, 1929

Plate V, fig. 9

Cytherella tuberculifera Alexander 1929, p. 52, pl. 2, fig. 3.

DIAGNOSIS: A species characterized by blunt projection in the middle of the posterior margin of right valve.

DESCRIPTION: Carapace in side view, oblong-ovate; highest hear center. Dorsal outline gently arched; anterior and posterior broadly rounded, but the right valve bears a prominent, blunt projection in the middle of the posterior margin. Right valve larger than left and overlaps around the entire periphery. In dorsal view, thickest near posterior. Hinge adont.

REMARKS: Only a few specimens were found. They were compared to topotype slide 844 in the H. V. Howe Collection and differed in that the anterior is more narrowly rounded and the posterior projection longer than in C. tuberculifera.

Dimensions: 0.91 x 0.55 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 8-4, 11-7, 13-3.

CYTHERELLA SP. 1

Plate V, fig. 12

DIAGNOSIS: A species with a "V" shaped depression just below centrodorsal area of left valve and a finely punctate posterior area.

DESCRIPTION: Carapace in side view, ovate; highest slightly anterior to center. Anterior broadly rounded; posterior narrowly and obliquely rounded; dorsal outline convex; ventral outline slightly convex. Right valve larger than left and overlaps around entire periphery. In dorsal view, thickest slightly posterior to center. Surface of both valves with punctate posterior and smooth anterior. Left valve with a shallow "V" shaped depression just below the centro-dorsal area. Hinge adont.

Dimensions: 0.72 x 0.44 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 11-9, 13-5.

CYTHERELLA SP. 2

Plate IV, fig. 17

DIAGNOSIS: A species with a concave dorsal and ventral outline and coarsely punctate surface.

DESCRIPTION: Carapace in side view, elongate, ovate. Anterior broadly rounded; posterior broadly and obliquely rounded; dorsal outline concave in the centro-dorsal and slightly arched near posterior-dorsal contact; ventral outline concave. Right valve larger than left and overlaps slightly around entire periphrey. Very shallow depression just below centro-dorsal area. Surface of both valves coarsely punctate except for ventro-central area which is smooth. Hinge adont.

REMARKS: Only one specimen, a complete carapace, was available for study.

Dimensions: 0.58 x 0.30 mm.

Localities: 13-1

Suborder PODOCOPA Sars, 1865

Family CYPRIDAE Baird, 1849

Subfamily PONTOCYPRIDINAE Muller, 1894

Genus ARGILLOECIA Sars, 1866

ARGILLOECIA SP.

Plate V, fig. 4

DIAGNOSIS: A species with a strong centro-ventral overlap and low pointed posterior.

DESCRIPTION: Carapace small, elongate; highest near center. Anterior obliquely rounded; posterior sub-acuminate at the venter; dorsal outline arched; ventral margin slightly convex on right valve and slightly concave on left. Right valve larger than left with strong centro-ventral overlap. Surface smooth. Internal features not seen.

Dimensions: 0.49 x 0.21 mm.

Localities: 8-4, 13-1, 13-3, 14-2.

Subfamily CYPRIDINAE Baird, 1846

Genus PARACYPRIS Sars, 1866

PARACYPRIS SP.

Plate V, fig. 8

DIAGNOSIS: A species with a concave ventral outline and a very acuminate posterior.

DESCRIPTION: Carapace elongate; highest anterior to center. Anterior broadly rounded; posterior very acuminate at the venter; dorsal outline convex and gently arched slightly anterior to center; ventral outline concave. Surface smooth. Line of concrescence departs from inner margin forming anterior and posterior vestibules.

REMARKS: Only one valve, a left valve, was available for study.

Dimensions: 0.88 x 0.35 mm.

Localities: 13-1.

Family BAIRDIIDAE Sars, 1923

Subfamily BAIRDIINAE Sars, 1923

Genus BAIRDOPPILATA Coryell, Sample and Jennings, 1935

BAIRDOPPILATA MAGNA Alexander, 1927

Plate V, fig. 2

Bairdia magna Alexander 1927, p. 32, pl. 6, figs. 7, 8.

Bairdia magna Alexander 1929, p. 63, pl. 3, fig. 8.

Bairdia magna Alexander 1934, p. 215

Bairdoppilata viticula Coryell, Sample and Jennings 1935, p. 4, figs. 3, 4.

Bairdoppilata viticula Jennings 1936, p. 44, pl. 6, fig. 6a-c.

Bairdoppilata magna Jenninge 1936, p. 44.

Bairdia magna Kline 1943, p. 65, pl. 8, fig. 4.

Bairdia magna Harris and Jobe 1951, p. 69, pl. 12, fig. 2.

Bairdoppilata magna Skinner 1956, p. 183, pl. 1, figs. 3a, b.

Bairdoppilata magna Howe and Laurencich, p. 80, fig.

DIAGNOSIS: A species characterized by large size, obtusely angled posterior, and surface with fine, evenly spaced punctae.

DESCRIPTION: Carapace large and sub-triangular in side view; highest in center. Anterior broadly and obliquely rounded; posterior obtusely rounded; dorsal outline strongly and evenly arched; ventral outline convex. Left valve larger than right with strong dorsal and centroventral overlap. Surface with fine, evenly spaced punctae. Line of concrescence departs slightly from inner margin on anterior and posterior forming very small vestibules. Wide marginal area. Hinge with crenulate terminal elements.

Dimensions: 1.33 x 0.89 mm.

Localities: 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 8-4, 9-2, 13-1, 13-3, 13-5.

Family CYTHERIDAE Baird, 1850

Subfamily XESTOLEBERINAE Sars, 1928

Genus XESTOLEBERIS Sars, 1866

XESTOLEBERIS SP.

Plate V, fig. 6

DIAGNOSIS: A species with small, plump carapace and antimerodont hinge with very strongly developed anterior and posterior hinge elements.

DESCRIPTION: Carapace plump, ovate in side view; highest slightly

behind center; widest behind center. Anterior narrowly rounded, posterior broadly rounded; dorsal strongly arched; ventral margin straight, ventral outline convex due to ventral tumidity. Carapace smooth with scattered, fine punctae. Line of concrescence departs from inner margin anteriorly forming small vestibule. Hinge antimerodont. Hinge of left valve with strongly crenulate anterior socket, weakly crenulate median bar and strongly crenulate posterior socket.

Dimensions: 0.44 x 0.30 mm.

Localities: 1-6, 1-7, 1-10, 8-4, 9-2, 11-7, 11-9, 13-1, 13-3, 13-5, 14-2.

Subfamily LOXOCONCHINAE Sars, 1925

Genus LOXOCONCHA (Sars), 1866

LOXOCONCHA CRETACEA Alexander, 1936

Plate III, fig. 2

Loxoconcha cretacea Alexander 1936, p. 693, pl. 93, figs. 5, 7.

Loxoconcha cretacea Schmidt 1948, p. 412, pl. 62, fig. 7.

Loxoconcha cretacea Skinner 1956, p. 200, pl. 4, figs. 5a-c.

Loxoconcha cretacea Butler and Jones 1957, p. 34, pl. 6, fig. 1.

Loxoconcha cretacea Howe and Laurencich 1958, p. 384, fig.

DIAGNOSIS: A species characterized by sub-quadrate carapace and coarsely reticulate surface with strongly developed longitudinal ridges and weakly developed cross ridges.

DESCRIPTION: Carapace small, sub-quadrate in side view; highest

near center. Sexually dimorphous, males more elongate. Anterior broadly rounded and compressed; posterior compressed with short caudal process above middle; dorsal outline straight; ventral outline slightly convex. Surface coarsely reticulate with strongly developed longitudinal ridges and weakly developed cross ridges. Line of concrescence departs from inner margin on anterior and posterior forming small vestibules. Marginal area broad. Hinge gonglyodont.

Dimensions: 0.40 x 0.25 mm.

Localities: 1-10, 2-1, 2-2, 2-3, 8-4, 11-5, 11-9, 13-1, 13-3, 13-5, 14-2.

Subfamily CYTHERURINAE Muller, 1894

Genus CYTHEROPTERON Sars, 1866

CYTHEROPTERON N. SP.

Plate IV, figs. 10, 12

DIAGNOSIS: A species characterized by coarsely reticulate lateral surface and well developed ala on each valve. Ventral surface of each valve with 3 longitudinal ribs.

DESCRIPTION: Carapace in side view, sub-ovate; highest near center. Anterior obliquely rounded, posterior compressed with well developed, up turned caudal process; dorsal outline strongly arched; ventral with well developed ala, more strongly developed on left valve. Lower part of lateral surface with longitudinal rows of coarse reticulations that are recurved dorsally and terminate near the posterior-dorsal contact. Ventral surface of each valve with 3 parallel ribs. Line of concrescence

departs from inner margin on the anterior forming small vestibule. Marginal area widest on anterior with straight, widely spaced radial pore canals. Muscle scars a vertical row of four with one in front. Hinge antimerodont with weakly developed accommodation groove above median element of left valve.

REMARKS: This species differs from Cytheropteron (Cytheropteron) penderensis of Brown 1957 by having a more strongly developed ala and lacking coarse reticulations over the entire surface.

Dimensions: 0.61 x 0.33 mm.

Localities: 1-6, 1-8, 3-2, 11-9, 13-1, 13-3, 13-5.

Genus ORTHONOTACYTHERE Alexander, 1933

ORTHONOTACYTHERE HANNAI (Israelsky), 1929

Plate IV, fig. 18

Cytheridea ? hannai Israelsky 1929, p. 12, pl. 2A, fig. 10, a, b.

Cytheropteron hannai Alexander 1929, p. 105, pl. 9, fig. 16.

Orthonotacythere hannai Alexander 1933, p. 200, pl. 25, fig. 1a-c; pl. 26, fig. 6a, b; pl. 27, fig. 14a, b.

Orthonotacythere hannai Alexander 1934, p. 65.

Cytheridea ? hannai Israelsky 1935, p. 482, pl. 2A, figs. 10a, b.

Orthonotacythere hannai var. Alexander 1939, p. 660.

Orthonotacythere hannai Skinner 1956, p. 202, pl. 4, figs. 9a, b.

Orthonotacythere hannai Butler and Jones 1957, p. 21, pl. 4, fig. 2.

Orthonotacythere hannai Brown 1957, p. 24, pl. 6, figs. 3-5.

Orthonotacythere hannai Howe and Laurencich 1958, p. 436, fig.

DIAGNOSIS: A species characterized by reticulate surface with 6-7 very prominent tubercles.

DESCRIPTION: Carapace plump, in side view sub-rhombic; highest in region of eye spot. Large, prominent, glassy eye spot in anterior dorsal angle. Anterior broadly and obliquely rounded with 6-8 coarse denticulations; posterior with slight caudal process above middle line; dorsal outline straight; ventral margin converges posteriorly. Surface reticulate with 6-7 very prominent tubercles; ventral row of 3 tubercles with others in front and behind median sulcus. Line of concrescence coincides with inner margin. Marginal area broadest on anterior. Muscle scars vertical row of 4 with 2 anterior. Anterior 2 scars on approximate line with top and bottom scars of vertical row of 4. Hinge merodont. Hinge of right valve with anterior and posterior crenulate teeth and connecting finely crenulate furrow.

Dimensions: 0.67 x 0.40 mm.

Localities: 1-3, 1-8, 1-10, 8-4, 11-5, 13-1, 13-3, 13-5, 14-2.

Subfamily CYTHERIDEINAE Sars, 1925

Genus CLITHROCYTHERIDEA Stephenson, 1936

CLITHROCYTHERIDEA ? N. SP.

Plate III, figs. 1, 3

DIAGNOSIS: A species characterized by a strongly developed antimerodont hinge and a coarsely punctate surface.

DESCRIPTION: Carapace in side view, elongate, highest near center. Anterior very obliquely rounded; posterior of right valve sub-acutely rounded at venter, posterior of left valve slightly produced at venter; dorsal outline regularly convex; ventral outline essentially straight. Left valve larger than right with strong ventral overlap. Surface strongly punctate with numerous coarse punctae or pits. Line of concrescence departs from inner margin anteriorly forming small vestibule. Marginal area relatively broad with numerous, unevenly spaced, straight radial pore canals. Hinge antimerodont with strongly developed hinge elements and weak accommodation groove above the median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Clithrocytheridea. This species resembles Haplocytheridea ? ulrichi (Berry) but differs in having an antimerodont hinge.

Dimensions: 0.79 x 0.37 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-8, 1-11, 2-1.

CLITHROCYTHERIDEA FABAFORMIS (Berry), 1925

Plate III, fig. 7

Cytherella fabaformis Berry 1925, p. 487, fig. 13.

Cytheridea fabaformis Alexander 1929, p. 76, pl. 5, fig. 18.

Cytheridea fabaformis Alexander 1934, p. 224

Haplocytheridea ? fabaformis Schmidt 1948, p. 426, pl. 62, fig. 23.

Cytheridea (Haplocytheridea) fabaformis Brown 1957, p. 17, pl. 2, figs. 7, 8.

Haplocytheridea ? fabaformis Howe and Laurencich 1958, p. 350, fig.

DIAGNOSIS: A species characterized by a rough surface with pits, furrows, and ridges.

DESCRIPTION: Carapace in side view, elongate, pyriform; highest near center. Anterior obliquely rounded with 7 or 8 short denticulations; posterior slightly produced near the venter with 4-7 short denticulations; dorsal outline arched; ventral outline straight to slightly convex. Left valve larger than right with centro-ventral overlap. Surface of valves rough, marked by pits, furrows, and ridges; on the antero-dorsal surface are obscure, parallel, diagonal furrows; a more prominent furrow extends posteriorly from the ventro-central area. Line of concrescence departs from inner margin on anterior forming narrow vestibule. Marginal area broadest on anterior with many straight radial pore canals. Muscle scars vertical row of 4 with 2 anterior and a little dorsal of median line. Hinge antimerodont with dorsal margin flattened above median element.

REMARKS: An antimerodont hinge removes this species from the genus Haplocytheridea.

Dimensions: 0.61 x 0.32 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 2-2, 2-3, 3-2, 11-5, 11-7, 13-3, 13-5, 14-2.

Genus Haplocytheridea Stephenson, 1936

HAPLOCYTHERIDEA N. SP.

Plate IV, figs. 3, 6

DIAGNOSIS: A species characterized by a rounded ridge slightly behind and parallel to anterior margin, punctate surface with 2-3 vertical furrows in central area of carapace, and the absence of an accommodation groove.

DESCRIPTION: Carapace in side view, ovate, pyriform; highest anterior to center. Anterior broadly rounded with short denticulations, rounded ridge slightly behind and parallel to anterior margin; posterior sub-acute at venter; dorsal outline arched, angulate on antero-dorsal margin; ventral outline straight to slightly concave. Left valve larger than right with ventral overlap. Surface punctate with coarser punctae forming 2-3 vertical furrows near center of carapace. Line of concrescence departs from inner margin anteriorly forming small vestibule. Marginal area relatively broad with numerous, straight radial pore canals. Hinge holomerodont.

REMARKS: This species is distinguished from Cytheridea (Haplocytheridea) carolinensis Brown 1957, by having no accommodation groove, having no rounded ridge on posterior margin, and the surface furrows not being as well developed.

Dimensions: 0.53 x 0.28 mm.

Localities: 1-1, 1-3, 1-5.

HAPLOCYTHERIDEA ? COUNCILLI (Brown), 1957

Plate IV, fig. 2, 5

Cytheridea (Haplocytheridea) councilli Brown 1957, p. 17, pl. 2, figs. 12-16.

DIAGNOSIS: A dimorphous species questionably referred to the genus Haplocytheridea. Accommodation groove present above median element of left valve. Characterized by surface with deep, prominent pits and a rimmed anterior margin.

DESCRIPTION: Carapace in side view, elongate, ovate; highest in center. Dimoprhous species with female being higher and having an arched dorsal outline. Anterior rounded with slight marginal rim; posterior margin sub-acute at venter; dorsal outline of male convex, dorsal outline of female arched; ventral outline sinuous due to ventro-central swelling of carapace. Left valve larger than right with centro-ventral overlap. Surface with deep, prominent pits; the pits (about 6) behind and parallel to anterior margin are the largest. Line of concrescence departs from inner margin anteriorly forming small vestibule. Marginal area broad with many straight radial pore canals. Hinge holomerodont with accommodation groove above median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.54 x 0.26 mm. (male)
0.53 x 0.30 mm. (female)

Localities: 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 3-2, 9-2, 11-5,

11-7, 11-9, 13-5, 14-2.

HAPLOCYTHERIDEA ? GLOBOSA (Alexander), 1929

Plate V, fig. 1

Cytheridea globosa Alexander 1929, p. 75, pl. 5, figs. 17-19.

Haplocytheridea ? globosa Howe and Laurencich 1958, p. 352, fig.

DIAGNOSIS: A species questionably referred to the genus Haplocytheridea. Strong accommodation groove above the median element of left valve. Characterized by an acute, low, slightly produced posterior outline and a globose carapace.

DESCRIPTION: Carapace globose, in side view pyriform; highest slightly anterior to center. Sexually dimorphous with the female having a greater height to length ratio and being more globose. Anterior broadly rounded; posterior low, acutely rounded, and slightly produced; dorsal outline strongly arched and angulate slightly anterior to center; ventral outline sinuous with a convex antero-ventral outline and a strongly concave postero-ventral outline. Left valve larger than right with strong dorsal overlap. Surface punctate with punctae a little coarser near center of valve. Line of concrescence approximately coincides with inner margin. Broad marginal area with many straight radial pore canals. Hinge holomerodont with accommodation above median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.70 x 0.47 mm. (female)

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 2-3, 3-2, 8-4, 11-5, 11-7, 13-1, 13-3, 13-5, 14-2.

HAPLOCYTHERIDEA MICROPUNCTATA (Alexander), 1929

Plate IV, fig. 13

Cytheridea micropunctata Alexander 1929, p. 77, pl. 5, fig. 20, pl. 6, fig. 6.

Haplocytheridea micropunctata Howe and Laurencich 1958, p. 355, fig.

DIAGNOSIS: A species characterized by a finely pitted surface with coarser punctae near center.

DESCRIPTION: Carapace in side view, pyriform; highest anterior to center. Anterior broadly rounded; posterior narrowly rounded at venter; dorsal outline slightly arched; ventral outline convex. Surface punctate with coarser punctae near center; a row of coarse punctae or pits forms vertical furrow near center. Line of concrescence departs from inner margin forming vestibule on anterior margin. Hinge holomerodont with no accommodation groove.

Dimensions: 0.60 x 0.35 mm.

Localities: 1-7, 1-8, 1-11, 2-1, 8-4, 9-2, 11-9, 13-1, 13-3, 13-5, 14-2.

HAPLOCYTHERIDEA ? MONMOUTHENSIS (Berry), 1925

Plate IV, fig. 15

Cytheridea monmouthensis Berry 1925, p. 486, fig. 10.

Cytheridea monmouthensis Alexander 1929, p. 74, pl. 5, fig. 11-14.

Cytheridea (Haplocytheridea) cf. C. monmouthensis Swain 1948, p. 212, pl. 14, fig. 14.

Haplocytheridea ? monmouthensis Swain 1952, p. 79, pl. 8, fig. 19.

Haplocytheridea plummeri Skinner 1956, p. 197, pl. 4, fig. 2a-d.

Cytheridea (Haplocytheridea) monmouthensis Brown 1957, p. 19, fig. 6.

Haplocytheridea monmouthensis Howe and Laurencich 1958, p. 355, fig.

DIAGNOSIS: A species questionably referred to the genus Haplocytheridea. Strong accommodation groove above median element of left valve. Characterized by projecting flange at the postero-ventral angle of the right valve.

DESCRIPTION: Carapace in side view, ovate, pyriform; highest anterior to center. Sexually dimorphous with the female more globose. Anterior broadly rounded; posterior obliquely rounded with projecting flange at the postero-ventral angle of the right valve; dorsal outline arched with a centro-dorsal angle and a postero-dorsal angle; ventral outline straight. Left valve larger than right with strong ventral overlap. Surface punctate with coarser punctae or pits arranged in vertical rows in middle of carapace. Line of concrescence departs slightly from inner margin both anteriorly and posteriorly. Marginal area narrow with many straight radial pore canals. Hinge holomerodont with accommodation groove above median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.67 x 0.40 mm. (male)

Localities: 13-1, 13-3, 13-5, 14-2.

HAPLOCYTHERIDEA ? PLUMMERI (Alexander), 1929

Plate V, fig. 14

Cytheridea plummeri Alexander 1929, p. 73, pl. 5, figs. 5-8.

Cytheridea plummeri Alexander 1933, p. 280, figs. 1a, b, 4a, b.

Cytheridea plummeri Alexander 1939, p. 66.

Haplocytheridea ? plummeri Schmidt 1948, p. 425, pl. 62, fig. 27-29; text fig. 2f.

Not Haplocytheridea ? sp. aff. H. ? plummeri Swain 1952, p. 79, pl. 8, fig. 15.

Not Cytheridea plummeri Skinner 1956, p. 198, pl. 4, fig. 2a-d.

Haplocytheridea ? plummeri Butler and Jones 1957, p. 16, pl. 4, fig. 9.

Not Cytheridea (Haplocytheridea) plummeri Brown 1957, p. 18, pl. 2,

Haplocytheridea ? plummeri Howe and Laurencich 1958, p. 356, fig.

DIAGNOSIS: A species questionably referred to the genus Haplocytheridea. Characterized by a punctate surface with 2 or 3 vertical rows of coarse punctae near center of carapace and an accommodation groove above median element of left valve.

DESCRIPTION: Carapace in side view, pyriform; highest slightly anterior to center; anterior broadly rounded; posterior obliquely rounded;

dorsal outline with antero-dorsal angle on left valve and antero-dorsal and postero-dorsal angle on right valve; ventral outline convex on left valve and straight on right valve. Left valve larger than right with strong dorsal and centro-ventral overlap. Surface with widely spaced punctae and 2 or 3 vertical rows of coarser punctae near middle of carapace. Line of concresence approximately coincides with inner margin. Marginal area broadest anteriorly with many straight radial pore canals. Hinge holomerodont with strong accommodation groove above median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.88 x 0.53 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-8, 1-10, 1-11, 2-2, 8-4, 9-2, 11-5, 11-9, 13-1, 13-3, 13-5, 14-2.

HAPLOCYTHERIDEA ? RAYBURNENSIS Butler and Jones, 1957

Plate IV, fig. 8

Haplocytheridea ? rayburnensis Butler and Jones 1957, p. 15, pl. 4, figs. 7a-e.

Haplocytheridea ? rayburnensis Howe and Laurencich 1958, p. 358, fig.

DIAGNOSIS: A species questionably referred to the genus Haplocytheridea. Strong accommodation groove above median element of left valve and a strongly punctate surface.

DESCRIPTION: Carapace in side view, small, pyriform; highest slightly anterior to center. Anterior broadly rounded; posterior obliquely rounded, dorsal outline strongly arched, ventral outline sinuous due to ventral swelling of carapace. Left valve larger than right with strong centro-ventral overlap. Surface strongly punctate with randomly spaced punctae. Line of concrescence departs from inner margin on anterior, posterior, and ventral margins. Marginal area narrow and radial pore canals straight but rather unevenly spaced. Hinge holomerodont with accommodation groove above median element of left valve.

REMARKS: The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.49 x 0.33 mm.

Localities: 8-4, 9-2, 11-9, 13-1, 13-3, 13-5, 14-2.

HAPLOCYTHERIDEA SARECTAENSIS (Brown), 1957

Plate III, fig. 8

Cytheridea (Haplocytheridea) sarectaensis Brown 1957, p. 17, pl. 7, figs. 1-3.

DIAGNOSIS: A species characterized by surface with vertical furrows and ridges and swelling of postero-ventral and antero-ventral areas.

DESCRIPTION: Carapace oblong, ovate in side view; highest anterior to center. Sexually dimorphous with female being shorter and more tumid.

Anterior broadly rounded; posterior obliquely rounded with 4-7 short denticulations; dorsal outline convex; ventral outline straight. Left valve larger than right with strong dorsal centro-ventral overlap. Surface with coarse punctae that form furrows separated by rounded ridges. Furrows and ridges (7-9) run sub-vertical; central furrows and ridges more pronounced. Carapace swollen in postero-ventral and antero-ventral areas. Line of concrescence departs from inner margin on anterior forming small vestibule. Marginal area broadest in anterior with many straight radial pore canals. Hinge holomerodont.

Dimensions: 0.67 x 0.37 mm.

Localities: 1-1, 1-3, 11-7, 11-9.

HAPLOCYTHERIDEA ? ULRICHI (Berry), 1925

Plate IV, fig. 1, 4

Cythere ulrichi Berry 1925, p. 483, fig. 3.

Cytheridea macropora Alexander 1929, p. 77, pl. 5, fig. 15.

Cytheridea macropora Scott 1934, p. 1153.

Haplocytheridea ? ulrichi Schmidt 1948, p. 426, pl. 62, fig. 18, 19.

Haplocytheridea ? macropora Schmidt 1948, p. 425, pl. 62, fig. 24.

Cytheridea macropora Skinner 1956, p. 197, pl. 4, fig. 3a-d.

Cytheridea (Haplocytheridea) ulrichi Brown 1957, p. 18, pl. 2, fig. 4, 5.

Haplocytheridea ? ulrichi Howe and Laurencich 1958, p. 358, fig.

Haplocytheridea ? macropora Howe and Laurencich 1958, p. 354, fig.

DIAGNOSIS: A dimorphous species questionably referred to the genus Haplocytheridea. Strong accommodation groove above median element of left

valve. Characterized by surface with deep, prominent pits and produced posterior.

DESCRIPTION: Carapace in side view, elongate, ovate; highest slightly anterior to center. Strongly dimorphous with female much higher. Anterior obliquely rounded; posterior produced at venter; dorsal outline arched; ventral outline convex due to slight ventral swelling. Left valve larger than right with slight dorsal and ventral overlap. Surface with deep, prominent pits. Line of concrescence approximately coincides with inner margin. Marginal area narrow with numerous straight radial pore canals. Holomerodont hinge with accommodation groove above median element of left valve.

REMARKS: Cytheridea macropora Alexander, 1929 is the female of Cythere ulrichi Berry, 1925. The presence of an accommodation groove removes this species from the typical Haplocytheridea.

Dimensions: 0.60 x 0.26 mm. (male)
0.60 x 0.32 mm. (female)

Localities: 1-1, 1-3, 1-5, 1-6, 1-8, 1-10, 1-11, 2-1, 2-2, 3-2, 9-2, 11-7, 13-5.

Subfamily Krithinae Mandelstom, 1958

Genus KRITHE Brady, Crosskey and Robertson, 1874

KRITHE CUSHMANI Alexander, 1929

Plate V, fig. 11

Krithe cushmani Alexander 1929, p. 67, pl. 4, figs. 9, 11.

Krithe cushmani Alexander 1939, p. 66.

Krithe cushmani Bonnema 1940, p. 118, pl. 2, figs. 48-54.

Krithe cushmani Albritton 1941, p. 49, 59.

Krithe cushmani Bold 1946, p. 77, pl. 4, fig. 18.

Krithe cushmani Butler and Jones 1957, p. 17, pl. 1, fig. 2.

Krithe cushmani Howe and Laurencich 1958, p. 377, fig.

DIAGNOSIS: A species with an oblong, smooth carapace and well developed vestibule.

DESCRIPTION: Carapace in side view, oblong; highest near the center. Anterior rounded; posterior truncated; dorsal outline arched; ventral margin straight to convex. Surface smooth with a few widely spaced punctae. Line of concrescence departs from inner margin anteriorly forming shallow, well developed vestibule. Marginal area wide with 12-15 long, straight, widely spaced radial pore canals. Hingement with a slight projection in right valve fitting into a shallow, finely crenulate groove in left valve.

Dimensions: 0.61 x 0.35 mm.

Localities: 11-9, 13-1, 13-3.

Subfamily PROGONOCYTHERINAE Sylvester-Bradley, 1948

Genus PROGONOCYTHERE Sylvester-Bradley, 1948

PROGONOCYTHERE ? SP.

Plate III, fig. 11

DIAGNOSIS: A species characterized by elongate carapace with parallel dorsal and ventral margins; surface with longitudinal ribs and corresponding furrows, and entomodont hinge.

DESCRIPTION: Carapace elongate with dorsal and ventral margins parallel. Anterior rimmed, broadly rounded; posterior broadly rounded with slight protuberance above middle; dorsal outline straight; ventral outline straight with rimmed margin. Surface with irregular, longitudinal, rounded ridges and corresponding furrows; furrows with numerous, weak cross ribs giving reticulate appearance. Line of concrescence departs slightly from inner margin on anterior. Marginal area broad with few, widely spaced, straight radial pore canals. Hinge entomodont. Hinge of right valve with strong, crenulate, stepped anterior tooth, shallow, crenulate post adjacent socket, finely crenulate groove, and strong, crenulate, posterior tooth.

REMARKS: Only one valve, a right, is reported. This is insufficient for designating a new species and more specimens must be found before this species can be properly described. This species belongs in the subfamily Progonocytherinae and is placed in the genus Progonocythere ?. It will probably have to be put into a new genus with information from more specimens.

Dimensions: 0.77 x 0.28 mm.

Localities: 1-1.

Subfamily BRACHYCYTHERINAE Puri, 1953

Genus BRACHYCYTHERE Alexander, 1933

BRACHYCYTHERE LEDAFORMA (Israelsky), 1929

Plate V, fig. 3

Cytheropteron ledaforma Israelsky 1929, p. 8, pl. 1A, figs. 5-7.

Cythere acutocaudata Alexander 1929, p. 87, pl. 7, fig. 5-6.

Brachycythere ledaforma Alexander 1933, p. 206, pl. 25, fig. 9; pl. 27, fig. 20.

Brachycythere ledaforma Jennings 1936, p. 49, pl. 6, fig. 15.

Brachycythere ledaforma Calahan 1939, p. 41, pl. 3, fig. 2.

Brachycythere ledaformis Bold 1950, p. 108.

Brachycythere ledaforma Skinner 1956, p. 187, pl. 2, fig. 2a-d.

Brachycythere ledaforma Butler and Jones 1957, p. 26, pl. 3, fig. 3.

Not Brachycythere ledaforma Brown 1957, p. 12, pl. 4, fig. 6.

Brachycythere ledaforma Howe and Laurencich 1958, p. 87, fig.

DIAGNOSIS: A species with compressed, produced posterior, ventral tumidity, and flat, striated ventral surface.

DESCRIPTION: Carapace in side view, sub-pyriform; highest near region of eye spot. Small eye spot near anterior-dorsal contact. Anterior compressed, broadly rounded; posterior strongly compressed, produced; dorsal outline arched, angulate near posterior dorsal angle; ventral outline sinuous due to strong ventral tumidity. Lateral surface smooth with few, widely spaced, fine punctae; flat ventral surface with several longitudinal striations. Line of concrescence coincides with inner margin. Marginal area wide with numerous, long, straight radial pore canals. Hinge hemiamphidont with strong accommodation groove above median element of left valve.

Dimensions: 0.74 x 0.46 mm.

Localities: 1-1, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 9-2, 13-5.

BRACHYCYTHERE OVATA (Berry), 1925

Plate V, fig. 5

Cythereis ovatus Berry 1925, p. 484, fig. 15.

Cytheropteron sp. A., Israelsky 1929, p. 7, pl. 1A, figs. 1a-c.

Cythere ovata Alexander 1929, p. 87, pl. 7, figs. 10, 13.

Brachycythere ovata Scott 1934, p. 1153.

Brachycythere ovata Jennings 1936, p. 48, 50, pl. 6, figs. 16a-b.

Brachycythere ovata Skinner 1956, p. 190, pl. 2, figs. 3 a-c.

Brachycythere ovata Howe and Laurencich 1958, p. 89, fig.

DIAGNOSIS: A species characterized by very tumid carapace and a tendency toward development of a weak ventral keel.

DESCRIPTION: Carapace very tumid, ovate in side view; highest slightly anterior to center. Large eye spot near anterior dorsal angle. Anterior compressed, broadly rounded; posterior slightly compressed, narrowly rounded. Dorsal outline arched, ventral outline convex due to very strong tumidity of ventro-central area. Left valve larger than right with strong dorsal overlap. Surface finely punctate. Tendency to develop weak peripheral keel parallel to ventral margin, stronger on right valve. Line of concrescence coincides with inner margin. Marginal area rather broad with numerous, straight, unevenly spaced radial pore canals. Hinge hemiamphidont with strong accommodation groove above

median bar of left valve.

Dimensions: 1.05 x 0.65 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 2-3, 3-2, 8-4, 9-2, 11-5, 11-9, 13-1, 13-3, 13-5, 14-2.

BRACHYCYTHERE RHOMBOIDALIS (Berry), 1925

Plate V, fig. 10

Cythere rhomboidalis Berry 1925, p. 481, figs. 1,2.

Cythere rhomboidalis Alexander 1929, p. 86, pl. 7, figs. 1, 2.

Brachycythere rhomboidalis Alexander 1933, p. 206.

Brachycythere jerseyensis Jennings 1936, p. 48, pl. 6, figs. 14a, b.

Brachycythere rhomboidalis Schmidt 1948, p. 414, pl. 62, figs. 8-10.

Brachycythere pietschkeri Skinner 1956, p. 187, pl. 2, figs. 1a-g.

Brachycythere rhomboidalis Butler and Jones 1957, p. 28, pl. 3, fig. 2a-b.

Brachycythere rhomboidalis Brown 1957, p. 11, pl. 4, figs. 5, 8-10.

Brachycythere rhomboidalis Howe and Laurencich 1958, p. 90, fig.

DIAGNOSIS: A species with strong dorsal overlap, central area of carapace coarsely punctate, and strong peripheral keel with 2 rows of coarse punctae on keel.

DESCRIPTION: Carapace in side view, ovate, sub-triagonal; highest near the center. Large glassy eye spot near anterior dorsal angle with small depression behind eye spot. Anterior margin compressed, broadly

rounded with weak marginal rim; posterior margin compressed with 4-7 spines and narrow outline due to a concavity just behind posterior dorsal angle; dorsal outline arched; ventral outline convex. Left valve larger than right with strong dorsal overlap, strongest overlap behind eye spot. Surface punctate with coarser punctae in central area of carapace. Strong peripheral keel parallels the ventral margin from the inner border of the compressed anterior to the inner border of the compressed posterior. Keel bears 2 rows of coarse punctae. Two fine ridges parallel the keel between the keel and ventral margin. Line of concrescence coincides with inner margin. Marginal area broad with numerous straight radial pore canals. Hinge hemiamphidont with strong accommodation groove above the median bar of the left valve.

Dimensions: 0.79 x 0.47 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 2-1, 3-2, 8-4, 9-2, 11-5, 11-7, 11-9, 13-1, 13-3, 13-5, 14-2.

Genus PTERGOCYTHERE Hill, 1954

PTERGOCYTHERE SARATOGANA (Israelsky), 1929

Plate V, fig. 13

Cytheropteron saratogana Israelsky 1929, p. 10, pl. 2A, figs. 4a-c.

Cythere cornuta gulfensis Alexander 1929, p. 85, pl. 8, figs. 1, 2, 6.

Brachycythere alata Alexander 1933, p. 207, pl. 25, figs. 15a-b; pl. 27, fig. 18.

Brachycythere alata Jennings 1936, p. 46, pl. 6, figs. 11a-b.

Pterygocythere gulfensis Hill 1954, p. 822, pl. 98, fig. 8a-b; pl. 100, figs. 6a-c.

Pterygocythere saratogana Butler and Jones 1957, p. 32, pl. 2, fig. 2a-b.

Pterygocythere saratogana Howe and Laurencich 1958, p. 484, fig.

DIAGNOSIS: A species with very strongly developed ventral alae and smooth surface.

DESCRIPTION: Carapace in side view, ovate; highest in region of eye spot. Large, glassy eye spot near anterior-dorsal contact. Anterior spiny, broadly rounded; posterior spiny, narrowly rounded; dorsal outline straight; ventral margin with a very strongly developed ala. Surface smooth. Line of concrescence coincides with inner margin. Marginal area narrow with long radial pore canals in irregularly spaced groups of 2-5. Hinge hemiamphidont with strong accommodation groove above median element of left valve.

Dimensions: 1.00 x 0.53 mm.

Localities: 1-6, 1-7, 1-8, 2-1, 8-4, 9-2, 11-9, 13-1, 13-3, 14-2.

Subfamily TRACHYLEBERINAE Sylvester-Bradley, 1948

Genus Cythereis Jones, 1849

CYTHEREIS COSTATANA Israelsky, 1929

Plate IV, fig. 11

Cythereis costatana Israelsky 1929, p. 16, pl. 3A, figs. 16a-c.
Cythereis costatana Butler and Jones 1957, p. 36, pl. 3, fig. 5.
Cythereis costatana Howe and Laurencich 1958, p. 191, fig.

DIAGNOSIS: A species with heavy dorsal and ventral ridges and coarsely punctate surface with coarse reticulations in dorsal and anterior areas.

DESCRIPTION: Carapace sub-triangular in side view, compressed laterally; highest in region of eye spot. Small, glassy eye spot developed near anterior dorsal angle. Anterior rimmed and broadly rounded, posterior rimmed and acutely rounded, spiny below middle; dorsal and ventral margin converging toward back; dorsal margin with thick ridge that turns down at posterior dorsal angle; ventral outline straight with broad ridge above margin. On many specimens, both dorsal and ventral ridge terminate in small node. Muscle node large. Left valve projects over right at anterior corner to form hinge ear. Surface with coarse punctae or pits and very coarsely reticulate in dorsal and anterior areas. Line of concrescence coincides with inner margin. Marginal area very broad with numerous, very long, straight radial pore canals. Hinge holamphidont.

Dimensions: 0.60 x 0.35 mm.

Localities: 8-4, 9-2, 11-9, 13-1, 13-3.

CYTHEREIS COMMUNIS Israelsky, 1929

Plate III, fig. 9

Cythereis communis Israelsky 1929, p. 14, pl. 3A, fig. 9-13.

Cythereis communis Alexander 1929, p. 101, pl. 9, fig. 18.

Cythereis communis Scott 1934, p. 1153.

Cythereis communis Jennings 1936, p. 52, pl. 7, fig. 3.

Cythereis communis Schmidt 1948, p. 419, pl. 61, figs. 11-13.

Cythereis (Pterygocythereis) cf. C. (P.) communis Swain 1948, p. 207, pl. 14, figs. 5-7.

Cythereis communis Skinner 1956, p. 196, pl. 3, figs. 7a-c.

Cythereis communis Butler and Jones 1957, p. 35, pl. 3, fig. 6.

Trachyleberis communis Brown 1957, p. 14, pl. 3, figs. 10-11.

Cythereis communis Howe and Laurencich 1958, p. 189, fig.

DIAGNOSIS: A species characterized by heavy median ridge and heavy dorsal and ventral rim with ventral rim tending to become sub-alate.

DESCRIPTION: Carapace in side view, sub-rectangular; highest in region of eye spot. Large, glassy eye spot near anterior dorsal angle. Anterior broadly rounded, rimmed, and spiny below the middle; posterior narrowly rounded with 3-5 large spines; dorsal outline irregular with heavy dorsal rim; posterior outline relatively straight with heavy marginal rim tending to become sub-alate. Median ridge extends back from muscle node. The marginal rims and median ridge all with coarse punctae. Left valve with hinge ear at anterior dorsal angle. Line of concrescence coincides with inner margin. Marginal area broad with numerous, straight radial pore canals. Pore canals more widely spaced above the middle. Hinge holamphidont.

Dimensions: 0.82 x 0.39 mm.

Localities: 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 8-4, 9-2, 11-5, 11-9, 13-1, 13-3, 13-5, 14-2.

CYTHEREIS HAZARDI Israelsky, 1929

Plate III, fig. 13

Cythereis hazardi Israelsky 1929, p. 19, pl. 4A, fig. 9.

Cythereis hazardi Alexander 1929, pl. 9, f. 15, 17.

Cythereis hazardi Israelsky 1935, p. 488, pl. 4A, fig. 9.

Cythereis hazardi Calahan 1939, p. 41, pl. 3, fig. 1.

Cythereis hazardi Skinner 1956, p. 196, pl. 4, fig. 1a-g.

Cythereis hazardi Howe and Laurencich 1958, p. 201, fig.

DIAGNOSIS: A species characterized by surface with strong dorsal and ventral ribs connected to strong median ridge by weaker cross ribs.

DESCRIPTION: Carapace in side view, oblong; highest in region of eye spot. Small glassy eye spot in anterior dorsal angle. Anterior broadly rounded and spiny with marginal rim that is spiny below middle; posterior compressed and rounded and very spiny; dorsal outline straight with strong dorsal rib that is notched behind eye spot; ventral outline straight with strong ventral rib that terminates posteriorly in a spine. Left valve projects over right at anterior corner to form hinge ear. Surface with strong median ridge that is connected to dorsal and ventral ribs by weaker cross ribs. Line of concrescence coin-

cides with inner margin. Marginal area rather broad with straight, widely spaced radial pore canals. Hinge holamphidont.

Dimensions: 0.88 x 0.44 mm.

Localities: 1-3, 11-7.

CYTHEREIS HUNTENSIS (Alexander), 1929

Plate IV, fig. 14

Cythere huntensis Alexander 1929, p. 88, pl. 6, fig. 12.

Cythereis huntensis Alexander 1934, p. 236.

Cythereis huntensis Jennings 1936, p. 53, pl. 7, fig. 5.

Cythereis huntensis Skinner 1956, p. 194, pl. 3, fig. 3a-d.

Cythereis huntensis Butler and Jones 1957, p. 39, pl. 4, fig. 10.

Cythereis huntensis Howe and Laurencich 1958, p. 204, fig.

DIAGNOSIS: A species characterized by a surface with a median, bifurcating ridge and a ventro-centro, diagonal ridge.

DESCRIPTION: Carapace sub-ovate in side view; highest near anterior-dorsal contact. Anterior denticulate and broadly rounded with high marginal rim; posterior narrowly rounded and spiny; dorsal outline slightly convex with high, sharp dorsal rib; ventral outline straight to convex with sharp ventral rib. Surface with 2 high, sharp longitudinal ridges and numerous weaker cross ribs. The more dorsal of the longitudinal ridges originates below the posterior-dorsal contact and lies just above the mid-line of the carapace. This ridge bifurcates, the upper ridge joining the margin at the anterior-dorsal

contact and the lower ridge terminating above the anterior-ventral contact. The more ventral rib originates near the dorsal ridge and runs diagonally toward the anterior margin, joining the margin at the anterior-ventral contact. Line of concrescence coincides with inner margin. Marginal area very broad with numerous, very long radial pore canals. Hinge holamphidont.

Dimensions: 0.60 x 0.33 mm.

Localities: 1-1, 1-8, 1-10, 1-11, 2-1, 2-2, 8-4, 11-7, 11-9, 13-1, 13-3, 13-5, 14-2.

Genus VEENIA Butler and Jones, 1957

VEENIA OZANANA (Israelsky), 1929

Plate IV, fig. 16

Cythereis ozanana Israelsky 1929, p. 13, pl. 3A, figs. 1-3.

Cythereis ponderosana Israelsky 1929, p. 13, pl. 3A, figs. 5-8.

Cythere ponderosana Alexander 1929, p. 83, pl. 6, fig. 3.

Cythereis ozanana Alexander 1933, p. 212.

Cythereis ozanana Loetterle 1938, p. 64, pl. 11, fig. 6.

Cythereis ozanana Alexander 1939, p. 66.

Cythereis ozanana Bold 1950, p. 108.

Veenia ozanana Butler and Jones 1957, p. 44, pl. 3, fig. 4a-e.

Veenia ozanana Howe and Laurencich 1958, p. 512, fig.

DIAGNOSIS: A species with sub-triangular carapace, 3 coarsely pitted, longitudinal ridges, and sulcus just behind prominent hinge

ear of left valve.

DESCRIPTION: Carapace in side view, sub-triangular; highest near anterior dorsal angle. Anterior very flattened, broadly rounded and finely denticulate; posterior flattened, acutely rounded with 3-4 short spines; dorsal and ventral margins converging toward posterior. Carapace with 3 longitudinal, coarsely pitted ridges. Strongly developed dorsal ridge notched by sulcus just behind prominent eye spot of left valve. Dorsal ridge recurved toward median ridge forming deep depression just below centro-dorsal area. Short median ridge with slight depression between median and ventral ridges. Strongly developed ventral ridge in ventro-central area and parallel to ventral margin. Left valve larger than right with strong hinge ear developed on anterior dorsal area of left valve. Line of concrescence coincides with inner margin. Marginal area broad with numerous, straight radial pore canals. Hinge amphidont.

Dimensions: 0.70 x 0.44 mm.

Localities: 8-4, 11-9.

VEENIA ARACHOIDES (Berry), 1925

Plate III, fig. 12

Cythere arachoides Berry 1925, p. 484, fig. 5.

Cythere rectangulapora Berry 1925, p. 483, fig. 4.

Cythere rectangulapora Alexander 1929, p. 84.

Brachycythere arachoides Schmidt 1948, p. 415, pl. 62, fig. 13-16.

Cythere multipora Skinner 1956, p. 90, pl. 2, fig. 4a-d.

Veenia arachoides Butler and Jones 1957, p. 46, pl. 5, fig. 4.
Velarocythere arachoides Brown 1957, p. 22, pl. 5, fig. 16-18.
Veenia arachoides Howe and Laurencich 1958, p. 510, fig.

DIAGNOSIS: A species characterized by sub-pyriform carapace and a coarsely reticulate surface with ridges, furrows, and deep sulcus behind the eye spot.

DESCRIPTION: Carapace in side view, sub-pyriform; highest near eye spot. Sexually dimorphous with males being longer. Anterior compressed, broadly rounded, and denticulate; posterior very compressed, acutely rounded, and denticulate; dorsal outline arched and notched just behind eye spot; ventral outline sinuous due to slight ventral tumidity. Left valve larger than right with strong centro-ventral overlap and hinge ear on antero-dorsal of left valve. Coarsely reticulate surface with ridges, furrows, and sulcus. Median, longitudinal ridge with longitudinal furrow just below and deep dorsal furrow just above. Dorsal margin with broad ridge that is recurved downward separating dorsal furrow from sulcus just behind eye spot. Line of concrescence approximately coincides with inner margin. Marginal area broad with many, long, straight radial pore canals. Hinge holamphidont.

Dimensions: 0.77 x 0.40 mm.

Localities: 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11, 2-1, 2-2, 3-2, 11-5, 11-7, 13-1, 13-3, 13-5, 14-2.

Genus AMPHICYTHERURA Butler and Jones, 1957

AMPHICYTHERURA ? CURTA (Jennings), 1937

Plate III, fig. 10

Cythereis curta Jennings 1937, p. 52, pl. 7, figs. 4a, b.

Amphicytherura ? curta Howe and Laurencich 1958, p. 47, fig.

DIAGNOSIS: A species with a ventral ridge that approximately parallels the ventral margin, median ridge that extends obliquely from the postero-dorsal area to the antero-ventral area, and a weak dorsal ridge.

DESCRIPTION: Carapace small, subrhomboidal; highest in region of prominent, rounded eye spot. Anterior obliquely rounded; posterior slightly produced above the middle; dorsal outline straight; ventral outline convex. Surface with a ventral ridge that approximately parallels the ventral margin, median ridge that extends obliquely from the postero-dorsal area to the antero-ventral area, and a weak dorsal ridge; median ridge bifurcates below eye spot; ventral and median ridges have short cross ribs. Ventral surface coarsely reticulate. Line of concrescence coincides with inner margin. Marginal area narrow. Hinge holamphidont.

Dimensions: 0.46 x 0.28 mm.

Localities: 1-5, 11-7.

Subfamily Uncertain

NEW GENUS N. SP. aff. CYTHERURA ? SARATOGANA Israelsky, 1929

Plate III, figs. 4-6

Cytherura ? saratogana Israelsky 1929, p. 7, pl. 4A, fig. 8.

DIAGNOSIS: A species characterized by elongate, sub-ovate carapace, paramphidont dentition, and surface with irregular, rounded ridges and furrows tending to be parallel with periphery.

DESCRIPTION: Carapace in side view, elongate, sub-ovate; highest near anterior-dorsal contact. Anterior obliquely rounded; posterior subangular; dorsal outline nearly straight with posterior hinge ear; dorsal margin flattened above median element of hinge; ventral outline slightly sinuous. Left valve larger than right with strong centro-ventral overlap and postero-dorsal overlap where strong hinge ear is developed. Surface with irregular, rounded ridges and corresponding furrows; furrows with numerous, weak cross ribs giving coarsely reticulate appearance. Ridges and furrows tend to be parallel with periphery. Line of concrescence approximately coincides with inner margin. Marginal area wide with numerous, very long, straight radial pore canals; pore canals widely spaced near anterior-dorsal contact. Hinge paramphidont. Hinge of right valve with crenulate anterior tooth, smooth post adjacent socket, finely crenulate groove, and crenulate posterior tooth. Hinge of left valve complementary.

REMARKS: The type specimen of Cytherura ? saratogana was not available and the comparison was based on the description and illustration by Israelsky. Israelsky described only the external form and positive comparison was impossible. However, if this is the same species, the paramphidont dentition and shape of carapace necessitates the removal of this species from the genus Cytherura. Externally this species has the same general outline and surface ornamentation as the

genus Cytheretta, but it does not have the "S" shape line of concrescence of Cytheretta. Also, the crenulate character of the terminal hinge elements is not possessed by Cytheretta.

Dimensions: 0.88 x 0.40 mm.

Localities: 1-1, 1-8, 1-11, 2-1, 2-2, 2-3.

LOCATION OF SAMPLES

The locations of all measured sections from which samples were collected for faunal study are listed below. The stratigraphic position of each sample is shown on Plate II.

RWS Locality 1, samples 1-1, 1-3, 1-5, 1-6, 1-7, 1-8, 1-10, 1-11.

Location: West bank of Chattahoochee River, 500 yards below bridge on U. S. Highway 82; 1.5 miles west of Georgetown, Quitman County, Georgia.

RWS Locality 2, samples 2-1, 2-2, 2-3.

Location: Left bank of Tobannee Creek, 20 feet above bridge of north-south trending county road; 1 mile south of Georgetown, Quitman County, Georgia. Section continued in ditch east of road up hill to the south.

RWS Locality 3, samples 3-2.

Location: County road trending north-south over Soapstone Creek; about 5 miles northeast of Georgetown, Quitman County, Georgia. Base of section exposed in east bank of road cut approximately 50 yards south of bridge.

RWS Locality 8, sample 8-4.

Location: East-west unimproved road into valley of Roods Creek, beginning 1 mile north of Templeton cemetery and extending into valley bottom; 3 miles west of Oak Grove Church, Stewart County, Georgia.

RWS Locality 9, sample 9-2.

Location: Northwest trending county road in valley of Colochee Creek. Outcrop exposed 6 miles northwest of Lumpkin, Stewart County, Georgia.

RWS Locality 11, samples 11-5, 11-7, 11-9.

Location: U. S. Highway 27, 3.7 miles north of Lumpkin, Stewart County, Georgia; road cut in hill south of Frog Bottom Creek.

RWS Locality 13, samples 13-1, 13-3, 13-5.

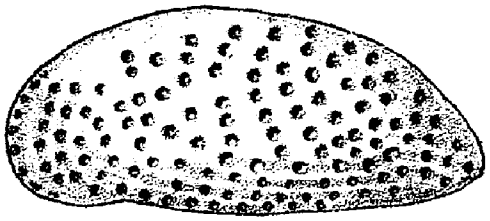
Location: U. S. Highway 280, section begins .5 mile north of Chattahoochee-Stewart County line at Renfroe, Georgia and continues north down the hill.

RWS Locality 14, sample 14-2.

Location: Northwest trending county road, 2.5 miles northwest of the Chattahoochee-Marion County line; outcrop on north side of road, 2 miles airline northwest of Liberty Hill Church and 1.3 miles airline east of Gobblers Hill School.

PLATE III

Figures		Page
1, 3	Clithrocytheridea n. sp. Fig. 1 exterior left valve, the holotype. Fig. 3 exterior right valve. Approximately X 70.	47
2	Loxoconcha cretacea Alexander. Exterior right valve. Approximately X 70	44
4-6	Cytherura ? saratogana Israelsky. Fig. 4 exterior left valve. Fig. 5 dorsal view of complete carapace. Fig. 6 right valve view of complete carapace. Approximately X 70.	75
7	Clithrocytheridea fabaformis (Berry). Exterior right valve. Approximately X 70	48
8	Haplocytheridea sarectaensis (Brown). Exterior right valve. Approximately X 70	57
9	Cythereis communis Israelsky. Exterior right valve. Approximately X 70	68
10	Amphicytherura ? curta (Jennings). Exterior left valve. Approximately X 70	74
11	Progonocythere ? sp. Exterior right valve. Approximately X 70.	60
12	Veenia arachoides (Berry). Exterior right valve. Approximately X 70	72
13	Cythereis hazardi Israelsky. Exterior left valve. Approximately X 70	69



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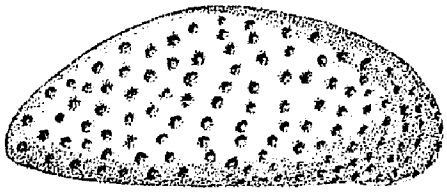

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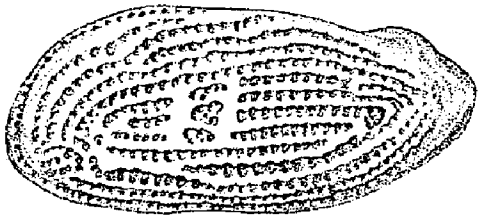

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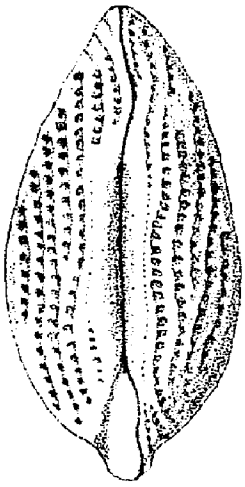

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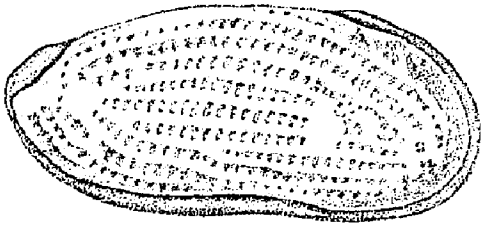

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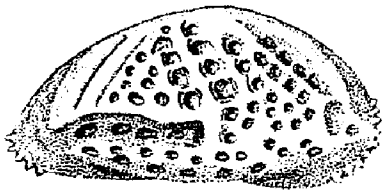

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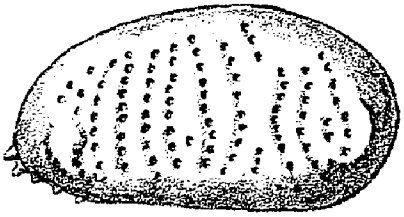

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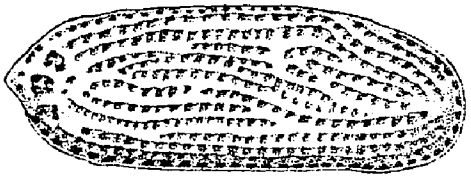

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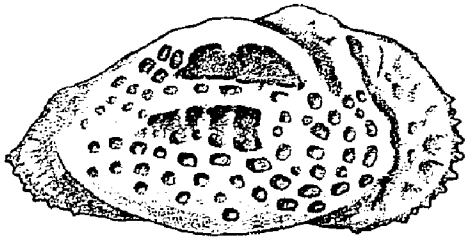

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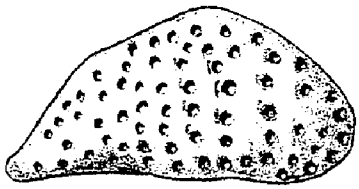
PLATE III

PLATE IV



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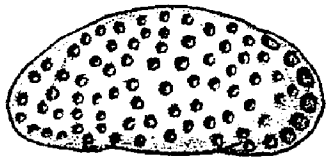

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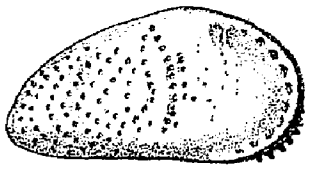

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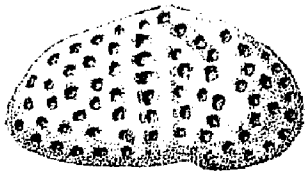

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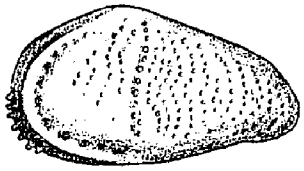

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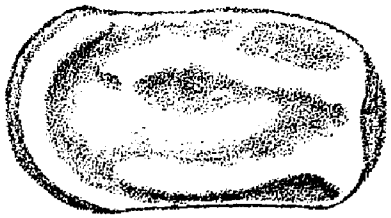

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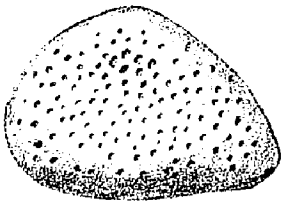

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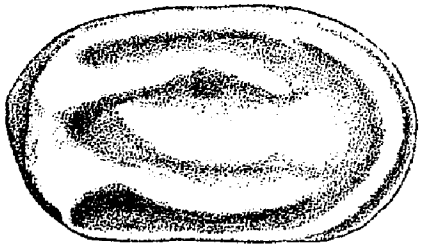

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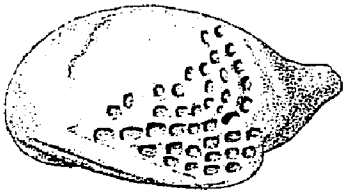

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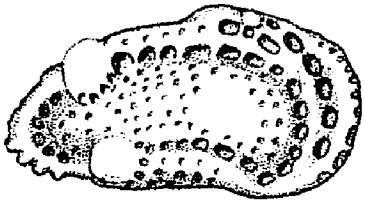

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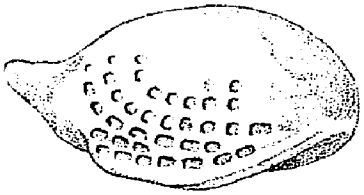

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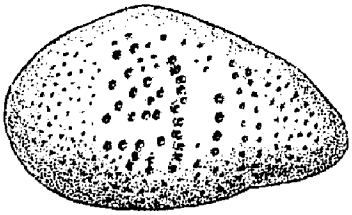

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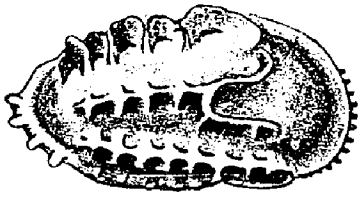

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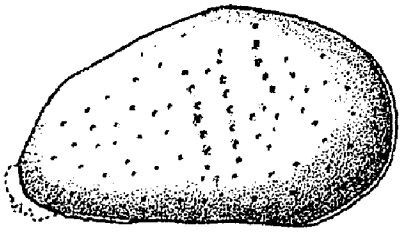

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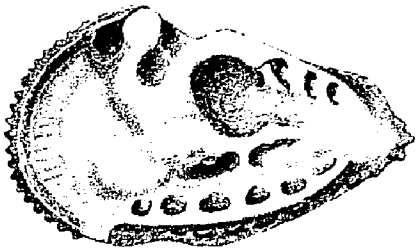

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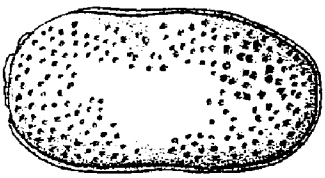

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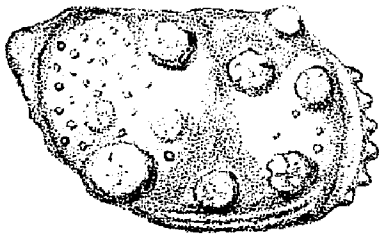

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PLATE IV

PLATE V

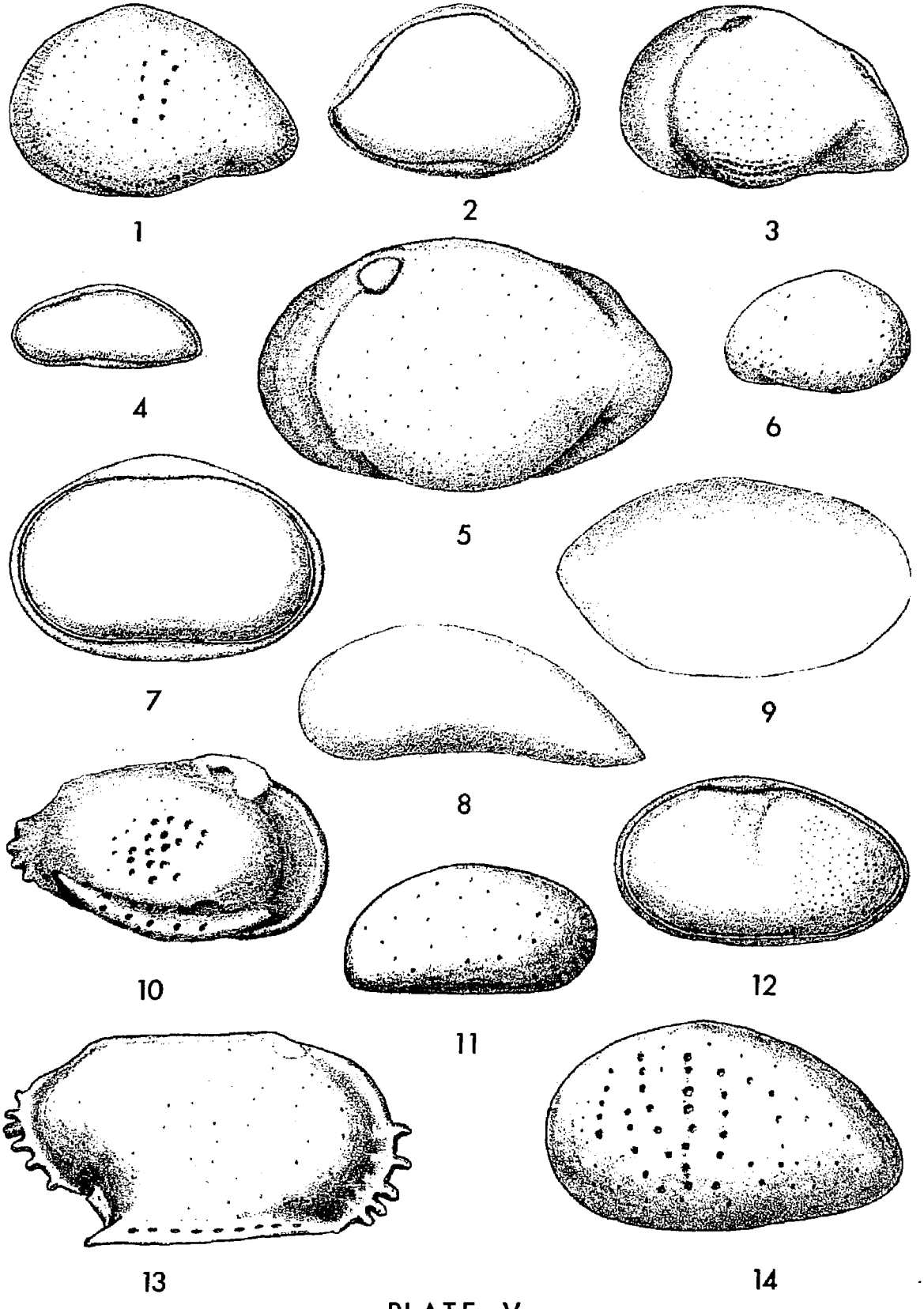

PLATE V

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VITA

Raymond Weathers Stephens, Jr. was born April 20, 1928 in Marietta, Cobb County, Georgia, the son of Raymond Weathers Stephens and Alice Stewart Stephens. He attended various elementary schools in Georgia and graduated from Reidsville High School in Reidsville, Georgia in 1945.

Stephens entered the University of Georgia in 1945 and after one year of study joined the United States Navy for two years. He returned to the university in 1948 and graduated with a B. S. in geology in 1951. While at the University of Georgia, he was treasurer of Sigma Alpha Epsilon fraternity and president of the Geography-Geology Club.

In 1951, he married Julia Ellen Askew, the daughter of Dr. and Mrs. J. Thomas Askew of Athens, Georgia. They have one son, Raymond Weathers Stephens, III.

Stephens was called to active duty with the United States Air Force in August 1951 and served one year of that tour as commander of an Arctic outpost.

He entered the Graduate School at Louisiana State University in 1953 and received the M. S. degree in geology in 1956, remaining at L. S. U. to work toward the Ph. D. degree. While at Louisiana State he was the recipient of the Magnolia Petroleum Company's fellowship in geology. From L. S. U., Stephens accepted employment as a geologist with Shell Oil Company in July 1959.

EXAMINATION AND THESIS REPORT

Candidate: Raymond W. Stephens, Jr.

Major Field: Geology

Title of Thesis: Stratigraphy and Ostracoda of the Ripley Formation in Georgia

Approved:

Grover E. Murray - W.V. Howe - C.O. Durham Jr.
Major Professor and Chairman

George H. Mickey
Dean of the Graduate School

EXAMINING COMMITTEE:

Grover E. Murray

W.V. Howe

C.O. Durham, Jr.

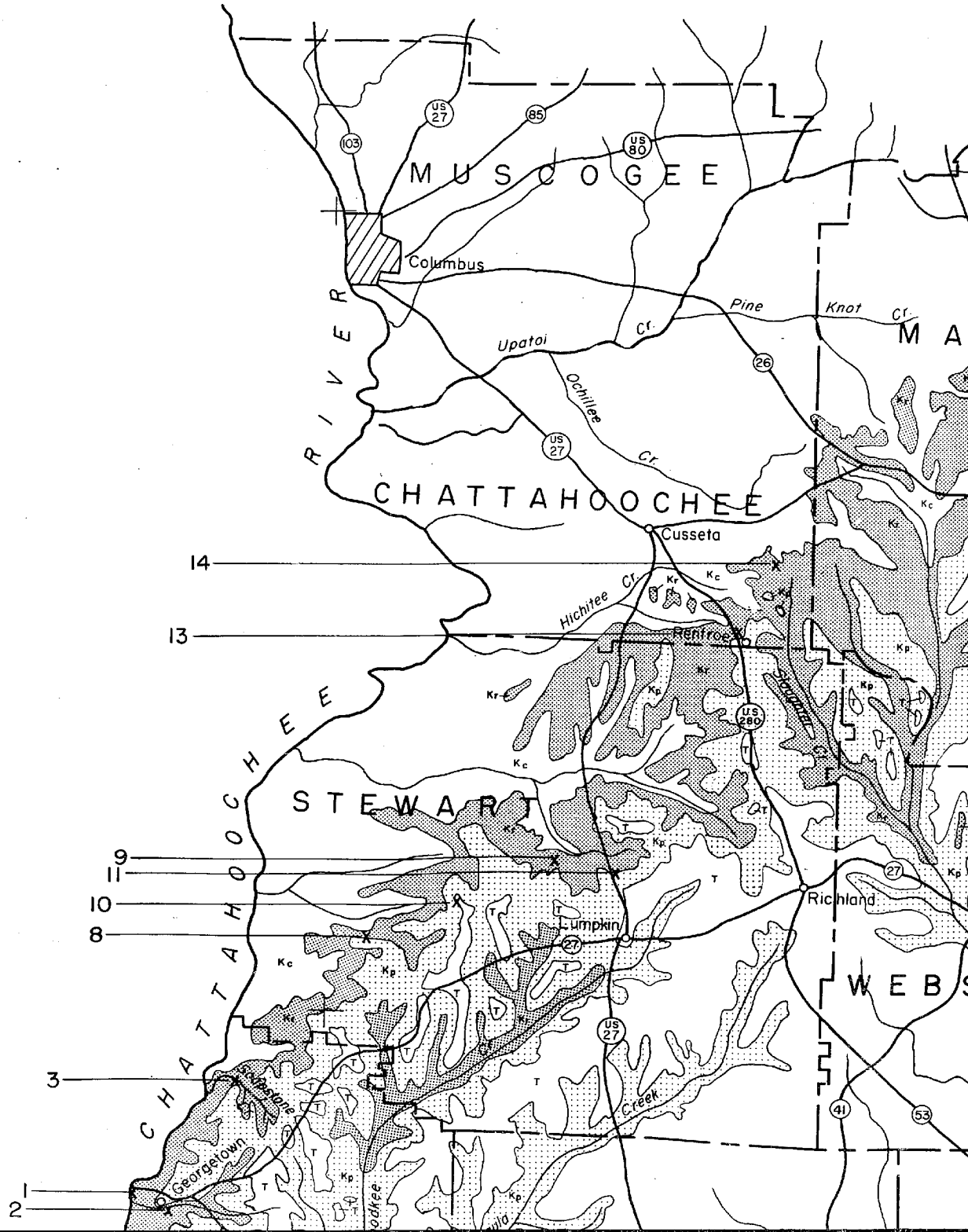
Alan Cheetham

H.V. Anderson

R.E. Sandberg

Date of Examination:

December 14, 1959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RIVER
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Pine Knot Cr.
Ochillee Cr.
Cusseta
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Henfroe
Stapleton Cr.
STEWART
Richland
Pumpkin Creek
Georgetown
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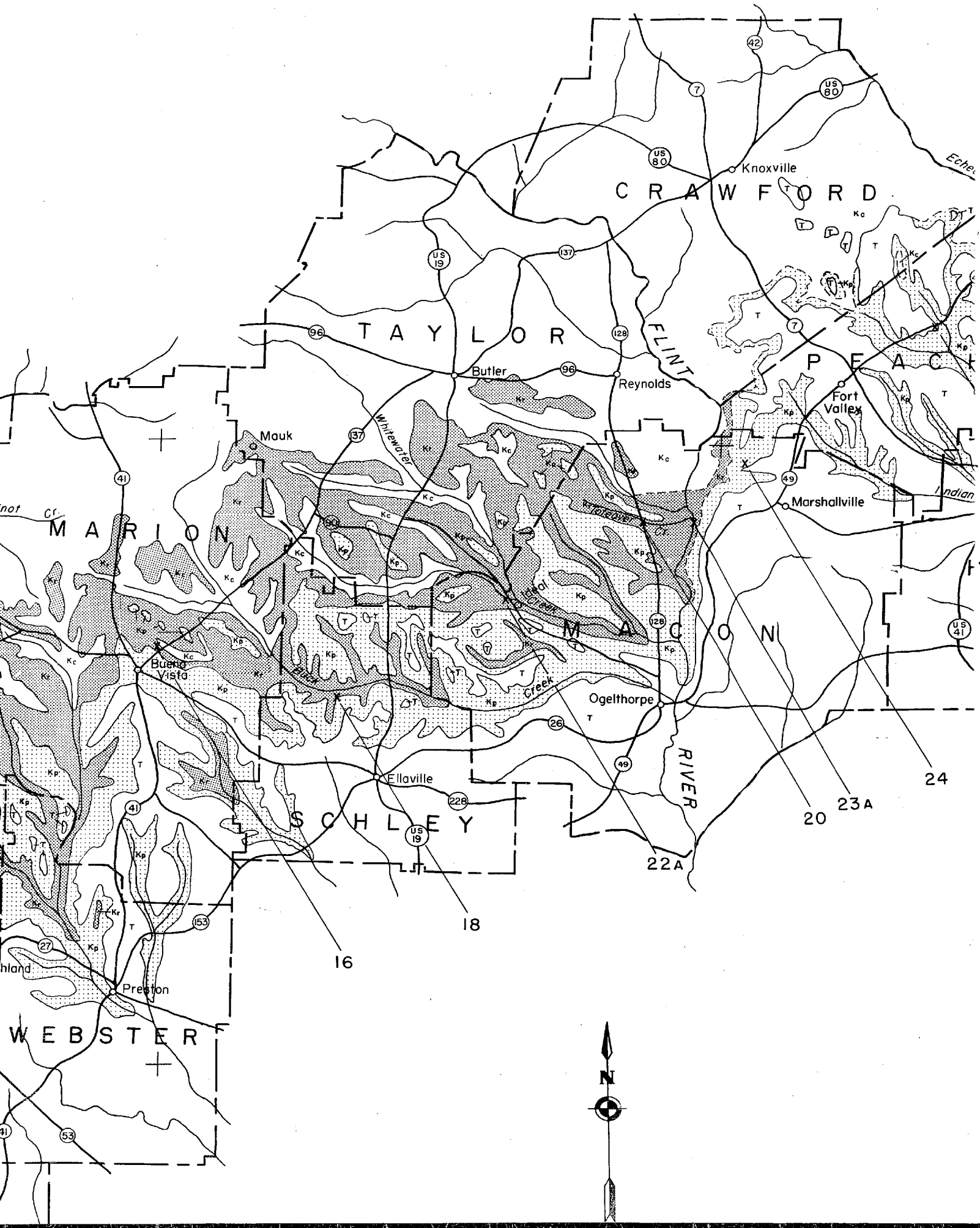
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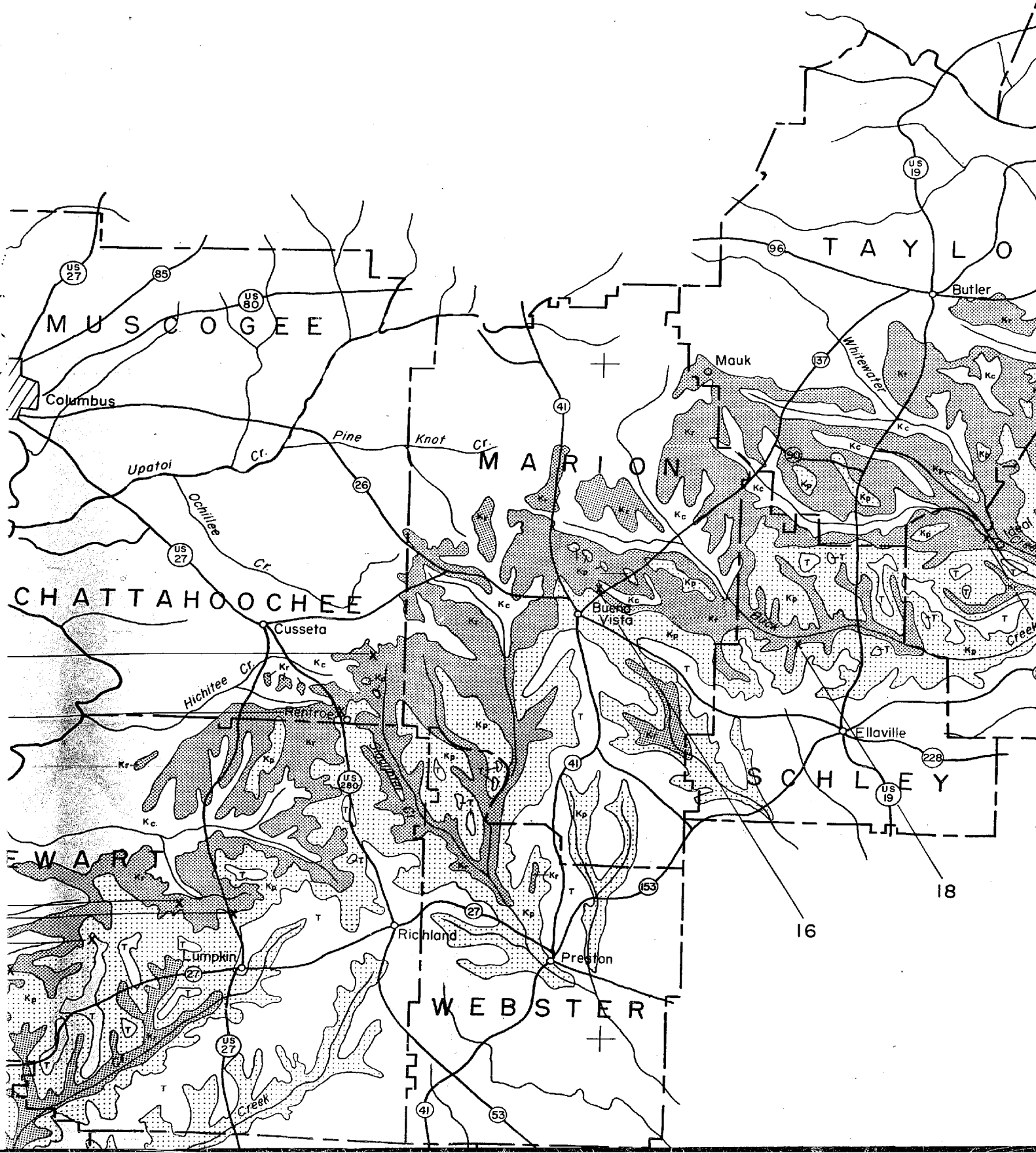
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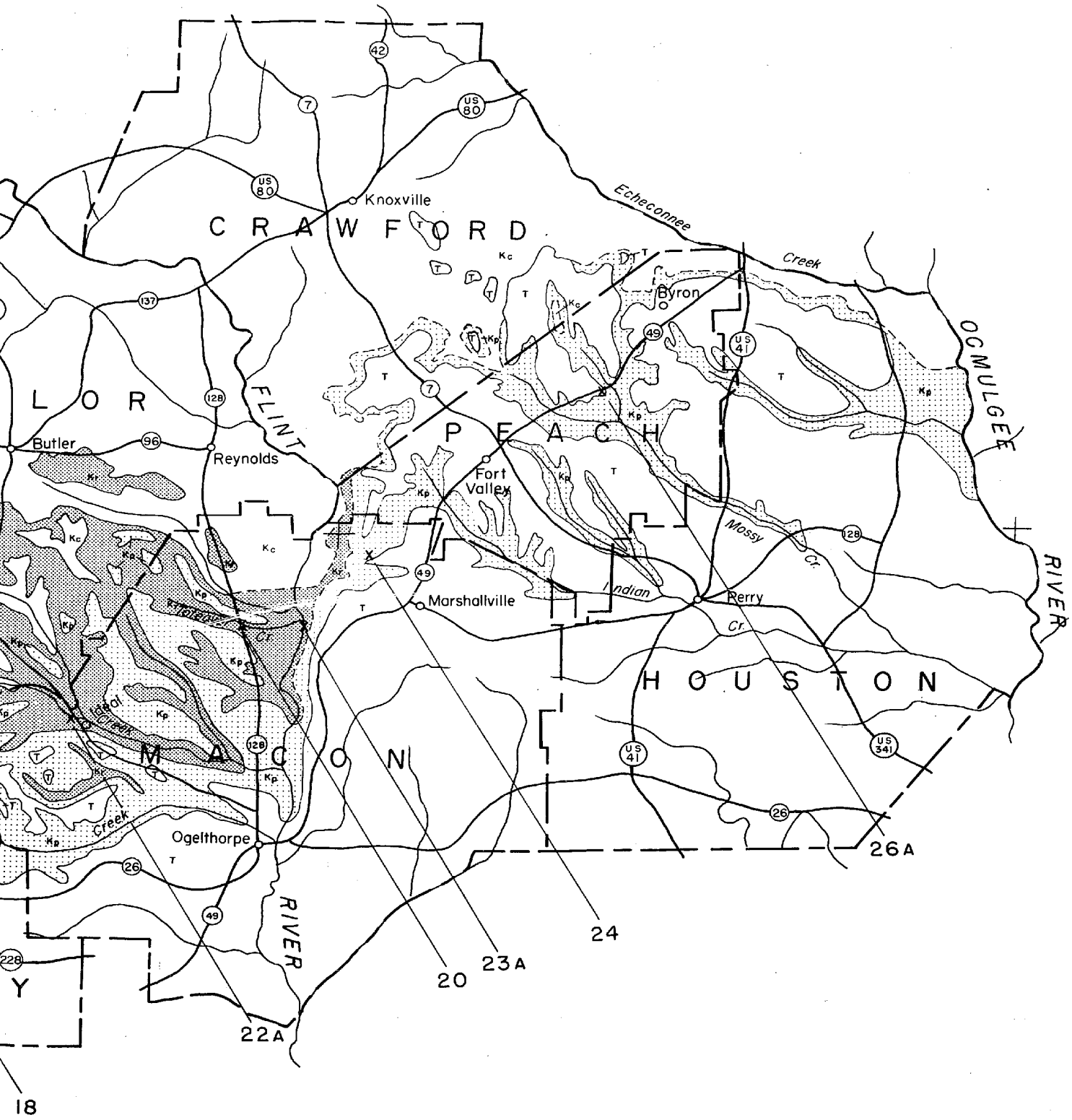
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Indian Cr.
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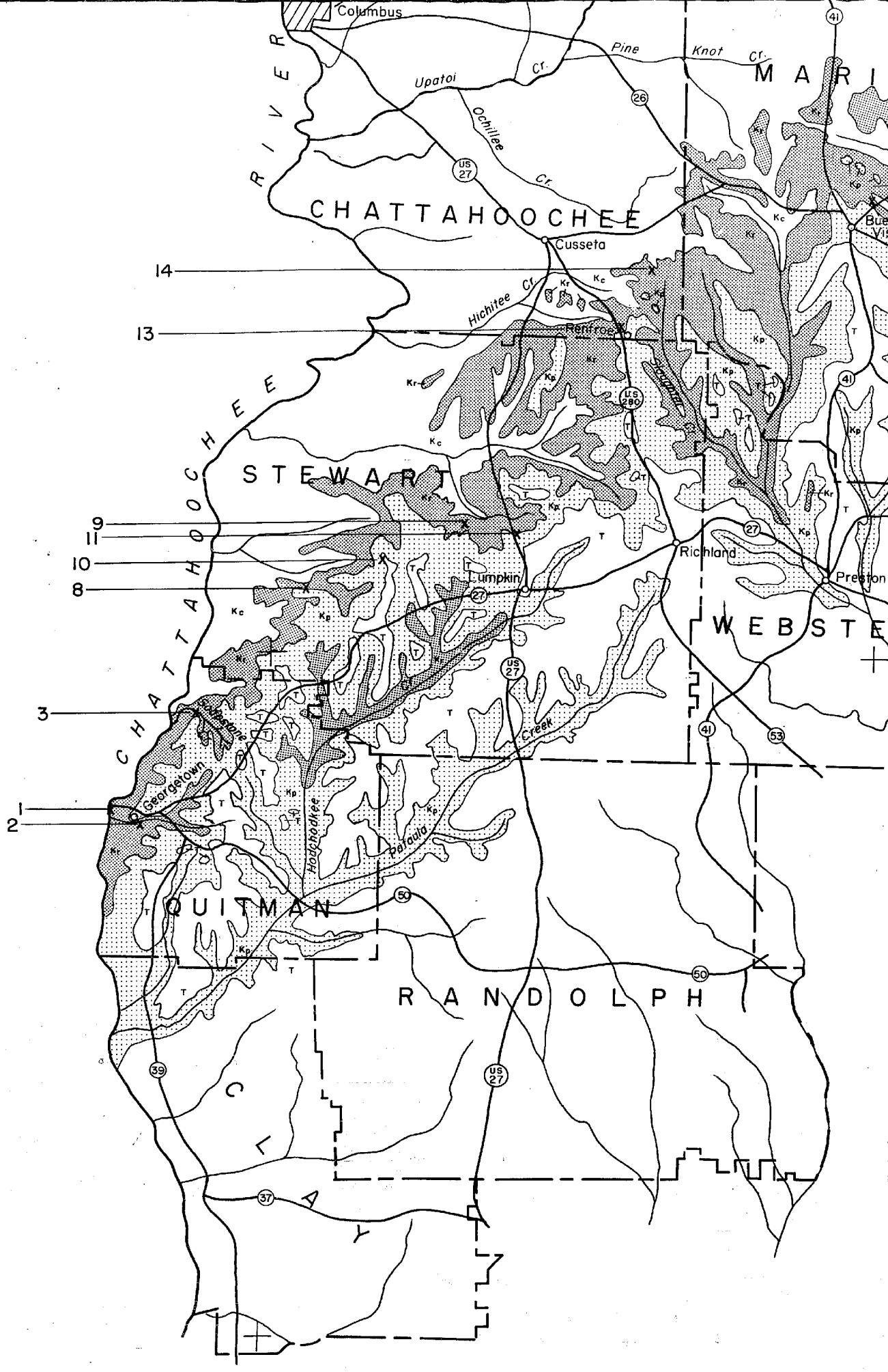
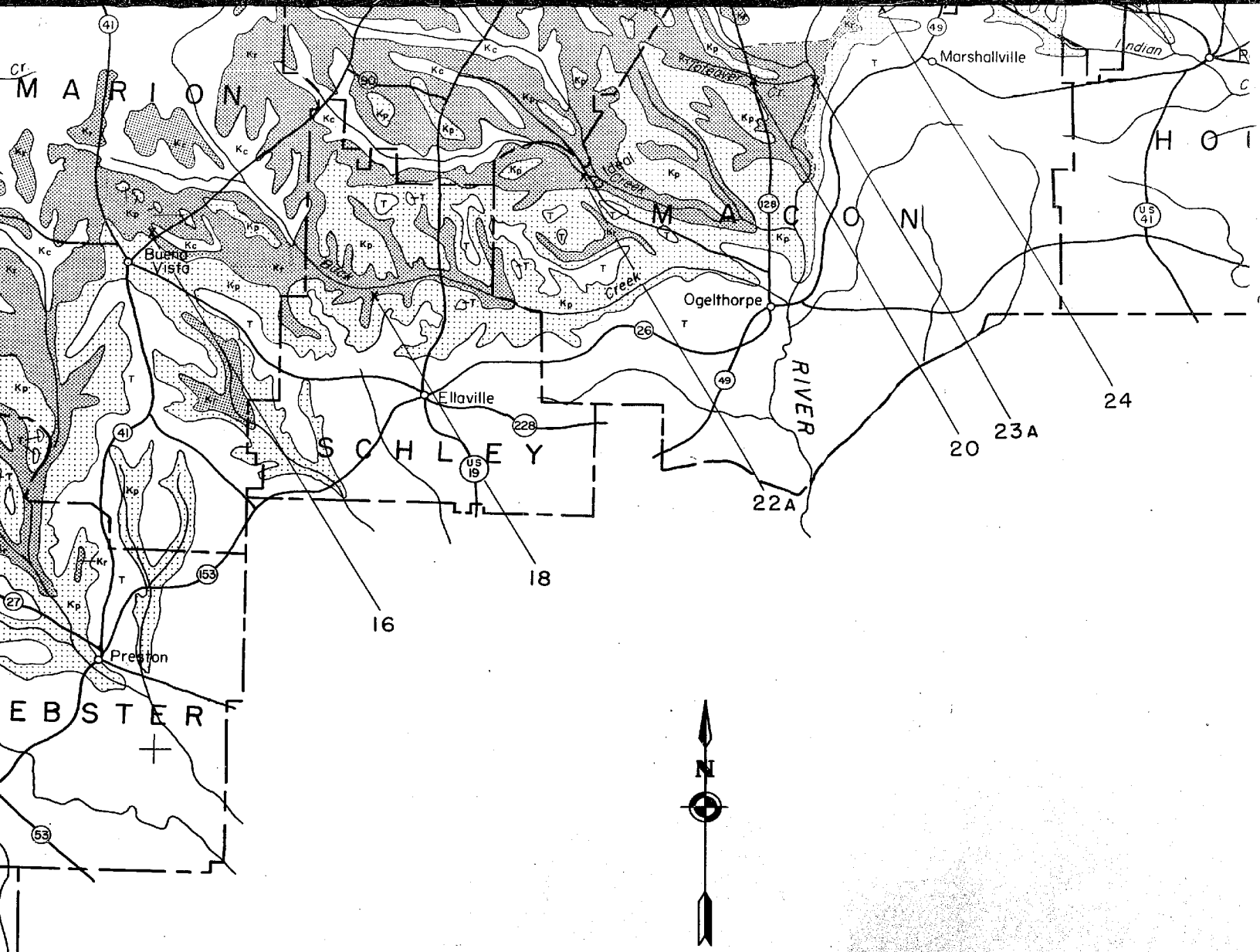
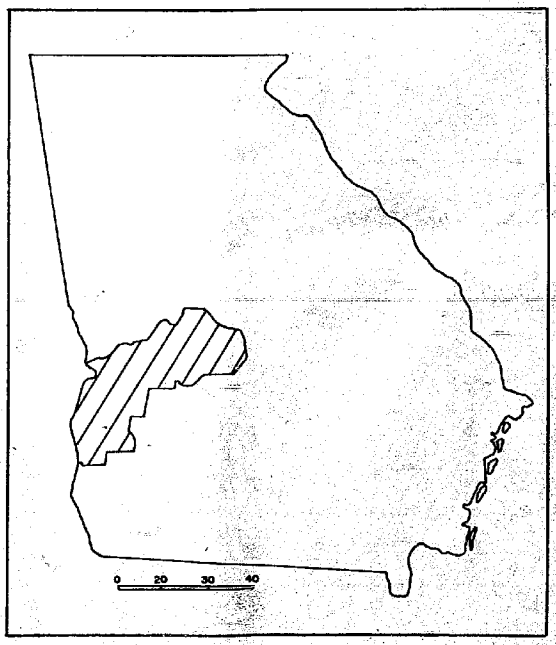


OUTCROPS WEST OF FLINT RIVER AFTER EARGLE, 1955





T Tertiary

Kp Providence

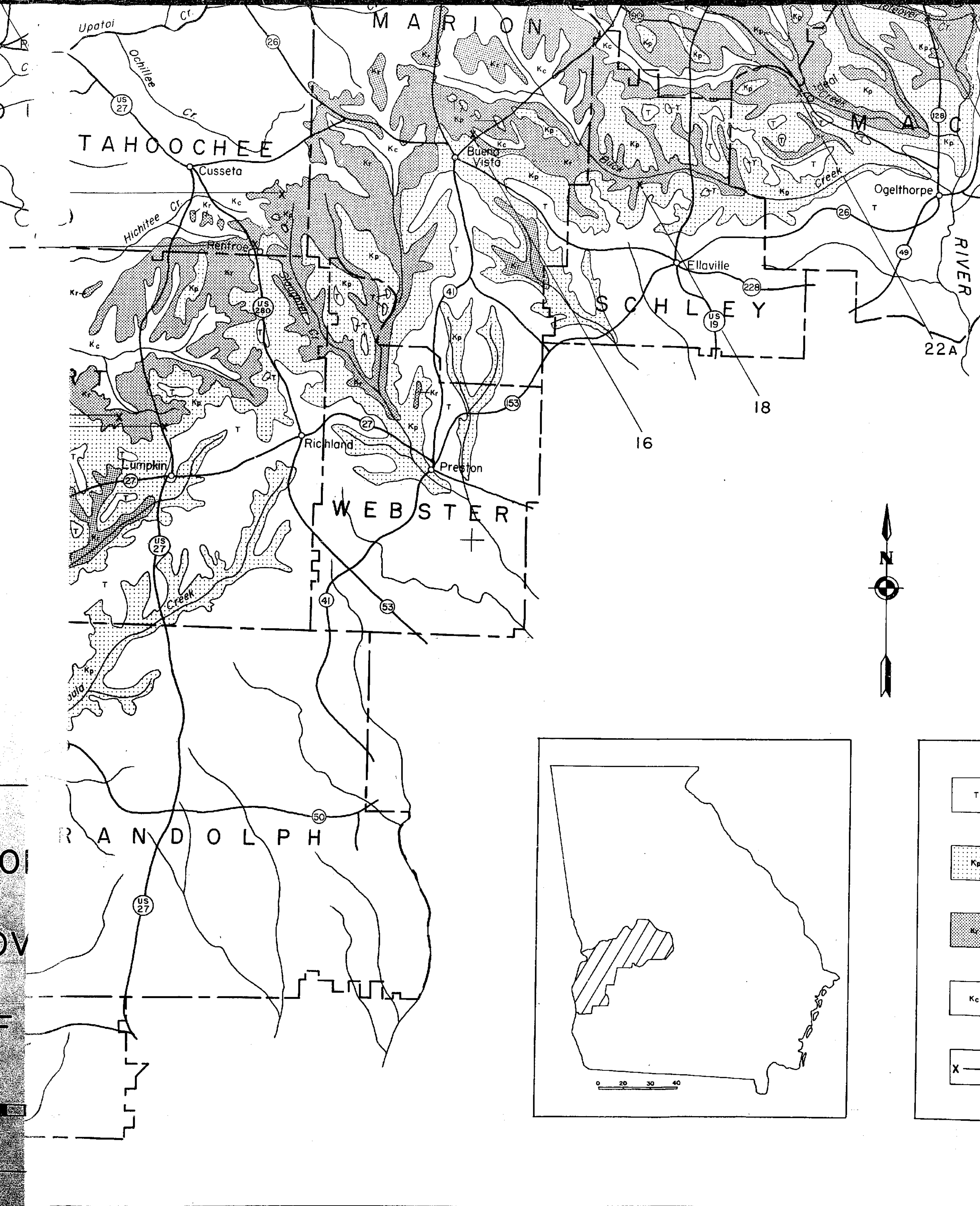
Kr Ripley

Kc Cusseta

x—8 x- Location of measured section
8- Text number of section

5

OUTCRO
PROV
OF



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Cusseta
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Ochillee Cr.
Hichitee Cr.
Renfroe
Buena Vista
Ellaville
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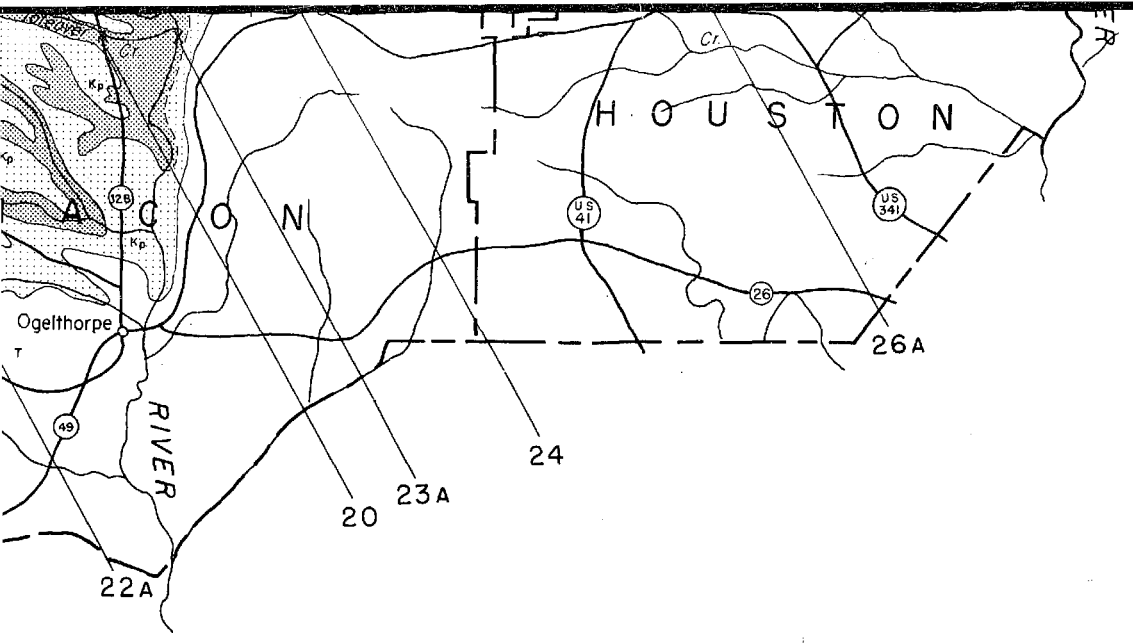


T — Tertiary

Kp — Providence

Kr — Ripley

Kc — Cusseta

X—8 — X- Location of measured section; 8- Text number of section

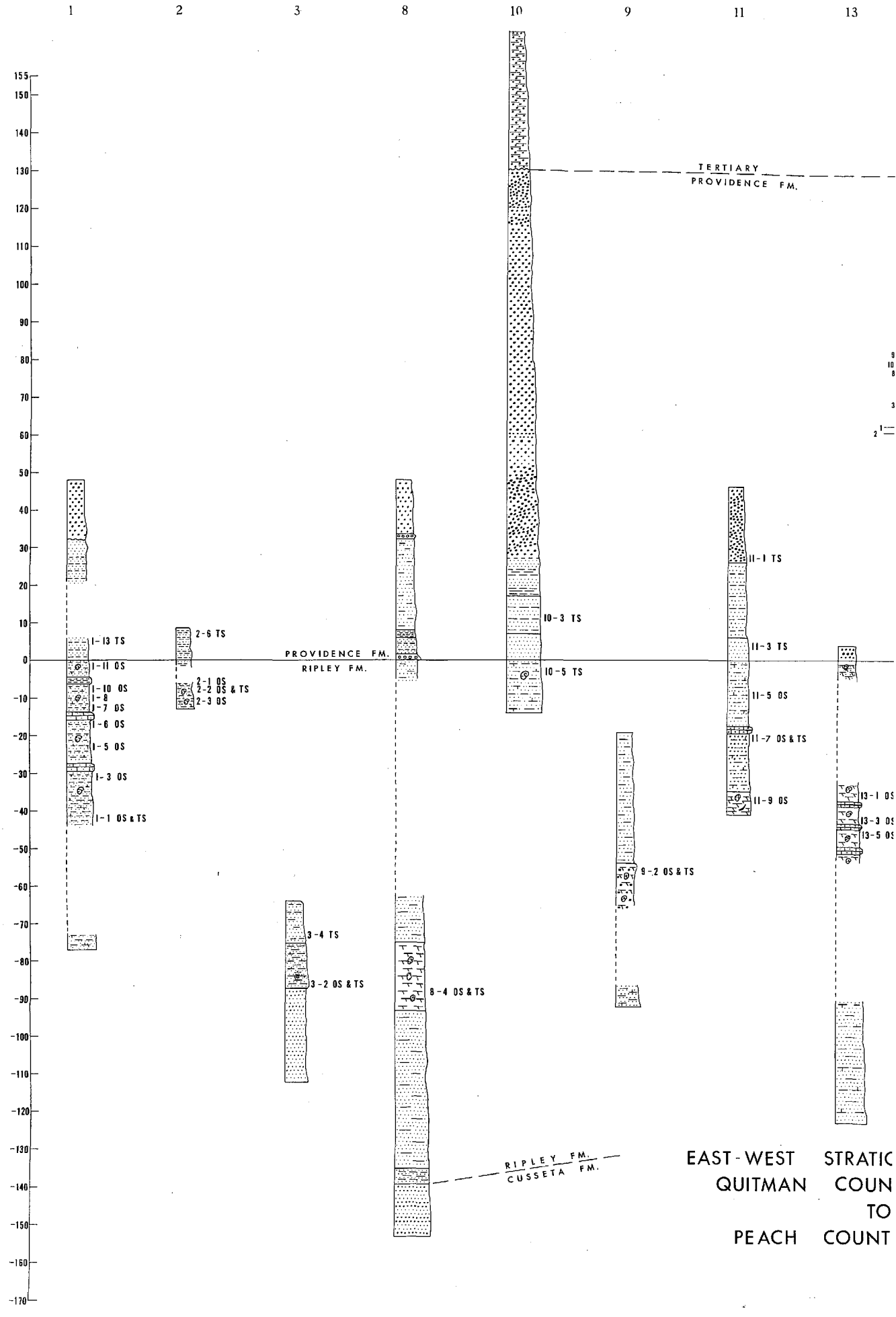
OUTCROP MAP OF RIPLEY AND PROVIDENCE FORMATIONS OF WESTERN GEORGIA

5 0 5 10 15 20

Scale

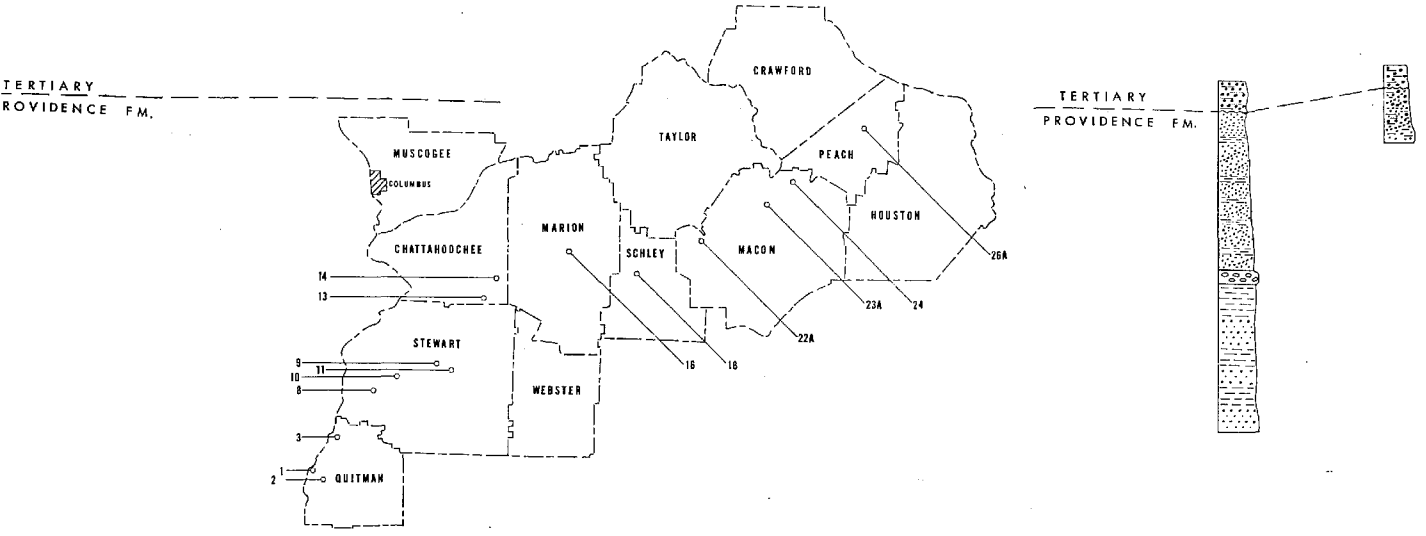
R. W. Stephens

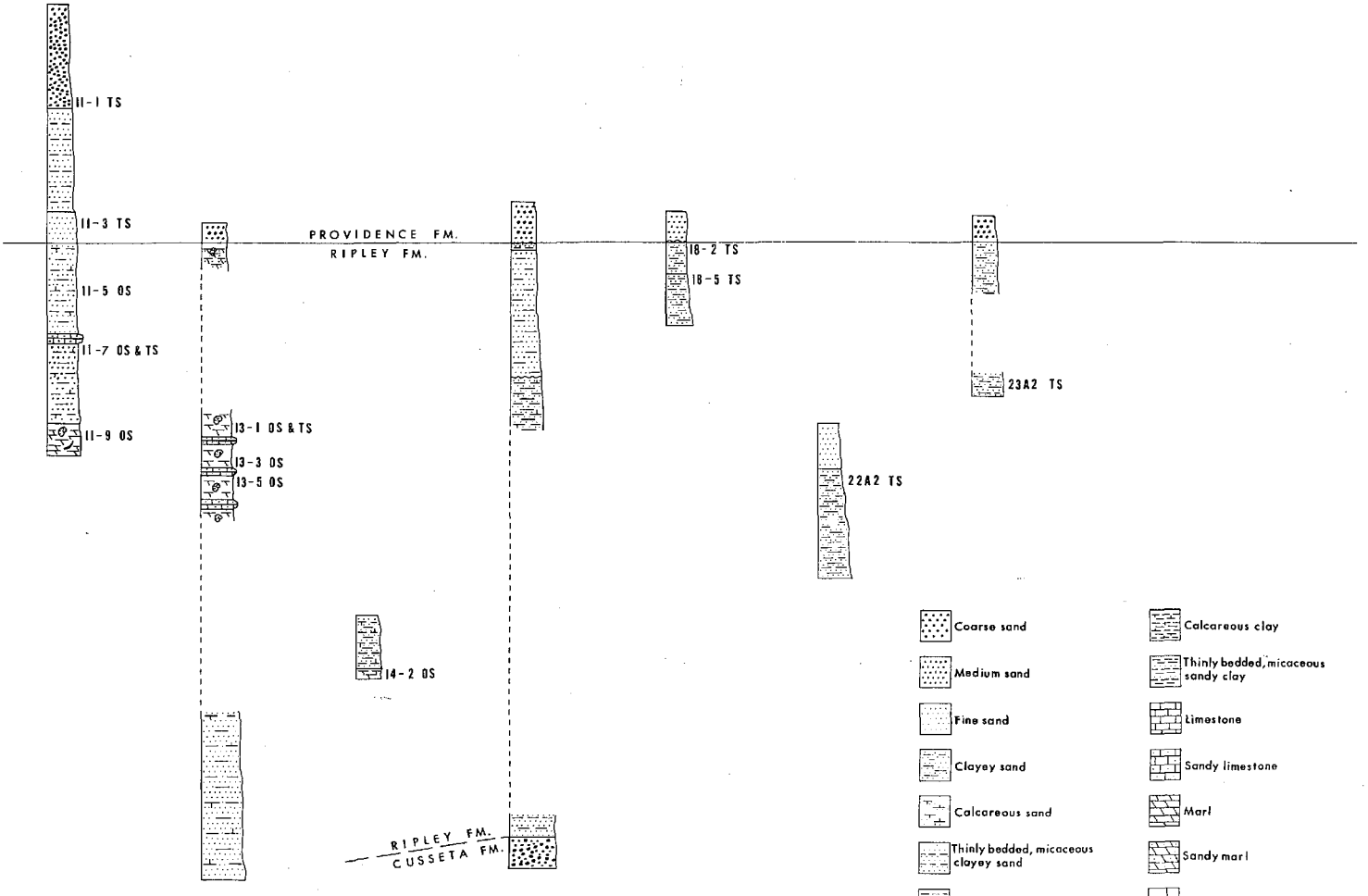
PLATE I



EAST - WEST STRATIC
QUITMAN COUN
TO
PEACH COUNT

11 13 14 16 18 22A 23A 24 26A





Coarse sand
Medium sand
Fine sand
Clayey sand
Calcareous sand
Thinly bedded, micaceous clayey sand
Clay
Sandy clay
Calcareous clay
Thinly bedded, micaceous sandy clay
Limestone
Sandy limestone
Marl
Sandy marl
Ironstone ledge

OS Ostracod samples
TS Rock thin sections

AST-WEST STRATIGRAPHIC SECTION
QUITMAN COUNTY, GEORGIA
TO
PEACH COUNTY, GEORGIA

R. W. Stephens

PLATE II