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Southeast Nebraska Geology: Field Trip 3

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FIELD TRIP 3

SOUTHEAST NEBRASKA GEOLOGY

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Late Pennsylvanian and Early Permian Biostratigraphy and Paleoecology in Richardson and Pawnee Counties, Nebraska

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Introduction

The purpose of this trip is to familiarize you with the latest Pennsylvanian and earliest Permian rocks that are exposed in extreme southeastern Nebraska. You will see eight exposures of these rocks and will have ample opportunity to collect lithologic samples, as well as samples for both macro- and micro-fossils. The stops have been selected to show you examples of several different environments that existed in southeastern Nebraska in the late Paleozoic. These include subaerial deposits with paleosols, nearshore and offshore marine clastic and carbonate sequences.

Each stop is covered in detail in the handouts that have been furnished to the trip participants. Subsequent readers will be able to find this information in the several references that are listed at the end of the text. All of the stops will be in Richardson and Pawnee counties (fig. 1).

Late Pennsylvanian and Early Permian rocks in the Midcontinent have been studied, especially in terms of cyclic sedimentation and in southeastern Nebraska, by students working under T. M. Stout, including Avers (1968), Bernasek (1967), Dishman (1969), McCrone (1955), Russell (1969), and Snyder (1968). R. C. Moore (1931, 1932, 1936) wrote several papers on rocks of similar ages in Kansas and Stout (1974, 1978) wrote several papers dealing especially with the Nebraska sections.

Heckel and Baesemann's (1975) and Heckel's (1977) papers on cyclic sedimentation in the Missourian of Kansas and Nebraska have been particularly useful. Their model fits only the lower part of cyclothems of the Wabaunsee and Admire groups, however; these complex cyclothems have probably been affected by Gondwanan glaciation (Veevers and Powell, 1987). The Wabaunsee and Admire cyclothems in Nebraska have been discussed by Pabian and Diffendal (1991); in Wabaunsee and Admire sediments, regressive limestone facies either fail to develop or are flooded out by clastics. In the trip area, cyclothems return to a more normal sequence that includes better developed regressive limestones, a sequence that disappeared after deposition of the Howard Limestone.

In the summer of 1992, Boardman (with Pabian and Diffendal) sampled many of the units listed by Pabian and Diffendal (1991) for conodonts. In addition to the above samples, Pabian, in 1994, has sampled additional units examined in the 1991 publication. Boardman has processed these samples for conodonts and his preliminary findings are shown with the faunal distributions that accompany each of the sections described herein. Legends for fossils and lithologies are shown in figure 2.

Stop la **(fig. 3a). This stop shows the earliest of the nonMissourian/ Shawnee cyclothems that have poorly developed regressive facies. Pabian and Diffendal (1989, 1991) described a section of similar age that is about 2 miles (3.2 km) east-southeast of Table Rock, and about 1.5 miles (2.4 km) west-southwest of this stop. The lowest unit at stop la is the Silver Lake Shale Member of the Scranton Formation, which is light gray, thinly bedded, with sandy stringers, marcasite (some altered to limonite) concretions and a few plant fossils. This represents a continental to nearshore, perhaps tidal or mudflat, area that was flooded by encroaching seas (represented by deposition of the overlying Taylor Branch Member of the Burlingame Formation). Pabian and Diffendal (1991) interpreted the Taylor Branch as being a transgresssive limestone and the overlying Winnebago Shale Member as the offshore shale.**

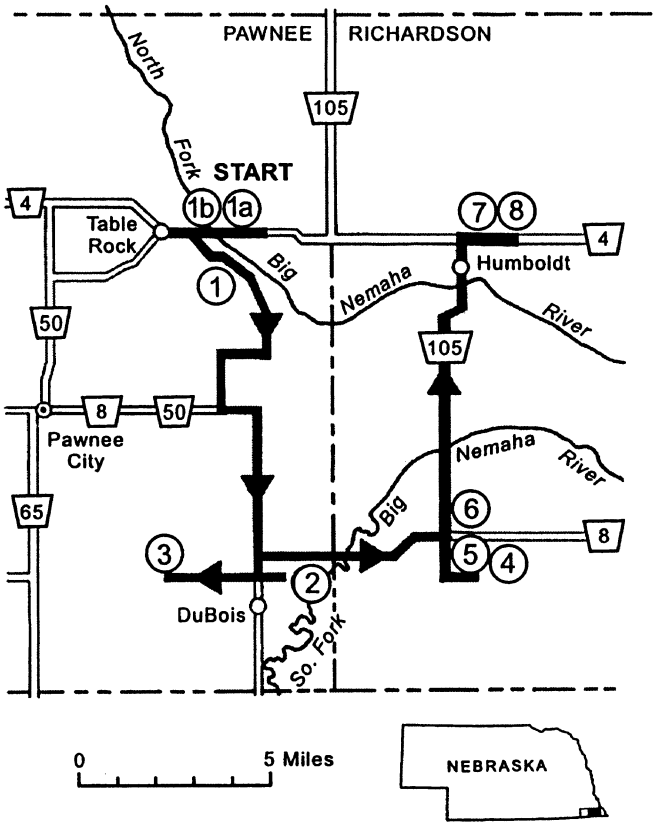


Fig. 1. Highway map showing route of field trip in Pawnee and Richardson counties.

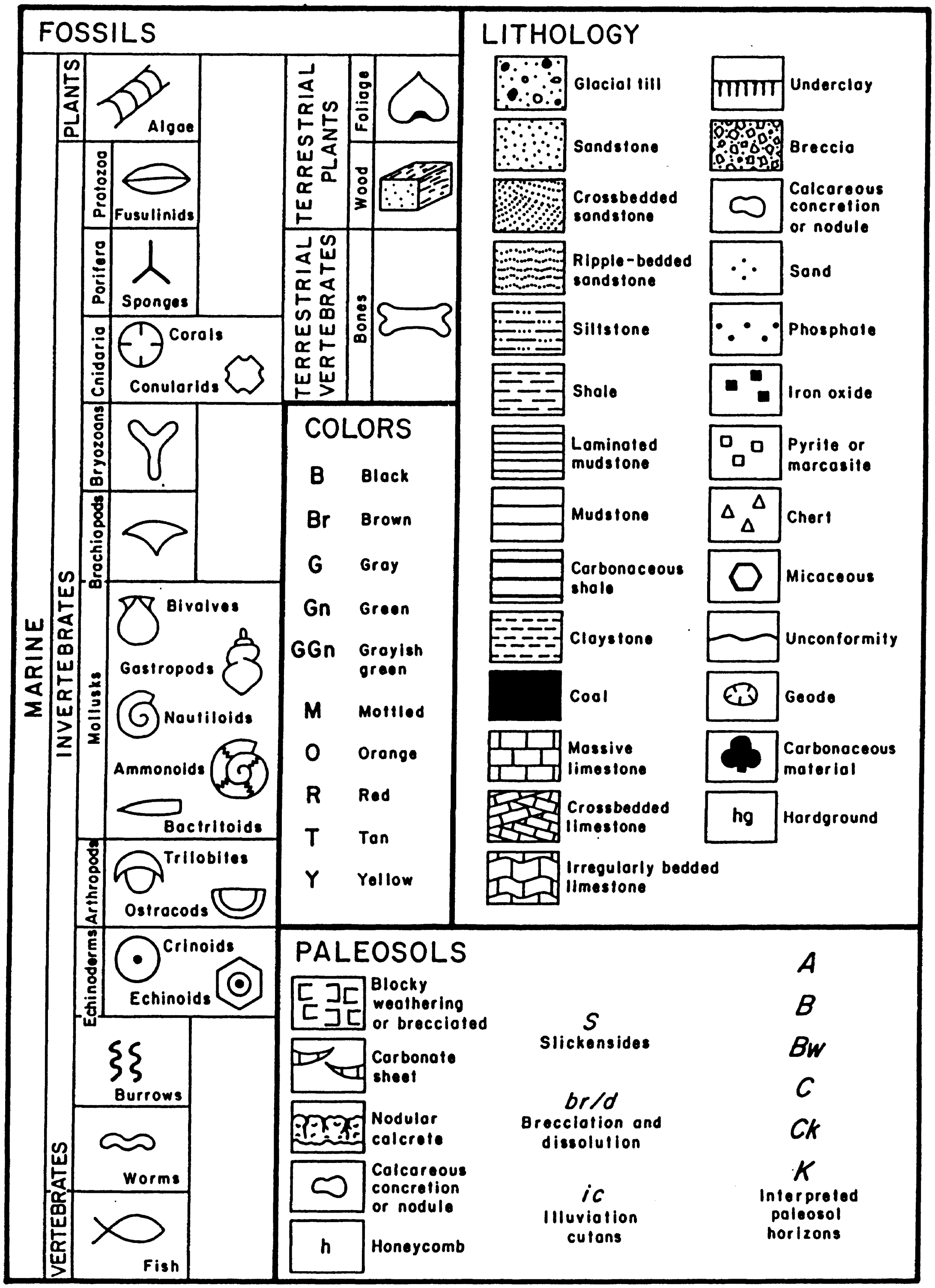
They called the South Fork Limestone Member and the Winnebago Shale Formation regressive facies. Pabian and Diffendal (1991) were unable to determine the nature of the Wakarusa Limestone, but Heckel (1979) stated that there was a complete transgressive-regressive sequence in this unit west of Topeka, Kansas. The South Fork Limestone here has bryozoans, brachiopods, and crinoid debris. The in-vertebrate fauna near the top of the Soldier Creek includes bryozoans, brachiopods, snails, crinoid and echinoid debris, and these may represent a nearshore fauna that lived in a time immediately preceding the deposition of the transgressive facies of the Wakarusa.

***Stop lb* (fig.3b). This stop shows the stratigraphic units that are immediately below the units seen at Stop la. The massive sandstone and cross-bedded sandstone beds were not recorded in early publications (e.g. Condra, 1927) nor were they shown on the map of Bengtson and others (ca. 1933). These channel deposits may have been uncovered at the time a county road, that does not appear on the ca. 1933 map, was constructed. About 28 feet (8.5 m) of thick, massive, sometimes cross-bedded sandstone are exposed here. Correlation of hanging sections of channel sandstone is difficult. We have not determined if this channel deposit correlates either with the White Cloud section recorded by Pabian and Diffendal (1991) or with the type White Cloud in the Topeka, Kansas, area. Above this unit is about 6.5 feet (2.0 m) of alternating sandstone and shale beds that may represent intertidal deposits. These give rise to about 5.5 feet (1.7 m) of dark, gray-green shale that may have been a tidal or mudflat. The Happy Hollow limestone above is conglomeratic and contains algae, some plant fragments, and many fragmental invertebrates. We have not determined whether the limestone at the top of this section correlates with the Happy Hollow limestone or an unnamed limestone recorded by Pabian and Diffendal (1991) that crops out about 1. 5 miles (2.4 km) southeast of here.**

Stop 1 (fig. 3). This stop shows the earliest of the non-Missourian/Shawnee cyclothems that have poorly developed regressive facies. It has been described by Pabian and Diffendal (1989, 1991).

The White Cloud Shale (units 1-5) is gray and contains some iron oxide in its lower part. Above the lower shale is a limestone that is about 2-ft (0.6-m) thick and contains fusulinids, brachiopods, and crinoids, all of which are heavily coated with algae. This bed appears to be only locally developed, and it has been observed in a roadcut about 1.3 mi north-northeast of here. The fossils are not algal-coated at the latter site. Up to about 20 ft (6 m) of the underlying shale are exposed in the roadcut, and the lower parts are more micaceous and sandier than the upper. Concretions containing plant remains have been recovered from this unit. South, toward DuBois, the White Cloud also tends to be sandier, and Condra (1927) showed channel sands in the White Cloud southeast of Rulo, about 40 mi from here (see Pabian and Diffendal, 1991, figs. 33n, 33o). There are three shale beds ranging from gray and green in the lower to brown in the upper two. There are calcareous and iron-oxide concretions in the upper beds. Boardman has suggested that unit 2, stop 1, this trip (=unit 2, stop 1, Pabian and Diffendal, 1991) is actually the Happy Hollow Limestone. This unit has yielded fusulinids, brachiopods, and crinoid stems, most of which are algal coated. This unit also contains a *Streptognathodus* biofacies. Unit no. 6, called Happy Hollow Limestone by Pabian and Diffendal (1991), is up to 2-ft (0.6-m) thick and is crumbly, weathered to dark yellow-orange; it has yielded no fossils here.

The Cedar Vale Shale (units 7, 8) is about 7-ft (2.1-m) thick, gray in its lower part and black, crumbly to fissile in its uppermost foot. The black facies contains abundant ostracodes *(Holinella)* and a few pectinoid bivalves *(Dunbarella)*. Above is the Rulo Limestone, a dense, dark gray, fossiliferous unit that weathers to yellow or brownish yellow; we have



Abbreviations:

Ad = *Adetognathodus*
St = *Streptognathodus*
.... = Alternate Sea Level Curve

Gl = Glauconite
PO_4^{-3} = Phosphate

Fig. 2. Legend of characters and abbreviations shown along measured sections.

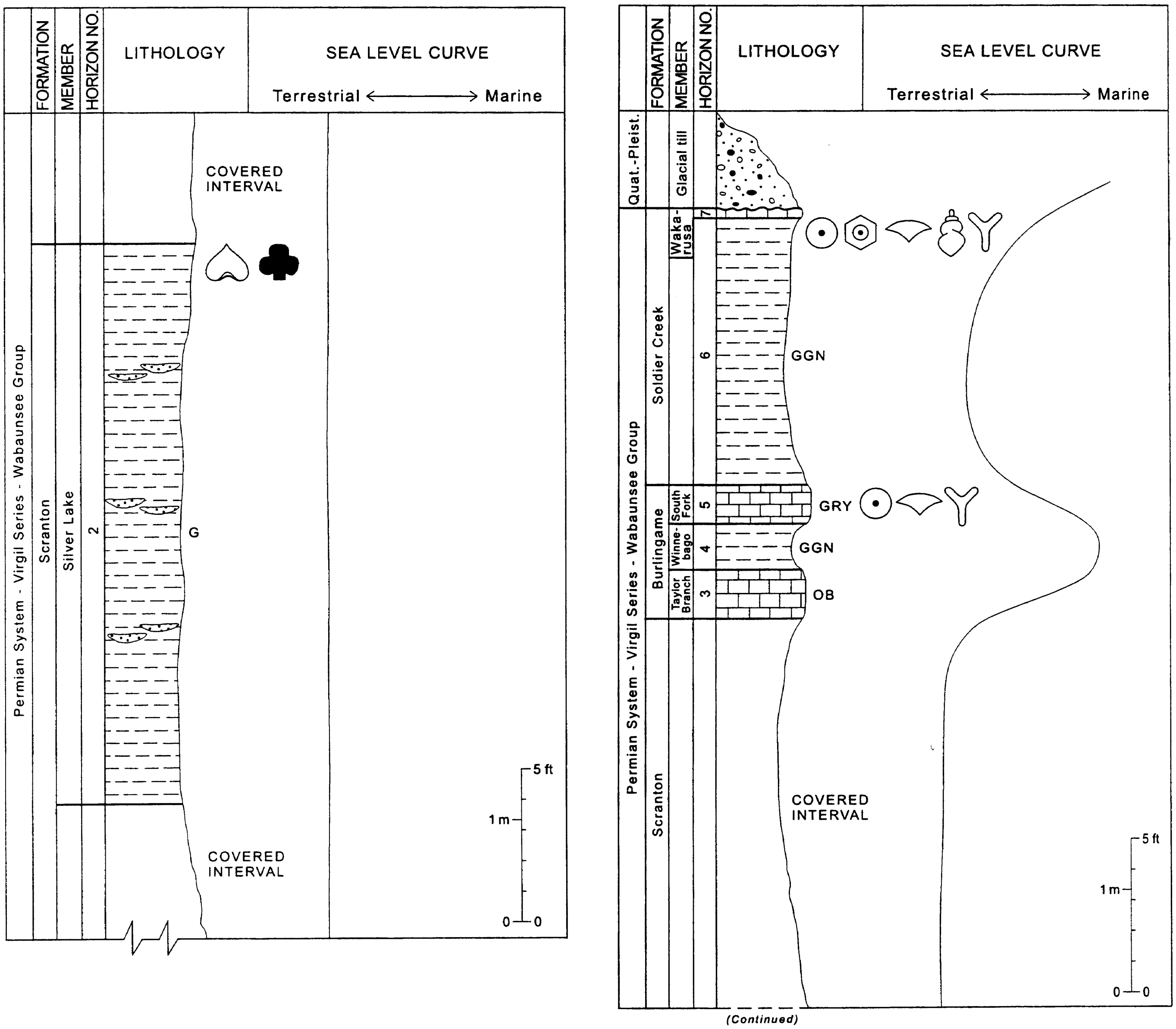


Fig.3a. Measured section of exposures of early Wabaunsee sediments at stop 1a.

interpreted this bed as the transgressive limestone inasmuch as it contains a *Streptognathodus* biofacies. We suggest that the regressive sequence was overwhelmed by clastics, preventing development of a regressive limestone. The lower part of the Silver Lake Shale (unit 10) is gray, clayey, and contains pyrite, marcasite, and limonite, and is about 15-ft (4.6-m) thick. This is followed by about 5 ft (1.5 m) of siltstone that contains some plant remains in concretions. About 2 ft (0.6 m) of clayey shale is overlain by about a foot of coal smut (unit 13), followed by about another foot of shale.

The Burlingame Limestone (units 15-17) contains a lower and an upper limestone separated by about 2 ft (0.6 m) of shale. The limestones are dense, medium-crystalline, and gray, weathering to yellow-orange--the lower contains a few brachiopods, whereas the upper one contains brachiopods, clams, snails, and rare conularids. The Soldier Creek Shale contains some bryozoans, brachiopods, snails, and echinoderms, many of which are large, ornate forms, suggesting this may represent a regressive unit. The Wakarusa Limestone (unit 19) is deeply weathered, but we have not established if the weathering took place in the Paleozoic or Pleistocene, as it is overlain by glacial till.

***Stop** 2* (fig. 4). The rocks here are a strong contrast to those seen at stop 1 inasmuch as the cyclic sequence here is much more similar to cyclothems seen in the Missourian and early Virgilian (Shawnee Group). The lower sequence contains somewhat more clastic material than the Missourian or Shawnee cyclothems (cf. Heckel and Baesemann, 1975, and Heckel, 1977).

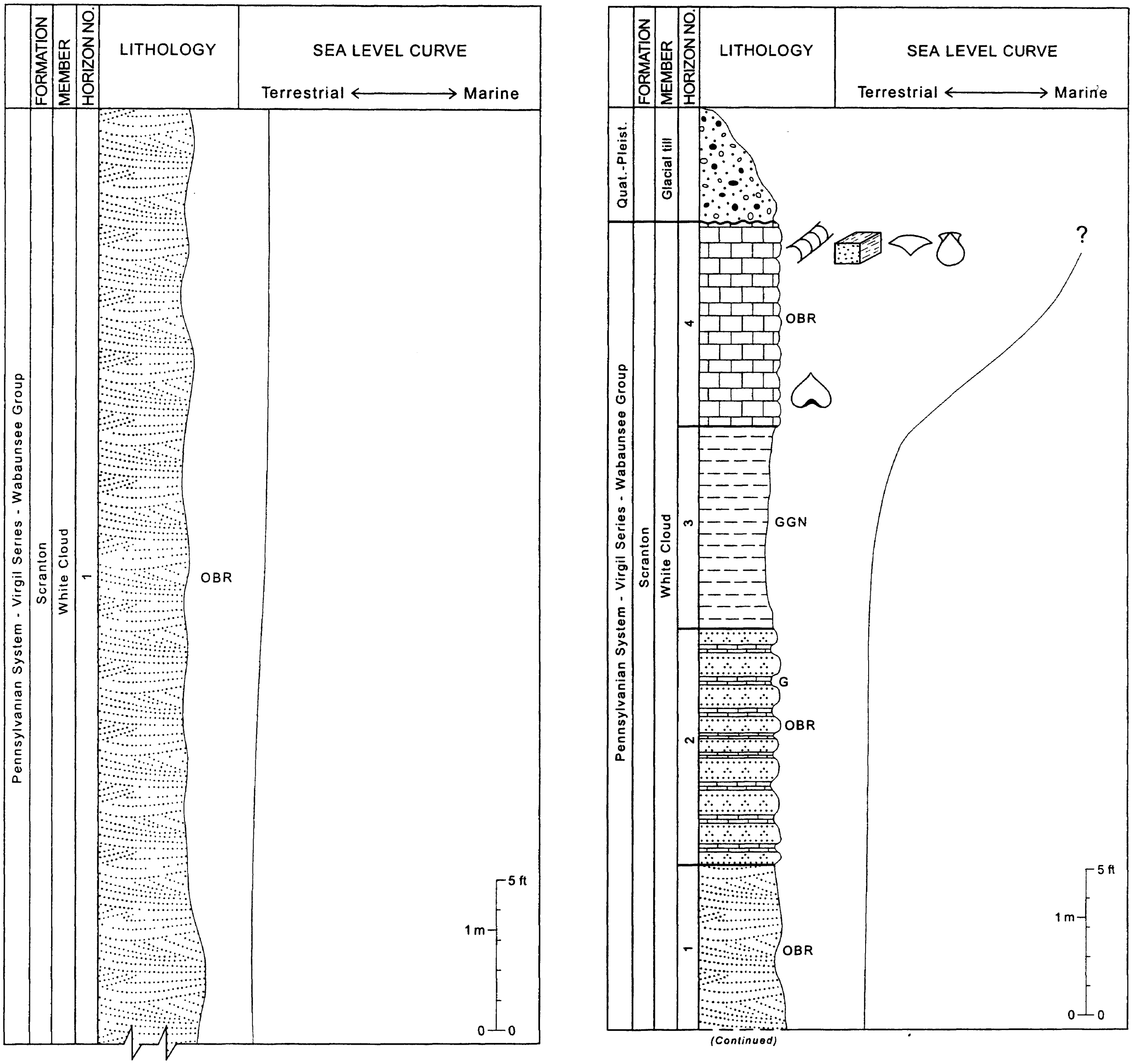


Fig.3b. Measured section of exposure of early Wabaunsee sediments at stop 1b.

The basal sandstone (unit 1) is micaceous, and ripple marks and cross beds can be observed in this unit if it is not covered with alluvium. The sandstone is overlain by about 2 ft (0.6 m) of siltstone, and about a foot of Nodaway Coal (unit 3) has been observed here. Immediately above the Nodaway Coal is a thin bed of calcareous concretions (top of unit 3) that contain pyritized and sphaleritized fossils, including brachiopods, clams, snails, goniatites, and bactritoids. We have interpreted this unit to be the transgressive limestone. Unit 4 contains *Streptognathodus* and is considered to be the lower part of a core shale. The overlying units (5, 6) have a very thin black shale that thickens to about 2 ft (0.6 m) over a very short distance. The black shale has produced goniatites, including one mature specimen, as well as the cranium of a fish (Martin, 1972); *Streptognathodus* is moderately abundant. The upper part of the shale is gray and contains brachiopods, bryozoans, and a few trilobites and crinoids. It is immediately overlain by the Howard Limestone, which contains fusulinids, bryozoans, brachiopods, clams, snails, nautiloids, and a few crinoids.

A few *Streptognathodus* were recovered from the top of the Severy Shale (unit 6) and the base of the Church Limestone (unit 7), whereas *Adetognathodus* is abundant at the top of the Church Limestone (unit 8) and moderately abundant in the Utopia Limestone (unit 10). A *Streptognathodus-Adetognathodus* biofacies in the Winzeler Shale (unit 9) sug-

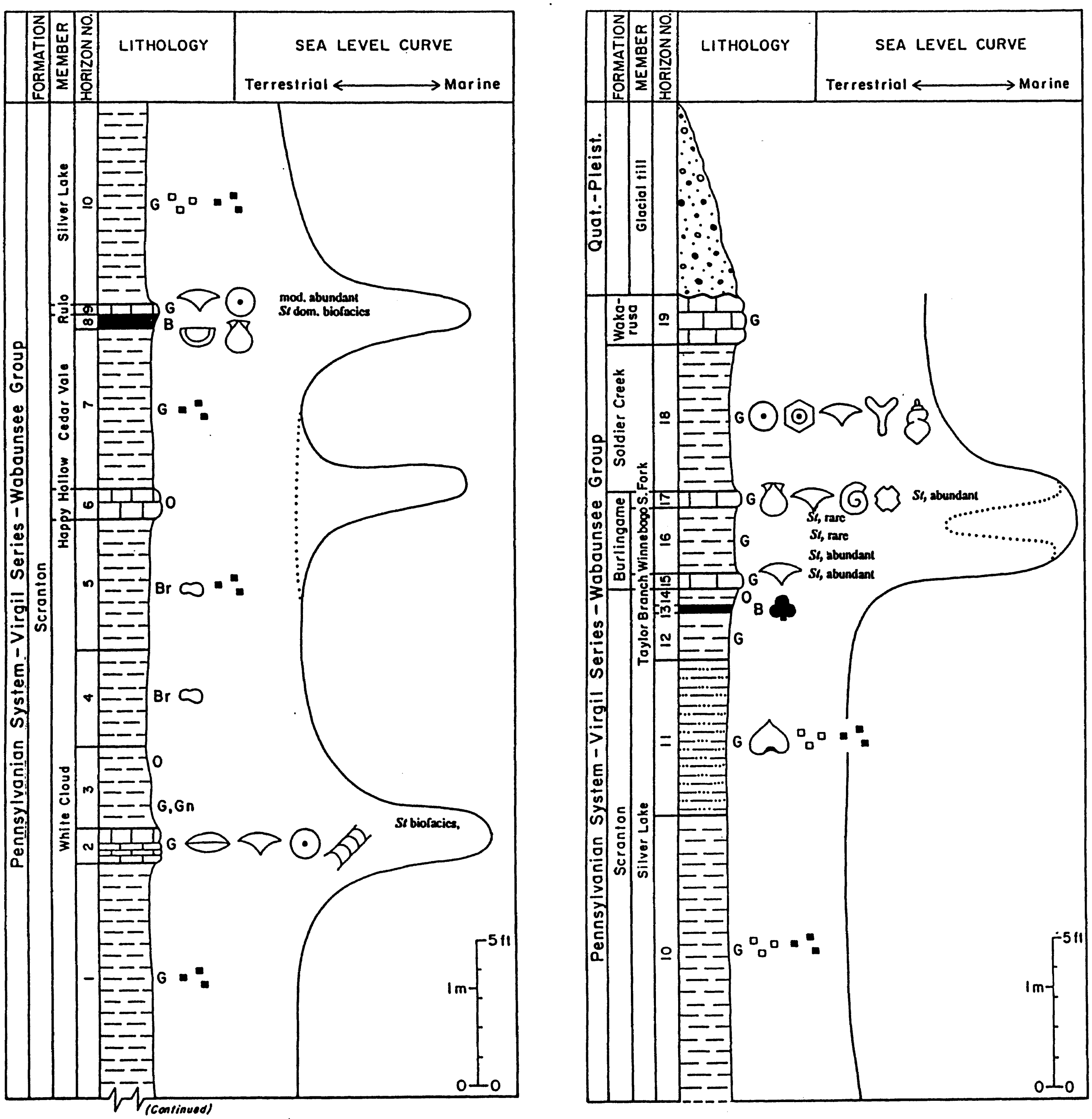


Fig. 3. Measured section of exposure of early Wabaunsee sediments at stop 1.

gests a short transgressive pulsation.

The erosional surface at the top of the Utopia Limestone is probably Pleistocene.

Stop 3 (fig. 5). The cut created during the construction of the emergency spillway at Iron Horse Lake Dam is probably the finest exposure of Auburn, Emporia, and Willard formations to be observed in Nebraska. It was the intent of the project engineer, Howard McNiff, to keep as much of the geology intact as possible in this area. McNiff's efforts have provided geology with an excellent outdoor laboratory. Huscher and Pabian (1989) subsequently described this section.

During and shortly after construction of the spillway, the lower part of the Auburn Shale (fig. 5, unit 1) was exposed, but this is largely overgrown or slumped over now. There were pyrite or marcasite concretions and some plant fossils in this unit, suggesting some of the Auburn was continental. The lower part of the Reading Limestone (units 2-7) contains alternating limestones and shales, with only *Adetognathodus* being found in units 2-9; the shales become less prominent in the upper Reading (units 8-10). The upper Reading is quite fossiliferous, with

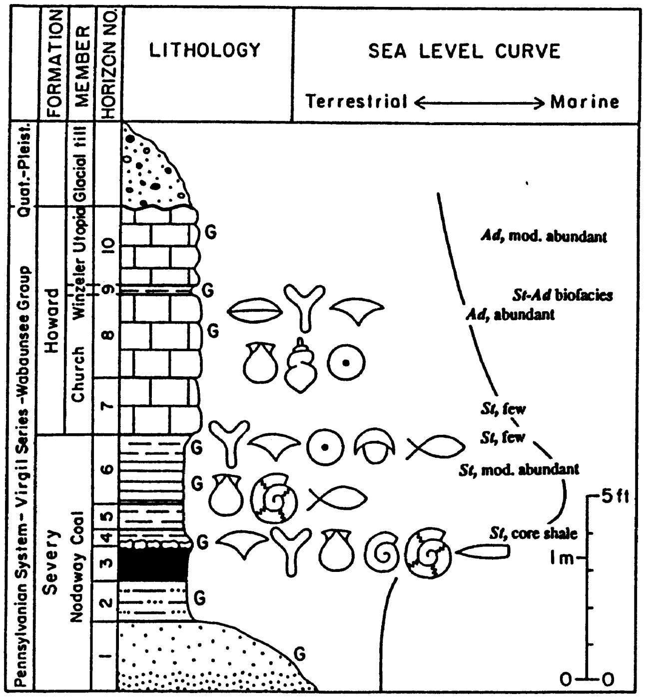


Fig. 4. Measured section of exposure of early Wabaunsee Cyclothem at stop 2.

brachiopods and crinoids being common. *Streptognathodus* has been found at the top of the Reading (unit 10). The Harveyville Shale (unit 11) has yielded an immature molluscan fauna, including clams, snails, and goniatites, as well as *Streptognathodus* being common at the base and middle and becoming abundant near the top. The lower part of the Elmont Limestone appears to be the regressive facies of a cyclothem; it contains brachiopods, crinoids, and snails, and some *Streptognathodus*. Unit 12 of the Elmont is a cross-bedded coquinoid limestone, suggesting very shallow conditions. Units 13 and 14 in the Elmont Limestone are very important, as the lower bed is a shale and the upper is a sandy shale with root mottling, suggesting an abbreviated regressive sequence and subaerial exposure. The upper Elmont (units 14, 15) may not be correlative with the upper Elmont at its type locality.

Thus, the new cycle in the upper Elmont, shown by the deposition of a transgressive limestone (unit 15), has almost no nearshore shale developed in the underlying unit 14, but the transgressive limestone is hard, dense and contains brachiopods, snails, crinoids, and a few shark teeth. *Streptognathodus* is abundant at the top of unit 15 and less common at the base of the Willard Shale (unit 16), suggesting a condensed section. The lower part of the Willard (unit 16) contains an immature molluscan fauna. A few mature clams have been found about 4 ft (1.2 m) above the base of the Willard Shale. The Willard is as much as 30-ft (9.1-m) thick locally and becomes sandier toward the top.

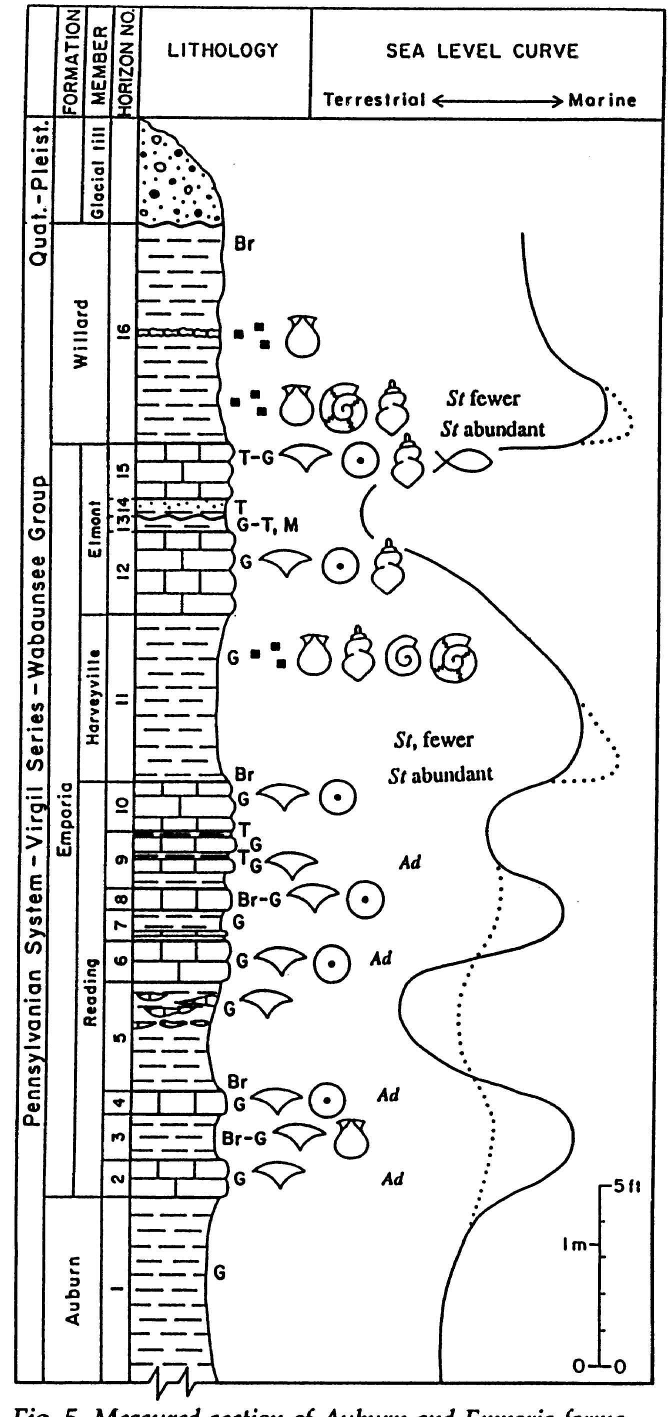


Fig. 5. Measured section of Auburn and Emporia formations exposed at Iron Horse Lake emergency spillway, Pawnee County, Nebraska, stop 3.

Stop 4 (fig. 6). Burchett and Arrigo (1978) have discussed the structural geology of this area, and some of the complex structure of this region is readily observed between stops 4 and 5, where the Bennett Shale is near the 1,200-ft (365-m) contour near the southwestern corner of section 15 and the 1,100-ft (335-m) contour near the southeastern corner of the section. Further, Burchett and Arrigo (1978, pl. 1) show the top of the Tarkio Limestone at 900 ft (274

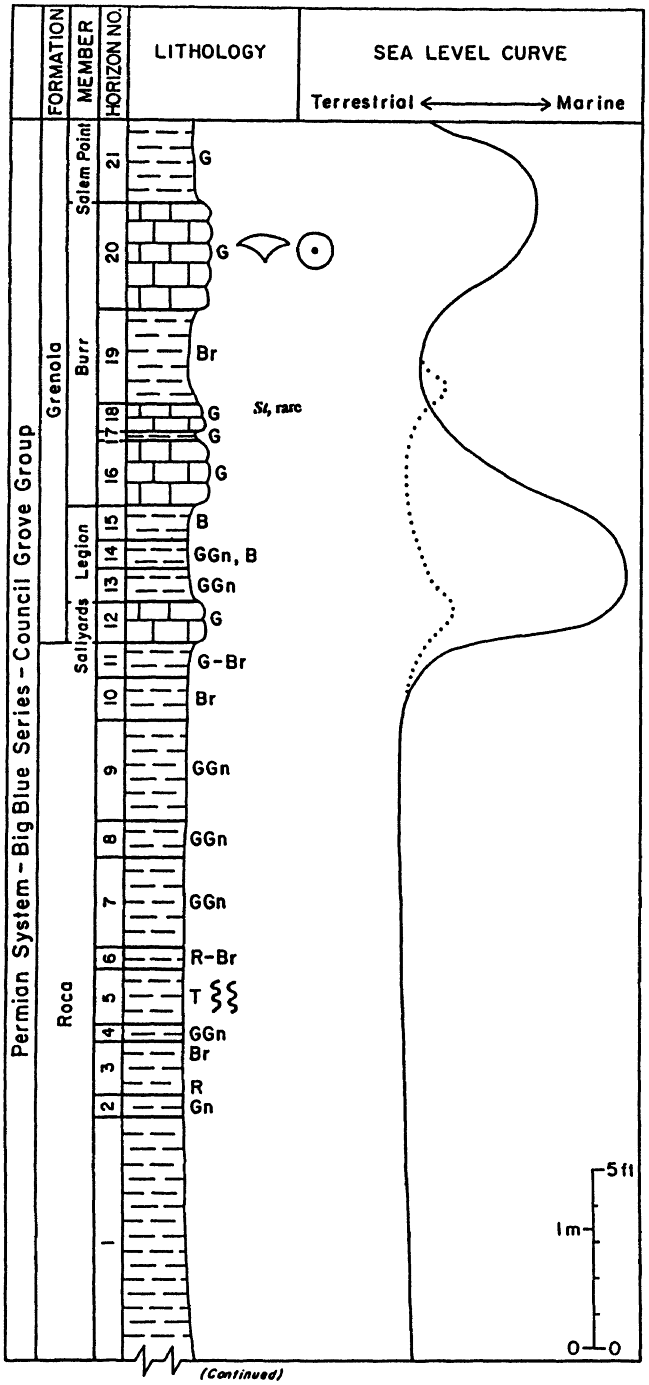


Fig. 6. Measured section of Council Grove sediments exposed in roadcut on Four Mile Hill, Richardson County, stop 4 (cont.).

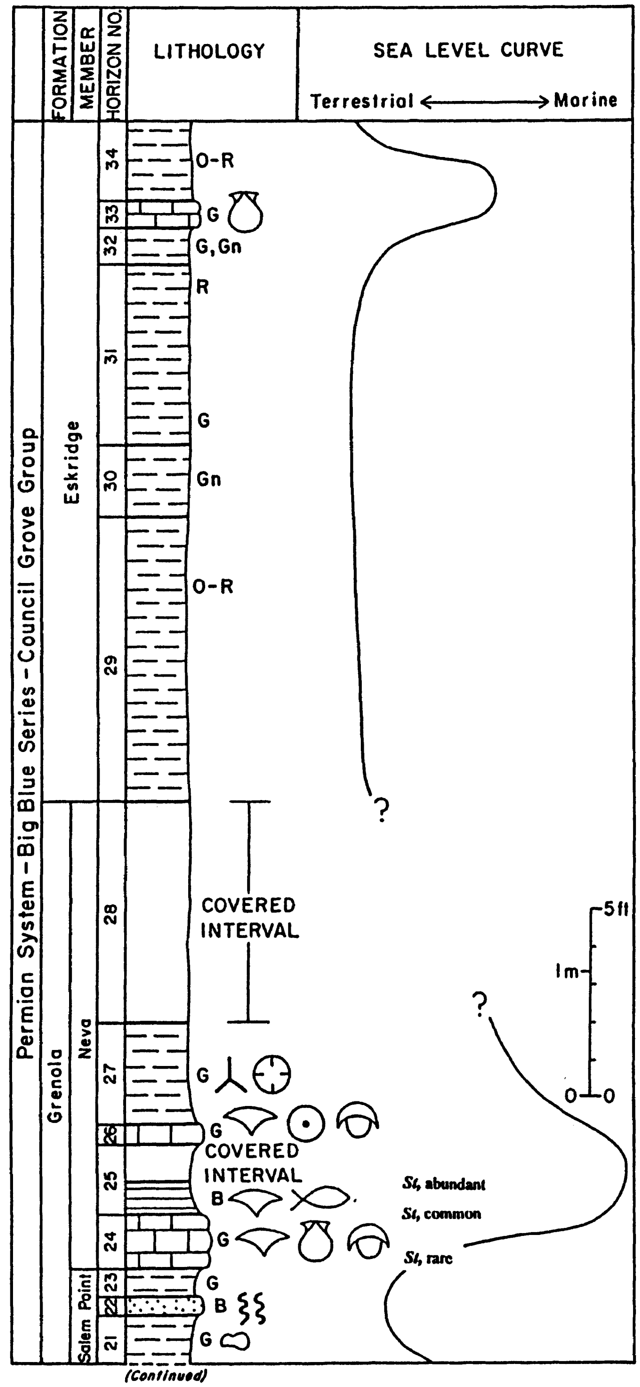


Fig. 6. Measured section of Council Grove sediments exposed in roadcut on Four Mile Hill, Richardson County, stop 4 (cont.).

m) in the southwestern corner and close to 800 ft (243 m) at the southeastern corner of sec. 15, T. 1 N., R. 13 E. The section exposed along Four Mile Creek and the road cut through the adjacent escarpment includes about 150 ft (45.7 m) of early Permian sediments.

The Roca Shale (units 1-10) is the outside shale of the first of at least three cyclothems exposed here. It is overlain by the dense Sallyards Limestone (unit 12) and the Legion Shale (units 13-15), which are thought to represent the transgressive facies of the cycle; however, only a single platform *Streptognathodus* has been recovered at the top of unit 12. The upper units of the Legion Shale may represent a paleosol. Pabian and Diffendal (1991) suggested that the Burr Limestone (units 16-20) may represent the regressive facies; however, rare *Streptognathodus* from the top of unit 18 may suggest this is actually

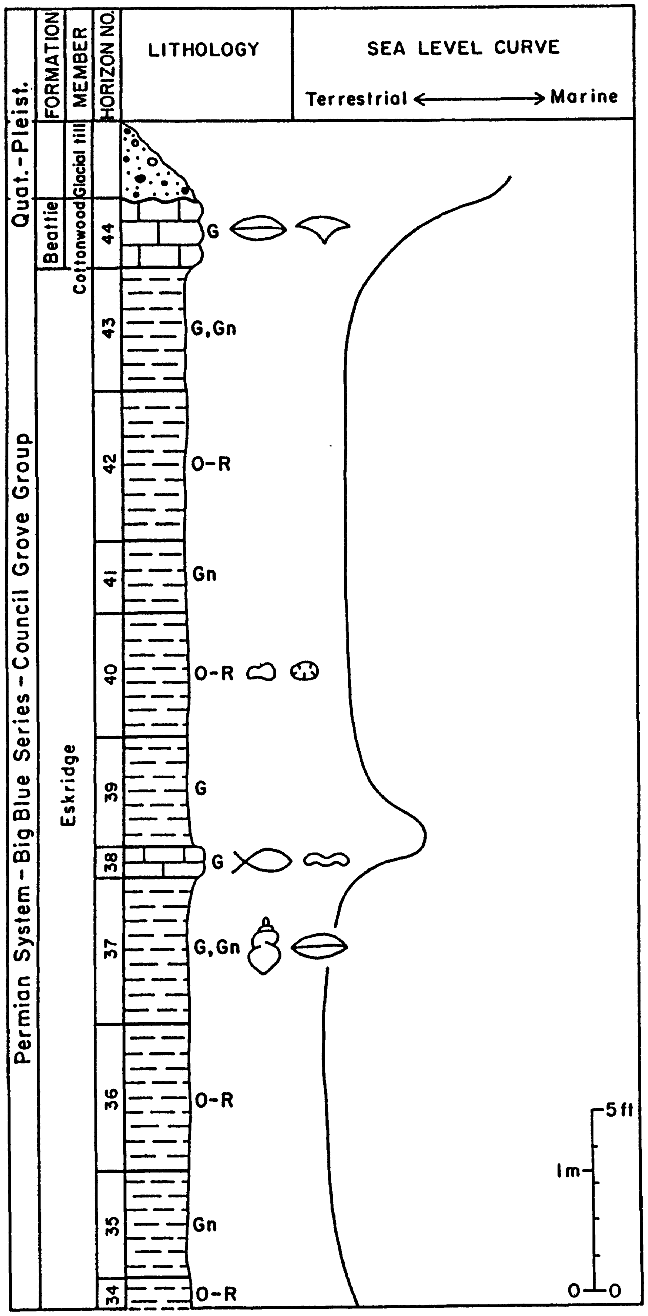


Fig. 6. Measured section of Council Grove sediments exposed in roadcut on Four Mile Hill, Richardson County, stop 4.

a transgressive limestone. The Salem Point Shale (units 21-23) may be an eolian deposit, and Joeckel (in Pabian and Diffendal, 1989) has demonstrated the presence of calcareous concretions in the unit. Near the top of the Salem Point is a foot-thick, thinly bedded sandstone that is bioturbated and represents the earliest marine incursions of the following cyclothem.

The lowest limestone in the Neva (unit 24) represents the transgressive unit of the cycle, and it contains brachiopods, mollusks, and a few trilobites; it has rare *Streptognathodus* near the base and common *Streptognathodus* near the top. *Streptognathodus* is abundant in the base of unit 25, suggesting this is an offshore shale. It is overlain by a dark brown to black, crumbly to somewhat fissile shale that contains inarticulate brachiopods and, in some areas, abundant shark teeth. Russell (1969) has called this unit a phosphorite and has traced it to the Manhattan, Kansas, area. Most of the regressive Neva facies have been quarried out of this area or are entirely covered by vegetation and removed overburden from the economic operations.

The Eskridge Shale (units 29-43) represents a long, emergent period with only a couple of thin marine limestones (units 33, 38). The upper part of unit 37 contains some fusulinids and snails, but it is root-mottled immediately below the limestone (unit 38). Unit 38 is made up almost entirely of spirorbid worm tests, and it has yielded some fish remains, including xenacanthids, suggesting freshwater deposits. Units 39-43 of the Eskridge contain numerous concretions, calcite geodes and some chert, suggesting caliche development here. About 3 ft (0.9 m) of the Cottonwood Limestone are exposed at the top of the section, and it contains numerous fusulinid molds.

Stop 5 (fig. 7). This stop shows the latest Admire and earliest Council Grove sediments. The West Branch-Hamlin shales are exposed at the lower part of the ditch (fig. 7, unit 2). This is a nearshore sequence of silts and shales that is followed by deposition of the Americus Limestone (units 3-5), which is a transgressive sequence containing brachiopods and conodonts. The lower part of the Hughes Creek Shale is dark gray, and it contains an immature molluscan fauna, including clams, snails, nautiloids and goniatites, as well as brachiopods and a few shark teeth (unit 6). The Hughes Creek becomes considerably more calcareous toward the top. There is an *Adetognathodus-Streptognathodus* conodont assemblage in unit 8 (fig. 7) and a *Streptognathodus*-dominant conodont assemblage at the top of unit 10 (fig. 7), suggesting separate pulses of deepening water. The upper Hughes Creek also contains large brachiopods, as well as bryozoans, trilobites, and crinoids; it had been regarded as a regressive sequence. However, the highest exposed bed (unit 14, stop 5) contains *Streptognathodus*, glauconite, and phosphate, suggesting deepening. Holterhoff and Pabian (1990) have discussed this fauna and suggested that it developed in regional depressions that formed as a result of subsidence along a down-dropped fault block along an active Nemaha Ridge. They erroneously assigned these units to the overlying Red Eagle Formation.

The ammonoids in the Hughes Creek Shale are similar to those in the Bursum Formation near Tula-

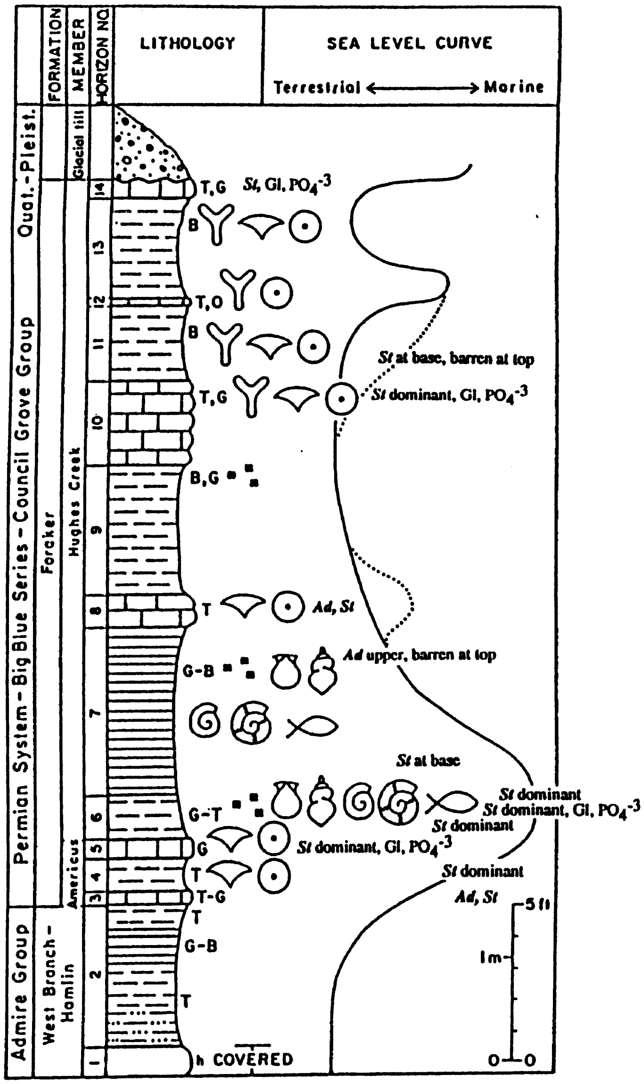


Fig. 7. Measured section of Hamlin and Foraker formations exposed in roadcut near Four Mile Creek, Richardson County, stop 5.

rosa, New Mexico, reported by Furnish and Glenister (1971).

Stop 6 (fig. 8). Pabian and Diffendal (1989, fig. 33e) showed about 75 ft (22.8 m) of the latest Pennsylvanian-earliest Permian sediments exposed in this long roadcut. Since then, "highway beautification" has obliterated beyond recognition about the lower third of this exposure. A proposed Pennsylvanian-Permian contact was not buried here, and is now the only such contact exposed in this area. This roadcut provides the only exposure of the Onaga Formation in this area, although the entire Onaga and overlying Falls City formations were completely buried by highway beautification at an outcrop about 3 mi north of here.

The upper part of the Dry Shale was exposed here, and it was made up of red beds with calcareous concretions; the lower part of the Dry, about 5 mi west, is marine and contains an immature mol-

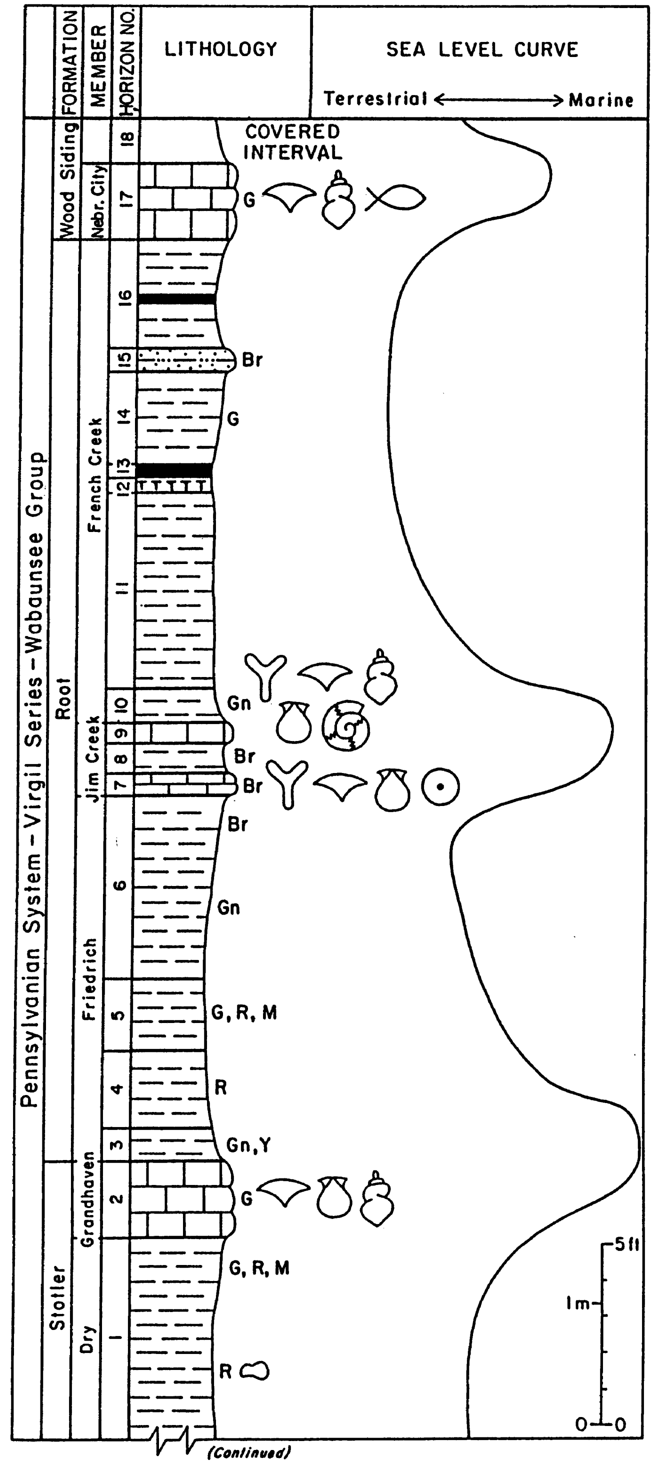


Fig. 8. Measured section of Root, Wood Siding, Onaga, and lower Falls City formations exposed on cut on Nebraska Highway 105, Richardson County, stop 6 (cont.).

luscan fauna with clams, snails, nautiloids and goniatites. The overlying Grandhaven Limestone (unit 2) contains brachiopods and mollusks; excellent examples of razor clams that were in vertical burrows were once seen here. The overlying Friedrich Shale (units 3-6) contains red beds and is most likely a continental or nearshore sequence that is overlain by

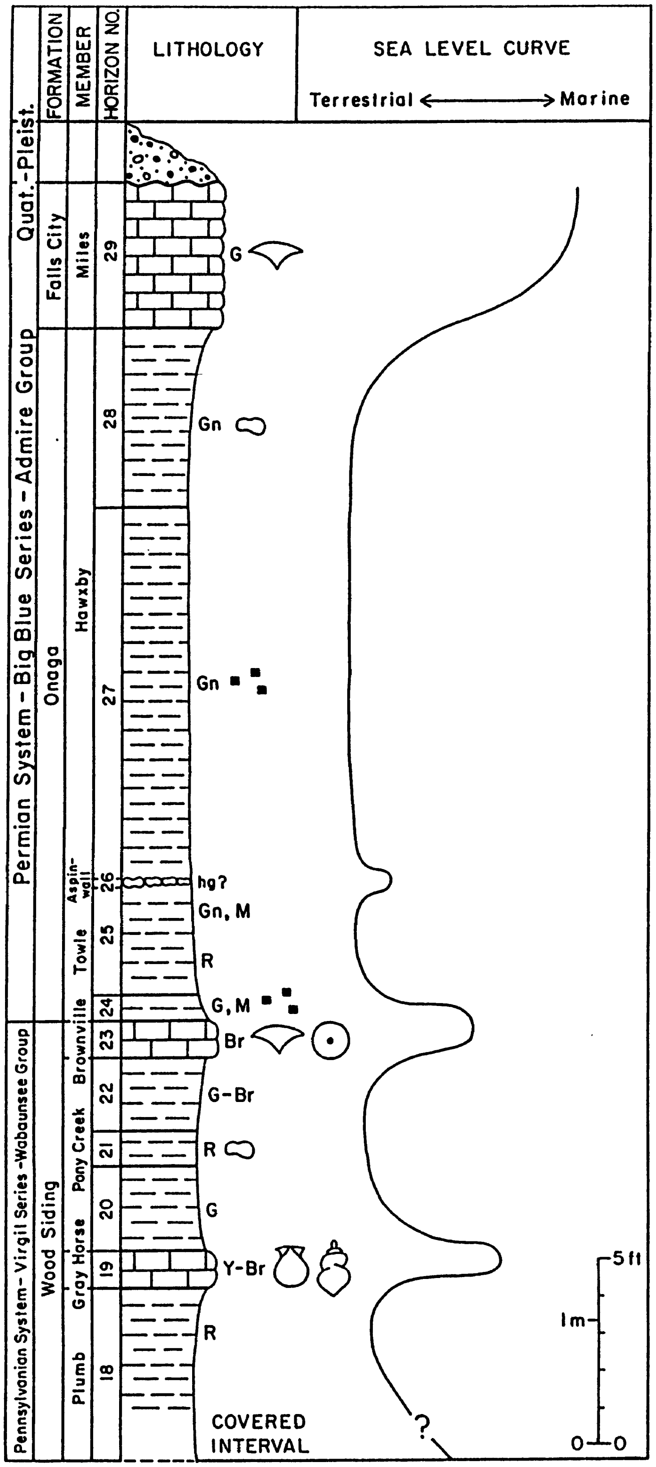


Fig. 8. Measured section of Root, Wood Siding, Onaga, and lower Falls City formations exposed on cut on Nebraska Highway 105, Richardson County, stop 6.

the Jim Creek Limestone. The lowest bed of the Jim Creek (unit 7) contains large productid brachiopods, myalinid bivalves, some bryozoans, and crinoid remains; it is probably a nearshore sequence. The upper Jim Creek (unit 9) is separated from the lower by about a foot of shale; it is dark gray and dense, and the lower part of the French Creek Shale (unit 10) contains an immature molluscan fauna with bivalves predominating and only a few goniatites. We have interpreted this as the transgressive facies of the cycle. The sequence then appears to have been flooded out by clastics; there is an underclay and coal (units 12, 13), followed by a shale and thin sandstone (unit 15). The overlying shale (unit 16) contains a coal bed in its middle.

The Wood Siding Formation (units 17-23) contains three limestones, the Nebraska City, Gray Horse, and Brownville, in ascending order, that are separated by shales. The intervening Plumb and Pony Creek shales contain red beds, suggesting subaerial erosion, whereas the Nebraska City and Gray Horse limestones contain immature mollusks, suggesting they were transgressive units.

The top of the Brownville Limestone has been considered the top of the Pennsylvanian in this area (Mudge and Yochelson, 1962); this correlation is based largely on fusulinids. We do not regard this to be a boundary section, however. There is currently much outstanding conodont data now being or having been recently collected, and these data will likely indicate where a boundary section should be located in the Midcontinent.

The Onaga Formation (units 24-28) consists mostly of shales here. There is a thin bed of concretions (unit 24) that we think is the Aspinwall Limestone. The thinning of the Aspinwall from its type locality about 40 mi east-northeast from here may be due to the proximity of this section to the Nemaha Ridge.

Stop 7 (fig. 9). This is the only exposure of the Five Point Limestone that is easily accessible in southeastern Nebraska. No unit in this section has yielded conodonts. The limestone near the top of this section has yielded a few bone fragments, suggesting this unit may be a freshwater deposit.

Stop 8 (fig. 10). Joeckel (1989, 1991) described paleosols in the Eskridge Shale from this site. The paleosol (fig. 10, units 3, 4) is at least 9.8-ft (3-m) thick here. It is underlain by mudstones and a limestone that contains molluskan and plant remains, suggesting nearshore conditions. The lower part of the paleosol is a red bed showing blocky weathering and containing carbonate sheets, and the upper 5 ft (1.5 m) is a gray mudstone with carbonate sheets. The land surface gave way to encroaching marine environments represented by the Cottonwood Limestone. The Cottonwood here contains abundant marine invertebrate fossils, including a few trilobites and a mature ammonoid. The lower part of unit 6 contains no conodonts, but upward, *Sweetognathus* and rare *Streptognathodus* have been found, and moderate concentrations of *Streptognathodus* have been found near its top. The Cottonwood contains several beds of chert nodules.

This is the only known spot where displace-

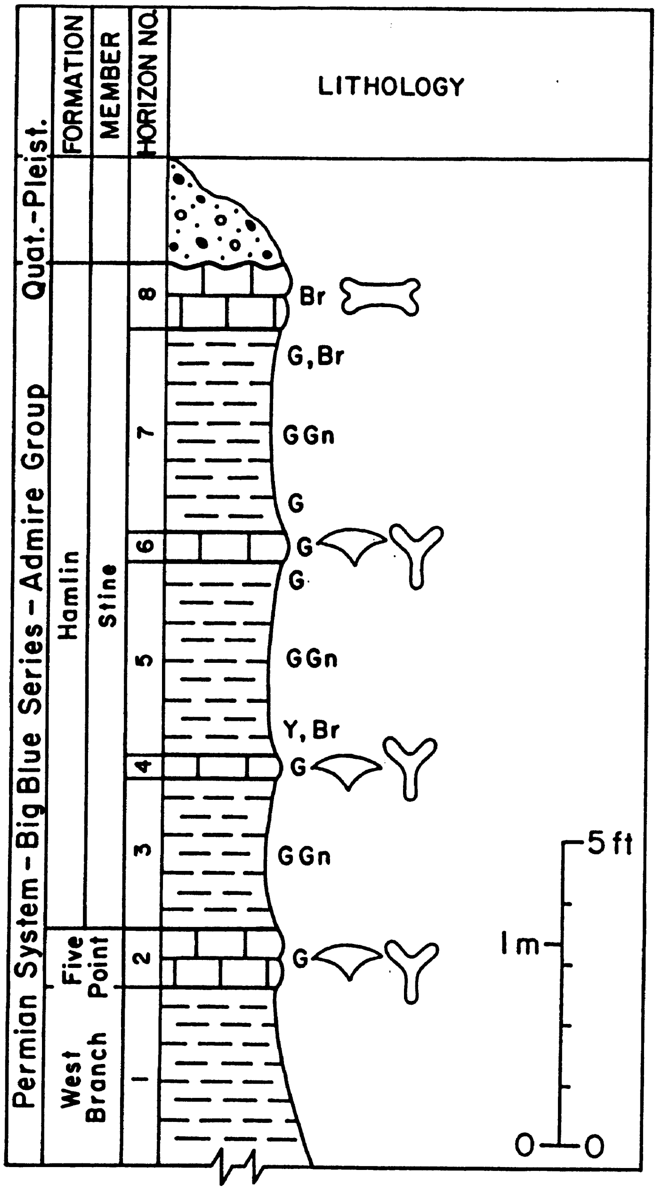


Fig. 9. Measured section of Five Point Limestone, Stine Shale, and Houchen Creek exposed on cut on Nebraska Highway 8, Richardson County, stop 7.

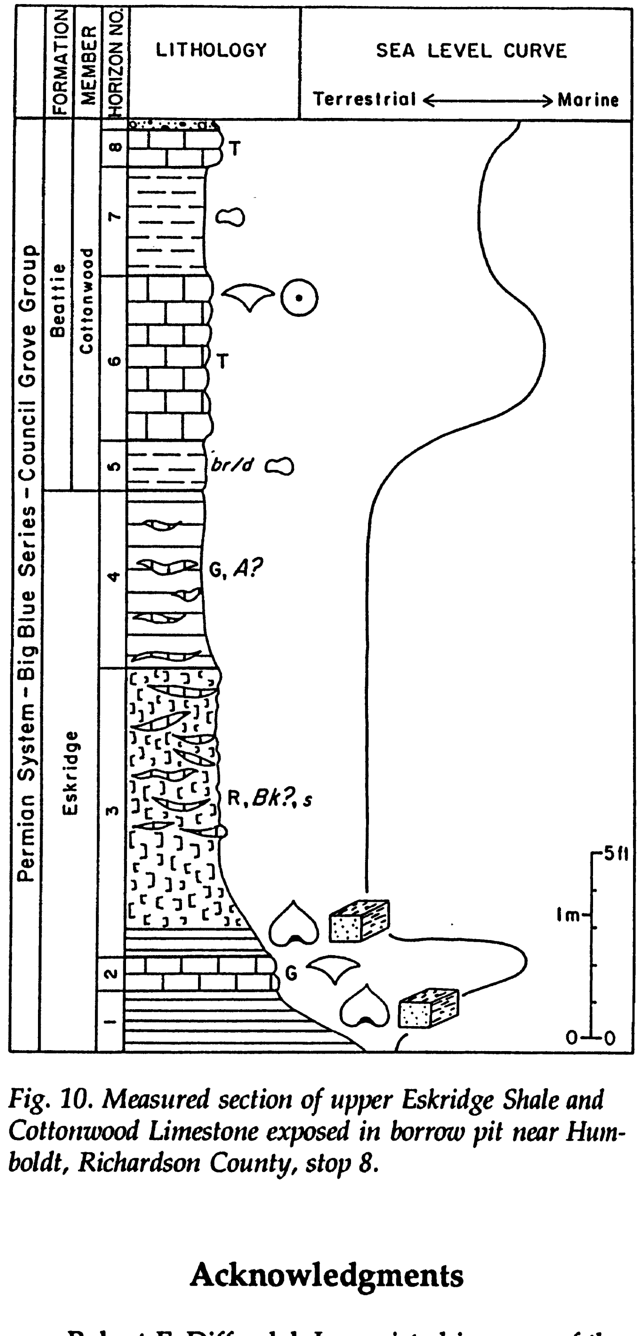


Fig. 10. Measured section of upper Eskridge Shale and Cottonwood Limestone exposed in borrow pit near Humboldt, Richardson County, stop 8.

ment along the Humboldt Fault can be seen in an outcrop. There appears to be about 6.4 ft (2 m) of displacement on the downdropped block that can be seen at the south end of the borrow pit. The trend of the fault has not been determined at this cut.

Acknowledgments

Robert F. Diffendal, Jr., assisted in some of the field work done for this guide and reviewed earlier copies of the manuscript. Perry Wigley also reviewed the manuscript. Charles Flowerday edited the text and provided useful comments.

Addendum

The trip will commence with sections at Stops 1 and 1a that Pabian and Diffendal (2003) used for the opening stops for their field trip held in conjunction with the 2003 North Central Section Meeting of the Geological Society of America, Kansas City Missouri, March 23 through March 26. Stop 1 of the 1995 combined meetings of the North Central and South Central Sections of the Geological Society of America Meeting held at Lincoln, Nebraska will be omitted from this trip. The latter section is now almost completely overgrown, whereas the former is relatively new. Both sections show the same rocks but channel sandstone is much better developed in the new section. The trip will follow the road log of the 1995 trip after the first stops, 1a and 1b.

Road Log

Mileage	**(Mileage between directions in bold.)**
0.00	Junction of Nebraska highways 4 and 65 (N-4 and N-65; Nebraska highways designated "N-#"), at the southeastern edge of Table Rock, near Taylor Branch. **(0.3)**
0.30	Near foot of overpass, turn right; proceed about 100 ft to "T" intersection; turn left (east). **(0.2)**
0.50	Cross Burlington Northern railroad tracks. CAUTION! **(0.2)**
0.70	Cross Burlington Northern railroad tracks. CAUTION! Turn left at intersection and follow road that goes parallel to the railroad tracks. **(0.8)**
2.20	Note outcrops of Scranton Formation to your right. **(0.5)**
2.70	**Stop 1.** This is located on the large hill on the northwestern corner of the intersection. Note that the railroad tracks now head toward Humboldt and no longer run parallel to the trip road. **(1.5)**
4.20	"T" intersection--continue straight. **(0.5)**
4.70	Turn right (west) **(0.2)**
4.90	Abandoned road. **(1.0)**
5.90	Turn left (south) **(1.5)**
7.40	Junction of N-50 and county road. Turn left (east). Exercise extreme caution! Sight distance to west very short. Continue on paved N-50 toward DuBois. **(4.9)**
12.30	Junction of N-50 and N-8. Continue straight. **(0.5)**
12.80	Junction of N-50 and county road. Turn left (east). **(0.55)**
13.35	**Stop 2.** Cross bridge across creek. Park. Walk south along creek to outcrops. Turn around; return to N-50. **(0.65)**
14.00	Cross N-50; continue straight (west). Note exposures of Auburn and Emporia formations. **(2.60)**
16.60	**Stop 3.** Entrance to Iron Horse Lake Recreational Area. Note earthen dam to the right (northeast). Turn right (north) and head toward parking area. The outcrop must be reached by walking across the earthen dam. **(0.3)**
	Lunch Break at Picnic Facilities. Restroom facilities and water available here. After lunch, return to county road.
16.90	County Road; turn left (east). **(2.6)**
19.50	Junction of N-50 and county road; turn left (north). **(0.5)**
20.00	Junction of N-50 and N-8; turn right (east). **(2.9)**
22.90	Dry Shale-Dover Limestone outcrop on left (alternate stop). **(2.3)**
25.20	Junction of N-8, N-105, and county road. Turn right (south) on county road. **(1.0)**
26.20	Intersection of county roads; turn left (east). **(1.0)**
27.20	**Stop 4.** Park in designated parking area. Return to county road; turn left (west); continue to intersection. **(1.0)**
28.20	Junction of county roads. Turn right (north). **(0.3)**
28.50	**Stop 5.** Continue northward. **(0.7)**
29.20	Junction of county road and N-8 and N-105; continue northward. **(0.4)**
29.60	**Stop 6.** Continue northward. **(7.2)**
32.50	**Alternate stop*.** Turn left (west); continue 1 mile; turn left (south); continue for 0.6 mi. Return to N-105.
33.70	**Alternate stop*.** Continue northward.
	***(Mileage between directions not included.)**
36.80	Enter Humboldt. Continue northward. **(1.0)**
37.80	Junction of N-105 and N-4. Turn right (east). **(1.0)**
38.80	**Stop 7.** Continue eastward. **(0.5)**
39.30	Intersection with county road; turn left (north). **(0.1)**
39.40	**Stop 8.** End of trip. Return to Lincoln via N-4, N-50, and N-2. Drive carefully!

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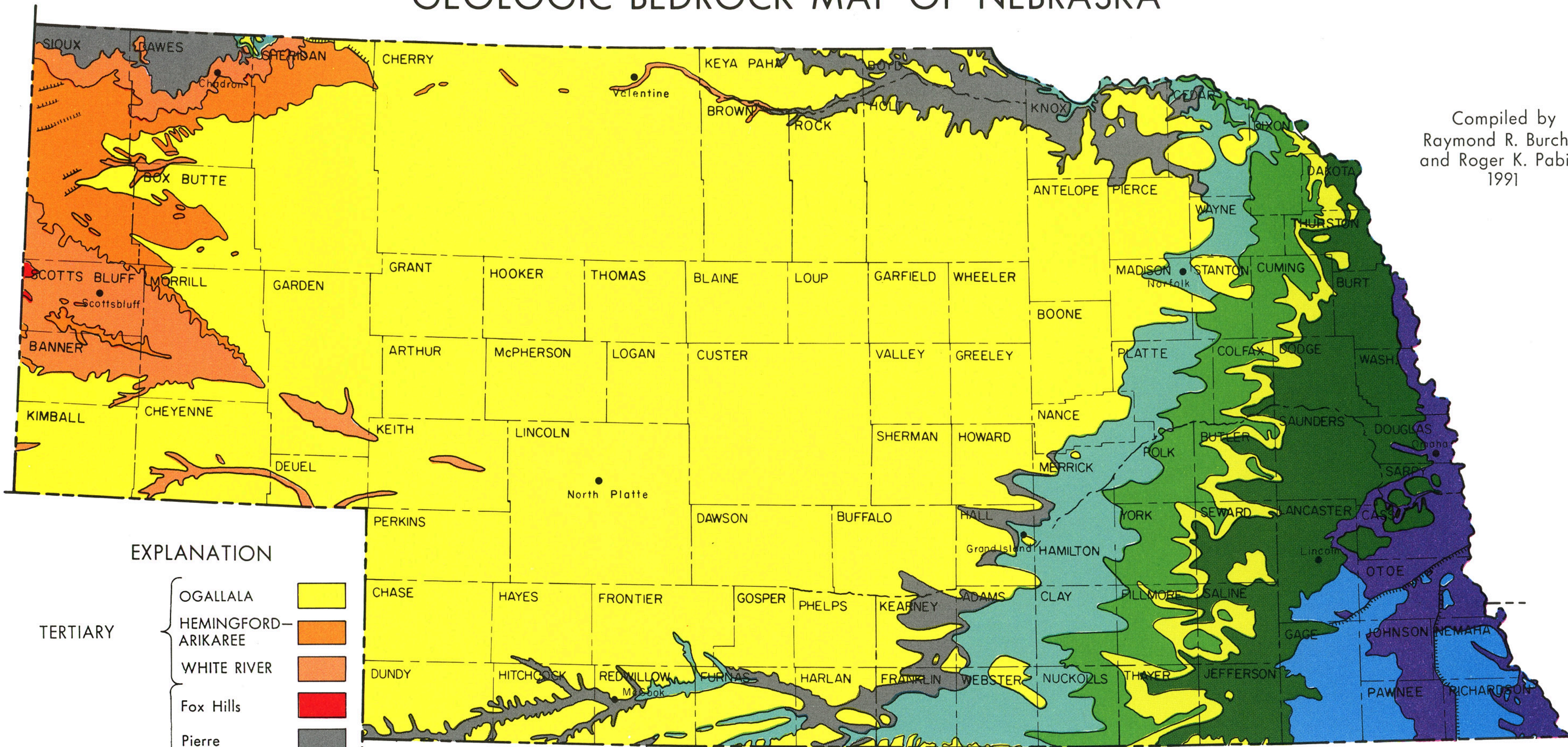
GEOLOGIC BEDROCK MAP OF NEBRASKA

Compiled by
Raymond R. Burchett
and Roger K. Pabian
1991



Drafted by Jerry P. Leach

EXPLANATION

TERTIARY
- OGALLALA
- HEMINGFORD–ARIKAREE
- WHITE RIVER

CRETACEOUS
- Fox Hills
- Pierre
- Niobrara
- Carlile
- Greenhorn–Graneros
- DAKOTA

JURASSIC

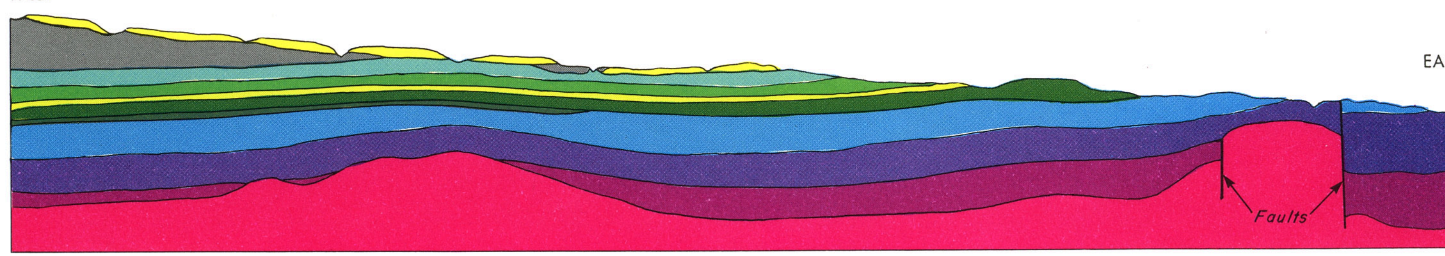
PERMIAN

PENNSYLVANIAN

MISSISSIPPIAN
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN

PRECAMBRIAN

Fault



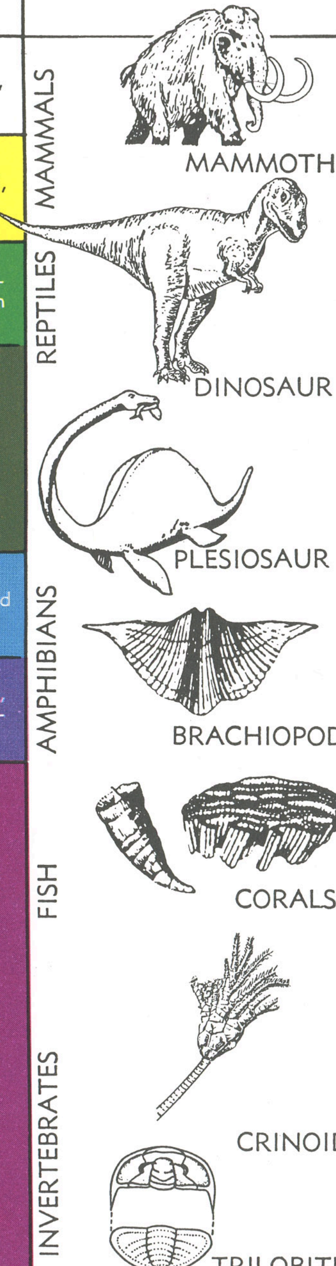
GEOLOGIC CROSS SECTION ALONG SOUTHERN NEBRASKA BORDER

20 0 20 40 60
Scale in Miles

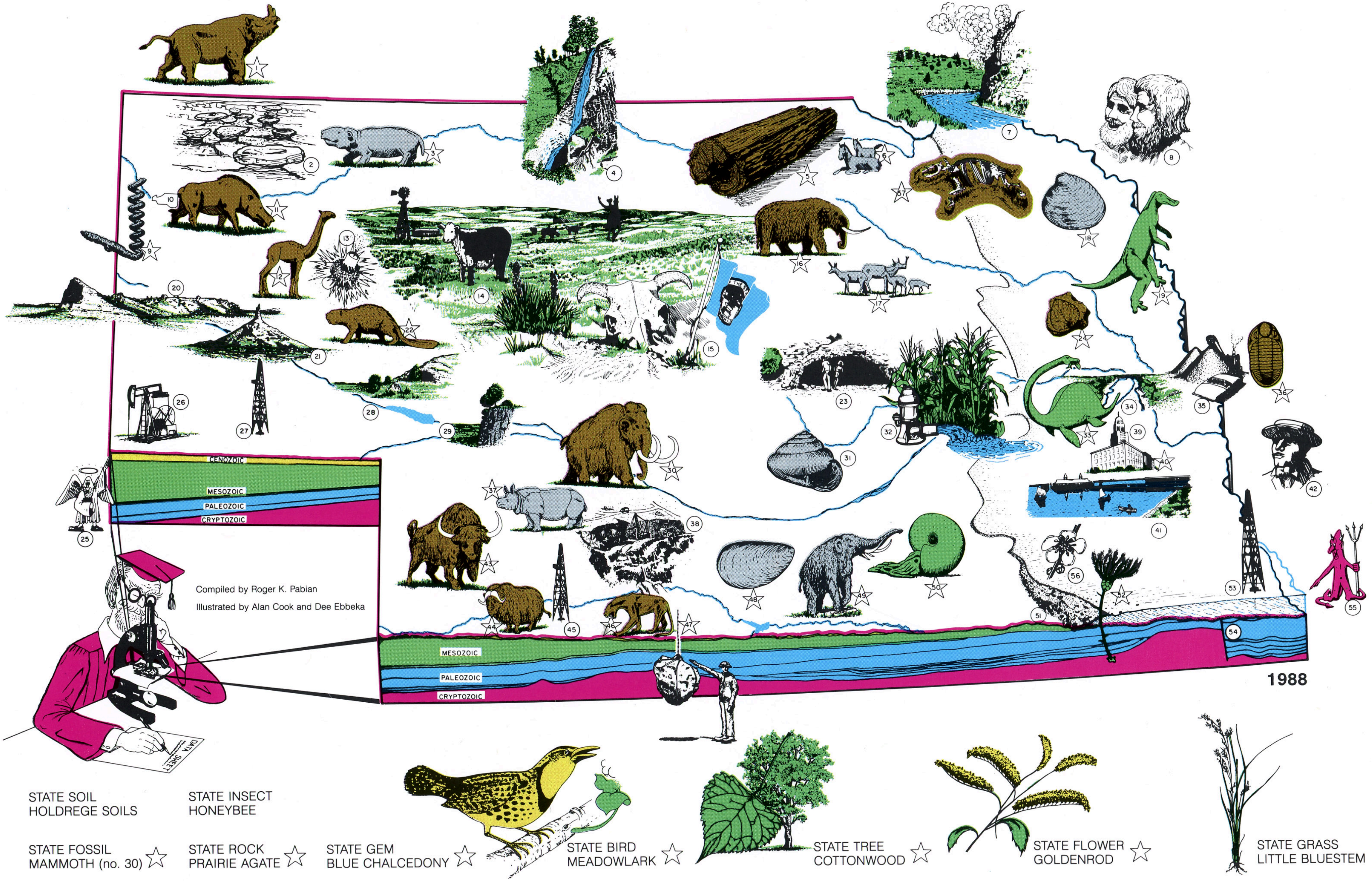
Conservation & Survey Division
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

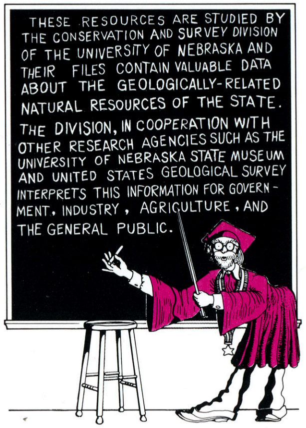
NOTE: Unconsolidated sediments of Recent and Pleistocene age cover the bedrock throughout much of the State and are not shown.

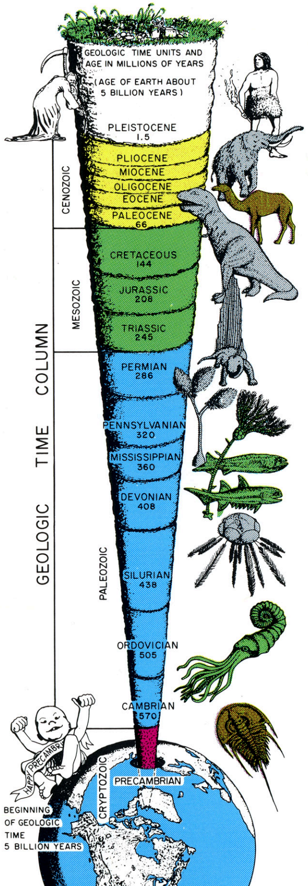
AGE (MILLIONS OF YEARS AGO)	GEOLOGIC TIME UNITS		ROCK TYPES	MINERAL RESOURCES AND PRODUCTS	TYPICAL FOSSILS
1.6	CENOZOIC (RECENT LIFE)	QUATERNARY (Recent and Pleistocene)	Glacial till, silt, clay, sand, gravel, volcanic ash.	Agricultural soil, water, sand & gravel, volcanic ash.	MAMMALS
66		TERTIARY	Sandstone, siltstone, clay, gravel, marl, volcanic ash.	Agricultural soil, water, sand & gravel, volcanic ash, riprap & uranium.	
138	MESOZOIC (MIDDLE LIFE)	CRETACEOUS	Chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate	Water, oil & gas, cement, brick, agricultural lime, & other construction materials.	REPTILES
205		JURASSIC	Subsurface only. Sandstones and shales		
240		TRIASSIC			
290	PALEOZOIC (ANCIENT LIFE)	PERMIAN	Shale, limestone, dolomite, gypsum, anhydrite sandstone, siltstone, chert.	Water, agricultural lime, oil, road rock, riprap.	AMPHIBIANS
330		PENNSYLVANIAN	Limestone, shale, sandstone, coal.	Oil, cement, brick, concrete aggregate, lightweight aggregate, road rock, agricultural lime, rip rap, water.	
360		MISSISSIPPIAN	Subsurface only. Limestone, dolomite.	Oil, water.	FISH
410		DEVONIAN	Subsurface only. Dolomite, gray shale.		
435		SILURIAN	Subsurface only. Dolomite.		INVERTEBRATES
500		ORDOVICIAN	Subsurface only. Dolomite, sandstone, shale.		
570		CAMBRIAN	Subsurface only. Dolomite, sandstone.		
	CRYPTOZOIC (HIDDEN LIFE)	PRECAMBRIAN	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.		?



RESOURCEFUL SCENES FROM PAST AND PRESENT







1. Titanotheres such as *Brontops* roamed western Nebraska during Oligocene time. Titanotheres stood as tall as 6 feet; however, their brains were only as large as a fist.

2. Toadstool Park, Sioux County. Erosion has carved these interesting badland features from a series of bedded sandstones and clays. The resistant sandstones formed the "toadstool" caps and the less resistant clays formed the pedestals. The rocks are of Oligocene age.

3. Oreodonts were perhaps the most abundant mammals ever to have roamed Nebraska. They appeared in Oligocene time and died out in Pliocene time. They resembled modern sheep or pigs and ranged in height from less than a foot to more than 3 feet.

4. Several scenic waterfalls are to be seen in Cherry County. Water cascades over resistant beds of sandstone and siltstone of Tertiary age in a number of tributary valleys of the Niobrara River valley.

5. Opalized wood is found in Miocene rocks of Cherry, Boyd, Keya Paha, and Brown counties. Large logs weighing several tons each have been found. Various kinds of petrified wood are found throughout Nebraska.

6. Fossil horses such as *Hipparion* have been found in Miocene rocks in Cherry, Boyd, Keya Paha, and Brown counties.

7. The "Ionia Volcano" along the Missouri River bluffs in Dixon County is presumed to have resulted from the oxidation of iron sulfides in the Cretaceous-age Carlile Shale, producing sufficient heat to cause condensation of moisture in the air.

8. Meek and Hayden led some of the early geological expeditions in Nebraska. They described and named many fossils and rock units, including the Cretaceous-age Dakota Group for Dakota County, Nebraska.

9. Devil's corkscrews, or "Daemonelices," are casts of burrows of a primitive beaver, *Paleocastor,* that lived in western Nebraska during early Miocene time. Some burrows contain the fossil skeleton of the beaver.

10. Agate Springs National Monument in Sioux County is known throughout the world for its abundant early Miocene fossils. The two best known fossil quarries, Carnegie Hill and University Hill, are in limy sandstones deposited in the channel of an ancient river.

11. *Dinohyus,* a large fossil hog, lived in Nebraska during early Miocene time. The largest known specimen was collected in Sioux County, Nebraska.

12. The world's largest fossil camel, *Gigantocamelus,* has been collected from Pliocene rocks near Lisco in Garden County.

13. Potash, an essential component of many explosives and fireworks, was produced from briny Sand Hills lakes in Garden and Sheridan counties between 1912 and 1921 until discovery of more commercially feasible deposits in other areas.

14. Where bison once teemed over the vast Sand Hills, cattle now graze on the luxuriant grasses stabilizing the dunes and growing in the wet meadows.

15. The geographic center of Nebraska is situated between Merna and Anselmo, Custer County.

16. The mastodont *Eubelodon* roamed Brown County during late Miocene time.

17. Small fossil antelope such as *Cosoryx* were plentiful in Cherry, Rock, and Brown counties during Miocene time.

18. During the last advance of Cretaceous seas, rocks were deposited containing clams such as *Cyrena,* the fossils of which have been collected in Dakota County.

19. The largest dinosaur remains discovered to date in Nebraska consist of a part of a femur of a trachodont (duck-billed dinosaur) found in the Cretaceous-age Dakota Group near Tekamah, Burt County.

20. Scotts Bluff, a prominent erosional feature composed of the Miocene- and Oligocene-age rocks of the Arikaree and White River groups, was a landmark for pioneer travelers on the Mormon and Oregon trails and for Pony Express riders.

21. Chimney Rock, Morrill County, was also a landmark to the westward-moving pioneers. It is an erosional feature composed of Oligocene rocks of the Gering Formation overlying the Brule Formation.

22. The remains of the large fossil beaver, *Castoroides,* have been collected from Pleistocene rocks in Sheridan County.

23. Chalk Mine State Wayside Area is now a favorite picnic spot in Greeley County. Chalk was once mined here from rocks of the Miocene-age Ogallala Group.

24. Fossil leaf imprints are abundant in sandstones and shales in the Cretaceous-age Dakota Group. The presence of many subtropical species indicates that the climate of ancient Nebraska was very different from the climate of our time.

25. The highest point in Nebraska, 5,424 feet above sea level, is in southwestern Kimball County.

26. The deepest hole drilled in Nebraska is in northwestern Kimball County. Drilled in 1979, it is 9,971 feet deep. In addition, some of Nebraska's deepest producing oil wells are located in Kimball County. Petroleum is an important industry in the southern part of Nebraska's Panhandle. Oil and gas are produced from sandstones of Late Cretaceous age and limestones of Early Permian and Middle to Late Pennsylvanian age.

27. The first producing oil well in Nebraska's Panhandle, Mary Egging No. 1 in Cheyenne County, was drilled in 1949.

28. Ash Hollow was the site where the pioneers on the Oregon Trail lowered their covered wagons from the uplands to the North Platte River valley. Archeological excavations show that some of the earliest Indians in the region inhabited this area.

29. A geologically important section of Miocene rocks is exposed at Cedar Point on the south side of Lake McConaughy, Nebraska's largest lake.

30. Remains of the largest known fossil elephant, *Mammuthus (Archidiskodon),* were collected from Pleistocene sediments near Brady in Lincoln County.

31. Fossil Pleistocene land snails are commonly found in loess deposits in most counties in central and eastern Nebraska.

32. Abundant groundwater has made it possible to irrigate much of the fertile soils of Nebraska. Many large, irrigated farms are seen along Interstate 80 in central Nebraska.

33. A plesiosaur collected near Valparaiso in Saunders County has the longest neck of any creature known to have inhabited the earth. The skeleton was collected by members of the Lincoln Gem and Mineral Club, whose work was supervised by personnel of the University of Nebraska State Museum.

34. Todd Valley, a broad terrace-plain feature in Saunders County, marks the course of a late Pleistocene river. It provides geologists with a classic example of the concept of stream piracy.

35. Limestone is an important product in Sarpy, Cass and Washington counties. The many quarries in this area serve as a nucleus of a large agricultural-lime, cement, building-stone, and road-aggregate industry.

36. Some of the "last of the trilobites," such as *Ditomopyge,* crawled over the bottoms of the Pennsylvanian and Permian seas that covered Nebraska.

37. Rhinoceros such as *Aphelops* once roamed much of Nebraska. Their remains are found in Miocene rocks in Frontier and Hayes counties.

38. The world's largest open-pit silica (volcanic ash) mine, now inactive, is in Pleistocene deposits in northeastern Frontier County.

39. The State Capitol in Lincoln is decorated with fine stone from all over the world. The mosaics and tiles should be seen by all lapidary students.

40. Some of the world's finest collections of vertebrate and invertebrate fossils and rocks and minerals are maintained by the University of Nebraska State Museum. The museum is best known for Elephant Hall, which has on display the world's most inclusive collection of fossil elephants.

41. Nebraska's Salt Lake at Lincoln is filled with salt water that has its source in sandstones of the Cretaceous-age Dakota Group. Salt was scraped from natural crusts and brine was evaporated from salt springs. Hopes for a salt-extraction industry led to the original settlement of Lincoln, but the industry never developed beyond its infancy. Nebraska's Salt Lake was once a popular resort known as Burlington Beach, later an amusement park area known as Capitol Beach, and now a housing development of that name.

42. Jules Marcoux, a French explorer, made the first geologic map of North America under the direction of Secretary of Interior Jefferson Davis (later president of the Confederate States of America). Marcoux did much of his better known work describing Pennsylvanian rocks near Nebraska City.

43. Large herds of bison roamed most of Nebraska in Pleistocene time. *Bison* is a common fossil; its remains are sometimes associated with artifacts made by Indians of the Folsom culture.

44. Musk-oxen are now restricted to the polar areas of the world. The presence of the fossil musk ox *Symbos* in Red Willow County tells of the harsh Pleistocene climate in Nebraska.

45. The first significant producing oil well in southwestern Nebraska, Barger No. 1, was drilled in Red Willow County in 1956 and opened this area to some of Nebraska's largest producing oil fields.

46. Saber-tooth tigers were among the large predators to have lived in Frontier and Red Willow counties during the Pleistocene age.

47. The largest recovered meteorite in the world to have been seen falling was collected near Beaver City, Furnas County, on February 18, 1948.

48. Fossils of the Cretaceous clam *Inoceramus* are abundant in exposures of the Niobrara Chalk in Harlan County.

49. A very well-preserved fossil four-tusked mastodont, *Trilophodon,* was collected from Miocene rocks near Red Cloud, Webster County.

50. Ammonites such as *Clioscaphites* swam through the Cretaceous seas of Nebraska. Their fossil shells are found in the Niobrara Chalk in south-central Nebraska.

51. The western boundary of Ice Age glacial deposits passes through eastern Nebraska. These deposits contain igneous and metamorphic rocks that were transported into Nebraska by the glaciers from as far north as Hudson Bay.

52. Some of the last primitive kinds of crinoids lived in the Permian seas of eastern Nebraska. Specimens of *Nebraskacrinus* have been collected near Odell in Gage County.

53. Nebraska's first producing oil well, the Bucholz well, was drilled in Richardson County in 1940. It produced oil from Devonian rocks in sufficient quantity to win the $15,000 bonus offered by the state for the first commercial oil well in Nebraska.

54. The down-dropped rocks along the Humboldt Fault mark the eastern flank of the Nemaha Ridge in southeastern Nebraska. These subsurface features record a period of mountain building in Nebraska's geologic past.

55. The lowest point in Nebraska, 840 feet above sea level, is in Richardson County.

56. Some the world's oldest fossil flowers have been found in shales of the Cretaceous-age Dakota Group in Jefferson County.

57. Numerous articulated skeletons of Miocene rhinoceroses, including babies and pregnant females, have been found at Ash Fall State Park near Royal in Antelope County. This is a world-class discovery of fossil mammal remains.

☆

Stars designate items on display at the University of Nebraska State Museum, Lincoln.

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