

DIVISION OF GEOLOGICAL SURVEY

GUIDEBOOK NO. 3

PENNSYLVANIAN CONODONT LOCALITIES IN NORTHEASTERN OHIO

BY

GLEN K. MERRILL



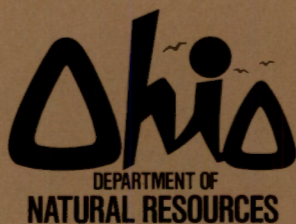
Prepared for annual meeting of the
PANDER SOCIETY
in cooperation with
THE GEOLOGICAL SOCIETY OF AMERICA
NORTH-CENTRAL SECTION
8TH ANNUAL MEETING
KENT, OHIO
MAY 8-11, 1974



STATE OF OHIO
John J. Gilligan, Governor

DEPARTMENT OF NATURAL RESOURCES
William B. Nye, Director

DIVISION OF GEOLOGICAL SURVEY
Horace R. Collins, Chief



SCIENTIFIC AND TECHNICAL STAFF
OF THE
DIVISION OF GEOLOGICAL SURVEY

ADMINISTRATIVE SECTION

Horace R. Collins, MS, *State Geologist and Division Chief*

Jean Simmons Brown, MS, *Geologist and Editor*
William J. Buschman, Jr., BS, *Administrative Geologist*
Merrienne Hackathorn, BS, *Geologist and Assistant Editor*
Michael C. Hansen, MS, *Geologist*
Edwin F. Helsler, BS, *Administrative Assistant*
Madge E. Rodgers, BS, *Geologist*
Pauline Smyth, MS, *Geologist*
Eleanor J. Hyle, *Secretary*
Jacqueline Connolly, *Clerk-Typist*
Donna M. Schrappe, *Clerk-Typist*

REGIONAL GEOLOGY SECTION

Richard A. Struble, PhD, *Geologist and Section Head*
Richard W. Carlton, PhD, *Geologist*
Michael L. Couchot, MS, *Geologist*
Richard M. DeLong, MS, *Geologist*
David S. Fullerton, PhD, *Geologist*
Gerald H. Groenewold, PhD, *Geologist*
Joseph R. Hatch, PhD, *Geochemist*
Donald O. Johnson, PhD, *Geologist*
Jeff L. Reese, BS, *Geologist*
David A. Stith, MS, *Geologist*
Robert G. Van Horn, MS, *Geologist*
Joel D. Vormelker, MS, *Geologist*
Geochemistry laboratory
Donald L. Streib, PhD, *Geochemist in charge*
George Botoman, MS, *Geologist*
Norman F. Knapp, PhD, *Chemist*
E. Lorraine Partlow, *Laboratory Technician*

WATER INVENTORY SECTION

Alfred C. Walker, BS, *Geologist and Section Head*
Herbert B. Eagon, Jr., BS, *Geologist*
Leonard J. Harstine, BS, *Research Associate*
Glenn W. Hartzell, BS, *Geologist*
Anthony R. Rudnick, BS, *Geologist*
James J. Schmidt, BS, *Geologist*
David S. Ziegler, BA, *Geologist*
Lloyd C. Flower, *Technician*
Otha B. Furlough, *Technician*
Donald M. Henry, *Technician*
V. Ruth Haldeman, *Geologist Aide*
Jane Kellermeyer, *Clerk-Typist*

SUBSURFACE GEOLOGY SECTION

Adriaan Janssens, PhD, *Geologist and Section Head*
Michael J. Clifford, MS, *Geologist*
Jeffrey B. Hermann, BS, *Geologist*
Ronald D. Stieglitz, PhD, *Geologist*
James Wooten, *Geologist Aide*
Barbara J. Adams, *Clerk*
B. Margalene Crammer, *Clerk*

LAKE ERIE SECTION

Charles H. Carter, PhD, *Geologist and Section Head*
Donald J. Benson, MS, *Geologist*
Walter R. Lemke, *Boat Captain*
Donald E. Guy, Jr., BA, *Geologist Aide*
Dale L. Liebenthal, *Geologist Aide*
Lynn M. Gerold, *Clerk-Typist*

PUBLICATIONS SECTION

Harold J. Flint, *Cartographer and Section Head*
James A. Brown, *Cartographer*
Donald R. Camburn, *Cartographer*
Philip J. Celnar, BFA, *Cartographer*
James E. Hairston, *Cartographer*
Leslie R. Lewis, BFA, *Cartographer*
Jean J. Miller, *Photocopy Composer*

STATE OF OHIO
John J. Gilligan, Governor
DEPARTMENT OF NATURAL RESOURCES
William B. Nye, Director
DIVISION OF GEOLOGICAL SURVEY
Horace R. Collins, Chief

Guidebook No. 3

**PENNSYLVANIAN CONODONT LOCALITIES
IN NORTHEASTERN OHIO**

by

Glen K. Merrill

Columbus
1974



CONTENTS

	Page
Trip at a glance	1
Geologic setting	1
General	1
Topographic maps	2
Road log	3
Stop 1A - Grindstone Run, Lowellville, Ohio	4
Lowellville Limestone	4
Lower Mercer Limestone	5
Upper Mercer Limestone	5
Stop 1B - quarry at Lowellville Rod and Gun Club	6
Vanport Limestone	6
Stop 2 - in bed of Yellow Creek, Poland, Ohio	6
Lower Mercer Limestone	6
Stop 3 - along old U.S. 30 west of Cannon's Mill	9
Brush Creek Member	9
Stop 4 - along Ohio Rte. 45 west of Round Knob	10
Cambridge Member	10
Stop 5 - along Ohio Rte. 213 at Yellow Creek	11
Washingtonville Shale	11
Stop 6 - road and railroad cuts near Broadacre	13
Ames Limestone	13
Stop 7 - hilltop west of Bowerston	14
Ames Limestone	14
Stop 8 - New Philadelphia roadcut	17
Putnam Hill Limestone	17
Lower Clarion Shale	17
Vanport Limestone and Chert	17
Upper Clarion Shale	18
Occurrences of Pennsylvanian conodonts in eastern Ohio: a brief summary	19
Phylogenetic and biostratigraphic summary	19
<i>Neognathodus</i>	19
<i>Idiognathodus-Streptognathodus</i>	21
<i>Cavusgnathus</i>	22
<i>Anchignathodus</i>	22
" <i>Spathognathodus</i> "	22
Zonation	22
Lithostratigraphic and paleoecologic summary	23
Acknowledgments	24
References cited	24

FIGURES

1. Route map	1
2. Composite columnar section at Stops 1A and 1B	5
3. Columnar section at Stop 5	12
4. Graphic portrayal of conodont data at Stop 8	16
5. Schematic summary of conodont occurrences in Pennsylvanian rocks of eastern Ohio	20

CONTENTS

TABLES

1. Generalized stratigraphic relationships between the various marine beds in the Pennsylvanian of Ohio 21
2. List of taxa with associates and occurrences 23

PLATES

1. Conodonts from the Putnam Hill, Upper Mercer, Lower Mercer, and Lowellville Members Following page 25
2. Conodonts from the Ames, Cambridge, Brush Creek, Washingtonville, and Vanport Members Following page 25

PENNSYLVANIAN CONODONT LOCALITIES IN NORTHEASTERN OHIO

by

Glen K. Merrill

THE TRIP AT A GLANCE

Purpose: To acquaint the participant with the wealth and breadth of Ohio Pennsylvanian rocks and their conodont faunas. More specifically, the goals include examination of a biostratigraphically wide range of faunas distributed under diverse environmental conditions, comprising elements commonly excellently preserved, and permitting multielement reconstructions, and provide the opportunity to collect not only representative, but also unusual and bizarre, conodont faunas, as well as topotypes.

Total mileage: 236.7 miles (This includes return mileage to Kent. Mileage to the final stop is 175.4, and some participants may wish to depart directly from the last stop.)

Duration: 0730-1730 approx.

Number of stops: 8

Age range of localities: middle? Morrowan to late Virgilian

Lunch stop and rallying point: roadside rest at junction of Ohio Rtes. 7 and 213, south of Wellsville, Ohio.

GEOLOGIC SETTING

Pennsylvanian rocks in Ohio are divided into four major lithostratigraphic units, generally classed as groups; in ascending order these are Pottsville, Allegheny, Conemaugh, and Monongahela. These four groups strike northeast-southwest across eastern Ohio and dip southeastward into the Pittsburgh-Parkersburg-Huntington syncline. From the Ohio River at Huntington, West Virginia, northward the strike is more north-south than east-west, but it curves gradually, proceed-

ing northward until in the region around Youngstown, Ohio, it is nearly east-west. As we follow the trip route (fig. 1) we will go generally eastward along the strike of the Pottsville rocks to the first stop in the Youngstown area, then southward across the dip upsection through the Allegheny and Conemaugh to Wellsville, Ohio, then westward initially more or less along the strike, but becoming more across the dip and downsection to the final stop at the base of the Allegheny near New Philadelphia. The first part of the return leg from New Philadelphia to Kent will largely follow the strike of the Allegheny Group, then across the dip of the Pottsville. All dips are on the order of 30 feet per mile.

The dominant influence during deposition of Pennsylvanian rocks in Ohio was a series of prograding deltaic complexes that originated from the south and southeast. These deltas were responsible for the large proportion of terrigenous material in the Pennsylvanian System, and also formed the sites for coal swamp growth. Marine transgressions into the deltaic complexes were relatively few in number, local in extent, and brief in duration. The resulting marine rocks are generally thin and inconspicuous parts of the total succession. Nevertheless, these marine rocks represent a considerable range in marine environments, and range in age of formation nearly throughout the Pennsylvanian Period.

GENERAL

Please assemble in the parking lot southwest of Dix Stadium so that we may leave promptly at 0730. Please share vehicles to the extent practical to conserve gasoline, reduce pollution, and simplify traffic control.

TOPOGRAPHIC MAPS

The route of the field trip may be followed on the Cleveland and Canton 1:250,000 topographic maps published by the U.S. Geological Survey and on the following 7½-minute quadrangles:

- | | | |
|----------------------------|-------------------------|---------------------------|
| Kent | East Liverpool North | Uhrichsville |
| Ravenna | West Point (STOPS 3, 4) | New Philadelphia (STOP 8) |
| Atwater | Wellsville (STOP 5) | Dover |
| Deerfield | Knoxville | Strasburg |
| Lake Milton | Richmond | Bolivar |
| Canfield | Smithfield (STOP 6) | Canton West |
| Youngstown | Cadiz | North Canton |
| Campbell (STOPS 1A, 1B, 2) | Jewett | Akron West |
| New Middletown | Scio | Akron East |
| East Palestine | Bowerston (STOP 7) | Suffield |

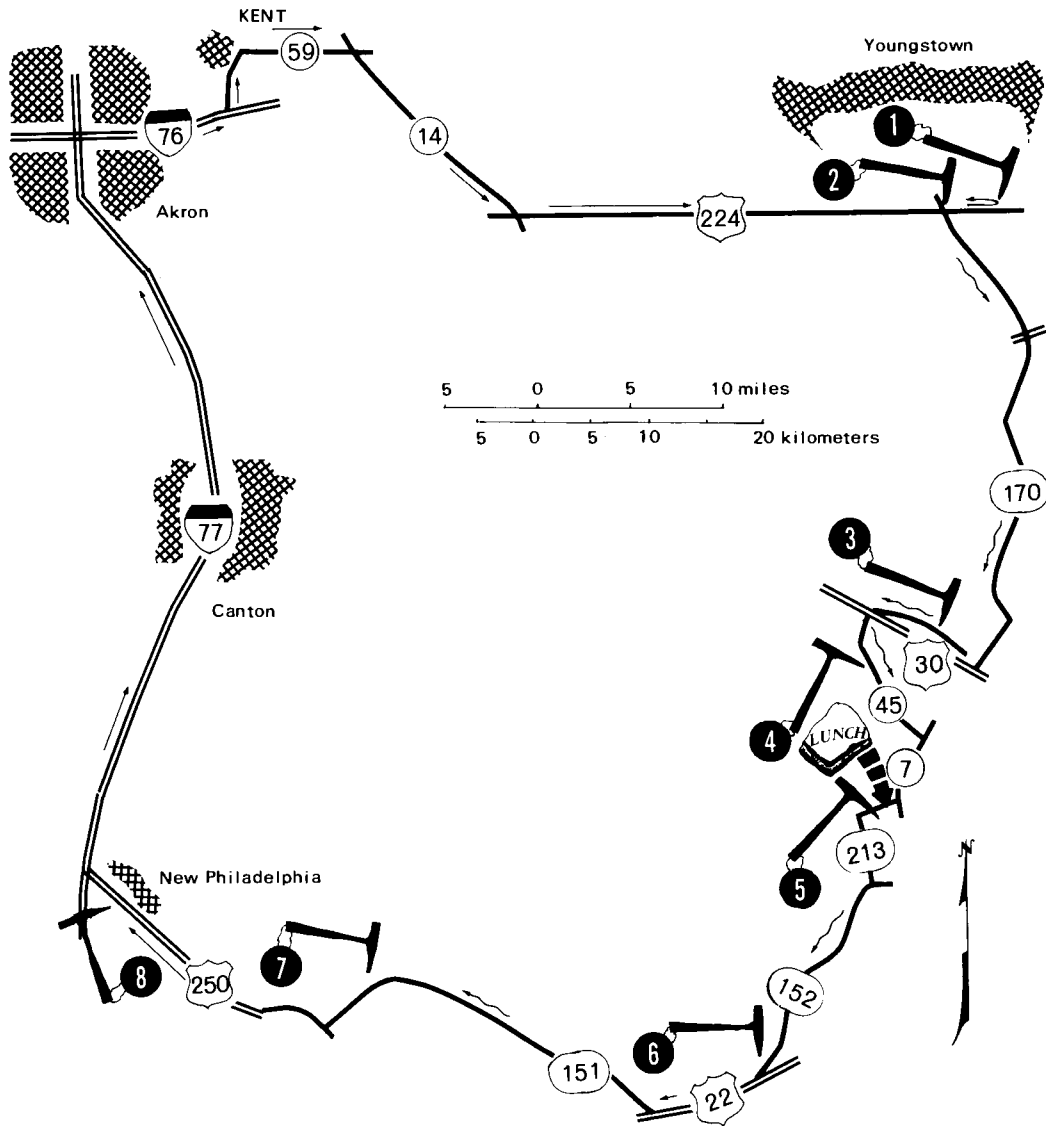


FIGURE 1.—Route map.

ROAD LOG

	<i>Mileage</i>		
Kent quadrangle	0.0	0.0	Depart southwest parking lot Dix Stadium at 0730. <i>Turn right</i> (west) on Summit Rd.
	0.2	0.2	<i>Turn right</i> (north) on Ohio Rte. 261.
	1.4	1.2	<i>Turn right</i> (east) on Ohio Rte. 59.
	3.6	2.2	Railroad overpass in Black Horse.
	4.3	0.7	Enter Ravenna. Straight ahead.
Ravenna quadrangle	6.0	1.7	Cross Ohio Rte. 88. Straight ahead.
	6.7	0.7	<i>Turn right</i> (southeast) on Ohio Rte. 14.
Atwater quadrangle	11.5	4.8	Pass under Interstate 80S (76).
	12.1	0.6	Pass through Edinburg. Southeastward from Kent we are traveling essentially across the strike of the Pottsville rocks. At Deerfield we will turn and drive nearly parallel to their strike. Exposures generally remain poor and scarce because of glacial cover.
Deerfield quadrangle	19.3	7.2	Traffic circle in Deerfield. Proceed around circle, exit on U.S. 224 (east).
	21.8	2.5	Enter Mahoning County.
Lake Milton quadrangle	22.7	0.9	One mile south of here along Mill Creek there are excellent exposures of both Upper Mercer (loc. 14) and Lower Mercer (loc. 25). Both have moderately good conodont faunas, but with lower frequencies than at localities we will visit later.
	24.7	2.0	Berlin Center. Cross Ohio Rte. 534. Straight ahead.
Canfield quadrangle	29.4	4.7	Ellsworth. Cross Ohio Rte. 45. Straight ahead. Good outcrops of Lower Mercer with a fine conodont fauna occur under the Ohio Rte. 45 bridge over West Branch Meander Creek, 0.75 mile south of this intersection (loc. 26).
	33.3	3.9	Canfield.
	34.4	1.1	Cross U.S. 62. Straight ahead.
Youngstown quadrangle	35.4	1.0	Overpass over Ohio Rte. 11.
	36.3	0.9	Overpass over Interstate 76.
	39.4	3.1	Cross Ohio Rte. 7 in Boardman. Straight ahead.

40.9	1.5	Cross Ohio Rte. 164. Straight ahead.
Campbell quadrangle		
41.9	1.0	Cross Ohio Rte. 170 in Poland. Straight ahead.
41.9	0.0	Cross Ohio Rte. 616 a few feet beyond. Straight ahead.
45.3	3.4	<i>Turn left</i> (north) on Quarry Rd.
46.0	0.7	<i>Turn right</i> (east). Descend <i>steep</i> hill road into Lowellville. We are entering the Mahoning valley, famous for its iron and steel production. Youngstown, together with such smaller nearby towns as Lowellville, once made the Mahoning valley one of the world's leading producers of iron and steel. The area is still important, but, unlike the early days when local Pennsylvanian iron ores were used, the ore is now imported. The Allegheny coals still provide much of the coke, however, and the Vanport Limestone ¹ is extensively quarried for flux stone as well as for cement-making, road metal, aglime, and other purposes. Northwest of here the Cuyahoga River achieved ecologic infamy by being declared a fire hazard. The Mahoning's environmental notoriety is that it is nearly hot enough to ignite the Cuyahoga. Used nearly <i>in toto</i> for coolant in the steel mills, the Mahoning River remains several degrees hotter than its tributaries throughout the year.
46.4	0.4	<i>Turn left</i> (west) on Jackson St.
46.5	0.1	STOP 1A. Park on large gravelled former steel mill site.

STOP 1A—GRINDSTONE RUN, LOWELLVILLE, OHIO

This is the most strenuous locality on the trip. We will walk half a mile uphill along the stream. The route has high gradient, irregular footing, moderately heavy brush, and a steep climb out at the end. Those with physical disabilities should consider not walking the stream. After exiting the valley we will ferry drivers back to the parking place to bring vehicles up to meet us at the head of the run. Stop 1B is 0.3 mile away. Some may prefer to walk along the road to the quarry. We will try to spend no more than one hour at this pair of stops.

Units will be discussed in the order they will be encountered, lowest first (fig. 2).

LOWELLVILLE LIMESTONE

Age: middle? Morrowan

Zone²: *Gnathodus noduliferus*

¹Stratigraphic terminology and capitalization in this guidebook do not in all cases agree with usage of the Ohio Division of Geological Survey.

²Zonation scheme is that proposed by Merrill (in Lane and others, 1971; 1972). All conodont frequencies listed herein are rounded estimates based on previous sampling.

Conodont frequency²: 25/kg

Preservation: fair to good

Biofacies: *Idioprioniodus*

Significant taxa: *Gnathodus noduliferus*, *Idiognathoides corrugatus*, *Idiognathodus cf. delicatus*

Locality data: along Grindstone Run at southwest corner of Lowellville (type section), Poland Tp., Mahoning Co., Ohio. 41°02'20" N., 80°33'03" W. (center of locality). Merrill's Lowellville loc. 1.

Discussion: No older Pennsylvanian conodonts are known from Ohio than these, although faunas of similar age are found in east-central and southeastern Ohio. Still older Pennsylvanian faunas may be represented in collections from Kentucky, West Virginia, and Alabama. There are discrepancies among published ranges and mutual occurrences of Lower Pennsylvanian conodonts in various regions, but the Lowellville fauna seems to belong with those described as Morrowan by Lane (1967) and others. A relatively large sample is recommended for adequate representation of the fauna.

Make a loop through the parking area onto McGaffney St.

- 46.6 0.1 *Turn right* (south) on Washington St.
- 47.1 0.5 Pick up passengers, *bear left* (south) on Quarry Rd.
- 47.4 0.3 *Turn left* (south) into Lowellville Rod and Gun Club. Park behind building. Walk 0.1 mile to outcrop.

STOP 1B—QUARRY AT LOWELLVILLE
ROD AND GUN CLUB

VANPORT LIMESTONE

Age: early Desmoinesian
 Zone: *Neognathodus medexultimus*
 Conodont frequency: 20-175, average 50/kg
 Preservation: excellent to exquisite
 Biofacies: mixed *Idioprioniodus*—*Aethotaxis*
 Significant taxa: *Neognathodus medexultimus*
 (type locality), "*Spathognathodus*" *coloradoensis*, *Aethotaxis* sp.
 Locality data: abandoned quarry owned by Lowellville Rod and Gun Club, 1 mile south of Lowellville, Poland Tp., Mahoning County, Ohio. 41°02'18" N., 80°33'03" W. Merrill's Vanport loc. 36

Discussion: The thick pure Vanport limestones in this area are a pleasure to work for conodonts. The limestones dissolve readily, leaving a small residue with good frequencies and striking preservation of specimens. This locality has been sampled twice, the first time in two-foot, the second time in one-foot increments. Exact topotypes of *Neognathodus medexultimus* can be obtained 4 to 6 feet below the top of the limestone, and figured specimens (pl. 2, figs. 38, 39) of "*Spathognathodus*" *coloradoensis* were derived 6 to 8 feet below the top. Both are common virtually throughout the outcrop, and the faunas are quite homogeneous, although frequencies and preservation are perhaps best in the upper half of the section.

- 47.5 0.1 Exit, *turn left* (southwest) on Quarry Rd.
- 48.0 0.5 *Turn right* (west) on U.S. 224, return to Poland.
- 51.0 3.0 *Turn right* (north) at traffic light on Riverside Dr.
- 51.2 0.2 *Turn left* (west), following Riverside Dr. Road circles left (west) around cemetery and crosses Yellow Creek.
- 51.4 0.2 *Turn right* (north) on Water St. (Ohio Rte. 616).
- 51.5 0.1 Park carefully along guard rail.

STOP 2—IN BED OF YELLOW CREEK,
POLAND, OHIO

The two benches of the Lower Mercer Limestone here form small waterfalls. There are some differences in the conodont faunas of the benches.

LOWER MERCER LIMESTONE

Age: middle Atokan
 Zone: *Neognathodus bassleri bassleri*
 Conodont frequency: 130/kg (upper); 500/kg (lower)
 Preservation: excellent in both benches

Biofacies: dominantly *Aethotaxis* (upper); mixed *Idioprioniodus*—*Aethotaxis* (lower)
 Significant taxa: "*Spathognathodus*" *orphanus*, "*S.*" *coloradoensis* (upper bench only); same taxa found in the Lower Mercer Limestone at Stop 1 (both benches)
 Locality data: in bed of Yellow Creek at north edge of Poland, Poland Tp., Mahoning Co., Ohio. 41°01'42" N., 80°31'27" W. Merrill's Lower Mercer loc. 27

Discussion: Despite the more abundant fauna of the lower bench the two *spathognathodids* were not found there, but are restricted to the upper bench. This is the only Lower Mercer locality that contains the

two species. Some of the "S." *coloradoensis* specimens have radiating nodes on the cup, unusual for this species. One specimen of this species is known from the Boggs Member (intermediate in age between the Lowellville and the Lower Mercer); all other known Pottsville specimens of "S." *coloradoensis* are from the upper bench at this locality. This is one

of the (now) three localities producing "S." *orphanus*; the other two, including the type locality, are in the Seville Limestone of northwestern Illinois. Recent collections from the Boggs Member have made "S." *orphanus* less of an orphan than previously. Its ancestor in the Boggs strongly suggests that this lineage is a branch of the *coloradoensis*-group phylogeny.

Continue north on Ohio Rte. 616 (Water St.).

51.7 0.2 Turn left (west) on Hill Dr., which loops back to Ohio Rte. 616.

51.9 0.2 Turn right (southwest) on Ohio Rte. 616.

52.3 0.4 Cross U.S. 224, then immediately turn left (southeast) on Ohio Rte. 170 (Main St.). We will follow Ohio Rte. 170 for the next 29.5 miles.

New Middletown quadrangle

55.1 2.8 Boundary of Connecticut Western Reserve and Congress Lands, in which townships are (mostly) sectionalized.

55.5 0.4 Radio towers in the middle distance on the right are on a well-reclaimed Columbiana (middle Desmoinesian) strip mine site (Merrill's Columbiana loc. 21, conodont frequencies of 200-300/kg). Three miles farther west (NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 1, Beaver Tp.) was the best Columbiana locality (loc. 20) studied to date, with excellent preservation and frequencies up to 3,000/kg. When sampled in 1965 this site was an active strip pit, 70 feet deep, covering most of sec. 1 and, in addition to its conodonts, had a superb invertebrate (mostly gastropod) fauna. When bulk sampling was attempted in the summer of 1966, the pit was found to be filled, leveled, and growing a crop of wheat. Reclamation is a two-edged sword!

55.6 0.1 Unreclaimed strip pit on the left on the coal beneath the Columbiana Member. In addition to being eyesores inactive unreclaimed strip mines are little better for preserving the marine beds above the coal than mines that are backfilled because of slumping and/or water fill. No outcrop is eternal, but those of Pennsylvanian marine shales produced in strip mines in glaciated terrain are especially ephemeral; not even float remains on the spoil banks. Regrettably, no Columbiana locality for which conodont data are available and that is near our route remains accessible; the Columbiana is the one major marine unit in the area traversed today that will not be examined.

57.3 1.7 New Middletown. Straight ahead on Ohio Rte. 170.

59.0 1.7 Partially reclaimed strip area on the right formerly exposed both Columbiana and Washingtonville Members. Frequencies were low in both (1/kg and 20/kg, respectively). Conodont production from these two uppermost Allegheny marine units ranges from barren to huge and generally is better in the Columbiana.

60.8 1.8 Pass under Interstate 76, enter Petersburg.

- 61.2 0.4 *Turn right* (west), following Ohio Rte. 170.
- 61.3 0.1 *Turn left* (south), following Ohio Rte. 170.
- 61.4 0.1 Township high school on right in Petersburg, with abandoned strip mine behind. An unproductive Columbiana locality.
- 62.1 0.7 Enter Columbiana County.
- East Palestine quadrangle
- 64.7 2.6 Unity. *Turn left* (east) on Ohio Rte. 170 with Ohio Rtes. 14 and 165.
- 65.5 0.8 *Turn right* (south) on Ohio Rtes. 165 and 170, leaving Ohio Rte. 14.
- 66.6 1.1 Descend hill into East Palestine. Straight ahead on Ohio Rte. 170, leaving Rte. 165. Southward from East Palestine we will continue across unglaciated Pennsylvanian rocks and will notice a spectacular change in topography. Relatively little of the Pennsylvanian in eastern Ohio is north of the glacial boundary, and the flat to gently rolling terrain we have just traversed is more similar to topography in northern Illinois than it is to the majority of the landscape formed on Pennsylvanian rocks in eastern Ohio.
- 68.4 1.8 Descend into valley of Leslie Branch through an exposure of Allegheny sandstones, coal, and underclay. We will follow this picturesque little valley several miles to its mouth.
- 70.9 2.5 Negley. *Turn left* (east), following Ohio Rte. 170.
- 70.9 0.0 Almost immediately *turn right* (south) on Ohio Rte. 170. The valley we are now following is that of the North Fork of Little Beaver Creek. A half mile east of here the Vanport crops out in the bed of the creek beside the Ohio Rte. 154 bridge and includes a black shale with pectens and a conodont frequency of about 200/kg (loc. 34).
- 71.5 0.6 The hilltops on the far left have been stripped for the coal beneath the Columbiana, unproductive in this area also.
- 73.5 2.0 Crest of hill. The topography is developed on lower Conemaugh shales for the next couple of miles.
- East Liverpool North quadrangle
- 76.1 2.6 Descend into valley of Little Beaver Creek. We pass from the rolling Conemaugh upland through a steep-walled valley developed in Allegheny sandstones to the level of the stream, cut in Pottsville sandstones. Relief is high, and within a couple of miles beds from the Upper Mercer through the Brush Creek are exposed. The Upper Mercer crops out (loc. 15, frequency 150/kg) in the bed of Little Beaver Creek 1 mile downstream from Fredericktown.
- 77.3 1.2 Cross Little Beaver Creek in Fredericktown. Pottsville sandstones exposed in the stream bed.

- 80.5 3.2 Enter Calcutta. We have travelled across rolling Conemaugh uplands most of the way from the valley of Little Beaver Creek.
- 80.8 0.3 Turn left (south), following Ohio Rte. 170.
- 80.9 0.1 Turn right (west), following Ohio Rte. 170.
- 81.8 0.9 Turn right (northwest) on westbound entrance ramp of U.S. 30 and Ohio Rte. 11, leaving Ohio Rte. 170.
- 82.6- 0.8 Cuts exposing lower Conemaugh shales and a coal, probably
83.3 at the top of the Allegheny.
- West Point quadrangle
- 84.1 1.5 Above section is repeated.
- 84.3 0.2 Turn right (north) on exit ramp for Ohio Rtes. 7 and 267.
- 84.5 0.2 Turn right (north) on Ohio Rte. 7.
- 84.9 0.4 Turn left (west) on old U.S. 30 (East Liverpool Rd.).
- 85.0 0.1 Park carefully along shoulder.

STOP 3—ALONG OLD U.S. 30 WEST OF
CANNON'S MILL

This is one of the most northerly Brush Creek localities in Ohio. Although increasingly overgrown, the part of the outcrop on the north side of the road is easily sampled and quite productive. The outcrop on the south side differs in some details, but is now mostly covered. Three samples on the north side of the road yielded the following results for a foot of shale above the limestone, the limestone lens, and the foot of shale below the limestone.

BRUSH CREEK MEMBER

Age: early Missourian

Zone: *Streptognathodus cancellus*—*S. opletus*

Conodont frequency: 200/kg (top shale);
2,500/kg (limestone); 90/kg (bottom shale)

Preservation: fair to good, best in the limestone

Biofacies: some *Aethotaxis* and *Idioproniodus*

Significant taxa: *Streptognathodus cancellus*

S. opletus, *Idiogmathodus cf. delicatus*

Locality data: along old U.S. 30, 1½ miles northwest of Cannon's Mill, NE¼SW¼ sec. 13, Madison Tp., Columbiana Co., Ohio. Merrill's (Lower) Brush Creek loc. 44

Discussion: The single Brush Creek Member in northeastern Ohio appears to be older than either the Upper or Lower Brush Creek Members farther south, but localities are numbered within the Lower Brush Creek locality sequence. Southward from this locality the Brush Creek thickens to as much as 25 feet of marine strata and then thins again, concurrently showing evidence of brackish conditions (*estherids*, *Lingula*, reduced diversity of macrofauna), until it becomes nonmarine near Carrollton. Faunas from (Lower) Brush Creek localities record the transition from dominantly cross-ridged platform conodonts (*Idiogmathodus*) to troughed derivatives (*Streptognathodus*). At this locality samples taken from the limestone and laterally equivalent calcareous shales should yield best results.

Continue west on old U.S. 30.

- 86.0 1.0 Strip mines ahead on upper Allegheny coals.
- 86.7 0.7 Brackish black shale (Dorr Run) on the right produced no conodonts.

- 88.7 2.0 Pass under Ohio Rte. 11 overpass. Cuts along Rte. 11 to the left give excellent exposures of upper Allegheny (Washingtonville) through lower Conemaugh (Brush Creek) strata.
- 88.8 0.1 Turn left (southeast) on Ohio Rte. 45.
- 89.6 0.8 Begin long climb from upper Allegheny (coal stripped on the left) through Brush Creek (no longer exposed) to middle Conemaugh Ames Limestone at the top of the hill.
- 90.9 1.3 Top of hill. Ames crops out along both sides of road. This is one of the most northerly outcrops of Ames and is characteristic for the northeastern Ohio region (loc. 79, frequency 1,500/kg).
- 91.3 0.4 Float nodules of Cambridge Limestone on the left.
- 91.9 0.6 Park carefully on the right.

STOP 4—ALONG OHIO RTE. 45 WEST OF
ROUND KNOB

CAMBRIDGE MEMBER

Age: middle Missourian
 Zone: *Streptognathodus excelsus*—*S. gracilis*
 Conodont frequency: 200/kg
 Preservation: fair to good
 Biofacies: some *Aethotaxis*
 Significant taxa: *Streptognathodus excelsus*,
S. gracilis, *S. elegantulus*
 Locality data: along Ohio Rte. 45, 1½ miles
 west of Round Knob, NE¼SE¼ sec. 21,

Madison Tp., Columbiana Co., Ohio.
 Merrill's Cambridge loc. 58

Discussion: The Cambridge is the most difficult major unit in the Pennsylvanian of Ohio for conodont work. Frequencies are generally very low, lithologies not amenable to disaggregation, residues voluminous, and outcrop distribution patchy. This small outcrop is one of the better ones in the state in terms of conodont content. The fauna is dominated by lobate streptognathodids in the same manner as is the somewhat younger Portersville Member in southeastern Ohio.

Proceed southeastward on Ohio Rte. 45.

- 92.1 0.2 Power line visible in extreme distance on the left is near the summit of Round Knob (elev. 1,447 feet), the highest point in eastern Ohio.
- 92.9 0.8 Glasgow.
- 93.8 0.9 Church on right and side road on left with horizon of Cambridge Limestone no longer exposed, near road junction.
- 95.9 2.1 Caution. Begin steep descent into the Ohio River valley from rolling Conemaugh upland.
- Wellsville quadrangle
- 96.5 0.6 Dark brackish shale on the left is Dorr Run equivalent. No conodonts recovered.
- 96.6 0.1 Washingtonville Shale over coal on left (loc. 21, frequency 10/kg).
- 96.8 0.2 Clay mine of the Porter Pottery, mining the clay a few feet below the Columbiana Member. Clays of the Allegheny Group have given Ohio a preeminent position in the American ceramics

industry. The East Liverpool-Wellsville area ranks especially high in this regard, with a diversified range of products from coarse exterior brick through specialized refractories to fine china. The most sought-after clays are those beneath the coals associated with the Putnam Hill and Columbiana marine beds, but several others are employed as well.

- 97.2 0.4 *Turn right* (south) on Ohio Rte. 7 at north edge of Wellsville. At the time this road log is being prepared (September 1973) it is necessary to follow Rte. 7 through downtown Wellsville. By May 1974 the new bypass will probably be open, substantially reducing the log mileage. The lead vehicle will follow the old route downtown so that participants can refuel their vehicles. Those not wishing to refuel can proceed directly to the lunch stop.
- 99.9 2.7 Junction of old and new portions of Ohio Rte. 7. From here to the lunch stop excellent road cuts are eloquent testimony to the futility of expecting widespread lateral continuity for locally named Pennsylvanian lithostratigraphic entities. Between the lunch stop and East Liverpool to the north *en échelon* deltaic sandstones and overbank siltstones effectively subdivide and separate marine zones such as the Washingtonville into several discrete bodies. The Columbiana stratigraphic position is well exposed above the lowest coal in these cuts, but it is represented by nonmarine strata. Cuts between Wellsville and East Liverpool (also on Rte. 7) expose local thin shaly Vanport Limestone and shale (loc. 37, frequency 25/kg) that belong to the *Cavusgnathus* biofacies. The stop immediately after lunch and these cuts along Rte. 7 to Wellsville constitute stops 1 through 3 of Ferm and Cavaroc (1969).
- 100.3 0.4 Enter Jefferson County.
- 101.2 0.9 *Turn right* (south) on Ohio Rte. 213.
- 101.3 0.1 *Turn left* into roadside rest. Lunch stop.
- 101.4 0.1 *Turn left* (southwest) on Ohio Rte. 213.
- 101.8 0.4 Park on gravelled pulloff on the right.

STOP 5—ALONG OHIO RTE. 213 AT
YELLOW CREEK

WASHINGTONVILLE SHALE

Age: late Desmoinesian
 Zone: *Idiogonathodus delicatus*—*Streptogonathodus cancellosus*
 Conodont frequency: 50/kg (above); 125/kg (below)
 Preservation: fair
 Biofacies: some *Aethotaxis*
 Significant taxa: *Idiogonathodus delicatus*,
Streptogonathodus cancellosus, rare neogonathodids

Locality data: along Ohio Rte. 213 south of Yellow Creek, ¼ mile above its mouth, SE¼NW¼ sec. 7, Saline Tp., Jefferson Co., Ohio (fig. 3). Merrill's Washingtonville loc. 19

Discussion: Collecting conodonts from the Washingtonville Shale is an uncertain matter. Some samples are reasonably productive; essentially identical ones from nearby sites are barren. For this reason it is suggested that at least two samples be taken here, one near the base and another from the upper pecten-bearing beds. As the youngest widespread Allegheny marine unit, the Washingtonville shows similari-

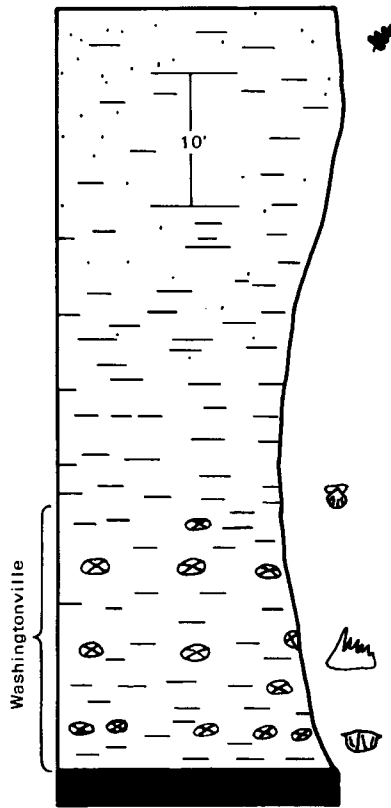


FIGURE 3.—Columnar section at Stop 5.

ties in its conodont fauna to both older Allegheny and younger Conemaugh faunas. Like the Allegheny faunas the dominant platform is *Idiognathodus*; neognathodids (mostly *N. dilatus*) are present, although quite rare. The Washingtonville shares with the Brush Creek the distinction of having a large proportion of the transitional forms between *Idiognathodus* and *Streptognathodus* (*S. cancellosus*).

We are parked almost precisely on the old Linton townsite. The Black Diamond Mine very near this location became famous in the last century for its vertebrate fauna from cannel coal at the base of the coal seam presumably occurring a few feet above the Washingtonville Shale. Coals below both the Washingtonville and Columbiana Members are also locally canneloid in northeastern Ohio, but have thus far yielded no more than a few scraps of vertebrate material. The cannel coal at Linton produced an abundant fish fauna, more than 50 species of stegocephalians, and what was then thought to be the oldest known reptile. The mines were closed before the turn of the century, ending vertebrate collecting.

Continue southwest on Ohio Rte. 213.

- | | | |
|-------|-----|--|
| 103.8 | 2.0 | Cross railroad. Brick works on the left. Begin climb out of valley of Yellow Creek, through Allegheny sandstones to an upland on Conemaugh shales. |
| 104.8 | 1.0 | Cross railroad in Hammondsville. Road bears left, then right. Over the next few miles we will climb through the entire Conemaugh section. |
| 108.0 | 3.2 | Monongahela coals stripped on both sides of the road. |

Knoxville quadrangle

- | | | |
|-------|-----|--|
| 110.1 | 2.1 | <i>Turn right</i> (west) on Ohio Rte. 152. Many strip mines on Monongahela coals are present over the next several miles and some nonmarine limestones can be seen in the strip pits and roadcuts. |
|-------|-----|--|

Richmond quadrangle

- | | | |
|-------|-----|--|
| 116.6 | 6.5 | <i>Turn right</i> (west) on Ohio Rtes. 152 and 43 in Richmond. |
| 116.8 | 0.2 | <i>Turn left</i> (south) on Ohio Rte. 152, leaving Ohio Rte. 43. |
| 118.7 | 1.9 | Cross Ohio Rte. 646. Straight ahead. |
| 121.1 | 2.4 | Descend through upper Conemaugh strata to valley of Cross Creek. |

Smithfield quadrangle

- 121.6 0.5 Ames Limestone on right.
- 122.2 0.6 Broadacre (formerly Skelley Station). Exposures on hill road to the right include the type Skelley Member.
- 122.4 0.2 Cross railroad.
- 122.8 0.4 Ames limestone on left in curve.
- 123.2 0.4 *Turn right* (west) on Ohio Rte. 152 (old U.S. 22).
- 124.5 1.3 *Turn right* (north) on road leading to the seminary, which is within sight of the junction.
- 125.2 0.7 Cross bridge over Cross Creek.
- 125.5 0.3 Park along sides of road. We will turn around here and retrace our route.

STOP 6—ROAD AND RAILROAD CUTS
NEAR BROADACRE

AMES LIMESTONE

Age: late Virgilian

Zone: *Streptognathodus elegantulus*—*S. elongatus*

Conodont frequency: 1,000/kg

Preservation: excellent

Biofacies: *Aethotaxis*—*Anchignathodus*Significant taxa: *Streptognathodus elegantulus*,
Aethotaxis sp., *Anchignathodus ellisoni*Locality data: road and railroad cuts, SW $\frac{1}{4}$
SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 24, Wayne Tp., Jefferson
Co., Ohio. Near Merrill's Ames loc. 82Discussion: This stop is intended to show the normal nature of the Ames Limestone in northern Ohio and its relationship to adjacent strata in this area. At the next stop we will see similar Ames, but with very poor exposure. A little over a mile from here is the type locality of the Skelley Member (NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, Merrill's Ames loc. 82). That section is badly covered now, but in conjunction with this and another nearby (N. cen. SW $\frac{1}{4}$ sec. 13, Salem

Tp.) some insight can be gained about the nature of the Ames-Skelley relationship. Here there is a single thin marine bed (Ames) with abundant macrofossils and excellent collecting (especially of brachiopods weathering free at the top of the bed). North of here in Salem Township the Ames thickens to 10 feet and is split by a shale parting. East of here at Broadacre there are two limestones and an intervening shale, suggesting that the Skelley is merely a split of the Ames.

Although this precise locality has not been sampled previously, the collecting data taken from Broadacre should prove approximately correct. Ames faunas are among the best in both abundance and preservation: frequencies in excess of 5,000/kg have been recorded in northern Ohio. The diversity of these faunas, especially among the platforms, is low, however, and this renders interregional correlation difficult. In addition to the taxa listed, the Ames in this area contains rare specimens of *Cavusgnathus merrilli*, and this stop or the next may provide a specimen or two.

Turn around, returning to Ohio Rte. 152.

- 126.6 1.1 *Turn right* (west) on Ohio Rte. 152.
- 126.7 0.1 *Turn right* (west) on entrance ramp for U.S. 22.
- 126.9 0.2 Cuts for the next three miles expose Monongahela coals and nonmarine limestones, with adjacent strip mines.

- 130.2 3.3 Join Ohio Rte. 151, enter Harrison County. Continue west on U.S. 22 and Ohio Rte. 151.
- Cadiz quadrangle
- 133.4 3.2 Turn right (north), exiting on Ohio Rte. 151, leaving U.S. 22.
- 133.6 0.2 Turn right on Ohio Rte. 151.
- 134.8-135.3 1.2 Old spoil banks from stripping of a Monongahela coal on the right, beautifully terraced with cow tours.
- 138.5 3.7 Junction with Ohio Rte. 9 in Jewett. Straight ahead on Rtes. 151 and 9.
- Jewett quadrangle
- 139.0 0.5 Turn left (south), following Ohio Rtes. 151 and 9.
- 140.0 1.0 Leave Ohio Rte. 9 and follow Ohio Rte. 151 northwest to Scio.
- Scio quadrangle
- 144.1 4.1 Scio. Straight ahead on Ohio Rte. 151.
- 145.6 1.5 Pass Ohio Rte. 332.
- Bowerston quadrangle
- 150.6 5.0 Cross railroad in Bowerston.
- 150.8 0.2 Pass Ohio Rte. 212.
- 152.4 1.6 Turn right (northwest) on Harrison County Rd. 44.
- 152.9 0.5 Park carefully on hilltop. We will turn around after this stop.

STOP 7—HILLTOP WEST OF BOWERSTON

AMES LIMESTONE

Age: late Virgilian

Zone: *Streptognathodus elegantulus*—*S. elongatus*

Conodont frequency: 2,500/kg

Preservation: excellent

Biofacies: *Aethotaxis*—*Anchignathodus*Significant taxa: *Anchignathodus ellisoni*, "*Spathognathodus*" *ohioensis*, *Streptognathodus elegantulus*Locality data: along County Rd. 44 at hilltop cemetery, SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 3, Monroe Tp., Harrison Co., Ohio. Merrill's Ames loc.

76

Discussion: Although this locality is poorly exposed and the amount of limestone exposed is small, even small samples should produce adequate or better collections. In addition to extremely high frequencies, preservation at this locality is excellent and rivals that of the Vanport at Stop 1. Such abundance and preservation are not unique, and many of the Ames localities we have passed today would produce as well or better. The reason for collecting here rather than elsewhere is that topotypes of both *Anchignathodus ellisoni* and "*Spathognathodus*" *ohioensis* may be collected at this site.

- 153.0 0.1 Turn around.
- 153.2 0.2 Sandstone quarry on the right in strata below the middle of the Conemaugh.
- 153.4 0.2 Overpass over railroad cut (formerly a tunnel). Brush Creek

strata are stratigraphically "due" somewhere in this cut, but only nonmarine deltaic deposits are present. We are south of the limit of the northern Brush Creek invasion.

- 153.5 0.1 *Turn right* (south) on Ohio Rte. 151.
- 153.6 0.1 "Cambridge" Conglomerate on right, just above road level. An unusual rock in that many of the "pebbles" appear to be genuine lithiclasts along with intraclasts. This is a beautiful ferruginous rock and either the matrix or the clasts produce a few conodonts (loc. 55, frequency 3/kg).
- 154.3 0.7 Coal on right marks the top of the Allegheny. Our westward route in this area has taken us mostly along the strike of the Conemaugh Group. We are now progressing across the dip and downsection to our last stop at the base of the Allegheny Group.

Uhrichsville quadrangle

- 156.8 2.5 *Turn right* (northwest) on U.S. 250 and 36.
- 157.6 0.8 Enter Tuscarawas County.
- 161.2 3.6 *Turn right* (northwest) on U.S. 250 and 36 in Dennison.
- 161.9 0.7 Big cuts along both sides of road exposing middle Allegheny strata.
- 162.3 0.4 *Turn right* (north), following U.S. 250 and Interstate 77.
- 164.7- 2.4 Cuts in middle Allegheny strata.
165.0

New Philadelphia quadrangle

- 166.6 1.9 Mine dump on the right.
- 166.9 0.3 Strip mine on the right. This and the mine dump just passed are probably on the coal beneath the Columbiana Member.
- 169.1 2.2 Cross Tuscarawas River.
- 171.4 2.3 *Turn right* (north) on exit ramp for Interstate 77 South. The large cut on the left is the section that will constitute our final stop, but for safety reasons we must follow a fairly devious route to reach it.
- 171.6 0.2 *Turn right* (east) on Ohio Rte. 39 (High Ave.).
- 173.3 1.7 Town square. *Turn right* (south) on Ohio Rte. 416 (Broadway).
- 173.9 0.6 Cross Tuscarawas River.
- 174.0 0.1 Pass under U.S. 250.
- 174.1 0.1 *Turn right* (west) on Ohio Rte. 211 (Commercial Ave.).
- 175.4 1.3 Park in turn-around area at the end of Commercial Ave. We will walk about 1,000 feet to the outcrop.

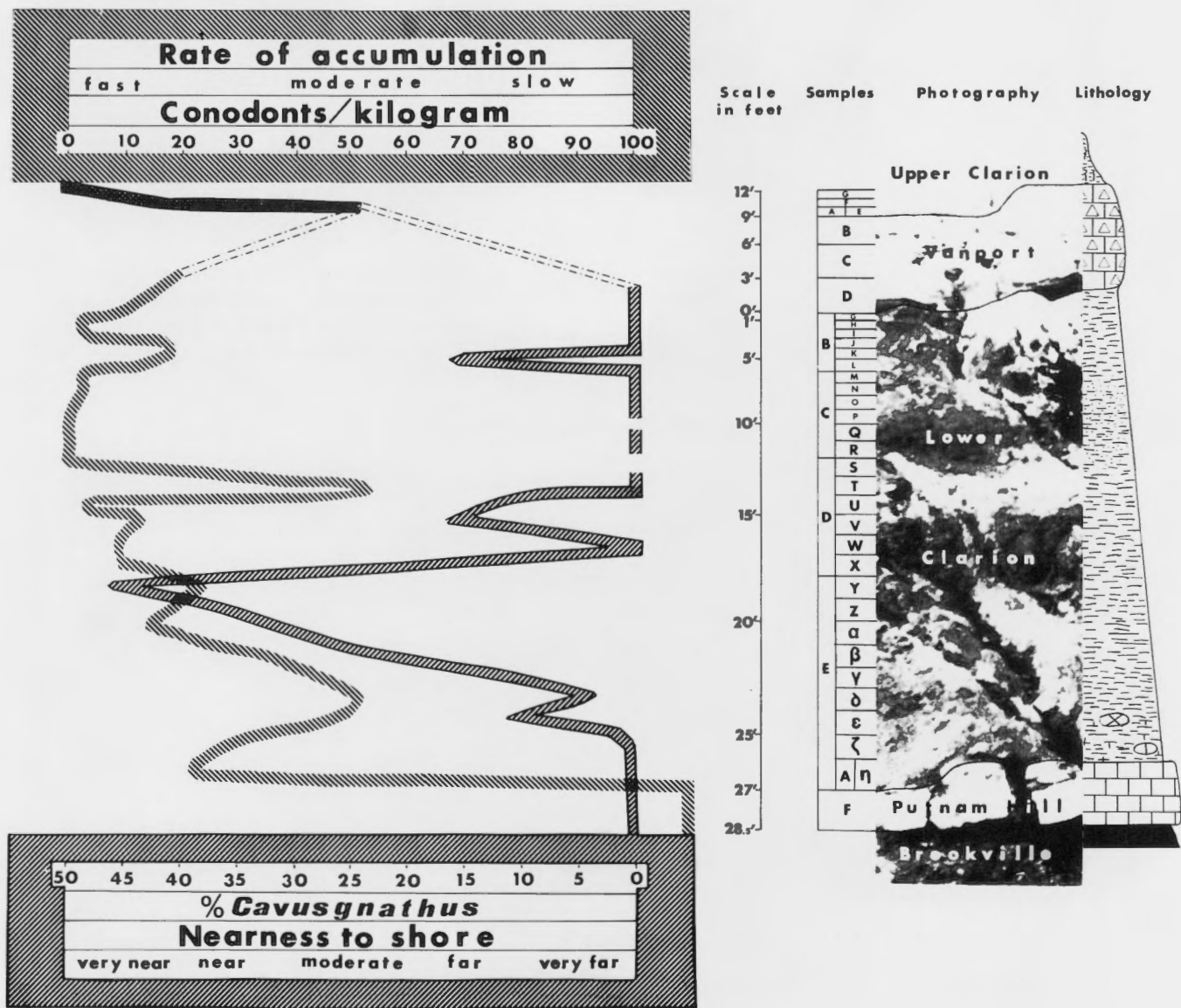


FIGURE 4.—Graphic portrayal of conodont data through a thick succession of marine beds in the U.S. 250 roadcut at New Philadelphia (Stop 8). All Lower Clarion samples are lettered within the Putnam Hill sample sequence and the Upper Clarion samples are lettered within the Vanport sequence. The footage scale is zeroed at the base of the Vanport Member, increasing in value both upward and downward; the apparent compression of this scale and of the one-foot sample increments is produced by the perspective of the photograph to which they are keyed.

Two sets of curves portraying the conodont data occupy the left portion of the diagram. The NW-SE crosshatching in the upper box and the curve below it represent the conodont frequency and the rate of accumulation based thereupon. After the high frequency was developed in the Putnam Hill, it fell off rapidly in succeeding beds, having two major and a couple of minor recoveries thereafter during deposition of the Lower Clarion. The frequency increases in the basal

Vanport Limestone, but most of the Vanport proved to be insoluble chert, consequently producing no conodonts, and these samples are portrayed by broken lines in contrast to two samples at zero frequency (in the Lower Clarion) that did reduce to a residue, but contained no conodonts. The second curve with NE-SW crosshatching and outlined borders illustrates the percentage of *Cavusgnathus* vs. other platform conodonts as a measure of nearness to shore (salinity?). The abundance maximum of *Cavusgnathus* in the Lower Clarion does not coincide with minimum frequency. The environment is inferred to have reached its most brackish state during the deposition of the shale now 9 feet above the base of the Lower Clarion. Worthy of note, however, is the coincidence of the two curves in the basal part of the Upper Clarion, where frequency rapidly decreases as *Cavusgnathus* abundance increases.

Reprinted by permission of the Geological Society of America from Special Paper 141 (1973).

STOP 8—NEW PHILADELPHIA ROADCUT

The illustration (Merrill, 1973b, fig. 4) of this locality is reproduced herein (fig. 4). Forty feet of marine beds are exposed here and will be discussed in ascending order: Putnam Hill, Lower Clarion, Vanport, and basal Upper Clarion.

PUTNAM HILL LIMESTONE

Age: early Desmoinesian
 Zone: *Neognathodus medadultrimus*
 Conodont frequency: 150/kg
 Preservation: good to excellent
 Biofacies: mixed *Idioprioniodus*–*Aethotaxis*
 Significant taxa: *Neognathodus medadultrimus*, related neognathodids
 Locality data: along U.S. 250 just east of junction with Interstate 77 at New Philadelphia, Goshen Tp., Tuscarawas Co., Ohio. 40°29'16" N., 81°28'35" W. Merrill's Putnam Hill loc. 3
 Discussion: With samples of Putnam Hill added to this morning's collections it is possible to trace the important steps in the first half of the *Neognathodus* phylogeny from Lower Mercer through Vanport. Putnam Hill microfaunas from acidized residues commonly include nicely pyritized ostracods, bryozoans, and other invertebrates.

LOWER CLARION SHALE

Age: early Desmoinesian
 Zone: *Neognathodus medadultrimus*–*N. medexultimus*
 Conodont frequency: ranges from 0 to 50+/kg, generally highest in bottom one-fourth, isolated peaks higher
 Preservation: mostly fair
 Biofacies: variable *Cavusgnathus* to *Idiognathodus* with generally too few specimens of either *Idioprioniodus* or *Aethotaxis* for assignment to either biofacies
 Significant taxa: *Cavusgnathus lautus*
 Locality data: as above
 Discussion: The two Clarion shales provide the only good examples of the *Cavusgnathus*

thus biofacies that we will see today. The fluctuations of this taxon through such a thick marine section cannot be duplicated at any known Appalachian Pennsylvanian locality.

VANPORT LIMESTONE AND CHERT

Age: early Desmoinesian
 Zone: *Neognathodus medexultimus*
 Conodont frequency: ?-15/kg
 Preservation: fair
 Biofacies: *Idiognathodus*
 Significant taxa: *Neognathodus medexultimus*
 Locality data: as above. Merrill's Vanport loc. 3
 Discussion: Thickness of the Vanport at this locality ranges from 0 to more than 10 feet. Of three 3-foot samples taken, only the one from the bottom 3 feet dissolved, the others being too siliceous. Too few conodonts were recovered for many conclusions other than that *Idiognathodus* and *Neognathodus* were present and *Cavusgnathus* was not. *Cavusgnathus* is present within the siliceous Vanport Limestone at other localities in the vicinity.

UPPER CLARION SHALE

Age: early Desmoinesian
 Zone: *Neognathodus medexultimus*
 Conodont frequency: up to 50/kg
 Preservation: fair
 Biofacies: *Cavusgnathus*
 Significant taxa: *Cavusgnathus lautus*
 Locality data: as above
 Discussion: When washed this green shale produces a red residue of oxidized siderite roses. Immediately above the Vanport the shales are moderately productive, with a fair proportion of the platforms belonging to *Idiognathodus* rather than to *Cavusgnathus*. A couple of feet higher, the frequency drops to under 10/kg, but *Cavusgnathus* considerably outnumbers *Idiognathodus*. The dark shale over a coal higher in the cut is correlated with the Columbiana Member, but yielded no conodonts here.

Turn vehicles around to retrace our route eastward along Commercial Ave. This stop concludes the formal route of the trip. Participants with destinations south and west will probably wish to return to Interstate 77, leave the trip, and proceed south. Some may wish to return to U.S. 250 and go eastward. The guidebook continues from this point to complete the northward circuit back to Kent.

	176.7	1.3	<i>Turn left</i> (north) on Ohio Rte. 416 (First St.).
	177.5	0.8	Town square. <i>Turn left</i> around square on Ohio Rte. 39 (High Ave.).
	179.2	1.7	<i>Turn right</i> (north) on entrance ramp for Interstate 77 North.
Dover quadrangle			
	180.8	1.6	Strip mine on left working coal under the Columbiana Member. Strip mines in this general vicinity expose all the Allegheny marine beds. In the SE $\frac{1}{4}$ sec. 1, Dover Tp., Putnam Hill (loc. 22, frequency up to 300/kg), Vanport (loc. 31, frequency 2/kg), and Columbiana (loc. 7, frequency up to 250/kg) are exposed. A couple of miles farther north in the SE $\frac{1}{4}$ sec. 19, Dover Tp., the Columbiana is barren, but the Washingtonville (loc. 13, frequency up to 250/kg) is productive.
Strasburg quadrangle			
	184.7	3.9	Old brick works on the right.
	188.4	3.7	Putnam Hill Limestone in cut, thick Pottsville sandstone below.
Dover quadrangle			
	189.3	0.9	Duplication of above section.
Bolivar quadrangle			
	191.3	2.0	Cross Ohio and Erie Canal between Tuscarawas River and Interstate 77.
	193.6	2.3	Enter Stark County, crossing Tuscarawas River.
	193.9	0.3	Upper Mercer Limestone at grade on the left (loc. 12, frequency 8/kg). Putnam Hill Limestone as float blocks on the spoil banks on the right. The Putnam Hill is extensively exposed in strip mines just beyond (loc. 24, frequency 25/kg). This is the type locality for the Tuscarawas Member, a local and to-date unproductive Allegheny marine bed. Vanport and Columbiana are also spasmodically developed nearby, although the Columbiana was not collected here (Vanport loc. 32, frequency 30/kg).
	197.0	3.1	Strip mine on right on coal beneath the Columbiana.
	199.1	2.1	Putnam Hill float on the right.
Canton West quadrangle			
	201.5	2.4	Canton (south) corporation limit. We have returned to glaciated terrain once again.
	205.3	3.8	National Professional Football Hall of Fame on the left.
	206.0	0.7	Pottsville coal on the left.
North Canton quadrangle			
	211.8	5.8	Enter Summit County.
	213.1	1.3	Pottsville sandstone along the road. The Lower Mercer crops out along the old streambed to the right. About 3 miles to

the northeast (S. cen. sec. 21, Lake Tp., Stark Co.,) thick Putnam Hill (loc. 10, frequency up to 110/kg) and Vanport (loc. 5, frequency up to 100/kg) have been quarried. The Putnam Hill contains abundant phylloid algae.

218.3	5.2	Arlington Rd. exit. Continue north on Interstate 77.
Akron East quadrangle		
Akron West quadrangle		
222.9	4.6	Pottsville sandstone on both sides of road.
223.3	0.4	<i>Turn right</i> (east), exiting on Interstate 76 eastbound (Youngstown exit).
224.0	0.7	Pottsville sandstone on right.
229.8	5.8	Enter Portage County.
Suffield quadrangle		
232.6	2.8	<i>Turn right</i> (southeast) on exit for Ohio Rte. 43 for Kent.
232.8	0.2	<i>Turn left</i> (north) on Ohio Rte. 43.
Kent quadrangle		
234.8	2.0	<i>Turn right</i> (east) on Ohio Rte. 261.
236.6	1.8	<i>Turn right</i> (east) on Summit Rd.
236.7	0.1	<i>Turn left</i> into southwest parking lot, Dix Stadium.

OCCURRENCES OF PENNSYLVANIAN CONODONTS IN EASTERN OHIO: A BRIEF SUMMARY

The route followed by the Pander Society's field trip covers about one-third of the area of Pennsylvanian outcrop in eastern Ohio. For this reason many lateral differences and some entire stratigraphic units will not be observed or available for sampling. Nevertheless the region, its rocks, and its conodont faunas are reasonably well represented by stops on the trip. With small adjacent areas in Pennsylvania, West Virginia, and Kentucky, the 15 significant marine members in the Ohio Pennsylvanian have been sampled at about 600 localities since 1955 and have produced more than 100,000 conodonts. This summary is designed to provide some general information as an aid in understanding the complex interactions that took place between time, environments, and conodont organisms and that governed the present distributions of rocks and fossils. For simplicity the summary will begin with evolution of several important conodont lineages and the biostratigraphic conclusions, regional and interregional, drawn from these occurrences of animals through time. Then the interactions between environments and animals and the resulting distribution of lithostratigraphic and paleoecologic units will be discussed. Zonation and paleoecologic relationships are summarized in

figure 5, and plates 1 and 2 illustrate representative conodonts from the units, and commonly the exact localities, to be seen on the trip. Table 1 shows generalized stratigraphic relationships of the marine beds.

PHYLOGENETIC AND BIOSTRATIGRAPHIC SUMMARY

Neognathodus.—Relative to the other best known areas of outcropping Pennsylvanian rocks in eastern North America (Illinois Basin and Kansas-Missouri) the Appalachian Pennsylvanian has more marine units of middle Atokan through middle Desmoinesian age and fewer of late Desmoinesian and younger ages. Consequently the upper Pottsville and lower Allegheny marine beds are especially useful for studying evolutionary developments that occurred among conodonts during the early part of the Middle Pennsylvanian. This is especially true for *Neognathodus*. The oldest species of the genus found in Ohio is *N. bassleri symmetricus* (Lane), recovered from the Boggs Member. This subspecies was derived from *Gnathodus noduliferus* (Straka and Lane, 1970) as found in the Lowellville, although no marine rocks of proper age to show this transition are known in Ohio. A detailed account of the evolutionary simplification from *Neognathodus bassleri bassleri* through *N. bothrops*, *N. medadulimus*, *N. medexultimus*

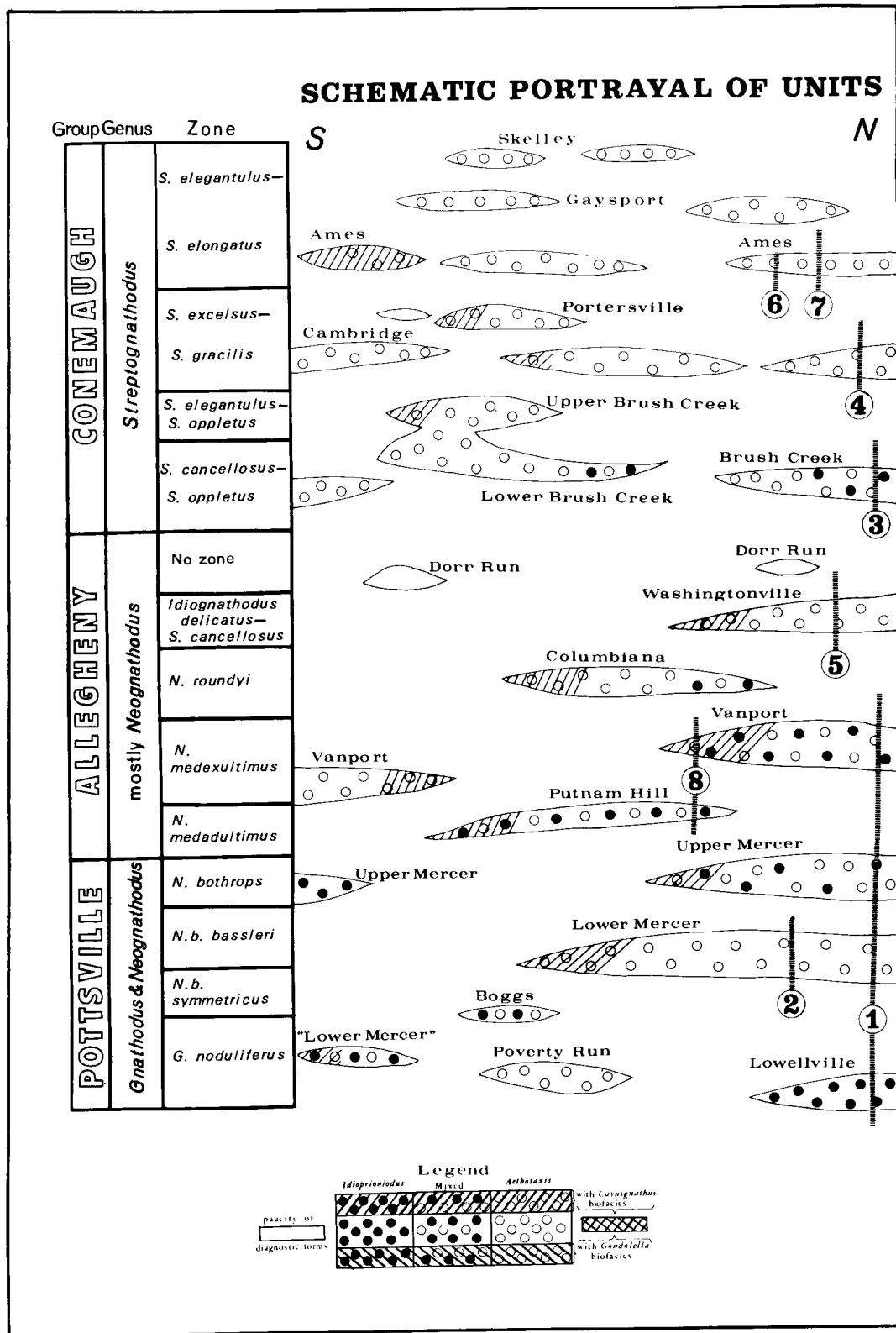


FIGURE 5.—Schematic summary of conodont occurrences in Pennsylvanian rocks of eastern Ohio. This diagram emphasizes the podlike nature of the marine beds, exaggerating both their extent and thicknesses, and places each within the zonal scheme discussed in the text. Symbols character-

ize the biofacies present in each unit; the numbered vertical lines indicate the relative location and the strata seen at the eight stops on the field trip.
 Modified from Merrill (1973b, fig. 7). Reprinted by permission of the Geological Society of America.

TABLE 1.—Generalized stratigraphic relationships between the various marine beds in the Pennsylvanian of Ohio (mostly from Stout, 1944)

Ohio units		Seen at stop(s)	Approximate chronostratigraphic equivalents	
Group	Member		Illinois correlative	Midcontinent correlative
Conemaugh	Skelley <i>interval 20 feet</i>	6,7	?	?
	Gaysport <i>interval 16 feet</i>		?	?
	Ames <i>interval 67 feet</i>		?	Bern
	Portersville <i>interval 25 feet</i>	4	?	Wyandotte
	Cambridge <i>interval 28 feet</i>		La Salle	Iola
	Brush Creek <i>interval 144 feet</i>		Cramer	Swope
			3*	
Allegheny	Washingtonville <i>interval 25 feet</i>	5	Brereton	Myrick Station
	Columbiana <i>interval 22 feet</i>	1,8	Oak Grove	Ardmore
	Vanport <i>interval 53 feet</i>		Seahome	Tiawah
	Putnam Hill <i>interval 46 feet</i>	8	--	--
Pottsville	Upper Mercer <i>interval 32 feet</i>	1	Seville	Seville
	Lower Mercer <i>interval 19 feet</i>	1,2	--	--
	Boggs <i>interval 27 feet</i>	1	--	--
	Lowellville <i>interval 127 feet</i> <i>base of Pennsylvanian</i>		--	--

*There are two Brush Creek members in southern Ohio, averaging 25 feet apart. The correlatives shown are more like the Lower Brush Creek in age, which in turn is considered to be closer in age to the single Brush Creek Member in northern Ohio.

to *N. roundyi* and *N. dilatus* was presented by Merrill (1972b); successively simplified populations can be collected from the Lower Mercer, Upper Mercer, Putnam Hill, and Vanport Members on this trip. The morphologic changes are subtle and gradual between members, but their total is substantial. Columbiana populations are mostly *N. roundyi* and are the last abundant occurrences of the genus in the Appalachians, although a few specimens are present in the Washingtonville. Younger rocks with abundant neognathodids continuing the simplifying trend are known from the Illinois Basin, but have no equivalents in the Appalachians (Merrill, 1972a; in preparation).

Idiognathodus—*Streptognathodus*.—By any criterion this generic plexus is the dominant group of conodonts in Pennsylvanian rocks of the Appalachian region. Every marine unit contains more platform elements of this plexus than of any other kind and commonly more than of all other kinds. Despite this abundance, there are presently severe limitations upon the biostratigraphic usefulness of the group. In addition to overwhelming abundance, morphologic diversity within the

group is immense. Merrill (1968) used with some success a visual clustering technique to make several groups (morphotypes) among Allegheny idiognathodids, but the fact remains that the great biostratigraphic potential of this group remains largely unrealized. Failure to effectively use *Idiognathodus* and *Streptognathodus* for biostratigraphy is due not to any lack of differences and changes in the conodonts, but to our ongoing inability to effectively and realistically evaluate and classify the differences. On one hand single new taxa, based on some morphologic quirk or presumed stratigraphic isolation, continue to be proposed, and on the other, the progress that has been achieved is imperiled by combining "form-taxa" with some biostratigraphic usefulness into "super form-taxa" with none. It is becoming apparent, among other things, that the entire genetic package must be treated simultaneously to make lasting taxonomic and biostratigraphic sense out of the component parts. Until this is done, any addition or revision will probably prove to be ultimately detrimental, however well intended; the least disruptive course of action remains the employment of

the established concepts of form-taxa (in the true meaning of the term) growing out of Ellison's (1941) revision. Such taxa are patently inadequate phylogenetically and philosophically, but they are expedient and have limited biostratigraphic and paleoecologic usefulness.

By such traditional taxonomy all the Pottsville and Allegheny faunas are dominated by *Idiognathodus* cf. *delicatus*. Several other form-species (*I. magnificus*, *I. lobatus*, *I. acutus*, *I. antiquus*) could be and have been recognized (Merrill, 1964) in these faunas up through the lower Conemaugh, but in addition to being genetically meaningless these species have proved to lack any biostratigraphic usefulness as well and are not currently employed. Younger Allegheny (especially Washingtonville) and older Conemaugh (both Brush Creek Members, especially the Lower) contain platforms transitional between cross-ridged and longitudinally troughed conditions. This conforms to the assumed phylogenetic progression from *Idiognathodus* to *Streptognathodus*. This concept, if not fallacious, is now known to be less than completely correct. Nevertheless, Washingtonville faunas have more specimens with more complete transverse ridges and Lower Brush Creek faunas have more specimens with more complete troughs. These units are placed in zones reflecting dominance by *I. delicatus* and *S. cancellosus*, respectively. Upper Brush Creek faunas stand farther from the fully cross-ridged condition and nearer the full deep trough situation found in younger faunas. There is a concurrent reduction in the accessory lobes, corresponding to the morphologic discrimination for *S. oppletus*.

Cambridge and Portersville faunas contain platforms most of which have fully developed longitudinal troughs. A large proportion of these have nodose lobes on one or both sides of the platform and generally conform to the form-species concepts of *Streptognathodus excelsus* and *S. gracilis*. The carinae of these platforms are significantly shorter than those on specimens found in the Brush Creek Members.

All of the Ames and younger platform conodonts have short carinae and generally lack lateral nodose lobes. These are extremely simple forms similar to those found high in the Virgilian Series of Kansas. A few can be compared with *Streptognathodus elongatus*, *S. simulator*, and *S. gracilis*, but overwhelmingly the characteristic form-species is *S. elegantulus*.

Cavusgnathus.—All pre-Missourian (older than Brush Creek) cavusgnathids in the Ohio Pennsylvanian belong to *C. lautus*. Missourian marine units in the Conemaugh contain both *C. lautus* and *C. flexus*, and the Virgilian units (primarily Ames) also contain *C. merrilli*. This last species is rare and had an environmental distribution different from the remainder of the genus (von Bitter, 1972). As a whole, *Cavusgnathus* is not very useful biostratigraphically.

Anchignathodus.—Although exceedingly common,

Anchignathodus has little biostratigraphic usefulness. *Anchignathodus minutus* ranges throughout the Pennsylvanian. It is joined, at least in some Missourian and Virgilian faunas, by the quite similar species, *A. ellisoni*.

"*Spathognathodus*."—As used here, this grouping combines what have been referred to as the *Spathognathodus coloradoensis* group and the *Spathognathodus orphanus* group (Merrill, 1973a). These conodonts belong neither with *Spathognathodus* nor with *Anchignathodus* and will receive a new generic name (in preparation). Although rare and environmentally restricted, these elements are proving to be excellent biostratigraphic indicators, whose use is limited only by their scarcity. "*Spathognathodus*" *orphanus* appears to be a temporally and ecologically restricted offshoot of the main phylogeny, but with its ancestor in the Boggs is potentially an extremely good zone fossil. Appalachian occurrences of "*S.*" *coloradoensis* are almost restricted to the Lower Mercer (at Stop 2), the Putnam Hill, and the Vanport (at Stop 1 and elsewhere). The Vanport occurrences are nearly identical in age to Murray and Chronic's (1965) holotype from the Minturn Formation of Colorado. The Lower Mercer specimens, on the other hand, are considerably older and differ in their overall size and shape as well as possessing a nodose cup in a few specimens. They may prove to be a distinct species. No representatives of this group are known from rocks between the Vanport and the Ames Members. Intermediate forms are known from other areas: Merrill (1973a and in preparation, late Desmoinesian and early Missourian of Illinois and Missouri), Baesemann (1973, Missourian of Kansas), and von Bitter (1972, middle Virgilian of Kansas) described elements of this kind. *Anchignathodus edentulus* of von Bitter appears to be ancestral to "*Spathognathodus*" *ohioensis* from the Ames, the only significant difference between them being the notch developed in the posterior edge of "*S.*" *ohioensis*. If similar notched forms can be found in the Midcontinent, this promises to be one of the better correlation criteria to place the Ames Member in terms of the Midcontinent standard section. Indeed, as additional occurrences of this entire group become known, they seem certain to become one of the best sets of tools for biostratigraphic correlation of Pennsylvanian rocks.

Zonation.—The zonation scheme for the Ohio Pennsylvanian is summarized in figure 5. The 15 significant marine units (plus Dorr Run) are placed in 12 zones based on 2 long-ranging evolutionary sequences. The *Gnathodus*–*Neognathodus* phylogeny is employed for the Columbiana and all older units and *Idiognathodus*–*Streptognathodus* is used to zone the Washingtonville and younger units.

Work in northwestern Illinois (Merrill and King, 1971; Merrill, 1972a and in preparation) and elsewhere has shown that the zonation based on *Neognathodus* is not only applicable in other areas, but may lend

itself to considerable refinement in the future through biometric quantification. Ultimately it should be possible to recognize age differences within a single thin body of marine rock and to produce previously unattained levels of precision in interregional correlations.

Study in other areas requires qualification of the younger zonation. Although the zonation is quite applicable in this region, it is now known that the complex evolutionary trends, especially in *Streptognathodus*, produced recurring morphologies by different means. Furthermore, idiognathodids, rare in the Cambridge and Portersville Members, occur in large numbers in some of their correlatives because of differing environmental conditions. It is becoming evident that a wide range in morphologies in this plexus coexisted and were commonly separated ecologically. A conodont zonation of Missourian and younger rocks that is completely valid and that has interregional significance must await detailed revision of the taxonomy of *Idiognathodus* and *Streptognathodus*. Until then, locally valid faunal zones can be developed for use in regional studies.

LITHOSTRATIGRAPHIC AND PALEO- ECOLOGIC SUMMARY

Details of local Ohio Pennsylvanian lithostratigraphy are available from several sources, the prime one being the various publications of the Ohio Division of Geological Survey. Several county reports provide the most detailed information, but studies encompassing

the entire outcrop of the Conemaugh (Condit, 1912) and Pottsville (Morningstar, 1922) give both detail and broad regional scope. Summary publications on the Allegheny Group by Ferm (1970) and Ferm and Cavaroc (1969), as well as theses and dissertations by Ferm's students (partial list in Ferm, 1970), make this the best understood of the major Pennsylvanian lithostratigraphic units in Ohio. Major conclusions about the Allegheny are applicable, at least in a general way, to the Pottsville and Conemaugh as well.

Pennsylvanian paleogeography in the Appalachians consisted of a relatively narrow shallow roughly east-west-trending seaway or bay with land areas contributing sediments from both north (relatively minor) and south (dominant). The northern area may have been a more important source of sediments than is presently realized, but the northern limit of the preserved rocks is relatively far from the probable northern shoreline.

A series of deltas built northward into this shallow seaway from a relatively broad coastal plain. How many rivers discharged into this body of water is uncertain, but termination of a single thin marine zone laterally in two or more directions against deltaic deposits probably indicates more than a single contemporaneous site of delatation. Lateral changes in the sites of deltaic deposition were produced on a small scale by crevassing and on a larger scale by stream avulsion. Stagnated deltaic lobes compacted, subsided, and were transgressed by marine waters. Individual clastic wedges have a thin veneer of coal and marine beds deposited on their tops. Wedges of similar age are staggered, those of different ages are com-

TABLE 2.—List of taxa with associates and occurrences

Taxon	Faunal associates	Occurrence
<i>Idiognathodus</i>	Almost any other taxon	Offshore; in the Appalachians there seems to have been no difference other than time
<i>Streptognathodus</i>	As above	
<i>Neognathodus</i>	Occurs rarely without the above	Normally like the ones above
<i>Cavusgnathus</i>	<i>Delotaxis sensu</i> von Bitter, 1972	Mostly shales, probably brackish
<i>Idioproniodus</i>	Almost any	Restricted environments, more common in older rocks, MIXES WITH BELOW
<i>Aethotaxis</i>	Almost any	Open environments, more common in younger rocks, MIXES WITH ABOVE
<i>Anchignathodus</i>	Usually with <i>Aethotaxis</i>	As for <i>Aethotaxis</i>
" <i>Spathognathodus</i> "		Restricted, but very difficult to categorize because of its rarity
<i>Gondolella</i>	Almost invariably with <i>Idioproniodus</i>	Absent from Appalachians, low pH environments

monly superimposed, producing vertically repeated duplications of a characteristic package of rocks. Marine rocks were deposited upon one lobe (stagnated) and beside or between others (prograding). Sites of marine deposition in the Appalachians were controlled directly by the locations of deltaic deposition, both defunct and viable, and included a wide range of environments. Fissile black shales, quite common in the Illinois Basin and Midcontinent, are relatively rare in the Appalachians, and limestones commonly directly overlie coal seams. Most types of marine limestone are represented in one or another Appalachian unit. Similarly, most biotic constituents found in other Pennsylvanian areas are present in the Appalachians as well.

Because of their mode of origin and the shape and extent of the present outcrop, no marine unit is contiguous throughout eastern Ohio. For the stratigraphic column as a whole, a maximum number of marine beds is present somewhat south of the trip route (Muskingum County). Northeastern Ohio has a larger number of marine beds in the lower part of the section (Pottsville-Allegheny) and more Conemaugh marine beds are present farther south (schematically shown in fig. 5). Minor interruptions exist in the marine character of the beds (notably the Columbiana and Washingtonville in this area), probably as a result of simultaneous deposition in adjacent interdistributary bays.

It is well to note that, without widespread unconformities and in spite of the overwhelming dominance of terrigenous sediments, many of them coarse, the Pennsylvanian section in the Appalachians had an overall slower rate of accumulation than the section deposited in the more carbonate environments in the Midcontinent.

Conodont biofacies.—Advances in our knowledge about the distribution and, in some instances, the probable causes of environmentally controlled faunas of Pennsylvanian conodonts are progressing quite rapidly. Any detailed explanation is beyond the scope of this summary, and the list of taxa and conclusions shown in table 2 is only a partial update of previous work (Merrill, 1973b) already badly out of date.

Figure 5 summarizes also the conodont occurrences of the more common biofacies for the named units examined on this trip. The figure is, of course, highly generalized.

ACKNOWLEDGMENTS

Work with Pennsylvanian conodonts was begun while I was an undergraduate student at Ohio University, and Dr. Myron T. Sturgeon of that institution deserves thanks for his encouragement and support. The Conemaugh conodonts formed the basis for a master's thesis at the University of Texas under Dr. Samuel P. Ellison, and the Allegheny conodonts were studied in a doctoral dissertation at Louisiana State University under Dr. John C. Ferm. These gentlemen have my sincere thanks.

Several property owners have given us access to their property and thus have contributed significantly to the success of the trip. I would like to thank Mr. Joseph Gennaro, Jr., Gennaro Pavers, Hillsville, Pennsylvania (Grindstone Run), the Lowellville Rod and Gun Club, and the Ohio Highway Department (access to the U.S. 250 cut at Stop 8).

Special thanks are due my wife, Stina, for her long-suffering patience during the preparation of this and other works.

REFERENCES CITED

- Baesemann, J. F., 1973, Missourian (Upper Pennsylvanian) conodonts of northeastern Kansas: *Jour. Paleontology*, v. 47, p. 689-710, 3 pls.
- Condit, D. D., 1912, Conemaugh formation in Ohio: *Ohio Geol. Survey Bull.* 17, 363 p., 12 pls.
- Ellison, S. P., Jr., 1941, Revision of the Pennsylvanian conodonts: *Jour. Paleontology*, v. 15, p. 107-143, pls. 20-23.
- Ferm, J. C., 1970, Allegheny deltaic deposits, in Morgan, J. P. (ed.), *Deltaic sedimentation modern and ancient*: Soc. Econ. Paleontologists and Mineralogists Spec. Pub. 15, p. 246-255.
- Ferm, J. C., and Cavaroc, V. V., Jr., 1969, A field guide to Allegheny deltaic deposits in the upper Ohio Valley: *Pittsburgh Geol. Soc. and Ohio Geol. Soc. Guidebook [Spring 1969 Excursion]*.
- Lane, H. R., 1967, Uppermost Mississippian and Lower Pennsylvanian conodonts from the type Morrowan region, Arkansas: *Jour. Paleontology*, v. 41, p. 920-942, pls. 119-123.
- Lane, H. R., Merrill, G. K., Straka, J. J., II, and Webster, G. D., 1971, North American Pennsylvanian conodont biostratigraphy, in Sweet, W. C., and Bergström, S. M. (eds.), *Symposium on conodont biostratigraphy*: *Geol. Soc. America Mem.* 127, p. 407-412.
- Merrill, G. K., 1964, Zonation of platform conodont genera in Conemaugh strata of Ohio and vicinity: *Univ. Texas, Austin, M.A. thesis (unpub.)*, 175 p., 7 pls.
- _____, 1968, Allegheny (Pennsylvanian) conodonts: *Louisiana State Univ., Baton Rouge, Ph.D. dissert. (unpub.)*, 184 p., 13 pls.
- _____, 1969, Pottsville (Pennsylvanian) platform conodonts from Ohio (abs.): *Geol. Soc. America Proc.* 1969, p. 149.
- _____, 1972a, Platform conodonts from Pennsylvanian rocks in northwestern Illinois (abs.): *Geol. Soc. America Abs. with Programs* 1972, p. 337-338.
- _____, 1972b, Taxonomy, phylogeny, and biostratigraphy of *Neognathodus* in Appalachian Pennsylvanian rocks: *Jour. Paleontology*, v. 46, p. 817-829, 2 pls.
- _____, 1973a, Pennsylvanian nonplatform conodont genera, I: *Spathognathodus*: *Jour. Paleontology*, v. 47, p. 289-314, 3 pls.
- _____, 1973b, Pennsylvanian conodont paleoecology, in

- Rhodes, F. H. T. (ed.), Conodont paleozoology: Geol. Soc. America, Spec. Paper 141, p. 239-274.
- Merrill, G. K., and King, C. W., 1971, Platform conodonts from the lowest Pennsylvanian rocks of northwestern Illinois: *Jour. Paleontology*, v. 45, p. 645-664, pls. 75, 76.
- Morningstar, Helen, 1922, Pottsville fauna of Ohio: *Ohio Geol. Survey Bull.* 25, 312 p., 16 pls.
- Murray, F. N., and Chronic, John, 1965, Pennsylvanian conodonts and other fossils from insoluble residues of the Minturn Formation (Desmoinesian), Colorado: *Jour. Paleontology*, v. 39, p. 594-610, pls. 71-73.
- Stout, Wilbur, 1944, Generalized geologic section of rocks in Ohio: *Ohio Geol. Survey Inf. Circ.* 4, chart.
- Straka, J. J., II, and Lane, H. R., 1970, Evolution of some Lower Pennsylvanian conodont species: *Lethaia*, v. 3, p. 41-49.
- von Bitter, P. H., 1972, Environmental control of conodont distribution in the Shawnee Group (Upper Pennsylvanian) of eastern Kansas: *Univ. Kansas Paleont. Contr.*, Art. 59, 105 p., 16 pls.

PLATE 1

(all figures $\times 40$)

Phylogenetically related specimens are inclosed in broken lines. Figures 1-9 are from the Putnam Hill Member, 10-18 from the Upper Mercer Member, 19-27 from the Lower Mercer Member, and 28-35 from the Lowellville Member. Figures 1-5 are from Putnam Hill locs. 19, 6, 11, 27, and 22, respectively, of Merrill (1972b); figures 6 and 7 are from Stop 8; figures 13, 17, and 18 are from Upper Mercer loc. 6 of Merrill (1972b); figures 19 and 20 are from Lower Mercer loc. 9 of Merrill (1972b); figures 21-27 are from Stop 2; and figures 28-35 are from Stop 1. Other localities for figures include, 8:SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 1, Springfield Tp., Muskingum Co.; 9:NE $\frac{1}{4}$ sec. 5, Salt Lick Tp., Perry Co.; 10, 15:38°37'03" N, 82°47'00" W, Scioto Co.; 11:NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 2, Pike Tp., Stark Co.; 12:NW $\frac{1}{4}$ sec. 30, Bethlehem Tp., Stark Co.; 14:40°04'16" N, 81°58'40" W, Muskingum Co.; 16:41°00'28" N, 80°59'08" W, Mahoning Co.

Figure 1.—*Neognathodus medexultimus* Merrill, oral view.

2-4, 10.—*Neognathodus medadultimus* Merrill, oral views; 10 transitional with below.

5, 11, 12.—*Neognathodus bothrops* Merrill, oral views.

6, 13.—*Idiognathodus claviformis* Gunnell, oral views.

7, 14-18, 21, 22, 30-32.—*Idiognathodus* cf. *delicatus* Gunnell, oral views.

8, 9.—*Cavusgnathus lautus* Gunnell, oral views of symmetry pair.

19, 20.—*Neognathodus bassleri bassleri* (Harris & Hollingsworth), oral views.

23, 24.—"*Spathognathodus*" *coloradoensis* Murray & Chronic, oral and lateral views.

25-27.—"*Spathognathodus*" *orphanus* Merrill, oral and two lateral views.

28, 29.—*Gnathodus noduliferus* (Ellison & Graves), oral views.

33-35.—*Idiognathoides corrugatus* (Harris & Hollingsworth), oral views of sinistral, dextral, and sinistral elements of symmetry pair.

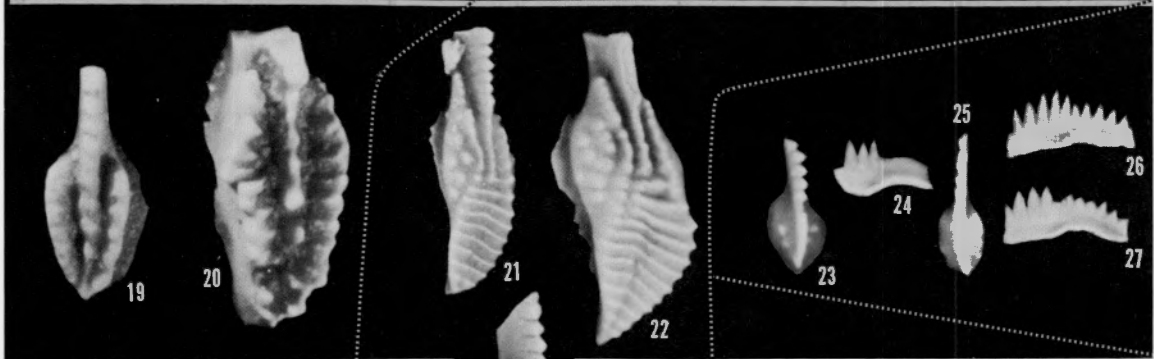
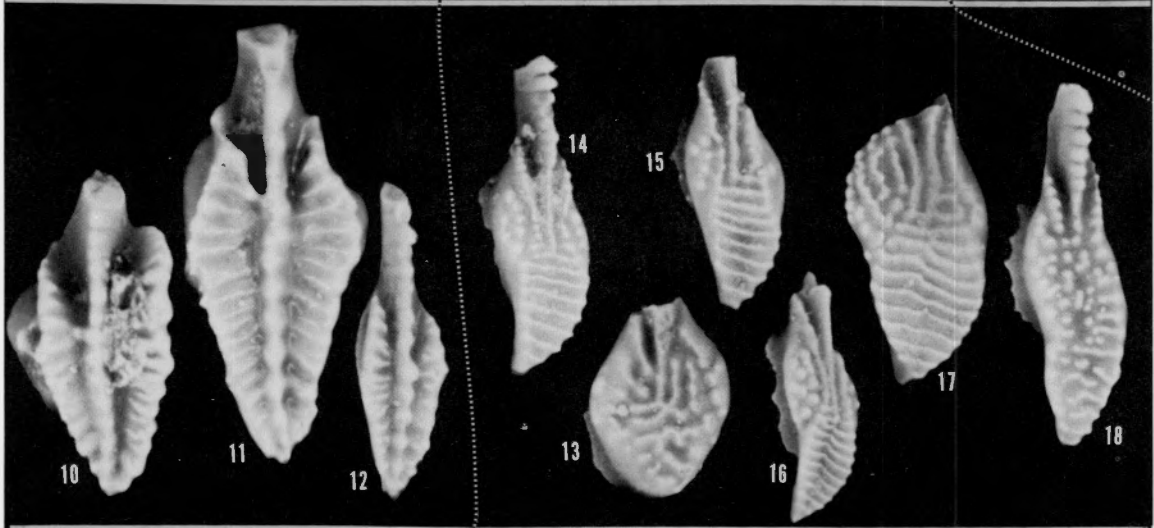
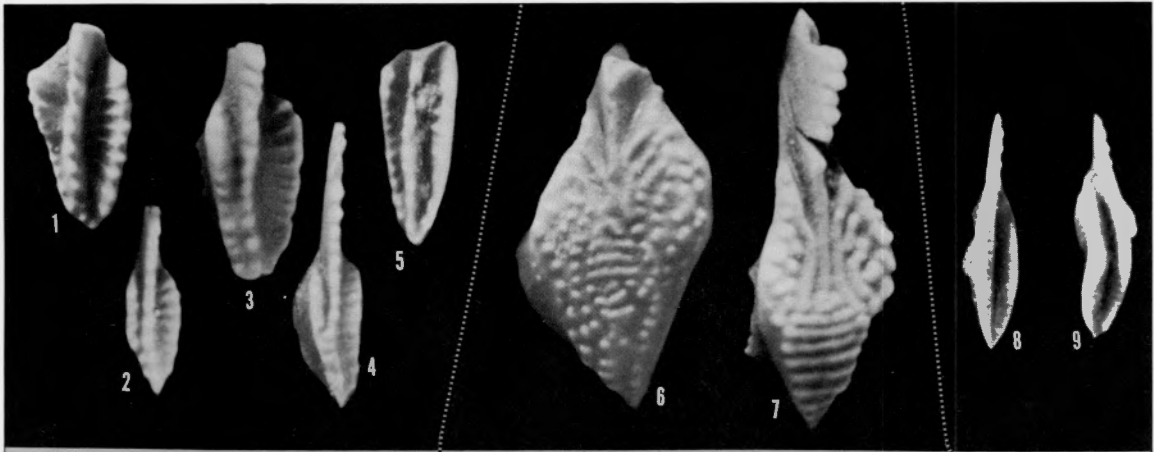


PLATE 2

(all figures $\times 40$)

Phylogenetically related specimens are inclosed in broken lines. Figures 1-8 are from the Ames Member, 9-16 from the Cambridge Member, 17-24 from the Brush Creek Member, 25-30 from the Washingtonville Member, and 31-39 from the Vanport Member. Figures 1-8 are from Stop 7; figures 9-11 and 16 from Stop 4; figures 17-24 from Stop 3; figures 25-27 from Washingtonville locs. 9, 9, and 23, respectively, of Merrill (1972b); figures 28-30 from Stop 5; figures 31, 32, and 35-39 from Stop 1; figure 33 from Stop 8. Other localities for figures include 12, 13: E. cen. sec. 31S, Harrison Tp., Muskingum Co.; 14, 15: NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, Washington Tp., Guemsey Co.; and 34: NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 27, Elk Tp., Vinton Co.

- Figures 1, 14-16.—*Streptognathodus gracilis* Stauffer & Plummer, oral views.
2-5, 11-13, 17.—*Streptognathodus elegantulus* Stauffer & Plummer, oral views.
6.—“*Spathognathodus*” *ohioensis* Merrill, lateral view.
7.—*Anchignathodus ellisoni* (Merrill), lateral view.
8.—*Anchignathodus minutus* (Ellison), lateral view.
9, 10.—*Streptognathodus excelsus* Stauffer & Plummer, oral views.
18-20, 33, 34.—*Streptognathodus cancellosus* (Gunnell), lateral, two oral, lateral, and oral views.
21-24, 28-30, 35-37.—*Idiognathodus* cf. *delicatus* Gunnell, three oral, lateral, and six oral views.
25-27.—*Neognathodus dilatus* (Stauffer & Plummer), two oral and lateral views.
31.—*Neognathodus medadultimus* Merrill, oral view.
32.—*Neognathodus medexultimus* Merrill, oral view.
38, 39.—“*Spathognathodus*” *coloradoensis* Murray & Chronic, lateral views.

