A Field Guide to Allegheny Deltaic Deposits in the Upper Ohio Valley

with

A Commentary on Deltaic Aspects of Carboniferous Rocks in the Northern Appalachian Plateau

by

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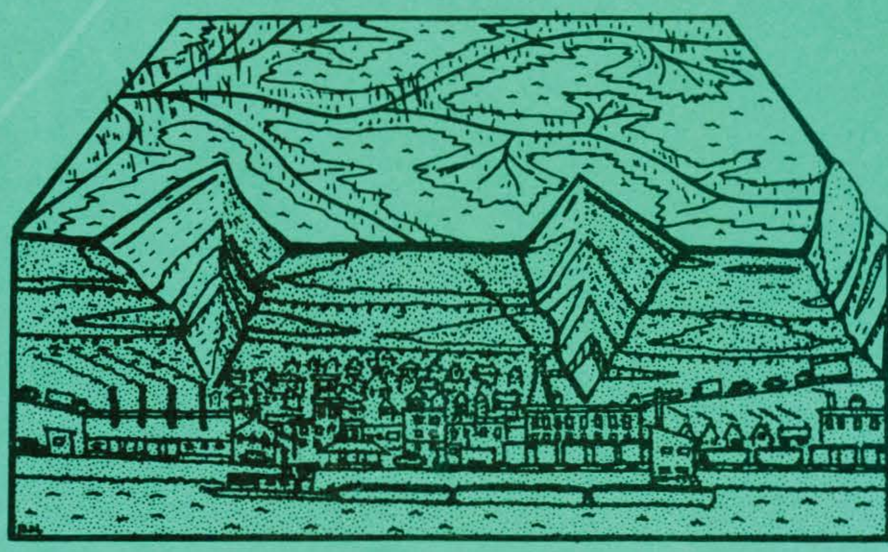

Under the auspices of

Ohio Geological Society
James A. Noel
Wright State University

Pittsburgh Geological Society
Walter S. Skinner
Duquesne University

ERRATA

p. iii, figure 5, line 4: after "11", insert ", and "

p. iv, figure 10, line 3: after "Hammondsville", insert ","
figure 12, line 3: delete "filled"
line 4: after "bay", insert "filled"

p. 1, col. 2, para. 1, line 33: delete "Pennsylvania", substitute "Pennsylvanian"
line 34-34: delete "coal measures", substitute "Coal Measures"
line 45: delete "ile", substitute "ie.,"

p. 2, col. 1, para. 1, line 24: after "Kentucky", insert ","

p. 6, col. 1, para. 2, line 23-24: delete all after "and"; after "by", insert "even closer spacing in complex areas."
para. 3, line 10: after "by", insert "study of"

p. 9, col. 1, entry 1, line 1: delete "LV.", substitute "Lv."
col. 2, entry 11, line 1: delete "lift", substitute "left"
entry 13, line 3: after "next", insert "mile"
Stop 1, line 10: delete "9", substitute "8"

p. 10, col. 2, para. 1, line 5: after "seaward", insert ","
Stop 2, line 13: after "level", insert "."; delete "the", substitute "The"
line 16: delete "is", substitute "in"

p. 11, col. 1, para. 1, line 4: delete "cust", substitute "cuts"
col. 2, para. 1, line 5: delete "disp", substitute "dips"
line 16: after "see", insert "stage"
para. 2, line 3: after "seam", insert "famous for its"

p. 12, col. 1, Stop 4, para. 1, line 4: after "beds", insert ","

p. 13, col. 1: insert entry 44A as follows:
"3.1 3.8 44A Right on exit to Ohio 170"
col. 1, entry 45, line 1: delete "3.2", substitute "0.1"
entry 46, line 6: after "Allegheny", insert "Formation and include all four of the best known Allegheny"
col. 2, Stop 6, para. 1, line 1: delete "included", substitute "includes"

p. 15, col. 1, item 86, line1: after "right", insert ","
Col. 1: following item 86, insert discussion of Stop 7 (p. 15, col. 2 and p. 16, col 1).

p. 16, col. 2, Stop 8, para. 3, line 7: after "the", insert "cut east of the road, shows the lower finer grained zone grading without break into the lower part of the"
para. 3, line 7: after "and sand", insert ","

p. 17, col. 1, para. 1, line 1: delete "upper", substitute "Upper"
item 99, line 1: after "Central", insert "Railroad"
col. 2, item 107, line 1: delete "left", substitute "right"

p. 18, col. 1, item 108, line 1: after "root", insert "along"
col. 2, Stop 10-A, para. 2, line 22: delete "dnd", substitute "and"

SCHEDULE OF EVENTS

Thursday, May 22, 1969

Registration: 7:30 PM - 9:30 PM

Friday, May 23, 1969

Registration: 8:00 AM - 8:45 AM

Bus leaves Travelers Hotel: 9:00 AM

Banquet: 7:30 PM, Holiday Inn, Chester, West Virginia

Saturday, May 24, 1969

Bus leaves Travelers Hotel: 8:30 AM

Bus returns to Travelers Hotel: 5:00 PM

PREFACE

As in most field trips, many people have a hand in making them a success. The Spring 1969 field trip is no exception. Like others before, it, it was held jointly with sister societies participating, the Ohio and the Pittsburgh Geological Societies.

This trip while perhaps not unique was implemented under conditions which were quite extraordinary. The logistics of the trip, the measurement of the road log, soliciting advertisements and the printing of the guide book were handled by the local committees. The lion's share of the work involved was performed by Dr. John Ferm and Mr. V. V. Cavaroc, Jr. Their contributions were the concept of the trip itself, skill and technical competence, the composing and writing of the guidebook and road log, and the actual leading of the trip. The success of the trip is due to the competence and dedication of these two men. The thanks and gratitude of both societies is extended to them.

Members of the committees are:

Ohio Geological Society

Robert Alexander	*Robert Elmore, Jr.*
Benjamin Brace	*Jay Henthorne, Jr.*
Horace Collins	*Mike N. Henderson*

James Noel, Chairman

Pittsburgh Geological Society

George Carini	*Lou Heyman*

Walter Skinner, Chairman

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INTRODUCTION AND ACKNOWLEDGMENTS

Every field trip has its own set of objectives or goals. Some are highly specialized both as to place and subject matter and are usually directed toward the solution of some very specialized problem in a specific area. At the opposite extreme, others appear to be a series of more or less chance encounters with geological phenomena in some locality chosen for its natural beauty or general availability. Finally to some degree all excursions provide an occasion for meeting old friends or making new ones in a pleasant outdoor atmosphere. Although this trip was not planned with the view of creating actual physical or mental misery or an occasion for anti-social behavior, the foregoing aspects were not given major consideration. The physical setting generally is not known for its scenic beauty; however, a rare combination of physiography and culture *do* provide exposures whose excellence is probably unmatched anywhere in the northern Appalachian Plateau. Neither is the stratigraphic interval particularly important; Pennsylvania sedimentary rocks are, save for coal beds, very similar to other detrital rocks and even with respect to other sediments, are not really unique. What this trip does provide is a rather carefully worked out example of sediments of deltaic origin in which an approach has been made to welding some of the concepts of sedimentary environments to conventional stratigraphic problems.

At the outset it should be made clear that this trip represents the work of a great many people and more than can be properly acknowledged. Present and past graduate students at Louisiana State University --David Davies, Richard Hoger, Harry Roberts, Ram Saxena and undergraduate Louis Jansen--have all contributed substantially to our knowledge of Upper Ohio Valley geology. E. G. Williams at Penn State has been a continuing and willing worker in developing concepts of Carboniferous sedimentation while J. M. Coleman and S. M. Gagliano at LSU have provided invaluable help in relating these ancient sediments to recent environments. Members of the Ohio Geological Survey--Russell Brant, Horace Collins, and Dick DeLong have cooperated with us in so many ways that our results must be regarded at least partly theirs. Finally all our efforts rest directly on a broad base provided by earlier workers of the Ohio, Pennsylvania, West Virginia and U. S. Geological Surveys whose data and ideas are essential to our present inferences.

STRATIGRAPHIC CONCEPTS

Many of our ideas about Carboniferous rocks were developed in the late 19th and early 20th centuries when a burgeoning industrial society demanded precise knowledge of the mineral resources of a vast and then remote area. Such demands were, and still are, always real and urgent and, in at least some cases, required more zeal than reflection. Thus, the way we think about the Carboniferous represents, for the most part, concepts that were relevant and important at that time. One of the most important of these was the basic notion of sedimentary rocks as essentially tabular bodies of considerable horizontal extent, a concept dating back to the origins of modern geology. What is more, the idea was well established that such rock units were deposited in a certain interval of time and that even if the rocks were not absolutely horizontally continuous, time was and time could be detected by fossil faunas and floras. In the Appalachian Plateau, the rocks that we know as Carboniferous had long been recognized as being generally equivalent to a sequence of coal bearing strata in Britain and, in addition, the distinction could be made on this side of the Atlantic between an upper, coal bearing portion with relatively few marine fossils and a lower portion essentially without coal but in most places with an abundant and diverse marine fauna quite different from the overlying unit. These differences, coupled with the fact that the rocks at the base of the coal measures were mainly sandstones (orthoquartzites as it turns out) with truncating basal contacts seemed justifiable evidence of a major physical break separating what came to be known as Mississippian and Pennsylvania time rock units. The fact that almost every other thick coal measure sandstone had a truncating basal contact seemed of little importance in view of major lithic and faunal changes associated with the boundary.

Further subdivision of the upper, coal bearing (Pennsylvanian) unit in western Pennsylvania and eastern Ohio was based mainly on gross rock properties. Thus the lower, orthoquartzitic sandstones with minor coal beds were designated the Pottsville "conglomerate" and the overlying rocks subdivided on the basis of the abundance of minable coal beds, ile. Lower Productive Measures, Lower Barren Measures, Upper Productive Measures, and Upper Barren Measures. (To conform to later trends in stratigraphic nomenclature the names were changed to Allegheny, Conemaugh, Monongahela and Dunkard and the units given rigid boundaries, usually a coal bed.) The principal advantage of such a system lay in its broad and easy application. In nearly every part of the Appalachian coal field a series of rocks containing important minable coal beds could be found overlying a group of thick orthoquartzitic sandstones and, in many places, were in turn overlain by rocks containing no major minable coal beds. The principal difficulty arose when it was found that individual coal beds which were also a basis of stratigraphic classification did not conform to boundaries set up in the basis of "high quartz sandstones" and "coaliness." Thus it could be shown that the "productive" coals of central West Virginia lay well below the Productive Measures of Pennsylvania and the "productive" coals of southern West Virginia and Virginia were, in turn, below those of central West Virginia. A solution to this problem was found in basing the principal divisions on individual coal beds, strata containing marine fossils, and some sandstones units which were thought to be laterally continuous for long distances. The "classical," large scale units in Pennsylvania and Ohio were retained and in southern West Virginia and eastern Kentucky the Pottsville was subdivided into units reflecting an underlying thick orthoquartzitic sandstone unit and an overlying relatively non-sandy portion containing abundant coal. The only major problem with this system rests in the assumption of continuity of individual beds. In some parts of the coal field, the continuity of some beds eg., the Vanport limestone and the Lower Kittanning coal, can be reasonably demonstrated, thus verifying on a very small scale the original concept of sedimentary rock units as essentially tabular bodies with considerable lateral continuity. In other parts, experience has shown that some general set of beds can be shown to be related to another set in some distant place, but none of the individual beds in any recognizable form extend more than a few miles. However, the broad framework has been shown to be essentially correct and problems of precise correlation are ordinarily of only limited interest.

One of the minor pitfalls which was a consequence of the concept of widespread rock units was the notion that each bed should bear a stratigraphic name. (Ohio now averages one stratigraphic name for every 10 feet of Pennsylvanian section.) Such an impulse is a natural one and is especially enhanced when certain beds are economically important in a local area. The outcome has been that unnumbered creeks, runs, towns and farms have received dubious immortality in stratigraphic nomenclature and have been further multiplied by prefixes "Lower," "Middle," "Upper" and "Little" and suffixes "Rider," and "Rooster," "A," "B," and at least up through "E." Thus Carboniferous stratigraphy at times seems to have fallen into a conflicting network of very precise but local names intertwined with long range correlations which are tenuous at best. It is a magic forest into which few are willing to venture and, worse luck, there is probably no sleeping beauty at the end.

Among the more recent concepts applied to Carboniferous stratigraphic problems is that of depositional models which state that individual rock types occur in one or more specific arrangement patterns with respect to one another and that these patterns can be related to certain genetic events. The older "tabular rock bodies" idea is, of course, a depositional model but differs in that no pattern or arrangement is implied. The model now most generally accepted is the cyclothem which was devised in the Illinois Basin and adapted to situations in other areas. In rudimentary form it consists of a vertical sequence which from bottom to top, is made up of sandstone with a disconformable base, siltstone, underclay with or without fresh water limestone, coal, dark shale and limestone with marine or brackish fossils, gray shale and siltstone which is truncated at the top by a disconformity separating it from the next overlying cyclothem. Strata from the coal downward are assumed to be non-marine whereas those above are primarily marine, thus producing a regressive-transgressive couplet as the major genetic mechanism. There has been considerable debate concerning the origin of these regressive-transgressive relationships but these are second order inferences which do not really challange the basic utility of the system. Two of the major difficulties that the model has experienced arise from its one dimensional character (a single sequence) and the rigidity with which the sequence has been applied. Even a cursory examination of Pennsylvanian outcrops shows that one or more of the elements of the most general cyclothemic sequence are not present whereas other exposures show rock types that are not included in the model. The general tendency in overcoming the first difficulty has been to state that beds were "missing" and could presumably be found elsewhere. The second difficulty has been treated by adding members to the general sequence in proper relation to known members and to build a composite which can be rarely, if ever, actually observed. A further attempt has been made to bring the cyclothem into conformity with natural situations by separating those members that are characteristic of a particular region from those that are more abundant in another, thereby creating regional type cyclothems. The number of exceptions, however, still seems too great for a completely general system.

In order to avoid those problems involved in a single vertical sequence model as well as rigidity of a certain specified number of members, an alternative has been proposed which states that the only totally unequivocal cycle is that which consists of deposits resulting from episodes of detrital (or clastic) sedimentation punctuated or interrupted by periods of minimal detrital influx and development of essentially autochthonous or chemical deposits. Among Pennsylvanian rocks, siltstones, shales, sandstones, and conglomerates are the common detrital deposits whereas the kind of chemical deposits depends on environmental setting. Thus coals and seatrocks will be the typical resultants of non-marine sites whereas ironstones (or glauconite) and marine limestone will reflect a marine or brackish environment. It is further stated that detrital rocks of any particular "cycle" will have some finite horizontal limits less than those of adjoining chemical rocks and at some point detrital rocks pass laterally into chemical sediments. Therefore if a detrital deposit is both preceded and followed by chemical deposits and occurs side by side with them, detrital components of any particular cycle can be expected to be surrounded on all sides by chemical or autochthonous rocks. Finally it is stated that if more than one grain size type is present in the detrital sequence (shale, siltstone or sandstone) the sequential order in which these types occur will be dependent on the marine or non-marine character of the underlying and particularly the overlying chemical rocks. Thus if both over- and underlying chemical rocks are marine limestone or ironstones, the detrital sequence will typically grade upward from fine to coarse whereas if coals and seatrocks comprise the limiting members, the reverse grain size trend is more frequently the case. This model is shown diagrammatically on figure 1. The projection here is a two dimensional section showing landward and seaward extremes, but a three dimensional concept can easily be obtained by dividing the section vertically near the middle and rotating the landward portion vertical to the section and rotating the seaward side in the same manner but in the opposite direction. The three dimensional figure thus generated will produce a lensoid shaped body through which vertical columns or cross sections can be drawn which will reproduce most stratigraphic columns or cross sections in the Appalachian Pennsylvanian. It should be borne in mind that this particular diagram is drawn so that there is no dominant transgression or regression. In actual practice most Pennsylvanian "cycles" are partially to strongly regressive so that the coal and seatrock components on the diagram should be extended in a seaward direction with attendent changes in the sequential arrangement of the adjacent detrital sediments.

One further aspect should be noted, namely the mineral composition of the sandstones. Most Pennsylvanian sandstones are composed of a mixture of quartz, micaceous or clayey rock fragments, coarse micas, feldspars and mica-clay matrix with quartz the principal component. In the depositional model there is a general trend of increasing quartz among sandstones from the landward to seaward direction and in some cases the seawardmost sandstones are almost pure orthoquartzites. It should be remembered however that these trends are often gradual and much effected by grain size; finer sand sized rocks contain less quartz than coarser ones. Therefore comparison should be made only between sandstones of the same grain size or between sands to which size corrections have been applied.

Finally the genetic connection between this model and the pattern of recent deltaic sediments should be noted. The general shape and sediment pattern is, of course, obviously similar to what is generally known of deltas but comparisons between sequences and lateral changes of the Pennsylvanian model and those known from the recent Mississippi River deposits show such close similarity that some of the terminology indicating specific recent environments are also included on the diagram.

APPLICATIONS OF THE "DELTA" MODEL

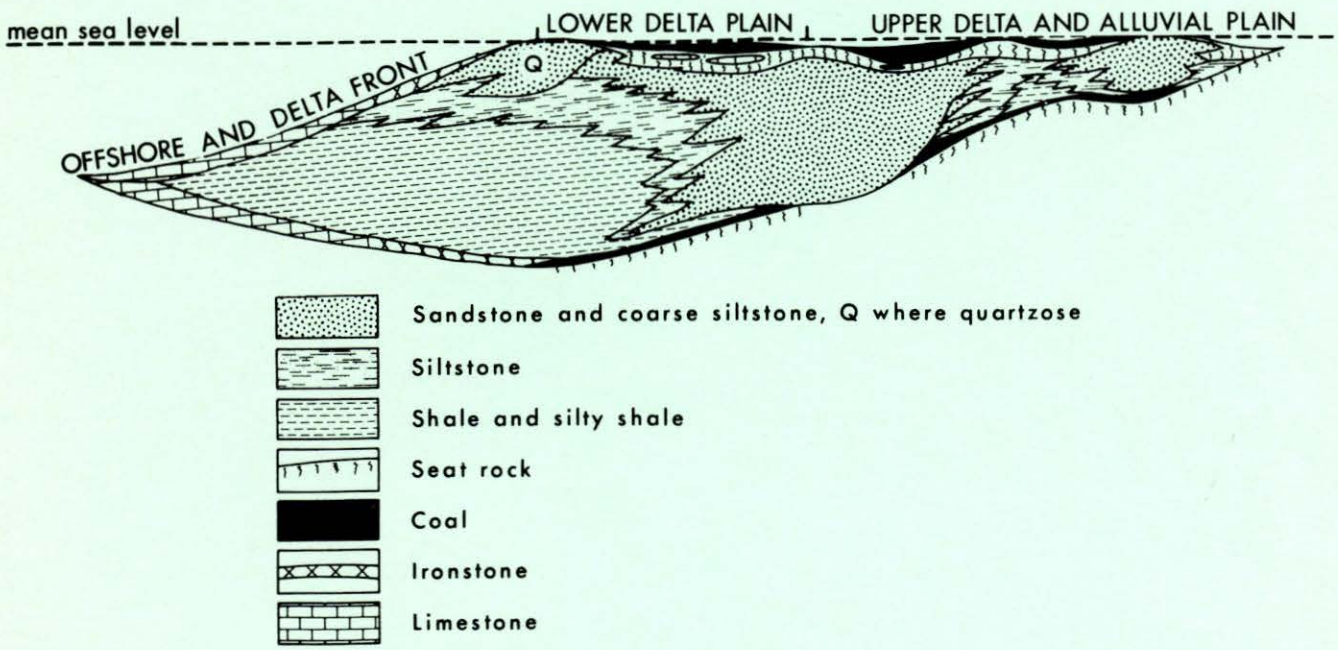
The proof of any hypothesis lies in its application and it is one of the major objectives of this excursion that the "delta" model be demonstrated in the field. In view of both time and space limitations, however, only a relatively small part of a very broad picture can actually be shown. Therefore, two applications of the model will be given in written form--

one in the Allegheny and lower Conemaugh strata of the Upper Ohio Valley, the area of the excursion; the other to the entire Carboniferous succession in the northern Appalachian Plateau.

Figure 2 shows a cross section of Allegheny and Conemaugh rocks from the vicinity of Wheeling, West Virginia to slightly south of New Castle, Pennsylvania (Figure 3). The lowest beds on the right side of the section (between the "Brookville" and Lower Kittanning coal beds) are mainly shale and silty shale grading upward to siltstone and thin sandstone at the top, essentially the delta front portion of the model. Northward in the New Castle (West Pittsburg) area, the thick limestone in the lower part of the sequence indicates an approach of typical seawardmost components of the model whereas the thick sandstones, thick coals, and seatrocks in the Wheeling (Warwood-Hopedale) area suggest landward fluvial components. In contrast, rocks between the Lower and Middle Kittanning coal beds are very thin and extraordinarily uniform, consisting of very dark gray shales which in many places contain marine fossils. These deposits are apparently at the margin of the delta near the strand where detrital influx is small, indigenous peats and soils are well developed but where the area is at times inundated by marine waters. These inferences are borne out by the fact that eastward in northwestern Pennsylvania, this interval is represented by thick delta front deposits similar to those between the Lower Kittanning and "Brookville" coal beds in the upper Ohio Valley. The Middle Kittanning-Lower Freeport coal interval is very uniform throughout the section but in contrast to the interval below consists of the sandstones of probable distributary origin passing laterally into "bay" sequences which grade from fine to coarse upward. That these attributes are maintained across the entire diagram indicates that the section is approximately along depositional strike, again a conclusion supported by facies mapping in eastern Ohio. The Lower to Upper Freeport interval presents greater contrasts. The northern part is primarily delta front with a sequence very similar to the "Brookville"-Lower Kittanning interval whereas the central portion seems to be mainly a "lower delta plain" facies similar to the underlying Middle Kittanning-Lower Freeport section. The diminished detrital interval and relatively great thickness of coal in the Hopedale area is suggestive of parts of the "upper delta plain" and the very thin and erratic section near Wheeling indicates the landward extremities of the model. It should be noted here that the thick coal facies at Hopedale is repeated in the Middle Kittanning zone in the Nelsonville area in southern Ohio and is repeated again but to a lesser degree in the "Brookville" zone still further south near McArthur. These criteria in conjunction with mapping of other attributes indicate an overall progradation from south to north in successive Allegheny episodes in eastern Ohio. The entire interval between the Upper Freeport and Brush Creek coal beds with thick sandstone, abundant though not well developed seatrock and erratic coal suggest the "alluvial plain" portion of the model although a greater abundance of thick coal in the northern part of the area indicates an approach to the upper deltaic plain facies. In this case, if the model were to be used as a prospecting device, the area directly north of this section could be viewed as an optimistic site for thick Upper Freeport and "Mahoning" coal. The section above the Brush Creek coal bed is known mainly from bore holes but its essential delta front character is reasonably well shown. In the Hopedale area, however, somewhat thicker coal and relatively thick sandstone suggests the beginnings of the lower deltaic plain whereas the sparce Wheeling sections indicate return of the lower delta plain.

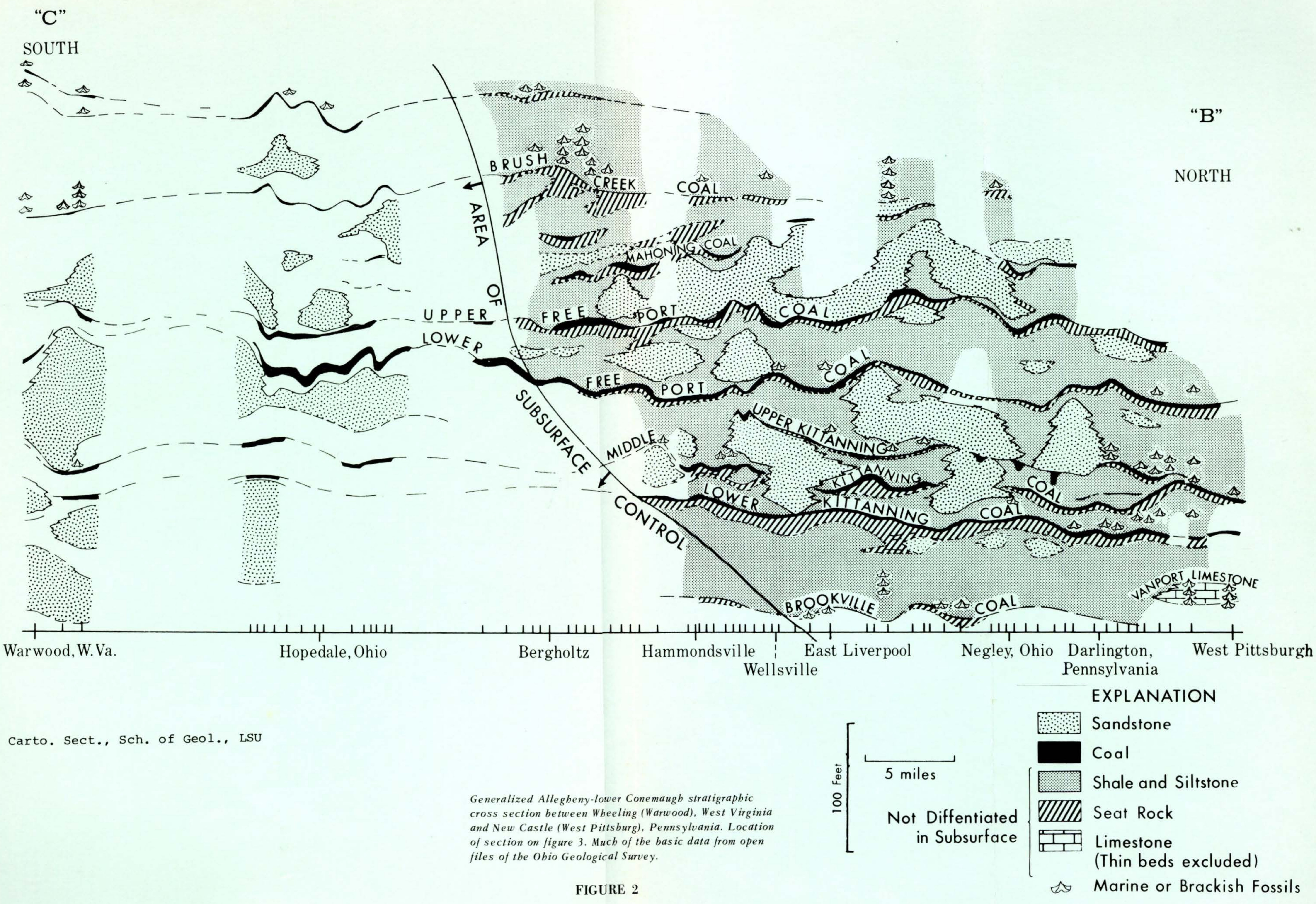
None of the sections on figure 2 show the quartzose sandstone of the "delta front" - "lower delta plain" portion of the model. This is at least partly fortuitous as both the Lower to Middle Kittanning, and Middle Kittanning-Lower Freeport intervals show this feature in some localities. However the overall impression is justified that this particular quartzose facies is not overwhelmingly common. Nonetheless its position in the model is verifiable and its paucity in this part of the Pennsylvanian section in this place is better explained by placing it in context with the Carboniferous succession.

Two important attributes of the proposed "delta" model are: 1) That a single stratigraphic section provides some indication of the environmental position within the rock body and 2) that the lateral changes from any particular section are predictable. In the later case, the level of prediction is greatly enhanced if the general shore line direction is already known. The first attribute has been used in reassessing the characteristics of the Appalachian Carboniferous and the second has been tested in the light of the results. Figure 4 shows a cross section of almost the entire



A generalized Pennsylvanian lithogenetic model showing inferred environments in a deltaic milieu.

FIGURE 1



Generalized Allegheny-lower Conemaugh stratigraphic cross section between Wheeling (Warwood), West Virginia and New Castle (West Pittsburg), Pennsylvania. Location of section on figure 3. Much of the basic data from open files of the Ohio Geological Survey.

FIGURE 2

Carboniferous from near Bluefield, West Virginia in the south to the vicinity of New Castle, Pennsylvania in the north (figure 3). In constructing this cross section a very large number of records of oil wells and coal test borings were examined to determine what particular part of the model was represented in the vertical sequence. Lateral connections between columns are based mainly on published correlations. Where independent evidence was sufficient, checks on these correlations showed a much lower level of precision than the nomenclature would suggest, but overall, reasonable accuracy on the order of 200 feet may be expected in the upper and northern parts of the section and of 400 feet in the south and west. In any case, examination of the sections shows that the Kittanning delta plain deposits in the northern part are represented in the south by alluvial facies, whereas upper Pottsville rocks which are alluvial and deltaic plain in the south pass northward into delta front and finally into orthoquarzitic sandstones in the north. These latter presumably represent a complex of beaches, barrier bars, and tidal deltas with minor sloughs and ponds which locally contain thick accumulations of peat. Seaward of these Pottsville ("New River") barriers, the principal rock types are red oxidized offshore clays and limestones which we call Mississippian. Similarly the lowest Pennsylvanian lower Pocahontas delta plain facies of southwestern West Virginia are represented northward by delta front and offshore "Mississippian" facies but without an intervening barrier bar. Viewed in this way, the entire Carboniferous succession seems to represent a continuous repetition of the delta model (formulated primarily on the Allegheny) except that the beach-barrier facies are much thicker and more wide spread. This later characteristic may be explained by assuming that by Allegheny time the area of open marine water was so reduced that neither major wave action or lateral transfer was sufficient to form a substantial shoreline system. The same situation probably prevailed during deposition of the Conemaugh, which, although more under marine influence than the Allegheny, seems to lack a major barrier-bar facies. The absence of a barrier in the Conemaugh would also explain the abundance of red silts and clays in these and higher Pennsylvanian rocks. For without a physical shield on the seaward side of the delta front, open circulation and attendent oxidation could penetrate deeply within the delta system.

The regional cross section on figure 4 also shows the manner in which depositional patterns are modified by tectonic setting. In the southern half of the section, sediments representing one or two depositional sites have accumulated thicknesses of 500 feet in one place, whereas in the north (also see figure 2) the total vertical interval is small, and delta front, delta plain and alluvial plain replace each other upward in rapid succession. This may be attributed to rapid subsidence in the south, presumably controlled by penecontemporaneous movement along the Paint Creek Fault zone, and as the rate of sedimentation exceeded the rate of subsidence, deltaic progradation advanced rapidly northward across an apparently less yielding shelf.

One of the most interesting aspects of applying the delta model to the whole Carboniferous section is its general conformity to the previously existing body of stratigraphic knowledge; it tends more to explain than to alter former stratigraphic ideas. Thus the migration of the productive coal facies northward the upward through the succession can be seen as a natural consequence of deltaic progradation, but rock units -- Pocahontas, Kanawha and Allegheny -- remain as valid but explainable rock units. Regrettably, problems of coal bed correlation and nomenclature are still with us but, with the notion or predictably different degrees of lateral continuity of coal beds in different environments, the problem can be approached on a somewhat sounder foundation. Those traditional rock units, the orthoquartzitic sandstones, by whatever stratigraphic name, remain as valid units but can now be considered as a kind of rock sieve which in places is penetrated from one side by deltaic dark shales and coals and in other places by reddish and light gray shales and limestones of the offshore facies. The disconformity so often observed at the base of these sandstones, truncating the underlying offshore facies, is explainable by beach scour or erosion in tidal channels and tidal deltas.

The principal difficulty lies in the nature of the Mississippian and Pennsylvanian as time rock units. Clearly figure 4 suggests that, in contrast to the way the terms are now used, they are not time rock but facies units which are at least in part the same age and that faunal changes associated with the present boundary are best ascribed to ecologic-environmental differences. This, of course, does not imply that the passage of time is not represented or that a time-faunal succession based on faunas and floras of differing depositional settings could not be devised. In fact this particular aspect of Carboniferous stratigraphy seems to be one demanding intensive investigation. Such a system of classification, however, would probably be very difficult to apply and would probably prove unsatisfactory to practicing field geologist and stratigrapher.

AND BEFORE WE BOARD THE BUS

On a trip of short duration in a limited area it is manifestly impossible to see any but a small part of the Carboniferous or even of the whole Allegheny Formation. Nonetheless, if not in particulars then certainly in general, the Allegheny rocks of the Upper Ohio Valley provide an excellent example of the main rock types and arrangement of rock types found in other parts of the Pennsylvanian. Emphasis on the trip will be placed on the "lower delta plain" portion of the delta model (figure 1) since this is one of the most difficult portions of the depositional system and one of the most commonly observed portions of Carboniferous rocks. The principal difficulty with this depositional setting arises from the rate of lateral change of component rock units relative to the spacing of control. Although some parts of the system, especially the channel areas, are characterized by abrupt lateral changes (on the order of ½ miles), other parts show a virtually unchanged succession for distances of 2 to 3 miles leading to the erroneous projections to distances of 6, 8, 10, and 20 miles and even further. In fact, our experience with this facies indicates a minimum spacing of about 2 miles for reasonably precise definition supplemented by and a great deal more central in complex areas.

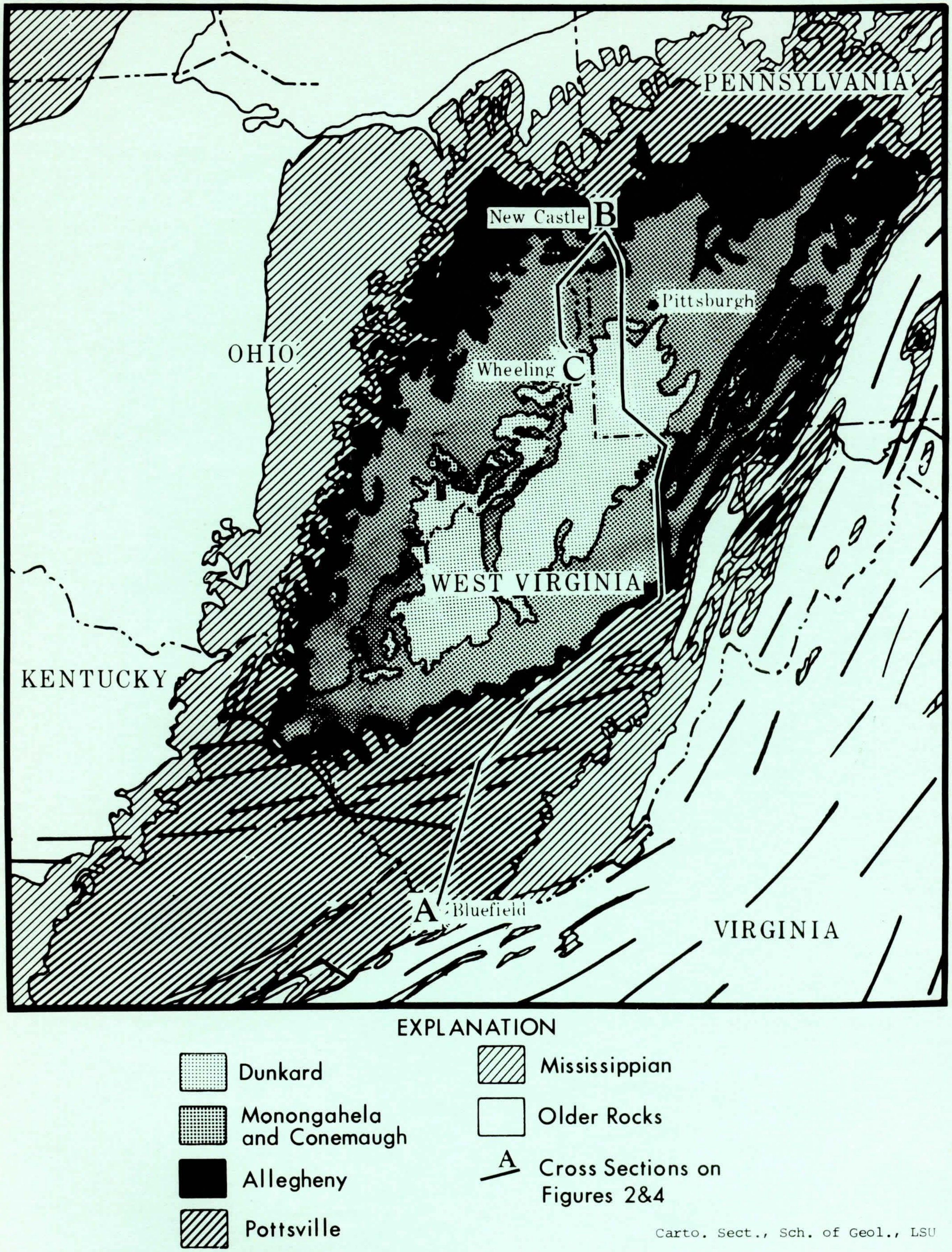
This lower delta plain facies between the Middle Kittanning and Lower Freeport is currently being studied by graduate students at L.S.U. and will be demonstrated in some detail. The first day will be devoted primarily to illustration of the "up stream" portions characterized by relatively narrow distributary channels alternating with relatively broad interdistributary bays. These data in a modified form may also be used as a model for the upper delta plain. Much of the second day will be occupied by flanking bay deposits and their extension to the barrier system at the margin of the lower delta plain. (See figure 5 and 6.)

Deposits of the delta front (figure 1) and much more laterally continuous than any of those more shoreward and will be illustrated by the rocks between the "Brookville" and Lower Kittanning coal beds in the Ohio Valley on the first day and will be contrasted with the offshore facies in the equivalent interval about 25 miles to the north. Deposits formed at the margin of major delta building will be illustrated by rocks between the Lower and Middle Kittanning coal beds on both first and second days and several outcrops of rocks directly above the Upper Freeport coal bed will serve to illustrate some of the characteristics of the upper delta and alluvial plains.

General route maps for the area are provided on figure 7 and for those desiring greater detail, the trip area is included on the Wellsville, Ohio, Columbiana, Ohio, and New Castle, Pennsylvania 15" quadrangles and on the following 7½" quadrangles: Wellsville, East Liverpool South, East Liverpool North, East Palestine and New Middletown, Ohio; and New Galilee and Bessemer, Pennsylvania.

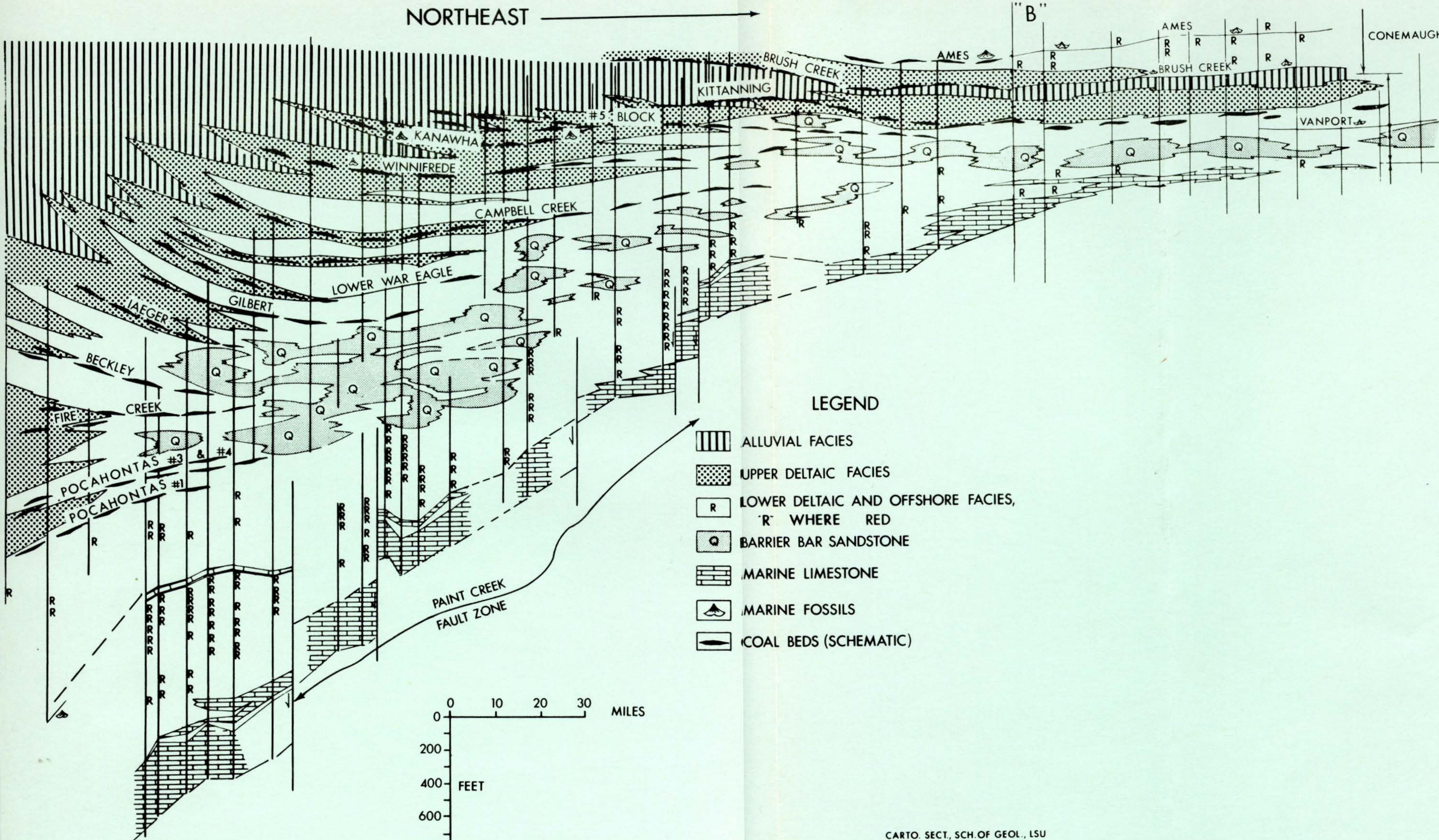
AND A NOTE OF CAUTION

One of the pleasures of field work in the upper Ohio Valley is the very excellent exposures in highway and railway cuttings and in open pit mines. Both such exposures however present distinct hazards. Very high traffic density both on highways and railways render them very dangerous to the geologist who may be temporarily absorbed in examining the rocks (and permanently absorbed on the front of a locomotive.) Open pit mines present special risks as the high wall cuts are very unstable and even the smallest bit of rock falling from the height of 40 or 50 feet can cause at least minor discomfort. The leaders of this trip will take every possible precaution to ensure the safety of the participants but the real burden, as usual, rests with the individual. Please be careful so that we may all have an enjoyable time.



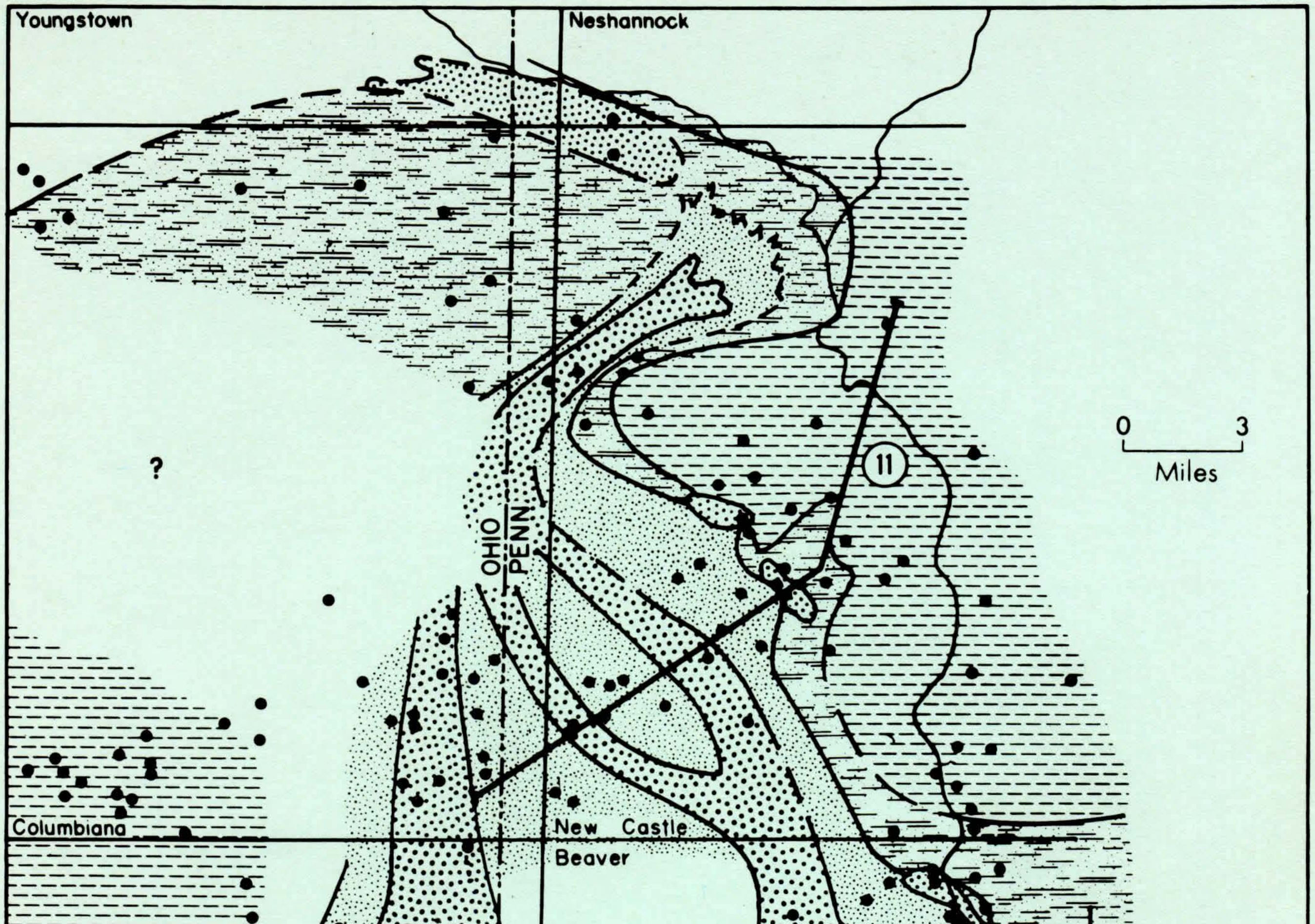
Carboniferous outcrop areas in the northern Appalachian Plateau. From U.S.G.S. Geologic Map of the United States.

FIGURE 3



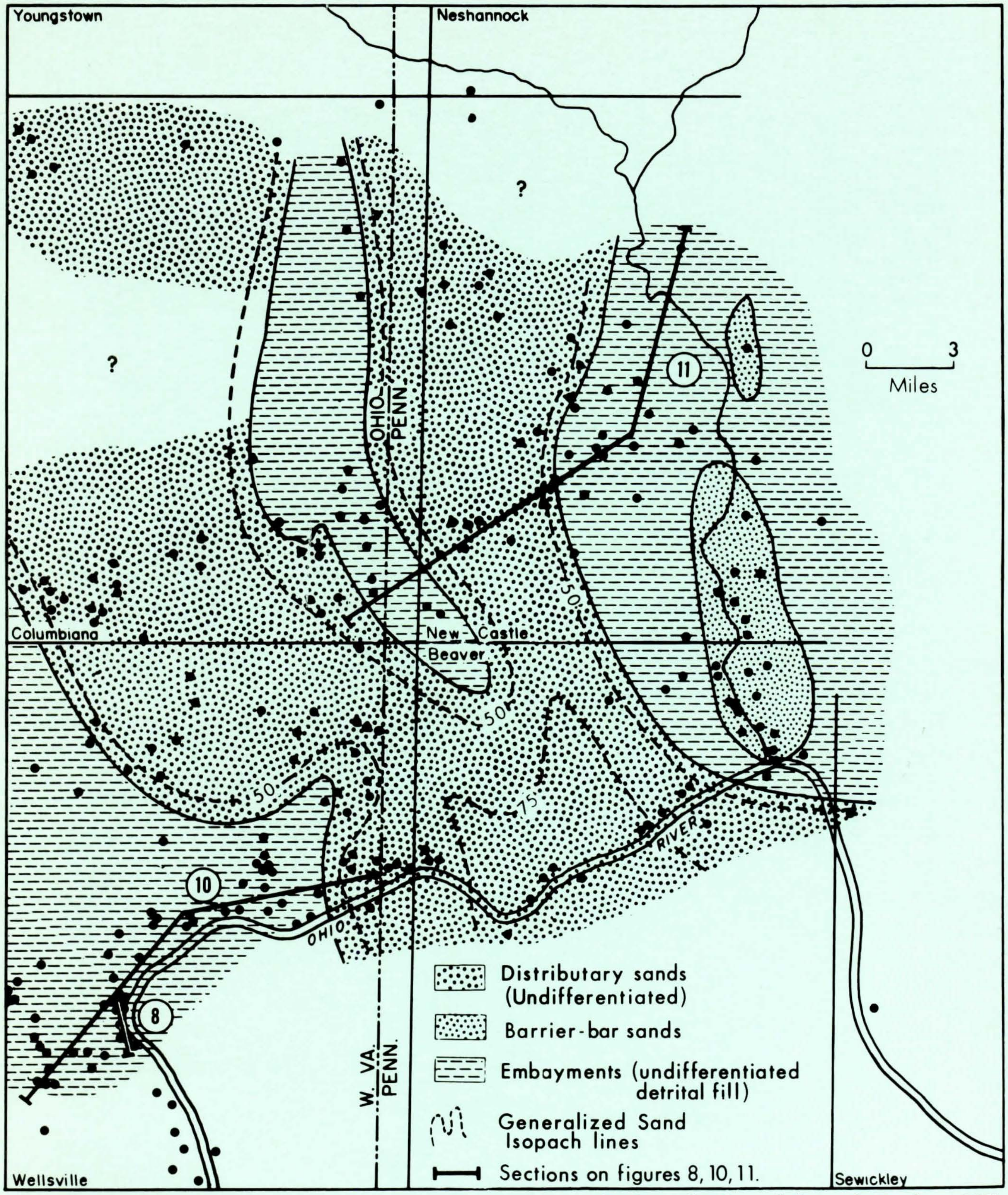
Generalized stratigraphic cross section of Carboniferous rocks between southern West Virginia (near Bluefield) and New Castle, Pennsylvania. Location of section on figure 2. Basic data mainly from the Pennsylvania and West Virginia Geological Surveys.

FIGURE 4



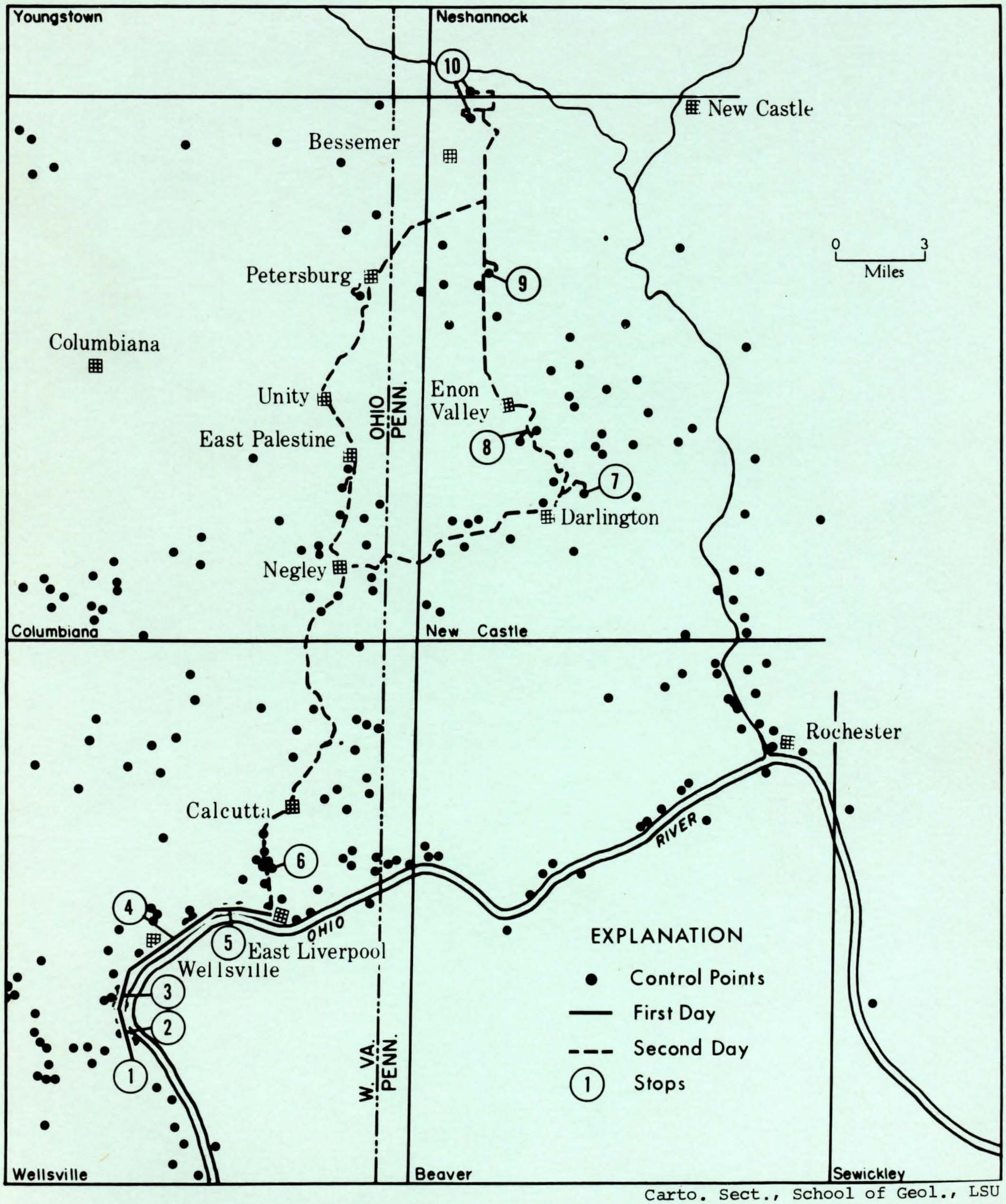
Paleo-physiographic map of strata between the Middle and Upper Kittanning coal beds in the upper Ohio Valley area. Also indicated are control points, lines of stratigraphic cross sections on figures 8, 10, and 11 location of U.S.G.S. 15 minute quadrangles.

FIGURE 5



Paleo-physiographic map of strata between the Upper Kittanning and Lower Freeport coal beds in the upper Ohio valley area. Also indicated are control points, lines of stratigraphic sections and quadrangle locations as on figure 5.

FIGURE 6



Route map of the trip.

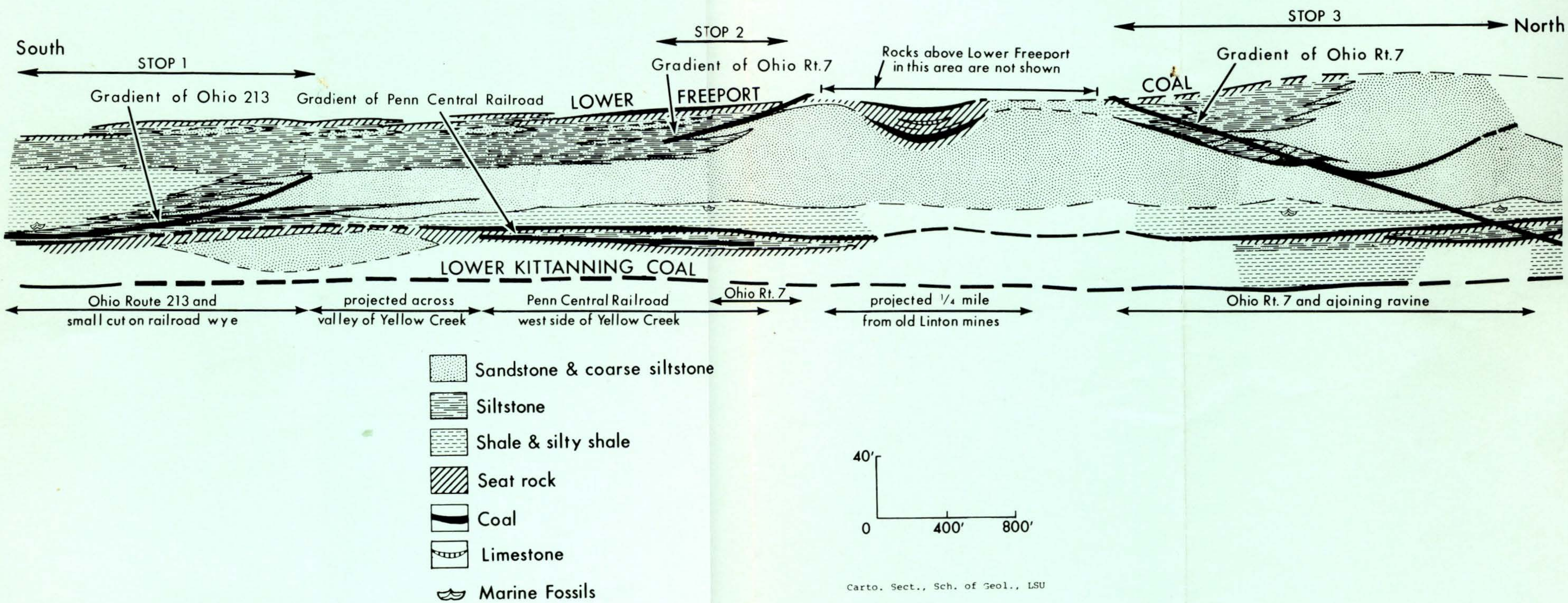
FIGURE 7

ROAD LOG OF FIELD TRIP

ON ALLEGHENY DELTAIC DEPOSITS

IN THE

UPPER OHIO VALLEY



Stratigraphic cross section of strata between the Lower Kittanning and Lower Freeport coal beds at Stops 1, 2, and 3. Inferred mode of origin of these rocks is shown on Figure 9.

FIGURE 8

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0	0	1.	LV. Traveler's Hotel (facing west at curb on hotel side of street). On Pleistocene terrace of the Ohio River.
		2.	Turn left at traffic light.
0.1	0.1	3.	Turn right onto U.S. 30 at second traffic light.
0.4	0.5	4.	Turn right (making loop) onto Ohio 7-39 toward Wellsville and Steubenville.
0.5	1.0	5.	Proceed on Ohio 7-39 traveling through rocks below the base of the Allegheny Formation.
0.7	1.7	6.	East Liverpool city limit. Begin road cut on right which exposes upper Pottsville and lower Allegheny strata.
0.1	1.8	6A.	Brick plant in ravine on right utilizes the Lower Kittanning underclay. This clay as well as some of the clays at the base of the Allegheny provides the principal source for the brick industries at East Liverpool and Wellsville on the north side of the Ohio River and at Chester, and Newell, West Virginia on the south side. This industry now is mainly devoted to the manufacture of refractory brick for the steel industry although quality face brick for interior and exterior use is also produced.
2.4	4.2	7.	Junction with Ohio 45 on the north edge of Wellsville. Wellsville, like East Liverpool, is a very old community that experienced considerable prosperity in the early days of river traffic and later with the ceramic industry and railroads. During the Civil War a raiding party led by Confederate General John Hunt Morgan was captured by Union Forces a few miles north of here and the prisoners interned at Wellsville. Security seems to have been lax as during the night the General escaped across the Ohio where Confederate sympatherizers soonreturned him to the Southern forces.
0.1	4.3	8.	Bear left on Ohio 7-39.
0.3	4.6	9.	Right on Ohio 7-39.
1.2	5.8	10.	Right on Ohio 7-39.
0.3	6.1	11.	Lift on Ohio 7-39.
0.9	7.0	12.	Continue south on Ohio 7. On right and left sides of road, the main works of the Porter Brick Manufacturing Company. The principal raw material is the Lower Kittanning clay which is mined from an entry up the hill slope on the right. For 2 miles southward the dip is relatively great and the Lower Kittanning drops to within a short distance of river level.
0.1	7.1	13.	On the right, the Middle Kittanning coal bed overlain by the Washingtonville marine shale. For the next the interval between the Middle Kittanning coal bed and rocks of the lower Conemaugh are exposed in a spectacular series of road cuts, some of which will be examined later in the day. The coal exposed near the crest of the road right of way is the Upper Freeport which in many places is scoured by the overlying sandstone.
1.0	8.1	14.	Bridge over the Penn Central Railroad and Yellow Creek.
0.2	8.3	15.	Turn right on Ohio 213.
0.5	8.8	16.	Park on right and disembark. Busses return to rest area.

Stop 1.

This stop as well as stop 2 and 3 are designed to illustrate some of the principal features of the lower deltaic plain facies of the delta model. The stratigraphic interval here is substantially that between the Middle Kittanning and Lower Freeport coal (figure 2) beds but in other localities the same features can be observed in other parts of the Carboniferious. The exposure directly opposite the parking area represents a relatively deep bay filled with silts and clays from a nearby distributary (see figure 9). The Middle

Kittanning coal, near road level, represents a peat swamp and the dark shales directly overlying the initial subaqueous deposits following subsidence of the swamp surface. The next overlying fossil bearing zone (Washingtonville) is silty and probably reflects environmental conditions suitable for a modest marine or brackish population coincident with the arrival of the silty edge of the advancing distributary mouth bar (see stage 1 on figure 9). The finer grained sediment overlying the fossil bearing zone reflects cut off of coarser sediment due to leveeing of the distributary channel and the gradual upward increase in grain size is indicative of lateral transfer of progressively coarser sediment as the bay progressively fills with detritus from the channel. The uppermost beds in the cut (approximately the Lower Freeport coal) represents minor crevasse deposits which extended over the surface of the filled interdistributary bay. The laminated thin silt-stones and sandstones reflect episodes of rapid sediment introduction during high water periods and the silty seatrocks episodes of plant growth which developed as the water receded. This type of sequence grading from shale or clay at the base to silt and silty sand at the top is so easily recognizable and so typical of interdistributary bays that it is sometimes called a "bay fill" although deposits of the delta front are quite similar.

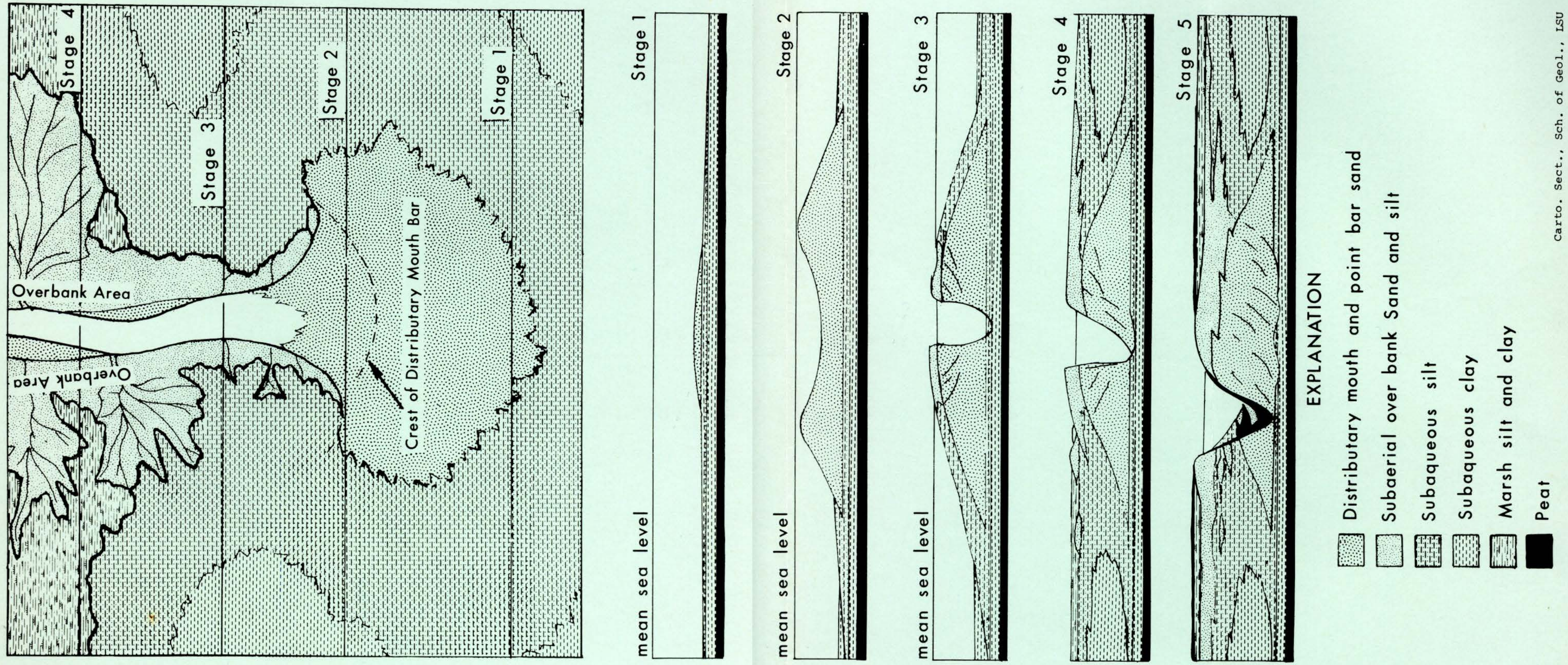
The remaining features of this stop are to be seen by walking northward along the road (toward the Ohio River) to the small bridge which crosses the railroad. In the road cuts and in the railroad cut below the bridge can be seen the outer margins of the distributary mouth bar. In this case the lower part of the bar deposits are riddled with roots and stumps and is interbedded with coal whereas in the upper part the amount of plant activity was apparently much reduced. This suggests that, in its initial stage, the bay was quite shallow but deepened, perhaps by loading, as more sediment was added. The lessening sand spread in the upper part of the bar is typical of this geomorphic feature in which minor (and ephemeral) channeling in the bar at the distributary mouth tends to concentrate major discharge into one or more narrow areas and at the same time provides a site for sediment accumulation on undissected portions of the bar. Ordinarily one of these "channelets" receiving the major flow becomes enlarged and lateral sediment dispersal is limited to finer grained materials which accumulate directly adjacent to the channel. Such overbank areas become sites for plants to take root providing an excellent sediment trap for the now even more restricted lateral discharge (stage 3 on figure 9). Thus in contrast to areas at the mouth bar and seaward accumulations of coarser detritus are limited primarily to the channel area. For those accustomed to "rock geology" the cuts at the railroad bridge are particularly instructive as they show a typical Pennsylvanian "channel sand," actually a distributary mouth bar, capped by a relatively coarse "bay fill."

As an additional item of interest, this stop is the approximate location of Linton, Ohio, a community long abandoned but famous for its vertebrate faunas collected from then active mines on the "Freeport" coal bed. The faunas which consisted of a variety of fish and amphibians as well as some of the earliest known reptiles apparently occurred in a very restricted area and, when the mines were abandoned, material became unavailable. The locality still does, however, have some local interest and amateur collectors in Wellsville and other nearby communities can be induced to show their finds.

		16A.	Reboard busses.
0.5	9.3	17.	Turn left onto Ohio 7.
0.2	9.5	18.	Cross Yellow Creek and Penn Central Railroad.
0.1	9.6	19.	Park on road shoulder at north end of bridge.

Stop 2.

To reach this locality, cross highway and follow foot path down the west side of the bridge abutment. To view this section in its entirety, one should cross the railroad and walk eastward beneath the highway bridge. Care is needed as the line is fairly heavily traveled and the curve to your left is blind. In the cut just west of the bridge abutment nearly the entire interval between the Middle Kittanning and Lower Freeport coal beds are exposed in a single cut (see figure 8). When the highway bridge was under construction abandoned clay workings, probably on the Lower Kittanning clay, were found below railroad level, the Middle Kittanning coal occurs about midway between railroad level and the overhanging sandstone ledge and the Lower Freeport coal bed lies just beyond the top of the cut. The sandstone is the lower part of the cut is the same distributary mouth



Evolution of distributary mouth and adjoining bays into alluvial deposits: a genetic explanation of cross section at Stops 1, 2, and 3 (figure 8). Cross sections indexed at areal map show deposits formed at any one stage of progradation as well as their relationships with previously deposited sediments. Stages 1 and 2 are essentially distributary mouth bar sands and off-shore silts and clays. Stages 3 and 4 show the outcome of levee development in the form of partial replacement of distributary sands by channel bar sands and filling of adjoining bays by finer grained sediment. As these bays become filled, coarser grained overbank sediments migrate over the filled surface producing a marsh. Stage 5 (a section further upstream and not on the map) shows the distributary-alluvial channel after abandonment. In the later stages of alluvial development, channel migration leads to replacement of distributary by channel bar sands and well developed levees present influx of detritus into adjoining back swamps except at very high water stages. Abandonment of the systems permits peat in increasing volume to accumulate in these back swamps and very thick accumulation of rafted plant material in the abandoned channel. Collapse of channel banks produces slump deposits on the margin of the channel.

FIGURE 9

bar sand that was seen at stop 1 in the railroad cut beneath the small bridge and its continuity between stops 1 and 2 can be verified by following it in the railroad cust westward from stop 2 and leveling into the stop 1 cut. The sand here is somewhat more robust as would be expected as we approach the distributary mouth and is overlain by a series of crudely bedded siltstones and silty sandstones formed on the flanks of the distributary channel (see stages 3 and 4 on figure 9). In a geomorphic sense these deposits could be termed natural levees but a more general term "overbank" is probably preferable. As pointed out at stop 1 deposits of this type, are critical in anatomical development of distributary sands in that they tend to fix the channel position. Aside from restricting the distribution of coarse detritus this event has two main effects: 1) the channel may then cut downward and at a later stage cut laterally in the familiar pattern of an alluvial channel and 2) bays adjacent to the channel are then cut off from major sediment influx and receive sediment either from overflow of the established channel or from reverse drift of fine material from the active channel mouth. As the delta progrades the latter mode becomes less important. In any event, these overbank sediments are distinctive components of the lower delta and can be distinguished both on the basis of internal characteristics and sequential position. An even better example of these sediments can be seen above the Lower Freeport coal bed near road level along Ohio 7 just north of where the buses are parked. Should time permit those interested may examine them in detail.

		19A.	Return to bus and proceed northward on Ohio 7.
0.5	10.1	20.	On left, Upper Freeport coal bed near road level.
0.4	10.5	21.	Park on right shoulder of highway.

Stop 3.

The main features of this exposure are best grasped by walking up grade on the east side of the road observing overall aspects and returning by the west side for details. The stratigraphic interval is the same as the two previous stops beginning with the Middle Kittanning coal bed and Washingtonville shale at the north end of the cut and ending with the thin Lower Freeport coal bed about half way up the road grade a short distance to the south (see figure 8). Between these two rather widespread coals is a highly erratic "Upper Kittanning" bed which is very thin near the north end of the cut but which thickens and disp sharply toward the south and disappears below road grade. A short distance further south the bed again emerges due to reverse of dip but is here badly disturbed by penecontemporaneous slumping. Throughout the exposure this bed lacks a seatrock, contains much "slate" and "bone" indicating a mass of rafted plant material rather than an "in situ" coal. The sandstone between the "Upper Kittanning" coal and Washingtonville shales is correlative with the distributary mouth bar sands at stop 2 but probably represents a well developed late stage alluvial feature (see 5 on figure 9). At least some of the sand probably represents the distributary mouth bar but the very large "accretion" type bedding suggests a lateral channel bar or point bar. The convex depression in this sand now occupied by the "Upper Kittanning" coal bed is probably the last site of open flow before abandonment and the coal itself represents plant materials accumulated in an essentially "dead water" slough. Bank collapse on the south wall of the channel after accumulation of rafted peat is indicated by slump deposits near road level. Later occupation of the same channel by a high energy system is indicated sandstone now overlapping the "Upper Kittanning" coal. This post "Upper Kittanning" channel system is very well exposed here and shows the same arrangement as the underlying one--namely sands underlying and laterally grading into fine grained overbank deposits.

It should be noted on figure 8 that the "Upper Kittanning" coal bed in this area occupies a position relatively close to the "Lower Freeport" seam fossil fauna at Linton and like the Linton bed occurs as a very local deposit. Should earlier correlations have been in error by only a few feet, this exposure may provide considerable insight into the nature of the earlier fossil locality.

		21A.	Return to bus and continue northward into Wellsville.
0.9	11.4	22.	Junction with Ohio 39, proceed straight.
0.1	11.5	23.	Turn right on Ohio 7-39.
0.1	11.6	24.	Sharp left on Ohio 7-39.
1.3	12.9	25.	Left on Ohio 7-39.
0.2	13.1	26.	Sandstone in bluff just ahead overlies the Lower Kittanning coal bed.

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0.0	13.1	27.	Right on Ohio 7-39.
		28.	Left on Ohio 45 from Ohio 7-39.
0.2	13.3	29.	Left into parking lot of Ohio Roadside Park. Lunch stop.
		29A.	Continue northward on Ohio 45.
0.5	13.8	30.	On right, mine of the Porter Brick Company on the Lower Kittanning clay.
0.1	13.9	31.	On right, sandstone overlying the Lower Kittanning coal bed.
0.2	14.1	32.	Park on right.

Stop 4.

The cut at this stop extends from the Lower Kittanning clay at the Porter Mine to the approximate position of the Upper Freeport coal bed slightly further up the hill (see figure 10). The "Upper Kittanning" coal, here very thin and overlain by the "Washingtonville" marine beds are exposed in the cut slightly above the level of the parking area. The Lower Freeport coal bed is exposed at the sharp curve slightly up grade from the parking area.

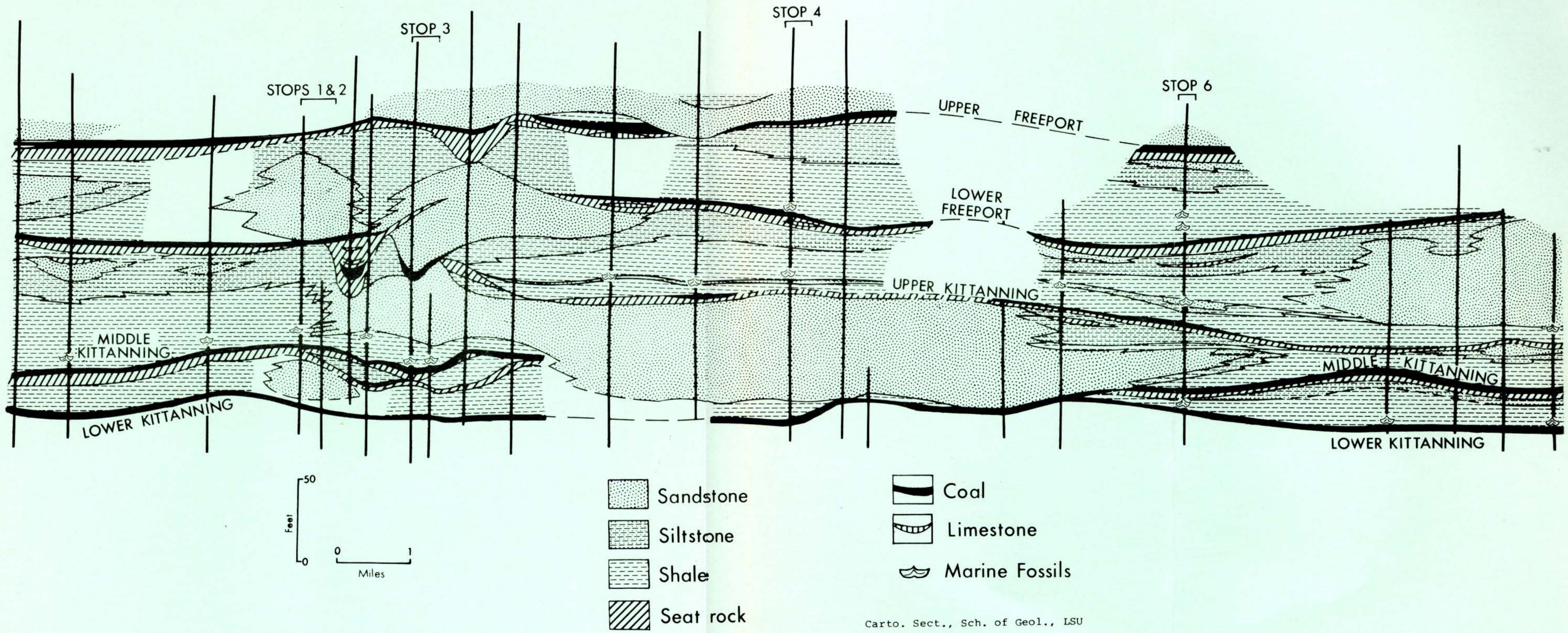
The principal feature of this exposure is the reversal in stratigraphic position of sandstone and "bay fill" sequences. At stops 1, 2, and 3 the "Upper Kittanning" to Upper Freeport interval was dominated by bar sands and overbank but are here replaced by "bay fills." Likewise the Lower-Upper Kittanning interval at stop 1 was primarily clay shale and coal but is here occupied by sandstone (see figure 10). This offset arrangement of sands and finer detritus is typical of delta plain deposits and arises from greater compaction of the area underlain by finer detritus and subsequent attraction of channel flow into physiographically lower areas. It also accounts for the overall uniformity of intervals between major widespread Pennsylvanian coal beds in contrast to the very rapid local variation in interval between beds.

		32A.	Return to bus. And proceed up the hill.
0.4	14.5	33.	Turn around in area near sign advertizing "Indian Hills", Museum and retrace route to junction of Ohio 7-39 and Ohio 45.
1.2	15.7	34.	Junction of Ohio 45 and 7-39, turn left.
2.3	18.0	35.	Disembark from bus which will proceed forward and park where road shoulder is wide enough. This stop is very risky as there is practically no road shoulder and the traffic often fast and heavy. Please remain on south side of road, observing cut on opposite side and walk forward toward the parked busses.

Stop 5.

This spectacular exposure shows the upper part of the Pottsville in the lower part of the cut, the interval between the "Brookville" coal and Lower Kittanning coal in the upper part and the sandstone overlying the Lower Kittanning (see stop 4) can be seen through the trees above the cut. The Pottsville here is composed of two major facies--finer grained silts, thin sands and seatrock clays and the thick sandstones. The seatrocks are well developed and, in the past, have been used by the brick industry. Such deposits probably represent ancient soils and the intercalated shales and laminated silts and thin sands were probably deposits in shallow ponds. The only place in the cut were lateral relationships between the finer grained sediment and the thick sands can be observed is a splendid example of erosional scour. In other localities, however, the relationship seems to be one of interfingering and there is too little data for precise environmental interpretation.

The beds above the Pottsville in the upper part of the cut is clearly a "bay fill" type sequence grading from fine grained dark shales and marine limestone (Putnam Hill?--Vanport?) upward through silty shale to siltstone and thin bedded sandstone at the top. This particular sequence, however, is extraordinarily widespread (see figure 2) in northeastern Ohio and, unlike deposits between the Middle Kittanning and Lower Freeport coal beds, is rarely interrupted by sandstone. The areal distribution of this widespread sequence between the thick Vanport limestone to the north and increasing intercalation of sandstone to the south (figure 2) as well as internal characteristics indicate that this unit can properly be referred to as a delta front where silts and clays from the distributary mouths are spilled out into a subaqueous marine setting. This cut as well as others in the immediate vicinity, shows that the surface over which this delta built was highly irregular as



Stratigraphic cross section of rocks between the Lower Kittanning and Upper Freeport coal beds in the Ohio Valley between Hammondsville Ohio and the Pennsylvania state line showing locations of Stops 1, 2, 3, 4, and 6. Locations of sections indicated on figures 5 and 6. Details of Steps 1, 2, and 3 area shown on figure 8.

FIGURE 10

the initial beds are confined to ancient topographic lows whereas later beds spread entirely across the outcrop. The upper surface, not shown here, is also highly irregular probably due to development and abandonment of distributary and interdistributary areas.

0.5	18.5	36.	Reboard bus and proceed eastward along Ohio 7-39.
0.4	18.9	37.	Junction with U.S. 30 bear right.
		38.	Turn left.
		39.	Turn left.
0.7	19.6	40.	Entrance to Traveler's Hotel--end of first day's trip.

ROAD LOG (Second Day)

0	0	41.	Leave Traveler's Hotel as previous day.
0	0	42.	Turn left.
0.1	0.1	43.	Turn right onto U.S. 30.
0.6	0.7	44.	Junction of Ohio 7-39 proceed straight on 30.
3.2	3.9	45.	Junction of Ohio 170, turn left.
0.2	4.1	46.	Turn left again onto eastbound U.S. 30, approximate position of Conemaugh Brush Creek limestone. Begin California Hollow sections which expose in one place the entire Allegheny marine beds. Only one stop will be made on this hill but some of the more significant features will be pointed out so that those interested may visit them later.
0.7	4.8	47.	On right, in cut at highway overpass, Upper Freeport coal bed overlain by sandstone.
0.4	5.2	48.	Cut on right shows Lower Freeport coal bed overlain by thick bay fill type sequence. About ten feet above the top of the coal, shale contains phosphatic brackiopods. (Dorr Run member)
0.5	5.7	49.	Coal bed on right is the Upper Kittanning and directly overlying is a 20 foot thick "bay fill" type sequence with marine fossils (large productids) in the thin sand at the top. This fossiferous zone is equivalent to the marine bed at stop 4 (figure 10) and is widely distributed in the area directly adjoining the Ohio River Valley. Northward the Upper Kittanning and Middle Kittanning coal beds converge and the marine zone is known as Washingtonville.
0.5	6.2	50.	Park on right shoulder.

Stop 6.

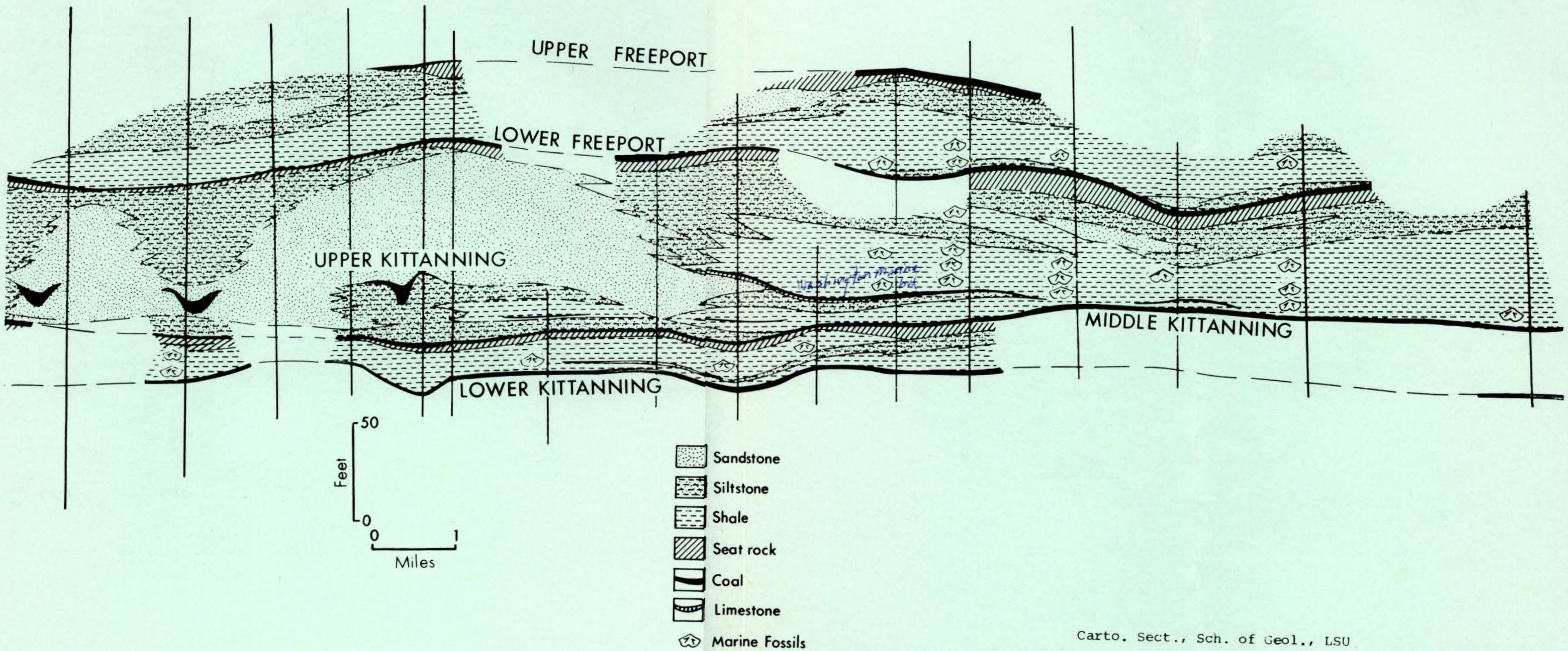
This cut included strata from the Lower Kittanning clayey seatrock at the base to slightly above the Upper Kittanning coal bed at the top (see figure 10). The interval here between the Lower and Middle Kittanning coal beds is typical for the area consisting of a relatively thin sequence of dark ironstone bearing shale containing some marine fossils (Columbiana) overlain and graditional into the seatrock of the Middle Kittanning coal. This type of sequence is characteristic of coastal areas marginal to deltas where indigenous deposits--peats soils and limestone--are interbedded with fine grained detritus drifted laterally from the delta front. In this particular case the major delta area is known to lie about 80 miles to the east in western Pennsylvania.

At this stop the sandstone and siltstone overlying the Middle Kittanning represent the diminishing edge of the major sand body that dominates the interval between the Lower and Upper Kittanning coal beds between Wellsville and East Liverpool. Eastward in the Ohio Valley area, other bodies of sand appear at this stratigraphic position but are overshadowed by and merged with a much thicker series of sands overlying the Upper Kittanning coal bed (figure 10).

		50A.	Return to bus and proceed eastbound on U.S. 30.
0.4	6.6	52.	On right, hill slope composed of Lower Kittanning clay.
0.1	6.7	53.	On right, delta front deposits between Lower Kittanning and "Brookville" coal and seatrock (the latter here are very thin).
0.1	6.8	54.	On right complex Pottsville siltstones below "Brookville" coal-seatrock. The latter is shown by wet zone near the top of the slope.
0.3	7.1	55.	Turn right toward Ohio 7-39.
0.4	7.5	56.	Turn left on Ohio 7-39.

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0.1	7.6	57.	Turn left onto access road toward westbound U.S. 30.
0.5	8.1	58.	Join westbound U.S. 30.
2.8	10.9	59.	Junction U.S. 30 and Ohio 170, turn right.
1.1	12.0	60.	Calcutta, Ohio, once a rural crossroad is now a suburb of East Liverpool. Left on Ohio 170.
0.1	12.1	61.	Right on Ohio 170.
1.5	13.6	62.	For the next mile the road flanks a steep walled valley cut into Allegheny rocks. Sandstones in the upper two thirds of the Allegheny support steep valley walls in contrast to rolling open land on the right underlain by less resistant Conemaugh strata.
1.1	14.7	63.	Small exposures on right in the Allegheny.
0.9	15.6	64.	Bridge across Little Beaver Creek. This valley is cut into the Pottsville orthoquartzites which are exposed in the creek bed on the right.
0.0	15.6	65.	Fredricktown, Ohio, for the next mile the road climbs steep walled valley supported by Allegheny sandstones.
1.3	16.9	66.	Next 2 miles on rolling Conemaugh upland.
3.3	20.2	67.	Small outcrop of Lower Freeport coal at the road junction. Strip mines on the Upper Freeport? or Mahoning? coal on opposite side of valley.
0.9	21.1	68.	Upper part of delta front sequence between Lower Kittanning and "Brookville" coals exposed on left.
0.5	21.6	69.	Bottom land of North Fork of Little Beaver Creek.
0.6	22.2	70.	Negley, Ohio; junction of Ohio 170 and Ohio 154 turn right on 154.
0.6	22.8	71.	Turn left off Ohio 154 onto "blacktop" road. Lower part of Brookville-Lower Kittanning delta front sequence exposed in creek bed on opposite side of flood plain. Strip mines on Lower Kittanning clays about 2 miles due south.

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0.2	23.0	72.	Cross tracks of the Youngstown and Southern Railroad.
0.8	23.8	73.	Cross Ohio-Pennsylvania state line; now on Pa. Rt. 651; steep valley slopes contain thick sandstones above the Upper Kittanning coal.
0.8	24.6	74.	On the left strip mine in the Lower Kittanning clay, brick works on the right.
1.7	26.3	75.	Cannelton, Pa. site of intensive mining of the Upper Kittanning coal (Darlington cannel) in the late 1800's. This coal, described as a bow or canoe shaped deposit with a length of about 3.5 miles and maximum width of about 600 feet presumably reflects filling of an abandoned distributary channel by fine grained organic sludge. The coal was thickest near the center line of the deposit and consisted of a bituminous layer (0.5' to 1') overlain by up to 12 feet of cannel. Massive sandstone formed the roof rock, and the coal rested upon dark sandy shale rather than seatrock. The latter yielded a diverse well preserved flora as well as a small eurypterid, *Eurypterus mansfieldi.* Similar, less developed cannel deposits were reported at several localities in the Cannelton-Negley area (figure 11).
0.2	26.5	76.	Cross railroad tracks.
1.8	28.3	77.	Cross Pa. 51.
0.3	28.6	78.	Junction with old Pa. 51; turn right.
0.2	28.8	79.	Old brick kilns on left, active during World War II.
0.5	29.3	80.	Cross tracks of Youngstown and Southern Railroad; brick plant on left is said to be one of the most modern automated plants in the U.S. Lower Kittanning clay, now trucked in from open pit mines was formerly mined on right side of road. Abrupt hill slope behind plant formed by thick sandstones occupying the interval between the



Carto. Sect., Sch. of Geol., LSU

Stratigraphic cross section of rocks betweenthe Lower Kittanning and Lower Freeport coal beds between Negley, Ohio and New Castle, Pa. Location of section on figures 5 and 6.

FIGURE 11

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
			Middle Kittanning to the Lower Freeport coal beds (figure 11).
0.1	29.4	81.	Enter Darlington, Pa; home of both the Darlington and Beaver Valley Polo Clubs.
0.3	29.7	82.	Junction with Pa. 168; continue straight onto Pa. Rt. 168.
0.6	30.3	83.	Road junction. Continue on Pa. Rt. 168 (right fork) at Darlington Lake Recreation Area.
0.3	30.6	84.	Cross North Fork of Little Beaver
0.3	30.9	85.	Turn right into light duty road.
0.4	31.3	86.	Park on right west of Penn Central Railroad overpass; proceed southward along trail across Clark's Run to strip mine on Lower and Middle Kittanning coals.

All of these attributes in addition to the position of this outcrop on the frontal edge of the crevasse system facing the open bay suggest considerable reworking of the prograded front by minor wave action and longshore drift. Such an explanation would account for the flat scour surfaces, better sorting of the sediment, as well as cross beds contrary to the direction of sediment introduction. Finally the thin persistant sand beneath the Upper Kittanning coal bed would not have been possible without periodic reworking of the marsh surface.

			Return to busses.
0.4	31.7	86.	Return to improved road.
		87.	Turn left.
0.3	32.0	88.	Junction of Pa. 168, turn left.
0.7	32.7	89.	Road junction (near Darlington Lake) turn right.
0.3	33.0	90.	On left, abandonded strip mine which exposes Lower, Middle, and Upper Kittanning and Lower Freeport coal beds.
0.5	33.5	91.	Bear left onto secondary road at bridge.
0.4	33.9	92.	Turn right, down slope.
0.6	34.5	93.	Crossing broad valley flat. From this general area northward effects of the Wisconsin ice sheet become more pronounced. Even the smallest valley may be filled with outwash and an increasing number of low slopes and hills bear a blanket of till.

DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0.3	34.8	94.	Turn left at road fork.
0.8	35.6	95.	Road junction, turn right and then in a short distance take left fork.

Stop 7

Most of the previous stops on this trip have demonstrated aspects of distributary channel development adjoined by deep bays where the fills were simple. For the remainder of the trip we will observe areas that are both seaward of and marginal to the main distributary path (figures 5, 6, 7, and 11) and although probably equally deep, received a distinctly different sediment imprint. First, due to the marginal position (the major channel lay approximately through Negley) the major fill mechanism was the crevasse distributary which, unlike ordinary overbank deposition, carries sediments far out into a subaqueous bay which is much larger than the amount of sediment fill. Thus the deposits will have attributes of a major distributary but there is much greater tendency for reworking and lateral transport yielding sand bodies with a sheet-like aspect. Also coarse sandy detritus is not abundant and many features of the major distributary which are made obvious by grain size contrasts between sand, silt and clay appear here only in subdued forms composed of silt and clay. Finally, the major distributaries are not so confined as in the landward direction and thus tend to produce broad, flaring sheet sands which are partly distributary in origin, but with a strong flavor of longshore drift and beach-bar type reworking.

A cross section of the marginal area that we will examine today is shown on figure 11. The groups of rocks with which we will be particularly concerned is, as in the earlier parts of the trip, the interval between the Middle Kittanning and Lower Freeport coals, two beds that seem to extend completely across the area. The Upper Kittanning coal bed is less widespread, rising stratigraphically westward as it approaches the main distributary channel and diminishing in thickness eastward as it falls toward the position of the Middle Kittanning coal. Strata between the Upper Kittanning and Lower Freeport beds on the western part of the section are dominated by thick distributary channel type sandstones similar to those at stops 1, 2, and 3. These grade north-east- into a major bay fill, similar to that above the Middle Kittanning coal south and west of Wellsville.

The Middle-Upper Kittanning interval which is very well exposed throughout the area and will command our greatest attention is substantially a minor bay and crevasse distributary for a time fed by a major channel lying to the west. For convenience this interval can be divided into three parts:

1. a lower shaley portion directly overlying the Middle Kittanning coal which, becoming coarser upward, reflects silts and clays covering the bay floor gradually increasing in grain size with the approach of the crevasse;

2. a middle sandy portion which represents the the sands related to the crevasse channels and

3. a finer grained upper portion reflecting the reduction of sediment influx as the system is abandoned. The overlying Upper Kittanning coal bed indicates total abandonment of the system and a return to accumulation of indigenous deposits. Variation in each of these lithic components between the Middle and Upper Kittanning coals reflects distinctly different outcomes in the crevasse system that is subjected both to sediment influx by one or more crevasse channels and to dispersal processes of the open bay.

This cut at stop 7 (see figure 12) which exposes mainly the interval between the Middle and Upper Kittanning beds, although apparently simple, is one of the most subtle and complex in the area. The tripartate division of lower finer grained zone, middle sandy zone, and upper finer zone is immediately apparent but the complexities emerge as the character of the middle sandy zone is examined in detail. First both base and upper surface of the more persistant sand unit is marked by a distinct scour surfaces which extend the entire length of the pit. Second there is a greater tendency for separation of grain sizes than is usually seen. This is manifest in two ways. First, excepting for the lowest sand ledges, most sands are separated from interbedded silts by very sharp contacts at both top and bottoms of the beds. Secondly, each bed of sand and finer material is internally very well sorted. Finally adding to an already complex situation the large planar type cross beds of some of the thicker sands tend to dip *toward* the direction of sediment supply (westward in this case). In addition the zone of finer grained sediment above the sands is anomalous in that a thin but persistant sand directly underlies the Upper Kittanning coal bed rather than the usually clayey seatrock.

0.5 36.0 96. Strip mines exposing the Lower Middle and Upper Kittanning coal beds on both sides of road.

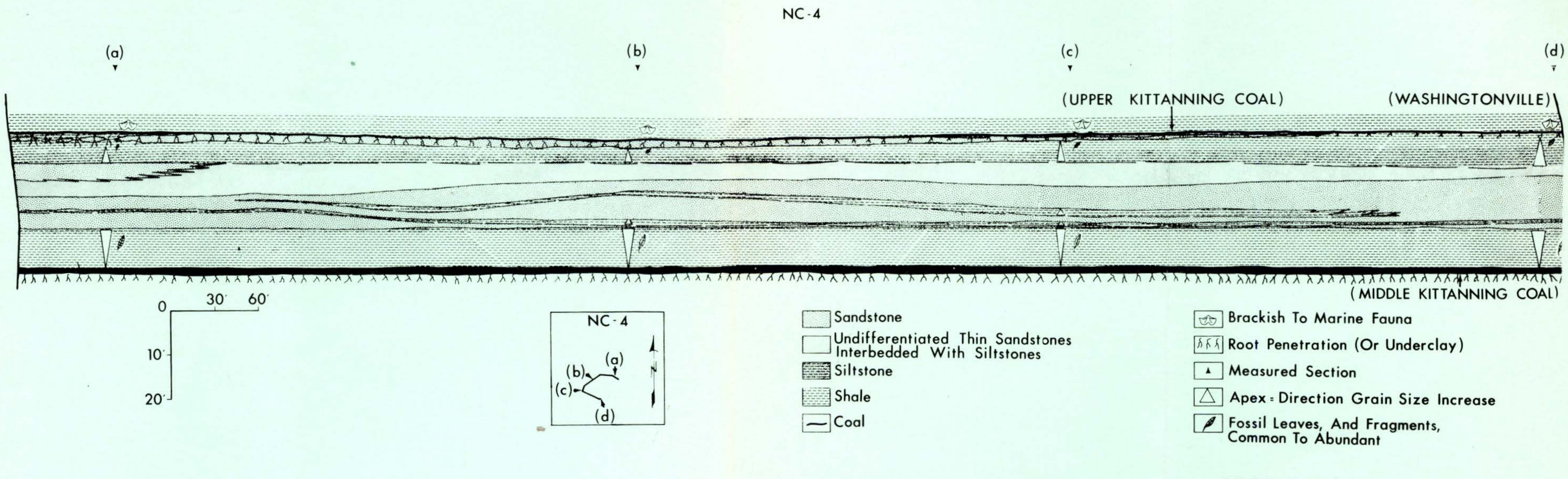
0.3 36.3 97. Stop 8.

Stop 8

Because the mines here are still active exact locations suitable for observing specific features are uncertain. Therefore this point in the log indicates a general location rather than a specific point of entry into the pits.

The cuts in this series of pits expose strata from the Lower Kittanning coal at the base upward to slightly below the Lower Freeport bed at the top. As in most localities in this area, the interval between the Lower and Middle Kittanning beds is composed of dark shale and silty shale with seatrock at the top whereas the Upper Kittanning-Lower Freeport interval is composed of gray "bay fill." Because this location is near the margin of the main distributary system, some of the cuts show excellent examples of interfingering of distributary and bay fill sediments.

The interval to which we draw attention, as in stop 7, is that between the Middle and Upper Kittanning coal beds. In general the sequence of a lower and upper fine grained zone and a middle sandy unit is the same as at the last stop but beyond this the similarity ends. Figure 13, a representative section of part of the sandy zone and, in fact, this segment of the interval represents a cross section of a number of low flat cones of silt and sand with sand concentrated in the central and upper part of the cone. Sand and silt beds within each cone or "pod" consist of sand-silt couplets with minor scour at the base of the sand which shows small scale trough and planar cross bedding. The sand beds, unlike those at stop 7, *grade* upward into silt with locally developed climbing ripples at the contact and with finer lenticular to parallel lamination within the silts. These sand-silt couplets have an amazing lateral extent and many can be traced from the central sandy portion in which the sand component dominates outward and downward parrallel to the upper surface of the cone where they pass into a laminated silt unit with a very thin sand bed at the base. The arrangement of these "turbidite"-like deposits within the silt-sand cones suggest a minor point source in the form of a very small distributary mouth which discharges its sediment in periodic pulses. Because several such pods can be observed at nearly the same stratigraphic position within this small area of outcrop, a highly diffuse multiple channel system can be visualized.



Cross section of portion of cut face at Stop 7 showing rocks between the Middle and Upper Kittanning coal beds. The environmental setting is a filled interdistributary bay with partially reworked crevasse sands.

FIGURE 12

The uppermost sandstones below the upper Kittanning coal bed continue with patterns of the lower ones with the major exception that instead of grading into underlying finer grained sediments they occupy truncating, scoured troughs in the underlying beds. This suggests the arrival of a much better organized channel similar to but at a much smaller scale than those of the major distributaries seen at stops 1, 2 and 3. The position of these channels, however, is controlled by similar to the underlying silt zone in that they occupy topographic lows between sites of major accumulation of underlying material.

Characteristics of the upper finer sediments above the sand sequence, the Upper Kittanning coal, and the Washingtonville shale on figure 13 also illustrate the influence of local topography during the overlap and burial of the crevasse system. The first is the absence of roots in rocks directly beneath the Upper Kittanning coal in areas directly at the side the thickest underlying sand. In an environmental sense this indicates an absence of plant growth in areas directly adjoining the old channel system. In the Lower Mississippi River such ponded areas are known as "levee flank depressions" and are ascribed to greater compaction beneath areas of thick sand introduction which is not filled with sediment except at the exact channel site.

The second effect of local topography is shown by the obvious absence of Washingtonville fossils over areas where the underlying sand is the thickest. Apparently these areas remained as local, perhaps subaerial, highs inhospitable to marine-brackish life.

			Return to busses.
0.3	36.6	97.	Continue northerly.
0.4	37.0	98.	Junction with Pa. 351 at Lawrence-Beaver County line; turn left.
0.5	37.5	99.	Cross above Penn Central
0.7	38.2	100.	Enon Valley, Pennsylvania, a rural village with strong Menonite and Amish flavor.
0.3	38.5	101.	Junction with Pa. 551, turn right onto Pa. 351-551.
0.9	39.4	102.	Continue right on Pa. 551.
0.1	39.5	103.	Cross North Fork of Beaver Creek.
0.9	40.4	104.	Cross above Pennsylvania Turnpike; strip mines on the right show the Lower and Middle Kittanning coal beds. In this area, the Middle and Upper Kittanning coals have converged and a thick, fossiliferous marine silty shale (Washingtonville) overlies the coal.
1.4	41.8	105.	Junction with Moravia-Petersburg Road; continue north on Pa. 551. Strip pit ahead to left also contains converged Middle-Upper Kittanning coal.
1.1	42.9	106.	Derringer Corners, turn right onto Pa. Alt. 551.
0.4	43.3	107.	Turn left onto mine road. Park.

Stop 9

The coals exposed in these pits are the same seen at stops 7 and 8, the Lower Middle and Upper Kittanning, and as in our last stop we will further examine characteristics of the Middle-Upper Kittanning crevasse system. The cut face that we are examining is illustrated on figure 14 and its location is indicated as NC-43-2.

The facies pattern here is almost exactly that of stop 8, i.e., low flat silt cones composed of thin "turbidite"-like sand-silt couplets, except that the amount of sand is greatly diminished, a predictable consequence of moving basinward within the system. Some of the couplets show both sand and silt components but others are almost entirely silt. At some places the coarser component is represented by small lenticular trough-shaped crossed bedded units indicating current regime substantially the same as at stop 8 but operating in a sand starved system.

The most striking feature of this exposure is the bow shaped depression occupied by the Upper Kittanning coal and the Washingtonville shale. This depression is similar to the deep channel scour in stop 8 in that it occupied a topographic low between two mounds of underlying silts but differs in its manner of fill. At stop 8 the volume of sand was apparently sufficient to plug the channel slot but here, after abandonment, the channel was left as an open water depression to be filled first by plant material now represented by a thickened mass of Upper Kittanning coal, and later by limey marine or brackish clays now reflected by a dark limestone and dark shale containing a diverse and abundant fauna which includes, among other things, solitary corals. This limey precipitation also had its effect on the underlying peat, producing a large coal ball near one edge of the depression. This type of fill of an abandoned channel presents an interesting contrast to those in the upstream part of the same system which filled with either woody rafted peat or cannel-producing finer particulate matter.

Return to busses and while in parking area note large pit north of the east-west trending Pa. Alt. 551. In this cut the Middle Kittanning coal bed is overlain by a distributary mouth bar sandstone with a maximum exposed thickness of 15 feet. At its thickest point the lower part of the sand has the familiar large scale cross bedding which grades rapidly upward to small scale ripples in the upper part. The sand is flanked by poorly sorted steeply dipping overbank silts which pass horizontally into laminated silts and clays. This feature, when compared to the cut that we have just visited, illustrates the "ragged" nature of the outer fringe of the crevasse system. At one place sufficient sand is present to produce a moderate sized bar and a short distance away only silts and clays are available.

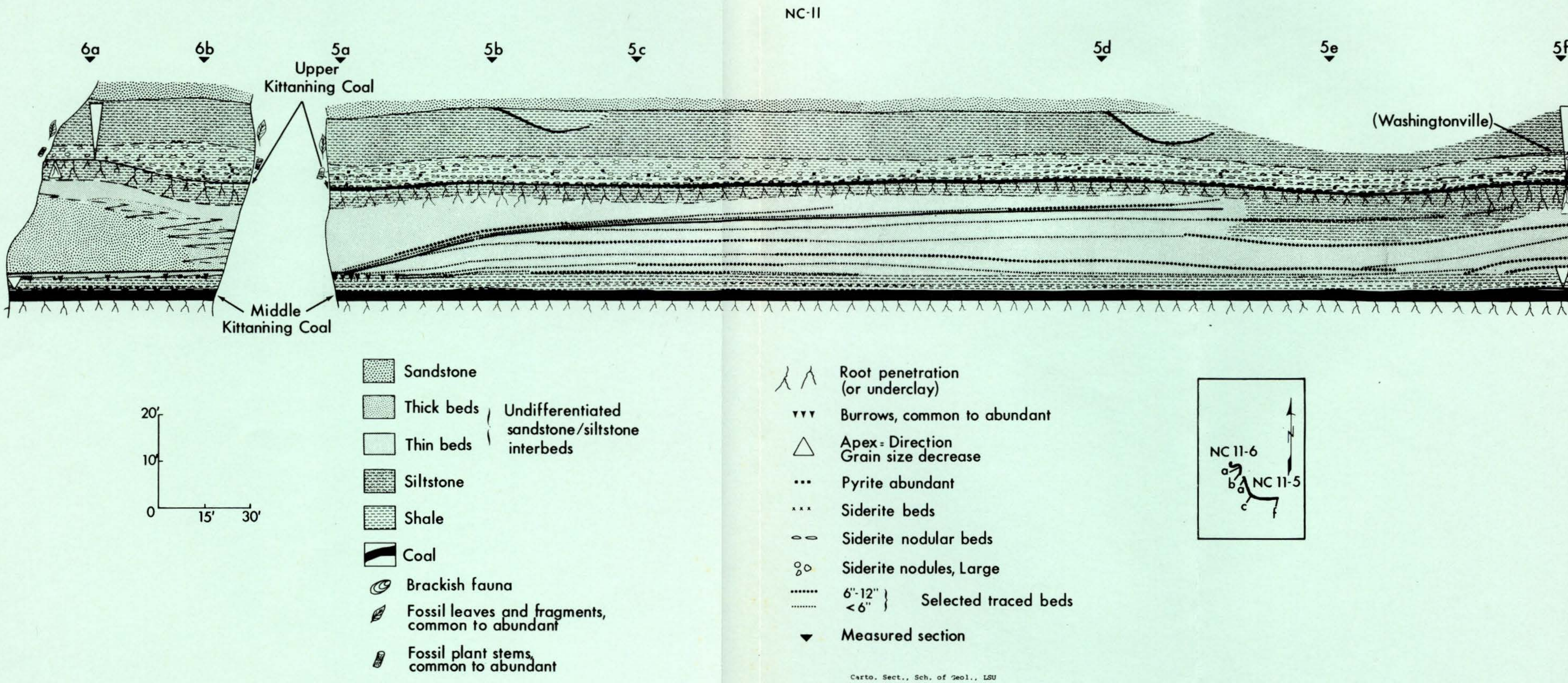
		108.	Reboard busses and retrace route earth road.
0.8	44.1	109.	Junction with Pa. 551 at Derringer's Corners, turn right.
1.3	45.4	110.	Junction with Pa. 108, continue straight on 108-551.
0.3	45.7	111.	Road fork, bear left off Pa. 108-551 onto Small's Ferry Road.
2.0	47.7	112.	Junction of Pa. 317, with railroad crossing just beyond junction; continue due north.
0.3	48.0	113.	Road fork, bear right. Deep pits on left are quarrys in the Vanport limestone (slightly over 20 feet thick here). The Vanport limestone, essentially the offshore equivalent of the "Brookville" to Lower Kittanning delta front in the Ohio Valley, is a stone of high purity and widely used as a blast furnace flux, cement stone, and road metal.
0.5	48.5	114.	Junction with Edenburg Road, turn left.
0.6	49.1	115.	Turn left at junction with Hoffmaster Road.
0.4	49.5	116.	Turn south on work road into pit.
0.2	49.7	117.	Stop 10A.

Stop 10A

This stop in conjunction with closely adjoining 10B is perhaps the most spectacular of the trip as it shows the "seaward" equivalent of Lower Allegheny rocks that have been observed in the Ohio Valley area. The interval between the Lower and Middle Kittanning coal beds which at the last stop was composed mainly of dark silts and clays here consists of 20 feet of clean sand with locally abundant mud cracks and animal borings. We formerly believed these sediments to be a southward progradation from a northern source. It now appears equally likely that these sands represent the shoreward side of a north facing beach barrier system and that the dark ironstone bearing marine clays in the Ohio Valley may have accumulated in a shallow lagoon which extended to a swampy shoreline still further to the south. (In the subsurface this shoreline was probably hear Wheeling, W. Va. and on the outcrop near Zanesville, Ohio.)

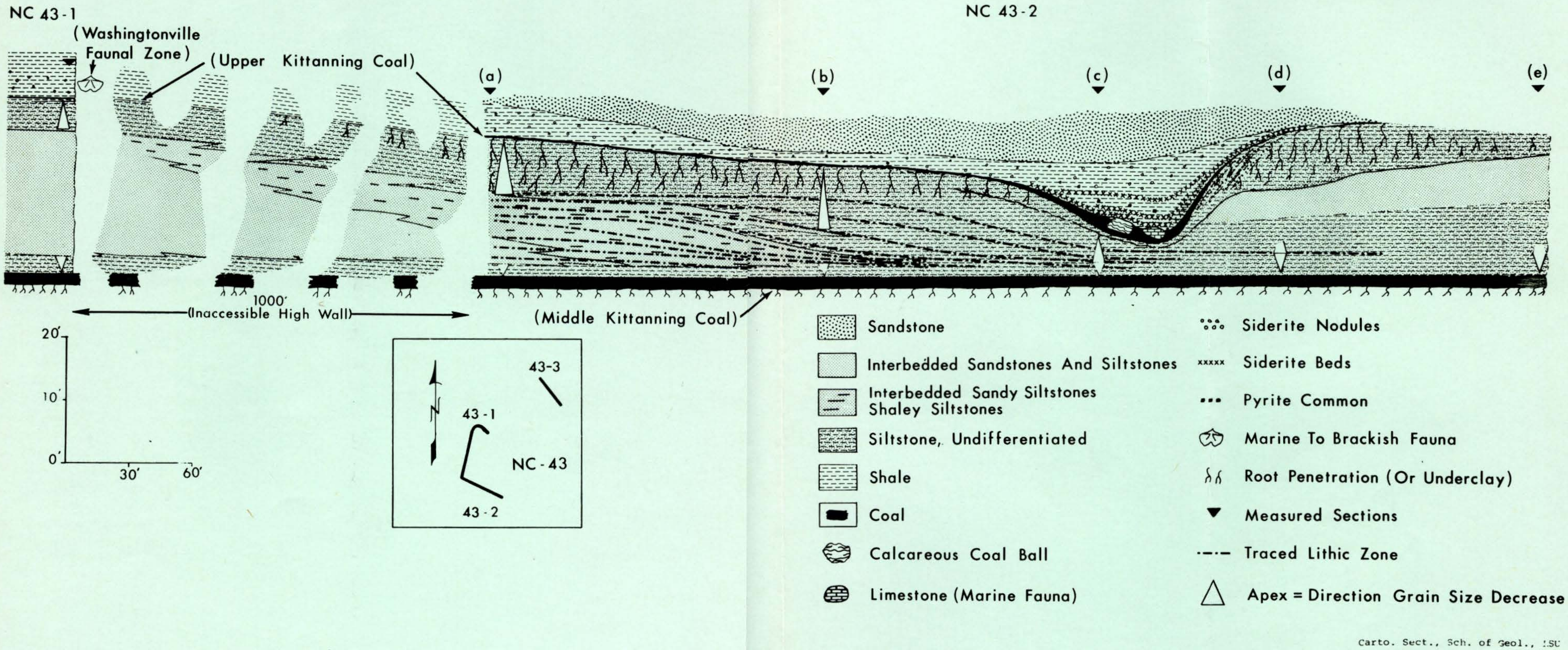
The rocks above the Middle Kittanning coal bed[1] in this cut have been studied in great detail and seem to represent the evolution of a "chenier" or scoured and backfilled beach overrun from the north by a transgressive offshore barrier bar. Figure 15 (NC-50/1) depicts the north-south wall as mapped in the summer of 1967, while figure 16 illustrates the inferred evolution of the system. Stages 1 and 2 on figure 16 illustrate the two major components in their earliest form, the "chenier" on the south formed by wave scour of an older marsh deposit and deposition of winnowed sand on the eroded surface. These sands grade seaward into silts and clays slightly offshore. The latter deposits in turn pass in a seaward direction (northward here) into a flaggy orthoquartzitic offshore bar sand formed mainly by longshore sand drift. Stages 3, 4 and 5 show a continuation of the main depositional elements consisting on the "chenier" side of periodic demise of the scour and fill process and overlap by marsh clay and peats. On the seaward side, the bar sand gradually grows and advances toward the chenier area dnd partial erosion of both marsh and chenier deposits by "runback" of waves and tides which now pass over the bar into the back beach area.

[1] The Upper Kittanning coal cannot be recognized this far basinward. At some places it merges with the Middle Kittanning, but at others, it seems to pinch out just before it reaches the top of the Middle Kittanning.



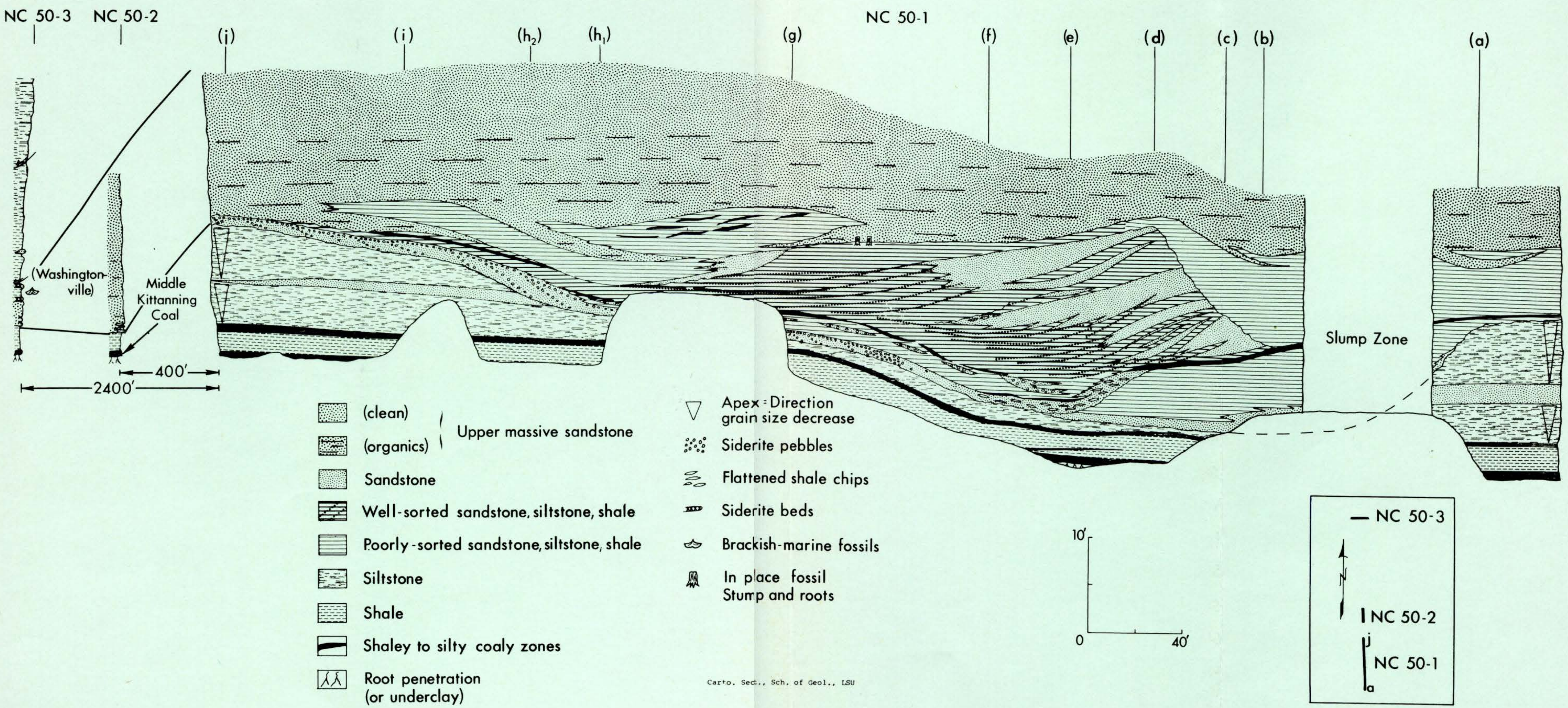
Cross section of portion of cut face at Stop 8 showing rocks between the Middle and Upper Kittanning coal beds. This outcrop shows overbank crevasse deposits with little sediment reworking.

FIGURE 13



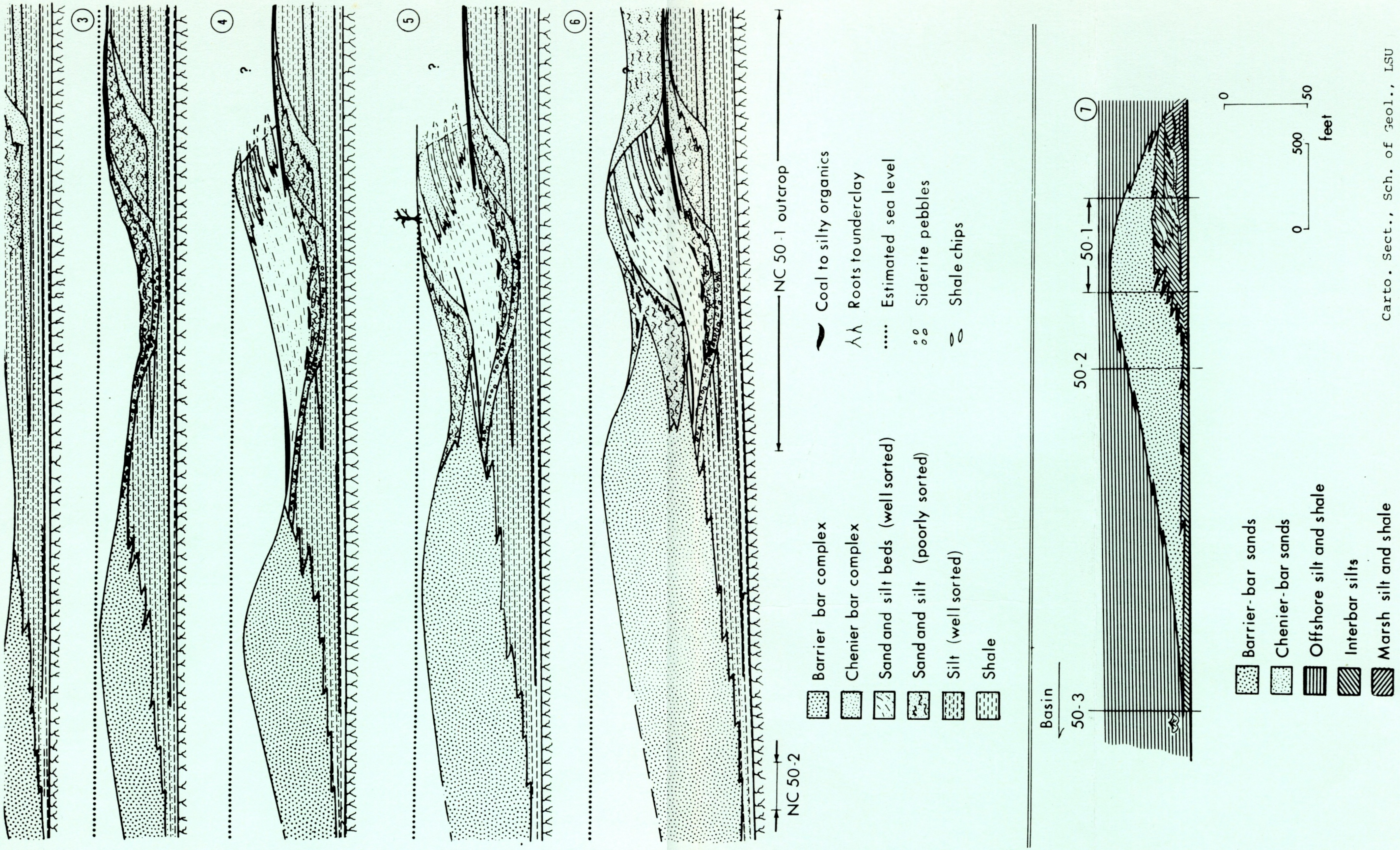
Cross section of cut facies at Stop 9 showing strata between the Middle and Upper Kittanning coal beds. This outcrop represents a sand starved portion of the distributary-crevasse system with a minor abandoned channel filled with marine-brackish clays.

FIGURE 14



Cross section of cuts at Stop 10A and B showing strata above the Middle Kittanning coal bed. These rocks represent a partially prograded beach overlapped from the north by off-shore bar. Evolution of this deposit is shown on figure 16.

FIGURE 15



Inferred evolution on the beach-bar complex at Stop 10A and B (see figure 15). The overall pattern is one of scour of the marsh face and progradational fill by chenier-like beaches concommitant with advance of off-shore bar over older beach deposits.

FIGURE 16

Post-shoreline events are shown on the final section of figure 16 which is based on partial exposures a short distance to the north. The northernmost of these show the thin seaward edge of barrier bar overlapped by the Washingtonville fossil bearing shale which is in turn overlain by thick "bay fill" type dark silty clays. These latter deposits indicate delta front deposits formed in advance of the next succeeding delta lobe.

			Reboard busses and return on work road to Hoffmaster Road.
0.5	50.2	118.	Junction of Hoffmaster Road and Edenburg Road, proceed straight.
0.5	50.7	119.	"Limestone Quarry Company"

Stop 10B

This series of cuts (see NC-50-3); figure 15) is approximately one half mile north of stop 10A and exposes strata between the Vanport limestone at the base and about 40 feet above the Middle Kittanning coal bed at the top. The strata between the base of the Vanport and the Lower Kittanning coal bed represents the seaward edge of the thick delta front in the Ohio Valley. The limestone reflects the seaward edge of the delta model shown of figure 2 and the overlying greenish gray "bay fill" type shales and silts the offshore and much reduced delta front portions. The Lower to Middle Kittanning interval which a short distance to the south was composed mainly of quartzose sandstone is here mainly silt and shale with a few thin sandy beds. Phosphatic brachiopods have been found in the shales directly above the coal. Strata above the Middle-Upper Kittanning are an extention of the same interval shown on figure 15 and reconstructed on the last cross section on figure 16. The thin seaward extention of the barrier bar sand closely overlies the coal and the upper surface is heavily bioturbated. The overlying bay fill sequences are cut here by at least two prominent north facing penecontemporaneous slumps. Slumps of this type and mud flow on the delta front of the Mississippi are currently being studied by personnel of L.S.U. Coastal Studies Institute.

			Reboard busses and return to Quarry entrance.
0.4	51.1	120.	Junction with Edenburg Road, turn left.

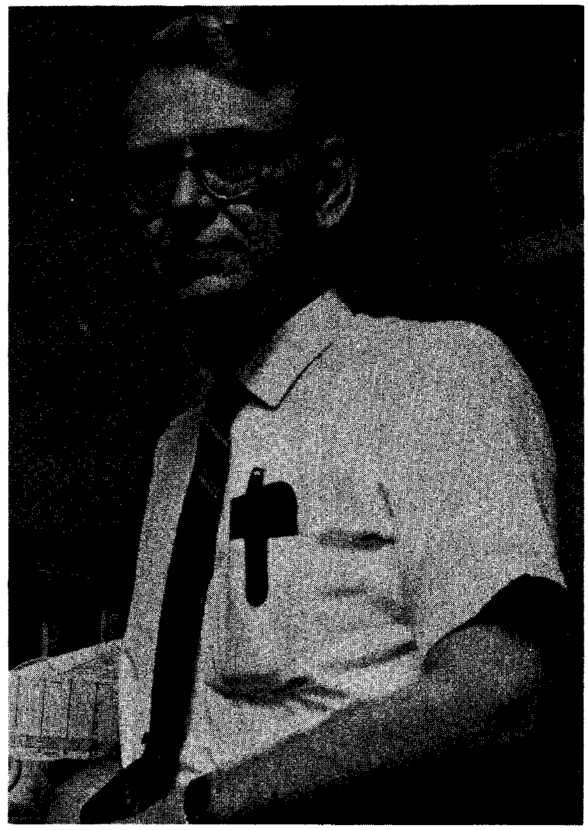
DISTANCE BETWEEN POINTS	CUMULATIVE MILAGE		
0.5	51.6	121.	Bear right off Edenburg Road into Small's Ferry Road.
0.9	52.5	122.	Junction with Pa. 317, proceed straight.
2.1	54.6	123.	Junction with Pa. 108-551, proceed ahead.
0.2	54.8	124.	Turn right on Pa. 108.
3.2	58.0	125.	Pennsylvania-Ohio State line, Mahoning County Ohio, change route number to Ohio 617.
0.5	58.5	126.	Junction with Ohio Turnpike, stay on Ohio 617.
		127.	Petersburg, Ohio.
0.3	58.8	128.	Junction of Ohio 90-170, proceed straight on Ohio 617-170.
0.1	58.9	129.	Road fork, follow Ohio 170.
0.2	59.1	130.	Strip mine in valley on right on Lower Kittanning coal bed.
0.7	59.8	131.	Mahoning-Columbiana County line.
2.9	62.7	132.	Unity, Ohio, junction with Ohio 14-165, turn left.
0.5	63.2	133.	Junction of Ohio 165-170 with Ohio 14, turn right.
1.0	64.2	134.	East Palestine, Ohio, continue on Ohio 170 through town.
1.0	65.2	135.	Cross Penn Central Railroad at grade.
0.1	65.3	136.	Junction of Ohio 170 and 165, continue straight on 170.
1.1	66.4	137.	Cut on left shows Upper Freeport coal bed and underlying fresh water limestone.
0.3	66.7	138.	For the next mile, "bay fill" like sequence between Upper Freeport and Lower Freeport coal beds.
1.0	67.7	139.	For the next one half miles, sandstone between the Lower Freeport and Middle Kittanning coal beds. This sandstone which can be observed in several small exposures around Negley is probably the main channel from which developed the crevasse distributaries that we have examined in the Darlington area to the east.
1.0	68.7	140.	Follow Ohio 170 to the right across Youngstown and Southern tracks.
0.1	68.8	141.	Negley, Junction with Ohio 154, turn left.
0.1	68.9	142.	Turn right onto Ohio 170 and re-

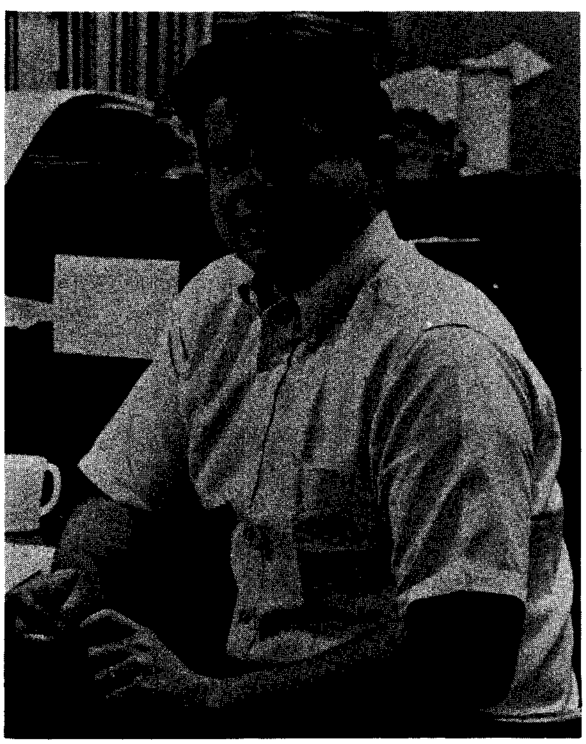
trace route earlier in the day following 170 to the junction of eastbound U.S. 30, 2 miles north of East Liverpool, then U.S. 30 into town.

15.1 84.0 143. Traveler's Hotel.

John C. Ferm was born March 21, 1925 in East Liverpool, Ohio and spent his childhood and early years in nearby Midland, Pennsylvania. Upon graduation from high school in Midland in 1943 he entered Pennsylvania State University and received his B.S. in 1946 and M.S. in 1949. After a year of graduate study in paleobotany at University of Michigan and one additional year of stratigraphic work at the University of Illinois he returned to Penn State to complete Ph.D. studies in sedimentology receiving his degree in 1957. From 1952 to 1957 he was a member of a U.S. Geological Survey group studying Pennsylvanian rocks in the Eastern Kentucky coal field and and from 1957 to the present he has been a member of the faculty of geology at Louisiana State University. In the fall of 1969, he will join the Geology Department at the University of South Carolina. During his stay at L.S.U. he continued the work on Pennsylvanian rocks begun during his graduate work integrating his results with those of members of the Coastal Studies Institute who were working with recent deltas, particularly those of the post-Pleistocene Mississippi. In addition, he has been a consultant to the Coastal Studies Institute in connection with studies of recent beaches. He is a member of the Geological Society of America, Society of Economic Mineralogists and Paleontologists, International Association of Sedimentologists, and American Association for the Advancement of Science.

In 1949 he married Doris L. Bye of Moylan, Pennsylvania and they have three children.





Victor V. Cavaroc, Jr. was born May 4, 1937 in New Orleans, Louisiana where he attended primary and secondary schools. Upon graduation from de la Salle High School in 1955, he entered Tulane University, and received the degree of Bachelor of Science in 1959, together with a Commission in the United States Naval Reserve. Discharged from active duty, he then entered graduate school at Louisiana State University in the fall of 1961, following a summer of field work in northern Mexico. Upon receiving the Master of Science degree in Geology in 1963, he was employed by Chevron Oil Company as a production and development geologist in the offshore Gulf of Mexico area until his return to graduate school at Louisiana State University in 1965. While at Louisiana State University, his field studies were concentrated in the general Allegheny interval of the Pennsylvanian of west-central West Virginia and westernmost Pennsylvania.

In 1967, Mr. Cavaroc married the former Miss Carolyn Wynn of Utica, New York. He will receive the Doctor of Philosophy degree in Geology in August of this year, and will join the faculty of North Carolina State University for the fall semester.

Current national affiliations include the Soc. of Sigma Xi, Amer. Assoc. Petr. Geol., Soc. Econ. Paleon. and Min., Amer. Stat. Assoc., and U.S. Naval Institute.

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