GUIDE TO THE GEOLOGY

of

NORTHEASTERN OHIO

Edited by

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&
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Northern Ohio Geological Society

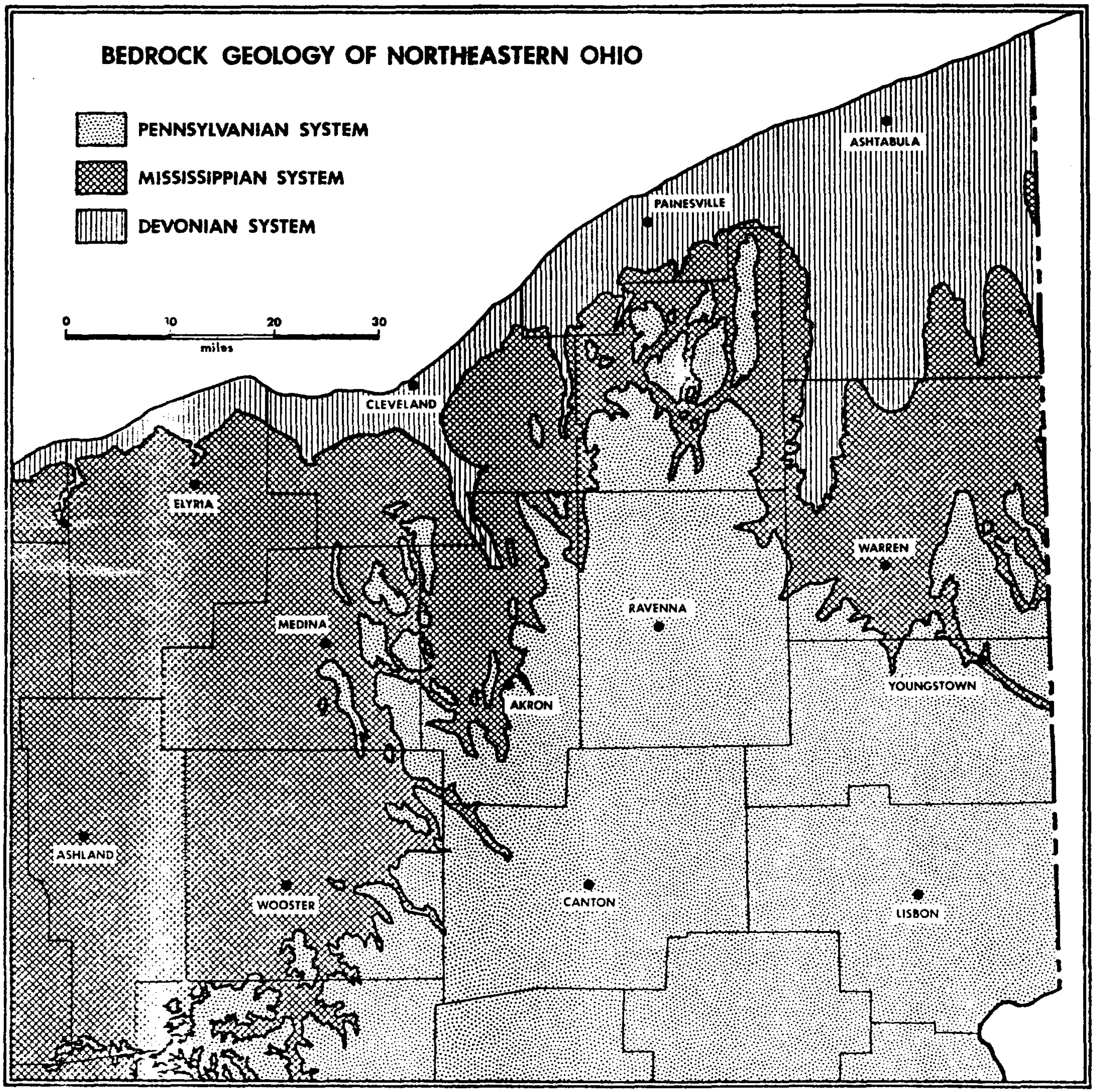

FIGURE [illegible]. Geologic map of northeastern Ohio. Individual formations within each time unit are not distinguished, and glacial deposits have been omitted. Because the bedding planes are nearly horizontal, the map patterns of the contacts closely resemble the topographic contours at those elevations. The older and deeper units are most extensively exposed where the major rivers have cut into them, while the younger units are preserved in the intervening higher areas.

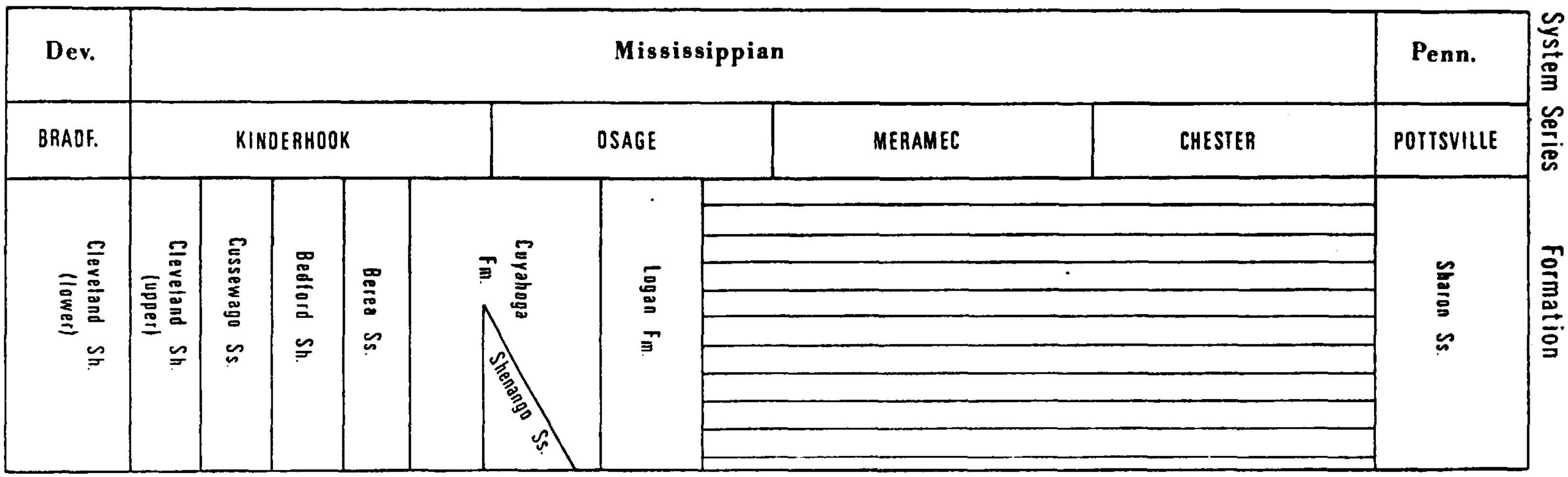

FIGURE 1. Columnar section of the major stratigraphic units in northeastern Ohio showing their relative positions in the standard geologic time scale. The Devonian-Mississippian boundary is not known with certainty to lie within the Cleveland Shale.

The base of the Mississippian in the northern part of the state is transitional with the Bradford Series of the Devonian System and may lie within the Cleveland Shale (Weller *et al.*, 1948). Although certain fossil evidence seems to favor assignment of the upper part of that formation to the Mississippian, the actual position of the systemic boundary in Ohio is still an unresolved problem. Because there is as yet no consensus among paleontologists regarding the geologic age of the Cleveland Shale it is not included in this report on the Mississippian System.

CUSSEWAGO SANDSTONE

GENERAL LITHOLOGY

The Cussewago Sandstone is a buff-brown, medium-grained quartzose sandstone, easily recognized by its friability, its tendency to assume greenish-yellow or greenish-brown hues when wet, and the presence of flat, discoidal pebbles of siltstone and shale. A maximum thickness of 30 feet is shown in sporadic exposures in Ashtabula and Trumbull Counties. Locally, the formation includes a few ripple-marked siltstones. Fossil remains are rare but significant; the brachiopods (*e.g., Rhipidomella* sp) and pectinoid pelecypods (*e.g., Aviculopecten caroli*) attest a marine or partly marine origin.

The contact with the overlying Bedford Shale most everywhere is sharp, but an exposure of 16 feet of flaggy sandstone above typical Cussewago lithology at Wick, Ashtabula County, is regarded by de Witt (1951) as, a gradational zone between the two formations. The lower contact of the Cussewago is nowhere exposed in Ohio.

INTERPRETATION

Outcrop exposures of the Cussewago Sandstone are too restricted to draw conclusions about its depositional environment, and recourse must be had to subsurface data. Well drillers generally know the Cussewago by the name "Murrysville sand". According to Pepper *et al.*, (1954), analysis of well logs in Ohio and adjacent areas shows the Murrysville to be an extensive fan-shaped deposit whose source lay far to the southeast in Maryland. They postulate a deltaic origin for the sandstone.

BEDFORD FORMATION

GENERAL LITHOLOGY

The type area of the Bedford Formation is the gorge of Tinkers Creek at Bedford, Ohio. There the Bedford constitutes an 85-foot thick sequence of blue-gray shales and siltstones, overlain by the massive cliffs of Berea Sandstone which cap the glen, and in turn lying in sharp but conformable contact upon the black Cleveland Shale. The lower contact is marked by a thin pyritic bed containing inarticulate brachiopods, conodonts, fish plates, and shark fragments.

The Tinkers Creek exposures represent one of two major mutually intergrading rock bodies in the Bedford Formation. The blue-gray shale-siltstone unit extends from the type region eastward to the Ohio-Pennsylvania line. Another unit, composed of dull red shale, predominates to the west. A third and less extensive phase, composed dominantly of massive siltstone, is recognized within the blue-gray shale-siltstone unit. The massive siltstone beds and portions of the other two units were deposited approximately at the same time but under different conditions of local environment. Units of this sort, each with distinctive lithologic attributes (but all part of a single formation) are called facies or lithosomes.

Red Shale Lithosome

The red shale lithosome is well exposed in Lorain and Cuyahoga Counties. It forms a north-south trending, flat-bottomed, upwardly convex body of rock, over 50 miles wide and extending lengthwise well beyond the geographic scope of this report into southern Ohio. Well logs indicate that a maximum thickness of 150 feet is attained in Lorain County (Pepper *et al.*, 1954). In the subsurface it locally contains channel-shaped "shoestring" sandstones, but surface outcrops reveal only the dominant lithology: soft, homogeneous, dull red or maroon shale, sticky when wet and deeply gullied by surface runoff. In its band of outcrop it is conformably underlain by at least a few feet of the blue-gray shale lithosome. Its upper surface, however, is a profound disconformity, representing a span of time during which a substantial thickness of sediments was eroded away prior to the deposition of the overlying Berea Sandstone.

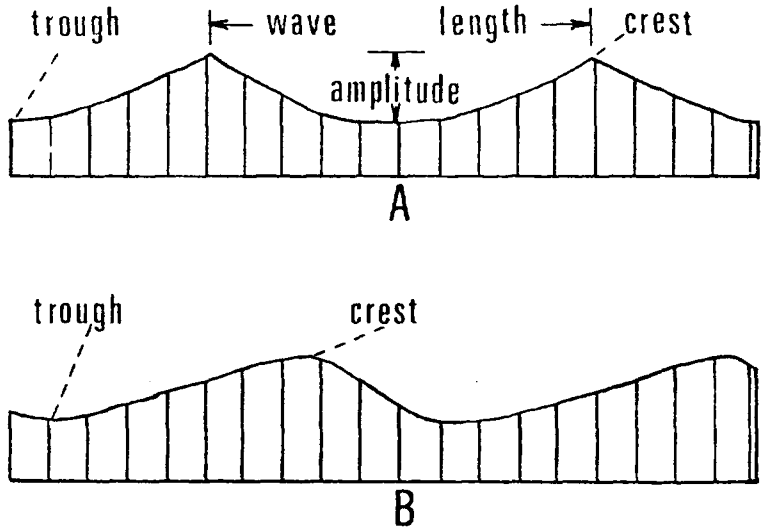

FIGURE 3. Diagrammatic profiles of the two types of aqueous ripple mark. A. Symmetrical (Oscillation or Wave) ripple mark. B. Asymmetrical (Current) ripple mark. Wave length is the distance between two crests measured normal to their trends. Amplitude is the vertical distance between a crest and the bottom of an adjacent trough.

The red shale lithosome gradually passes into the gray shale lithosome toward the east. At outcrops near Independence and Brecksville, in central Cuyahoga County, the blue-gray phase replaces much of the maroon shale. No trace of the red beds is to be found at Bedford, Brandywine Falls, Peninsula, or outcroppings to the east.

The red shale beds are virtually devoid of fossils. Plant fragments and local concentrations of miniscule spore case impressions constitute the sum of the living record preserved in northern Ohio.

Gray Shale Lithosome

This unit is composed dominantly of silty, flaky- to blocky-fissile, blue-gray to olive-gray shale with interbeds of thin siltstones, mostly 2 to 8 inches thick. The siltstones may contain sufficient sand-sized material to give the appearance of fine-grained sandstones. Some beds wedge out in a few yards but many persist uninterrupted through outcrops as extensive as the Tinkers Creek section.

Calcareous beds are rare except in exposures located in Trumbull and Ashtabula Counties where they commonly assume the form of large egg-shaped concretions. They are tough, tightly bonded siltstone beds with "luster-mottling" on fresh surfaces, that is, light reflected off broad, flat cleavage surfaces of calcite (or dolomitic calcite) cement.

In western Cuyahoga County, at Skinners Run in Parma, and along the tributaries of Rocky River near Berea, the lower part of the Bedford Formation (up to 27 feet above the base) consists mostly of gray-black shale and large deformed siltstone bodies from which stem numerous siltstone dikes (Prosser, 1912; Cushing *et al.*, 1931). This atypical lithology is noteworthy because it occurs at approximately the same stratigraphic position as the Euclid Member (see next section) of the Bedford Formation.

The gray shale lithosome thins eastward from the type section to less than 20 feet at the Pennsylvania line. In most exposures it rests upon the Cleveland Shale except in Ashtabula County where an intervening wedge of Cussewago Sandstone separates the two units.

Symmetrical oscillation (or "wave") ripple marks abound on the siltstone surfaces. Preliminary work reveals that the mean trend of their crests, at least in Summit County and eastern Cuyahoga County, is N. 60°W.

Sole markings are also common. Typically they are short linear ridges (named striation casts, groove casts, or brush casts) that can be seen on the bottom surfaces of overhanging siltstone ledges (see Fig. 26 B). Originally they were narrow, linear furrows made by current-impelled objects that had gouged themselves into marine muds lying on the basin floor. The gouges in the muds served as molds for the casts, or linear ridges, now preserved on the bottom surfaces of the overlying siltstones (see Potter and Pettijohn, 1963). These markings are parallel to the direction in which the sediments were transported. Limited observations in Summit and Cuyahoga Counties indicate that sole mark trends are nearly normal to the mean ripple mark orientation, namely N.40°E.

Also to be observed on the bottoms of siltstone beds are randomly disposed knobby mounds and narrow grooves which give a mammillary form to the surface (See Fig. 4). Most of these are load cast structures, whose origin is usually attributed to deformation following rapid accumulation and unequal loading of silts upon waterladen, plastic muds. Load casts are not believed to have any special environmental significance. Casts of burrows produced by bottom-dwelling animals can result in similar protuberances.

The Bedford Formation is not a prolific producer of fossils but diligent search of the basal beds of the gray shale lithosome usually proves fruitful especially at the classic collecting localities, Tinkers Glen and Brandywine Falls. Among the more common specimens are small brachiopods: the oval *Lingula*; the semicircular *Chonetes* whose hingeline is crested with stubby spines; or the unique, trigonal *Trigonoglossa* with its dark glistening surface ornamented by fine raised ridges. Small clams such as *Palaeoneilo bedfordensis* are often found in a fine state of preservation. The choice item, however, is the rare brachiopod *Syringothyris bedfordensis*, large and wing-shaped, whose internal molds reveal a rod-shaped siphuncle peculiar to this genus. More complete listings of Bedford fossils can be found in Cushing *et al.*, (1931) and Hyde (1953).

Massive Siltstone Lithosome

The Euclid and Sagamore Members are integral components of the gray shale lithosome; yet they merit special attention because their environmental significance is disproportionately greater than implied by their moderate stratigraphic thickness and limited geographic extent. Each is composed of massive to thin-bedded siltstone or sandy siltstone and interbedded gray shale, and each attains a maximum thickness of over 20 feet. The more extensive Euclid Member is probably a lenticular deposit, nearly 30 miles long and 5 miles wide, whose long dimension is parallel to the eastern margin of the red shale lithosome. In eastern Cuyahoga County, where a sandy phase was once extensively quarried and known by the trade name "Euclid bluestone", it is underlain by 2 to 10 feet of gray shale and overlain by a substantial thickness of similar beds which in turn are succeeded by red shale. Outcrops of the comparable but less well known Sagamore Member are confined to Sagamore Creek and its environs.

Aside from ubiquitous symmetrical ripple marks and commonplace load casts the most notable sedimentary structures in this lithosome are "ball-and-pillow" or "flow roll" beds. They are contorted kidney- or pillow-shaped bodies of siltstone, ranging from a few inches to several feet in breadth, usually more deformed at the base, and confined by undisturbed beds above and below to a limited stratigraphic zone or even a single bed. Underlying shale beds appear to have been squeezed up between the margins of adjacent

FIGURE 4. Load cast structure on the bottom surface of a siltstone slab from the Bedford Formation at Tinkers Creek, Cuyahoga County. The maximum dimension of the slab is approximately one foot.

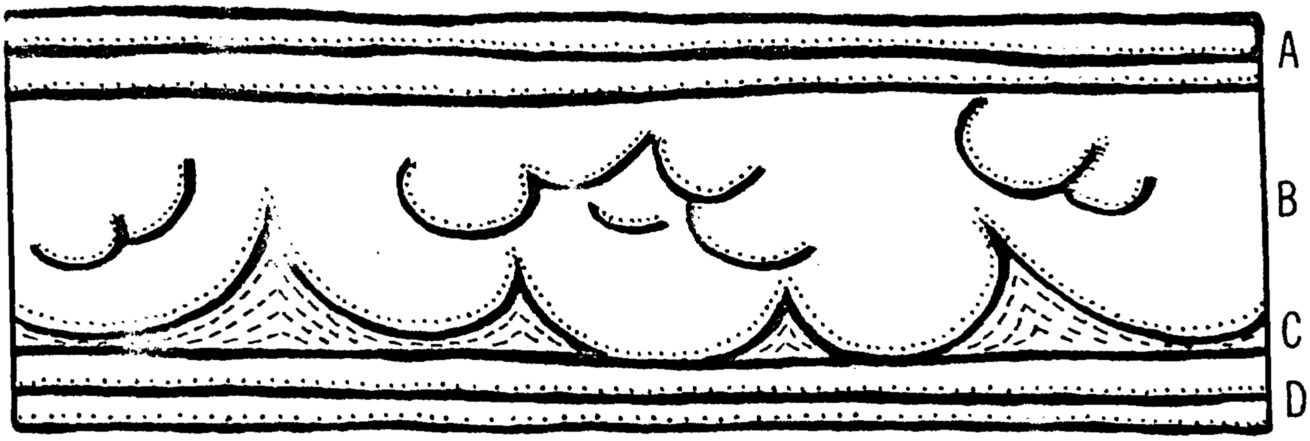

FIGURE 5. Diagrammatic sketch of ball-and-pillow structure. A and D, undeformed sandstone beds. B, ball-and-pillow zone of deformed sandstone. C, distorted shale zone.

pillows. These structures undoubtedly developed in unconsolidated deposits by veritcal foundering, lateral displacement, or a combination of the two movements. The lack of systemically arranged folding within the pillows suggests foundering of the silts into water-charged clays, possibly set in motion by earthquake shocks. On the other hand, differential loading of the silts upon almost imperceptibly sloping mud deposits could eventually lead to down-slope movement as a contributing factor in the formation of the pillows.

An accessible section showing excellent pillows in the Euclid Member is located in a cut on Granger Road, State Highway 17, Newburg Township, Cuyahoga County (Fig. 6)

INTERPRETATION

Largely by analysis of subsurface data Pepper *et al.*, (1954) concluded that the red shale lithosome is deltaic in origin. The pertinent data are two-fold: 1) coarse sandstones in the red shale which assume a meandering and braided pattern in plan view, analogous to similar stream patterns in the lower reaches of the modern Mississippi River, and 2) the size and flat-bottomed form of the red shale and its gradation into unequivocally marine gray Bedford beds in all directions except due north.

FIGURE 6. Euclid Member of the Bedford Formation in cut on State Highway 17, Newburg Township, Cuyahoga County, showing ball-and-pillow structure. Gray shales of the Bedford Formation are exposed below the thick-bedded Euclid sandy siltstones.

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The giant finger of red shale pointing toward the south and enveloping north-south trending shoestring sandstones suggests a southward-growing delta whose source lay to the north, probably in Ontario. Corroborative evidence includes the red color of the shale, generally regarded as resulting from oxidation of iron in the sediments during subaerial exposure, and the dearth or lack of marine fossils.

Available evidence suggests that the red bed delta first developed along the northern margin of the Appalachian basin. Its outward growth caused the shallow sea to regress toward the center of the basin. At its acme of development the delta was a long, narrow salient (See Fig. 11). During a later phase the basin was apparently tilted toward the south, resulting in a northward transgression of the sea which inundated a large portion of the depressed delta. Perhaps the same period of tilting uplifted the northern part of the delta and the mainland, rejuvenating the streams which then incised themselves into the red Bedford muds and eroded channels that were subsequently filled with Berea sands.

Interpretation of the gray shale lithosome is based on the numerous oscillation ripples and the fossils. Oscillation ripples indicate a standing body of water; the frequency of their occurrence suggests very shallow water; and the presence of marine fossils such as brachiopods indicates that the water body must have been a shallow sea which covered most of the northeastern counties of Ohio.

The Euclid Member of the massive siltstone lithosome was most likely a sedimentary bar or barrier beach that formed in a shallow sea marginal to, and a few miles removed from the incipient Bedford delta. This is suggested by its elongate form aligned parallel to the lower beds of the red shale promontory, and the profuse oscillation ripples. Flanking bars are similarly aligned along the seaward margins of many modern deltas. Further evidence for this interpretation is afforded by the geographic and stratigraphic position of the anomalous gray-black Bedford beds which can be explained as accumulations of mud in marine or brackish lagoonal waters confined by a delta on the west and sand bars on the east, thus setting up the restrictive, stagnant and de-oxygenated conditions that commonly result in black, carbonaceous deposits.

The Euclid Member was probably constructed during a period of relative basinal inactivity and stillstand of the delta margin, allowing sufficient time for waves to rework the sediments and leave behind the coarser silts by winnowing out the clays. As basinal downwarping resumed, the Euclid bar was depressed well below sea level and subsequently inundated by a renewed influx of sedimentary debris derived from an expanding delta. This is inferred from the thick sequence of gray and red Bedford clastics that overlie the Euclid beds.

BEREA SANDSTONE

GENERAL LITHOLOGY

The Berea Sandstone merits perhaps better than any other major sandstone in the state the epithet, "great sandstone of Ohio". The impressive Berea Sandstone excavations at South Amherst are among the deepest sandstone pits in the world, and the famous quarries at Peninsula were extensively exploited for millstone and abutment stone well over a century ago. Where deeply buried the sandstone contributes significantly to the general welfare as a reservoir of oil, gas, and potable water. It is resistant to weathering and erosion and has markedly influenced the topography of northeastern Ohio by forming extensive terraces and escarpments, gorges, rapids, and plunge pools.

In the early days of Ohio geology the sandstone was a subject of great interest because of the locally profound unconformity at its base. The magnitude of this unconformity led many to judge it to be a boundary between the Devonian and Mississippian Systems, a belief that lingered into the third decade of this century despite accumulating fossil evidence indicating otherwise.

Channel Sandstone Lithosome

This is the famous quarry stone: massive, moderately cross-bedded, medium-grained, clay-bonded sandstone, with local concentrations of rounded quartz or discoidal shale pebbles and rare interbeds of lenticular shale. It attains a maximum thickness of well over 200 feet at South Amherst, where its lower contact cuts through the Bedford and Cleveland Shales into the Devonian Chagrin Formation. In Geauga and Cuyahoga Counties, the thickness decreases but the disconformity is still a surface of considerable relief. The channel phase consists of several north-south trending, moderately sinuous shoestring sands with rounded bottoms and locally, as in the Buckeye quarry at South Amherst, asymmetrical profiles similar to modern meandering streams with steep cut slopes and gentle slip-off slopes (Pepper *et al.*, 1954, Fig. 43).

FIGURE 7. Berea Sandstone overlying maroon shales of the Bedford Formation at Chippewa Creek, Brecksville, below the State Highway 82 bridge.

FIGURE 8. Blanket sandstone lithosome of the Berea Formation showing cross-bedded sandstone overlain by even-bedded sandstone. Outcrop located on State Highway 17, Newburg Township, Cuyahoga County.

Among the more noteworthy sedimentary structures, rarely encountered in other Mississippian rock units of northeastern Ohio, are current ripple marks with asymmetrical slopes and rounded crests and troughs, which give the sense of current, the steeper side facing down current (Fig. 3). The crests are generally disposed normal to the long direction of a channel sandstone, with the steeper lee slope facing south.

Mud cracks along sandstone-shale contacts are present at several horizons in the Berea Sandstone, many of them in the channel lithosome. Good examples may be found in Lake, Geauga, and Ashtabula Counties at several accessible localities such as Big Creek, Bates Creek, Phelps Creek, and Warner Hollow. The cracks are polygons an inch or more wide which resulted from shrinkage of the mud due to dessication under subaerial conditions. Deposits of sand later filled and covered the cracks.

For the most part fossil remains in the channel sandstone consist of comminuted plant debris, spores and occasional larger identifiable carbonized fragments of *Annularia* and a few other plant genera. Specimens greater than a foot in length are decidedly uncommon. A few coaly lenses one to three inches thick, generally aligned parallel to the trends of the channel sands, may be observed along freshly excavated quarry walls in Lorain and Cuyahoga Counties.

Blanket Sandstone Lithosome

Overlying the channel sandstone is a comparatively thin but widely distributed sandstone which extends from Huron County to eastern Trumbull County where it pinches out. Over most of the region it maintains a rather uniform thickness of 20 to 40 feet. The blanket lithosome comprises two distinct phases: an upper buff colored, rather loosely cemented medium-grained sandstone whose thin, even beds bear oscillation ripple marks; and a lower phase similar in many respects but distinguished by steeply dipping foreset beds.

Carbonized plant fragments are in places abundant in this lithosome, but of more significance are the very rare and poorly preserved brachiopods in the even-bedded sandstone which indicate a marine environment.

FIGURE 9. Oscillation ripple marks in the blanket lithosome of the Berea Sandstone.

Siltstone Lithosome

This unit is confined to outcroppings east of the Grand River Valley. The maximum exposed thickness is about 25 feet. Fine exposures are located in Williamsfield Township, Ashtabula County, and in Kinsman Township, Trumbull County, especially along Maple and Stratton Creeks. In marked contrast to typical Berea lithology, the beds of this lithosome are composed of very coarse silt to very fine sand, with the silt component generally predominating. Oscillation ripple marks are common. The siltstones are everywhere capped by a distinctive thin, gnarly pyritic bed containing very abundant shells of *Lingula melie*. Lingulids and other brachiopods such as *Trigonoglossa* may occasionally be found in beds below the pyritic cap.

INTERPRETATION

The downward convexity of the linear sandstones of the channel lithosome, locally showing asymmetrical profiles in cross-section, and cutting deeply into subjacent strata; the absence of a marine fossil fauna; and the direction of paleocurrent flow inferred from asymmetrical ripple marks, all indicate a continental or deltaic depositional environment dominated by streams with southerly courses. Initially the rivers had sufficient energy to erode their own beds and transport most of their sedimentary loads away into Ohio Bay, a shallow sea which inundated most of the state of Ohio. Prevention of permanent deposition in the valleys under such conditions is termed "by-passing".

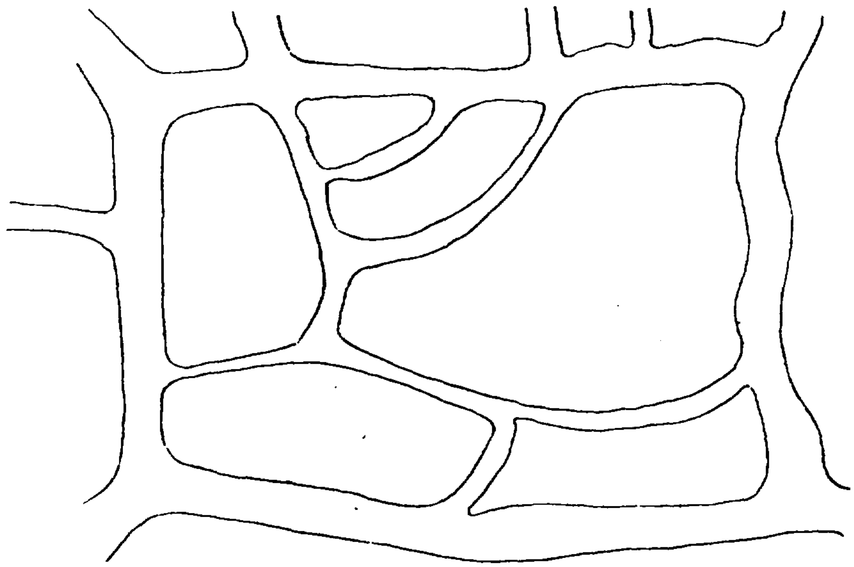


FIGURE 10. Sketch of mud cracks in the lower shaly zone of the Berea Formation at Bates Creek, southeast of Painesville. Natural size. (After Prosser, 1912.)

Valley-cutting and by-passing was succeeded by a valley-fill phase, in which aggrading streams deposited the Berea sands derived from an uplifted source land in Ontario. The change in stream regimen from erosional to depositional probably reflects, at least in part, cessation of tilting along the northern margin of the Appalachian basin.

The filling of channels and continued subsidence of the basin resulted in the transitional (partly continental, partly marine) blanket sandstone. The lower cross-bedded sandstone was probably deposited above sea level along the irregular margins of a delta having two or more salients whose shorelines grew outward or at least maintained their geographic position.

A waning supply of sediment from a topographically reduced source land, coupled with an accentuated subsidence of the sedimentary basin, gradually pushed the shoreline northward again until by late Berea time almost all of northern Ohio was inundated by a shallow transgressing sea whose currents reworked medium-grained sands into even beds. The downwarping, inundation and final disappearance of the early Mississippian delta complex is documented in the upper part of the blanket lithosome by the even, wave-reworked beds bearing oscillation ripple marks. The few poorly preserved brachiopods collected from these beds provide supporting evidence.

During the deposition of the coarse lithosomes of the Berea Formation, fine-grained sands, silts, and clays of the siltstone lithosome were accumulating slowly in a shallow sea which covered the northeastern corner of Ohio. The sea was probably very shallow and perhaps occasionally brackish as attested by the presence of locally abundant inarticulate brachiopods, notably *Lingula*, an extant genus that prefers warm, shallow and brackish waters.

CUYAHOGA FORMATION

GENERAL LITHOLOGY

The Lower Mississippian Cuyahoga Formation and its contiguous temporal equivalents, the Shenango Sandstone and Hempfield Shale, are composed of two major stratigraphic rock bodies: a sandstone-conglomerate (coarse-clastic) lithosome and a siltstone-shale (fine-clastic) lithosome. Individual members of this heterogeneous formation have lithologies characteristic of one or the other lithosome. They are grouped as shown below.

Coarse-clastic lithosome	***Fine-clastic lithosome***
Black Hand Member (River Styx facies)	Wooster Member (Shale unit)
Black Hand Member (Toboso facies)	Armstrong Member (Flaggy unit)
Rittman Member	Meadville Member (Flaggy unit)
	Strongsville Member (Mostly shale)
[Shenango Sandstone]	Sharpsville Member (Flaggy unit)
	Orangeville Member (Shale unit)
	[Hempfield Shale]

In accordance with historical precedent and long-standing tradition the Shanango Sandstone and Hempfield Shale are regarded as separate formal units independent of the Cuyahoga Formation; but because they are partly contemporaneous with the Cuyahoga Formation and are in mutual intertonguing relation with it, they are here grouped informally with the members of that formation, as indicated by the brackets enclosing their names.

The fine-clastic lithosome comprises two distinct rock sequences: shales and flaggy beds. The shales include fissile, gray-black units (Sunbury; some of the Strongsville beds), and less fissile blue-gray to olive-gray beds (Orangeville; Wooster). The flaggy units are siltstone-shale sequences with beds ranging from a few inches to over two feet in thickness. The siltstones are actually mixtures of very fine sand, silt, and clay, but dominantly coarse silt to very fine sand. The term siltstone, though not strictly correct for all these beds, obviates confusion with the distinctly sand-sized lithology of the coarse-clastic lithosome and at the same time indicates to the reader the large proportion of silt in most of the flaggy beds. Quartz is by far the dominant mineral in the flags but mica, feldspar, and comminuted plant fragments can also be identified.

The flaggy units include several zones of compact, calcareous siltstones, typically 1 to 2 feet in thickness, in the form of tabular beds or large, spheroidal, cylindroidal, or egg-shaped concretions. Luster-mottling on fresh surfaces is a distinctive textural feature.

Many of the flaggy beds are virtually devoid of fossils; others, especially those in the Meadville Member, are biostromal: replete with fragmented and intact brachiopods, bryozoans, snails, clams and other invertebrate groups.

The coarse-clastic lithosome is composed of cross-bedded, fine- to coarse-grained sandstone locally containing abundant well-rounded quartz pebbles. The coarse clastics are composed of a higher percentage of quartz than the flaggy units. Secondary enlargement of the quartz grains is common.

The base of the Cuyahoga Formation is in sharp, conformable contact with the Berea Sandstone. The upper contact at the base of the Shenango Sandstone in Trumbull County is also conformable, but from eastern Trumbull County to Wayne County a regional unconformity of considerable relief marks the upper surface. In this region the overlying formation is generally the Sharon Sandstone; less commonly the Massillon Sandstone or other unit of the Pottsville Group of Pennsylvanian age. In northern Wayne County and the region to the south, the contact between the Cuyahoga and the overlying Logan Formation is generally conformable but locally it is a minor unconformity or a reworked surface.

In Crawford and Mercer Counties, Pennsylvania, and in the adjacent counties in northeastern Ohio, the Cuyahoga Formation is about 200 feet thick. The overlying Shenango Sandstone and Hempfield Shale comprise an additional 90 feet. In the northern band of outcrop extending across Trumbull, Geauga and Cuyahoga Counties the thickness ranges from well under 100 feet to about 375 feet owing to the irregular pre-Pottsville erosion surface. Southward from Medina County the unconformity ascends stratigraphically and lies above the Logan Formation in Wayne and Ashland Counties where the Cuyahoga beds attain a thickness of 550 to 625 feet.

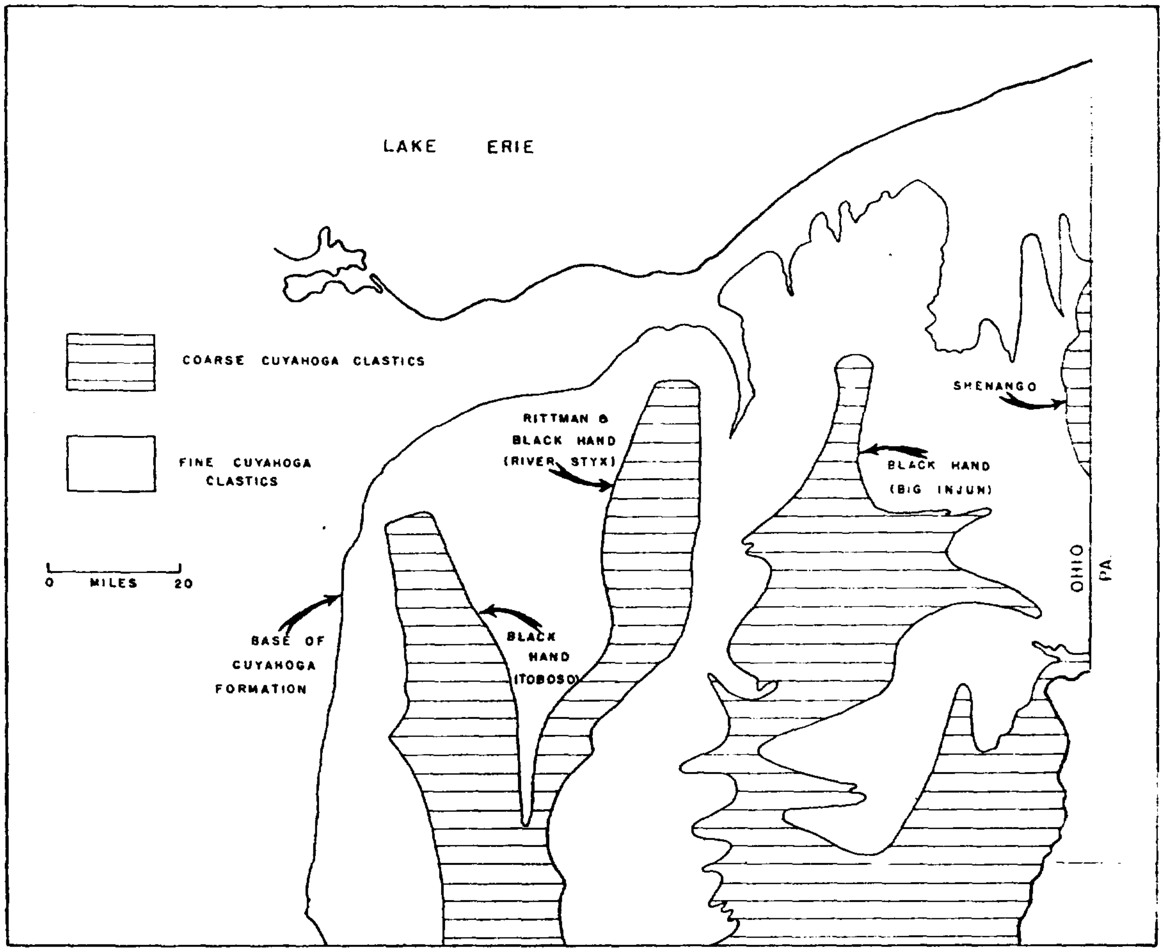


FIGURE 22. Map showing the distribution of coarse and fine clastics in the Cuyahoga Formation in northeastern Ohio. (Adapted in large part from Ver Steeg, 1947.)

indicate that prior to the inception of Logan sedimentation the depositional surface of the Toboso lobe was a topographic "high" that stood well above the contiguous and contemporaneous Wooster Shale depositional surface (See Fig. 21).

The few fossils (*e.g., Syringothyris, Chonetes*) collected from the sandstone cliff at Pleasant Hill dam attest a marine origin for at least part of the Toboso lobe; unequivocal evidence favoring a nonmarine environment seems to be lacking.

The subsurface equivalent of the Black Hand is called "Big Injun" by well drillers. The Big Injun as well as the fine clastic units of the Cuyahoga Formation have been traced eastward by means of well logs into the thick, largely nonmarine Pocono Sandstone, which appears on the surface as a prominent ridge-making sandstone and conglomerate in the Ridge and Valley province of Pennsylvania (see Pepper *et al.*, 1954, plate 14).

Shenango Sandstone

The medium-grained Shenango Sandstone, characterized by abundant "ironstone" concretions and a golden-brown color, is 40 feet thick in its type region, the Shenango Valley of northwestern Pennsylvania. It gradually diminishes in thickness westward and wedges out in northeastern Ohio near Yankee Run, Trumbull County. Fossils are common in some zones but except for inarticulate brachiopods and fish remains they are mostly imprints or molds, often difficult to identify. The fauna bears close affinity to that of the eastern part of the Meadville Member.

such as churches, schools or restaurants or small residential developments including apartments and mobile home trailer parks. Figure V-9 shows the majority of the sanitary waste dischargers are clustered in the unsewered areas near the larger metropolitan centers in the northern portion of the planning area, i.e. in Sheffield and Sheffield Lake east of Lorain, in the communities south of Elyria, and, in Amherst and South Amherst along Beaver Creek. In the less populated southern half of the basin, there are not as many sewage treatment plants. Those present are more uniformly distributed than in the northern half of the basin.

Water treatment plants are generally located within the smaller cities in the southern half of the planning area. The Elyria and Lorain water treatment plants are located on the lake and serve the northern half of the planning area.

H. Hydrology[11,12,13]

The hydrology in the Black River planning area is directly related to geological formations and soil conditions which have minimal water storage capacity. Surface materials are generally rather dense and impermeable and the glacial deposits contain only limited amounts of permeable sand and gravel. Bedrock in the area is mainly shale and contributes virtually no groundwater to stream flow. Hence, groundwater storage is limited. In addition, there are no significant reservoirs or water developments to augment flows in the basin. The result of the above conditions is that stream flows fluctuate widely with changes in precipitation but are typically very low during sustained dry weather periods. A more detailed description of the streamflow characteristics of the Black River and Beaver Creek follows:

Black River

Figure V-10 is a cumulative drainage area graph for the Black River showing both the drainage area and the location on the main stem of major and minor tributaries. Approximately 80 percent of the total drainage area lies above the USGS stream gage at Elyria (River Mile 15.2). Significant changes in the slope of the main stem are illustrated in Figure V-2 along with the location of manmade impoundments in the Elyria area. These low head dams were originally installed to maintain a supply of river water for withdrawal during periods of low flow. However, only the dam on the West Branch near East 15th Street is currently used to provide an industrial water supply for Republic Steel. Reservoirs supplied by the Black River near Grafton, Oberlin, Spencer, and Wellington are used as water supplies by these municipalities.

Figure V-11 is a flow duration curve for the Black River at the USGS gaging station in Elyria. As shown, the flow of the stream is expected to be greater than 50 cfs only 50 percent of the time and greater than 8 cfs about 90 percent of the time. Conversely, the flow is expected to be greater than 750 cfs about 10 percent of the time. These data are also illustrated in Figure V-12 which includes a monthly hydrograph of the stream at the same location. These data are significant in that while expected mean monthly flows may range between 31 cfs in September and October to over 800 cfs in March, the flow is expected to be greater than 50 cfs only half of the time. The expected mean annual flow is just below 300 cfs.

As illustrated by these figures, the water quality design flow throughout the basin above French Creek is extremely low, with the Elyria sewage treatment plant contributing much more than half of the water quality design flow above the lake-affected portion of the stream. It is significant to note that of the 140 dischargers in the Black River basin, 112 discharge to streams or segments with water quality design flows of zero or streams with no natural flow.

Depending upon the level of Lake Erie, the Black River reaches lake level between River Mile 6.5 and River Mile 5.1 where French Creek discharges into the main stem. From this point to the mouth of the stream at Lorain Harbor, the river is considered an estuary. The flow regime is altered further from River Mile 5.0 to 2.5 by the intake pumpage and discharges of the U.S. Steel-Lorain Works. Additional information concerning the water quality design flow of the stream in this area can be found in Appendices II and III.

2/1/82 : USGS data shows the 100 year flood elevation at Chemical Reco
is just over 697 feet

includes East Branch and West Branch

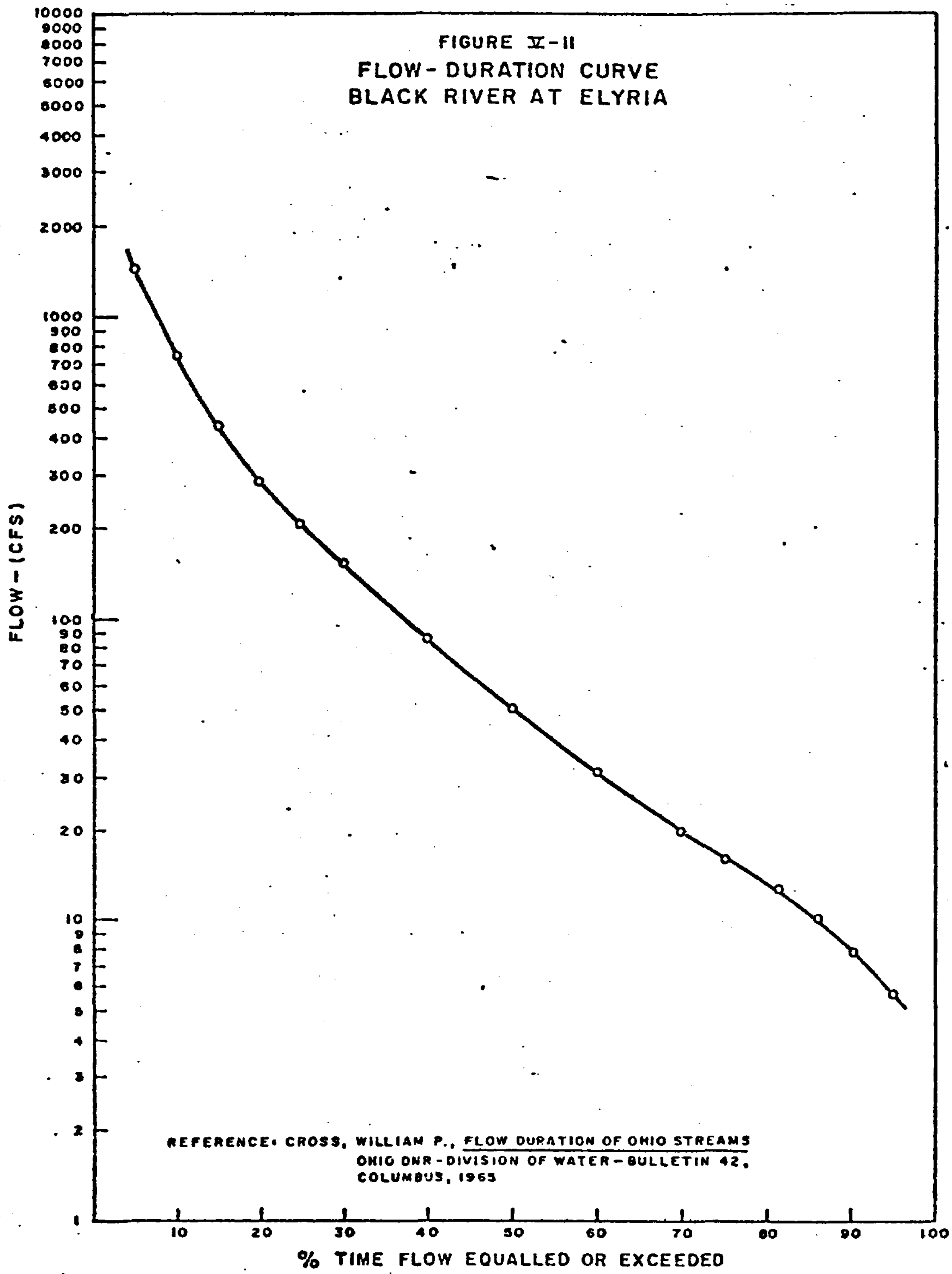


FIGURE V-II
FLOW-DURATION CURVE
BLACK RIVER AT ELYRIA

REFERENCE: CROSS, WILLIAM P., FLOW DURATION OF OHIO STREAMS
OHIO DNR-DIVISION OF WATER-BULLETIN 42,
COLUMBUS, 1965

Total Drainage Area at USGS gage = 390 mi^2
Drainage Area of East Branch = 220 mi^2 = 56% of Drainage Area at USGS gage.

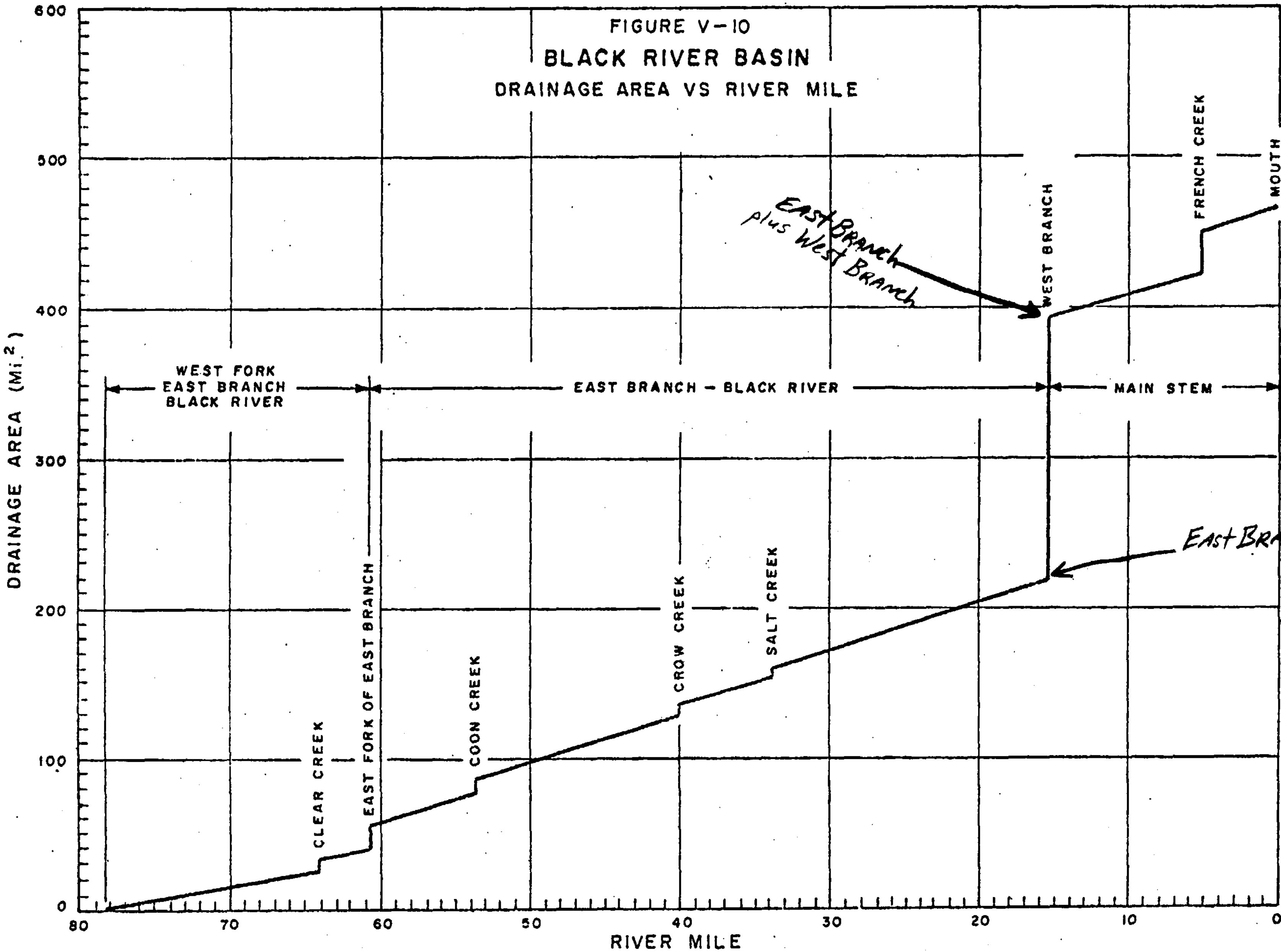
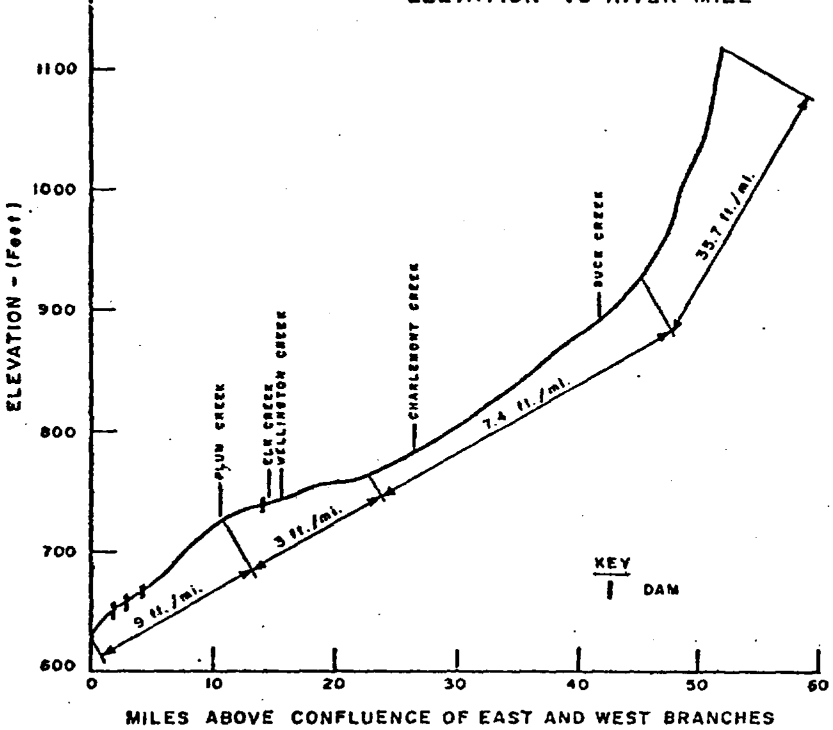
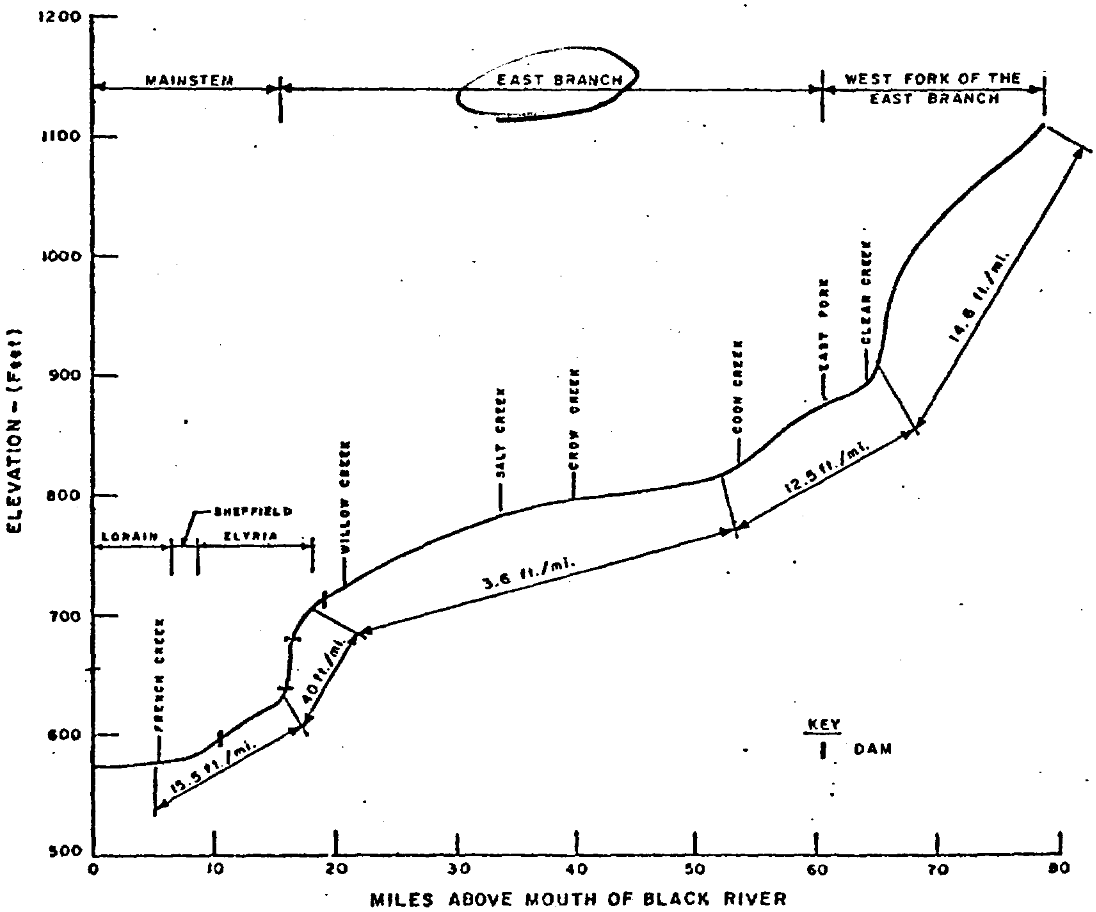


FIGURE V-2
WEST BRANCH AND MAINSTEM OF BLACK RIVER
ELEVATION VS RIVER MILE





Elyria City ... indicated river bottom elevation = 675 feet and water surface elevation ... survey ... 1973

THE QUATERNARY PERIOD[1]

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INTRODUCTION

Deposits of Quaternary age can be found in all of the counties included in the guidebook (Fig. 1). They occur as an heterogeneous assortment of unconsolidated sediments that cover the bedrock over much of this area.

These deposits are the result of severe climatic fluctuations that occurred during the last several million years. At least four major episodes of world-wide climatic deterioration have been recognized during this interval. In North America these climatic conditions either permitted or initiated a general descent of mountain glaciers to lower elevations and the formation of ice sheets in the region of Hudson Bay. The ice sheets flowed outward in all directions from their centers of accumulation and covered large areas of the United States and Canada. The spread of the ice sheets was intermittently interrupted by the inception of warmer intervals, during which time they were considerably reduced in area. In North America, the intervals of time and the sequences of sediments representing these major advances and retreats of the ice are termed stages and have been given the following formal names:

Wisconsin glacial stage (youngest)

Sangamon interglacial stage

Illinoian glacial stage

Yarmouth interglacial stage

Kansan glacial stage

Aftonian interglacial stage

Nebraskan glacial stage (oldest)

The effects of these events on northeastern Ohio were enormous. Soils that had been developing on Paleozoic bedrock as the result of millions of years of weathering were stripped off. Many pre-glacial valleys were deepened and widened, and the bedrock hills were rounded and subdued by glacial erosion. Much of the pre-glacial drainage was diverted by the ice. As the glaciers receded, debris carried either directly by the ice or by meltwater from the ice completely filled many of the valleys with hundreds of feet of sediment. Laminated silts and clays, over 100 feet thick in places, accumulated in lakes that were formed where the valleys of some streams were impounded behind ice-dams. Lake Cuyahoga and Grand River Lake. (Goldthwait *et al.*, 1961), the largest of these glacial lakes in northeastern Ohio, covered several hundred square miles at their maximum extent.

The types of deposits associated with glaciation are classified in two different ways: by their topographic expression, and by their composition. Most of the glacial landforms found in the guidebook area usually occur on a scale too large to be readily recognized by the untrained observer on the ground. Included in this group are such features as end moraines, ground moraines, kames, kettles, and outwash and till plains. Although all of these landforms can be found in the area covered by the guidebook, they usually can best be seen by examining topographic maps and aerial photographs. Encompassed in the second category under the general term of *glacial drift* are all types of sediments that have been deposited directly or indirectly

[1] Contribution No. 42 of the Department of Geology, Kent State University