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Steam-locomotive and excursion cars of the Knox, Kane, Kinzua Railroad crossing the steel Kinzua Viaduct (see article on page 2). View is from the north side of the Kinzua Creek valley. Photograph by J. D. Inners.

PENNSYLVANIA GEOLOGY

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STATE GEOLOGIST'S EDITORIAL

Of What Men Choose to Forget

The title is a line from a poem by T. S. Eliot that refers to the inevitability of damaging floods like those reported so extensively in the public media during the past summer. To earth scientists, these events, as well as most other natural catastrophic events, are to be expected and endured inasmuch as they are cyclically repetitive and exceed most human ability for prevention. They are and should be understood as a reality of nature and, by understanding, possibly ameliorated.

Yet many do not understand the nature of catastrophic events and look to science for solutions. Scientists, in their hubris, generally have offered technological solutions, but have forgotten that education perhaps better serves humanity than does a technology. When the technology is overwhelmed, such as with breached or overtopped levees, confidence in such solutions (and science) is lessened. For many human problems, particularly natural geologic hazards, the only real solution for the affected person is to move. Damage and destruction of human constructions is inevitable when they are placed in the paths of natural catastrophic phenomena such as on the floodplains of rivers. To not understand their inevitability is to attempt to escape some basic realities of life.

Continued population growth will place greater stress on natural systems, and more damage will occur unless earth scientists offer more education and fewer "solutions." Changing society's attitude from one that desires to avoid natural hazards by quick technological fixes to one of understanding natural catastrophic events will not be easy. Yet I feel that we must make the effort if we are to use our scientific understanding of the earth's natural forces for the benefit of all. If we who understand do not choose to provide a basic understanding of earth systems, we fail in the proper use of our knowledge. We need to continually remind our fellow humans "of what men choose to forget."

Donald M. Hoskins

Donald M. Hoskins
State Geologist

Carrying the Sky on Its Back: The Historical Geography of the Kinzua Viaduct

by William E. Kochanov, Jon D. Inners, and Joseph M. Tarantino
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INTRODUCTION. "Economics + geology + engineering = railroads!" This was the formula that led to a profusion of great civil-engineering works throughout the world during the latter half of the nineteenth century and early part of the twentieth. Economics created the incentives for construction of a railroad between two points, geology formed the natural barriers, and engineering overcame these barriers. The most famous example of this formula in Pennsylvania was the railroad conquest of the Allegheny Front by J. Edgar Thompson's Horseshoe Curve in 1854. Not far behind in Pennsylvania's railroad lore, however, was the vaulting of the Kinzua Valley in 1882 by Adolphus Bonzano and Octave Chanute's wrought-iron Kinzua Viaduct (the viaduct was rebuilt of steel 18 years later).

A viaduct is a bridge that crosses a valley in which the width of the water course is only a small fraction of the total distance required to be traversed (Thornton, 1987). In addition to the Kinzua in McKean County, Pennsylvania boasts two of the world's other great railroad viaducts: the stone Starrucca Viaduct (1848) in Susquehanna County and the concrete Tunkhannock Viaduct (1915) in Wyoming County (Jackson, 1988; DeLony, 1993). Of these, the Starrucca and the Tunkhannock are noteworthy for their impressive strength and bulk, but neither of these renowned structures carries the sky on its back with the grace of the Kinzua.

PHYSIOGRAPHY AND GEOLOGY. Kinzua Creek rises at an elevation of 2,180 feet near Cyclone, McKean County, and, after flowing westward in an irregular sweeping curve (concave to the north) for 26.5 miles, empties into Kinzua Bay of the Allegheny Reservoir at an elevation of 1,328 feet (Shaw, 1984; see back cover). Before construction of the Kinzua Dam on the Allegheny River just east of Warren, the creek continued northwest for another 8 miles and joined the Allegheny at the now-inundated village of Kinzua.

In its course across the Allegheny High Plateau from Cyclone to the Allegheny Reservoir, Kinzua Creek has carved a broad, deep

Figure 1. View of the Kinzua Creek valley and the High Plateau, looking southwest from the middle of the Kinzua Viaduct. Note the remarkable accordance and flatness of the plateau upland surface, most of which is capped by Pottsville Group sandstones. The U shape of the valley, evident in the distance, is probably due to intense colluviation in the weak, shaly Mississippian-Devonian rocks beneath the Pottsville caprock.

valley that is more than 300 feet deep at Kinzua Bridge State Park and more than 700 feet deep at the site of Kinzua village. The upland terrain on either side of this valley is remarkably flat (Figures 1 and 2), particularly on the south side where the "Big Level" forms the divide between the drainage basin of Kinzua Creek and those of the upper Allegheny and Clarion Rivers (Ashburner, 1880). This conspicuous divide, as well as most of the flat terrain bordering the stream valley, is developed mainly on resistant, subhorizontal sandstone units in the Pottsville Group of Early Pennsylvanian age (Figure 2). One of these sandstones forms the overlook within the state park. Less resistant shales and sandstones of Mississippian and Late Devonian age underlie the valleys of Kinzua Creek and its major tributaries (Figure 2). These older rock units in the Kinzua Valley are overlain by an unknown, variable thickness of Recent alluvial silt, sand, and gravel, possibly exceeding 30 feet locally.

CONSTRUCTION HISTORY OF THE TWO VIADUCTS. By the last quarter of the nineteenth century, exploitation of the abundant oil, natural gas, and bituminous coal contained in the late Paleozoic rocks of McKean County and nearby areas was proceeding at a

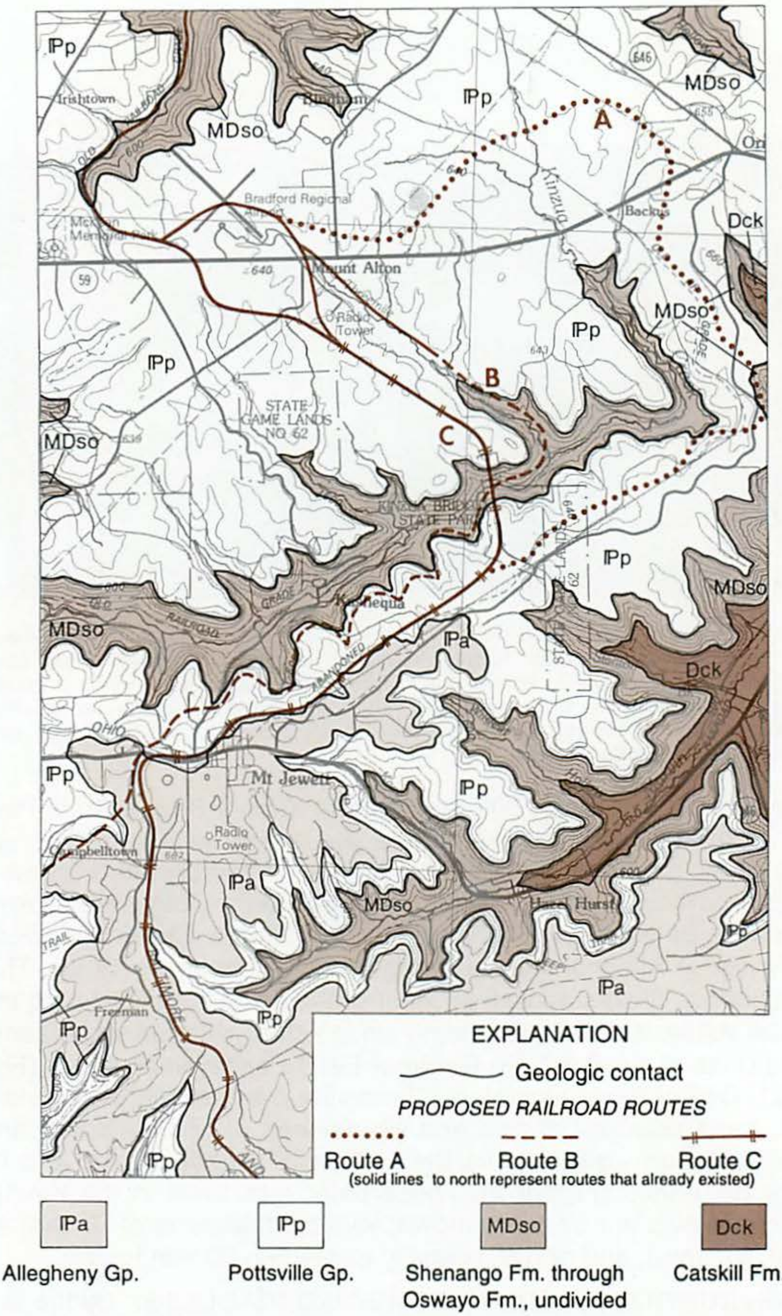

Figure 2. Geologic map of the Kinzua Bridge area (generalized from Berg and Dodge, 1981). Base map from U.S. Geological Survey Bradford 30- by 60-minute quadrangle; contour interval 20 meters. Railroad routes from The Railroad Gazette (1882a).

brisk pace. This was the era of vast railroad land holdings, and the situation in the northern tier counties of Pennsylvania mirrored that in the rest of the nation. Most important to the Kinzua story were the real-estate transactions of the Erie Railroad and its local subsidiary, the New York, Lake Erie and Western Coal and Railroad Company.

Sometime after the end of the Civil War, the Erie Railroad purchased about 27,000 acres of coal lands in Elk and Jefferson Counties 25 miles south of the site of the future Kinzua Viaduct. Economic production of coal from these large holdings was seriously limited, however, by the circuitous routes that coal trains were forced to take to both eastern (via Emporium, Pa., to Olean, N. Y.) and western (via Warren, Pa., to Buffalo, N. Y.) markets. The increasing demand for coal in western New York and the lake ports made it imperative that the Erie construct a more direct line to the new coal fields, from which it was anticipated that 3 million tons per year could be marketed (The Railroad Gazette, 1882a). Considering the railroad's existing holdings, it was clear that the best route lay directly north to the Erie main line at Carrolton, N. Y. Unfortunately, a few miles north of the midpoint of the proposed line and squarely across it lay the east-west valley of Kinzua Creek, 2,000 feet wide and 300 feet deep.

The Erie went quickly to work and created the subsidiary New York, Lake Erie and Western Coal and Railroad Company to carry out the project. General Thomas Leiper Kane (1822–1883), Civil War hero and president of the new company, and Oliver W. Barnes, its chief engineer, took on the task of constructing the railroad line from Mount Alton in McKean County across or around the Kinzua Valley and south to the coal fields in Elk County (see back cover). Chief Engineer Barnes was faced with three possible ways of traversing the Kinzua Valley (Figure 2). One was to avoid the valley entirely (line A on Figure 2); this would have extended the length of the route by 8 miles. The second was to build the track down one side of the valley, cross a 125-foot-high viaduct, and then ascend the other side (line B); but this approach would limit the weight of trains, consume more energy to run the trains, and increase the operating cost. The third (line C) was to construct a viaduct directly across the valley (The Railroad Gazette, 1882a; Thornton, 1987).

Barnes chose the third option, which resulted in the grade shown in Figure 3 for the segment of the railroad in the immediate vicinity of the Kinzua Valley. After reviewing numerous proposals for a structure across the valley, Kane and Barnes selected a wrought-iron viaduct design by the Clarke Reeves Division of the Phoenix Bridge Works of Phoenixville, Pa. The main structural design was by Adolphus Bonzano and T. C. Clarke of Clarke Reeves. Octave Chanute (1831–1910), Chief Engineer of the parent Erie

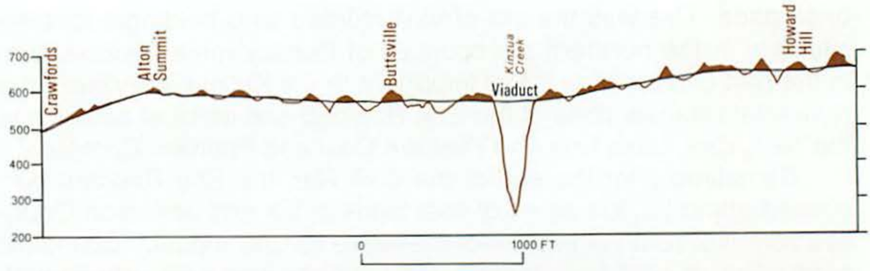

Figure 3. Final grade of the New York, Lake Erie and Western Railroad from Mount Alton to Howard Hill (now Mount Jewett) (after The Railroad Gazette, 1882b).

Railroad and already famous for his work on the Hannibal Bridge in Missouri and the New York City elevated railroad, was site engineer for the actual erection of the viaduct (The Railroad Gazette, 1882b; Clarke, 1891; Thornton, 1987). During the summer of 1881, the site was cleared, and abutments and pier foundations were constructed from 7,000 cubic yards of local Pottsville sandstone. The piers, 110 in number, extended as much as 35 feet below the alluvial floor of the valley and up to 16 feet aboveground (subsequent to completion of the second viaduct and between the years 1907 and 1933, the sandstone piers were encased in concrete) (The Railroad Gazette, 1900; Thornton, 1987; Pennsylvania Department of Environmental Resources, 1990).

Work was halted during the winter months and resumed during the spring of 1882. The erection of the ironwork structures began in April. With materials brought in by a temporary rail line, erection of the viaduct proceeded at a rate of 500 feet per month. In just 94 days, on August 25, 1882, a crew averaging 125 men completed the highest and longest railroad viaduct erected to that time at a cost of between $167,000 and $275,000 (The Railroad Gazette, 1882b; Clarke, 1891; Thornton, 1987).

The engineering statistics of the original viaduct are given in Table 1. The structure was designed to handle consolidation locomotives weighing a little over 100,000 pounds and hauling coal cars having an average capacity of 40,000 pounds (The Railroad Gazette, 1900). Early boasts that the bridge could carry the "heaviest trains at high speed" (The Railroad Gazette, 1882b) proved to be unrealistic, and trains were from the first restricted to a speed of 5 miles per hour to minimize vibrations on the rather spindly structure (Thornton, 1987).

Table 1. Engineering Statistics of the Original (1882) Kinzua Viaduct
(from Clarke, 1891; Thornton, 1987; and Jackson, 1988)

Elevation of railroad grade	2,060	feet
Length	2,053	feet
Height	301.5	feet
Width of towers	38.5	feet
Connecting spans	61	feet
Depth of girders	6	feet
Width of platform	18	feet
Gauge of railroad	4.7	feet
Inclination of pier posts	1:6	
Weight of iron	3,135,000	pounds

From the beginning, the Kinzua Viaduct served as a mecca for tourists and excursion trains. In fact, revenues from excursions to the old viaduct are reported to have offset the cost of its construction (Thornton, 1987). Nearly a century later, this public romance with the Kinzua proved to be its salvation.

The wrought-iron viaduct served well until 1900. By that time, however, the greater power and weight of locomotives, with consequent increase in total train tonnage, dictated that the viaduct be strengthened. A total reconstruction, using steel in place of wrought iron but keeping the same dimensions as the original and using the original pier footings, commenced on May 24, 1900, just 10 days after train traffic had been stopped. Steel was obtained from the Elmira Bridge Company and erected by Gratton and Jennings and Company of Buffalo. Under the supervision of resident engineer C. W. Bucholtz, Chief Engineer of the Erie Railroad, it took only four months to tear down the original viaduct and build its replacement (see front cover) (The Railroad Gazette, 1900; Thornton, 1987).

The final steelwork was placed on September 6, 1900, and the first train crossed the new viaduct on September 24. Steel replacing iron increased the weight of the structure to 6,715,000 pounds. This allowed trains with consolidation locomotives weighing 190,000 pounds and hauling cars having a capacity of 100,000 pounds each to safely cross the new viaduct, but still at reduced speeds.

LATER HISTORY: ABANDONMENT AND REUTILIZATION. Train traffic across the Kinzua Viaduct continued until June 1959, at which time the Erie Railroad abandoned the portion of its Bradford Division containing the Kinzua Viaduct. In an age when oil, not coal, was "king," hauling coal to Buffalo did not pay. The viaduct and adjacent trackage and land were sold in 1963 to the Commonwealth of Pennsylvania for a proposed state park (Thornton, 1987; Burkholder, 1993).

After several years of debate had finally established the historical and scenic value of the viaduct, Kinzua Bridge State Park was dedicated on July 5, 1975. In 1977, the viaduct was entered into the National Register of Historic Landmarks, and in 1982, in the year of its centenary, it was designated a National Historic Civil Engineering Landmark.

But merely preserving such an engineering masterpiece as the Kinzua Viaduct is like putting a fine racehorse out to pasture; it retains but a shadow of its former glory. Luckily, however, the great bridge did not long remain unused. If its usefulness to industry and commerce had come to an end, its old fascination as a tourist attraction proved to be as strong as ever.

The reuse of the viaduct started with the 1982 acquisition of Knox (Clarion County) to Kinzua Bridge trackage by the Knox, Kane, Kinzua Railroad. Then, in 1986, the Knox, Kane, Kinzua Railroad entered into an agreement with the Pennsylvania Department of Environmental Resources to lease and maintain the viaduct. After new track was laid from Mount Jewett to Kinzua Bridge and a turnaround "Y" constructed on the north side of the Kinzua Creek valley, the rejuvenated railroad ran its first tourist excursion train across the viaduct on August 7, 1987.

As a result of this imaginative cooperation between private enterprise and state government, the Knox, Kane, Kinzua Railroad now operates excursion trains to the Kinzua Viaduct from the first of June to the last day of October. A trip on the Knox, Kane, Kinzua Railroad provides an entertaining introduction to the geology of the Kinzua region, from the bedrock-controlled "Big Level" west of Mount Jewett through the numerous cuts in crossbedded Pottsville sandstone between Mount Jewett and the state park (see front cover) to the deep, incised valley of Kinzua Creek at the viaduct crossing. It also provides an unparalleled opportunity to ponder the boldness of conception, the ingenuity of construction, and the skill of workmanship that are reflected in that "eighth wonder of the world"—the Kinzua Viaduct.

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Giving the Mississippian/Devonian Boundary a Facelift

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INTRODUCTION. There is a new face on the stratigraphy of Pennsylvania. Geologists and anyone interested in the organization of geologic time periods need to be aware that because of a growing list of paleontological evidence now believed to be indisputable, the boundary between the rocks of the Mississippian and Devonian Periods was changed in 1992.

STRATIGRAPHIC CHANGES. Stratigraphy is a branch of geology whose name means, literally, writing about layers (strata). It is the science of describing, naming, correlating, and mapping rock layers by using the physical, chemical, and biological properties of the rock such as composition, color, and fossil content. Stratigraphy is a complex science that is practiced by many geologists but completely and correctly understood by only a few. Its rules, embodied in the code of stratigraphic nomenclature (North American Commission on Stratigraphic Nomenclature, 1983), encompass such a broad spectrum that they tend to confuse the nonspecialist. Understanding and properly using them may even challenge those who feel that stratigraphy is their specialty.

Additions, corrections, and other changes in the vast nomenclature of stratigraphy occur on a regular basis. Hardly a day goes by without the naming of at least one new stratigraphic unit in a professional publication somewhere in the world. In the comment and reply sections of earth science magazines and journals, geologists argue over the merits of changing the status of stratigraphic units or using one set of names over another. "State-line fault" is a humorous, informal term used to describe the confusion that results when geologists in adjacent states apply different names or assign different geologic ages to the same set of rocks. Such confusion often upsets those whose interests are more oriented toward geologic processes, prompting the late petrologist/sedimentologist Paul D. Krynine to observe, "stratigraphy is the triumph of terminology over common sense" (Miall, 1984, p. 3).

Minor changes occur in the stratigraphic terminology of Pennsylvania on a regular basis, and currently there are numerous geologists holding conflicting views of strata included in Pennsylvania's stratigraphy. A geologist using the name Tuscarora "Formation" will find disagreement from others insisting on the more restricted name Tuscarora "Sandstone." Less common are changes in formation age, which are made when a researcher reassigns a set of rock units from one geologic age to another. Under the current rules of stratigraphy, a formation (a rock unit) cannot define an age (a time unit), nor can an age, recognized by radioactive isotopes and fossils, be used to define a formation. Although isotopes and fossils are found in rock units, rock units are basically independent of fossil and isotope data. For example, the Tuscarora Formation (or Sandstone) is Early Silurian in age. We may change the name Tuscarora Formation to Tuscarora Sandstone because the unit is composed mostly of sandstone, or to Medina Group because over many miles, the rocks change from mostly sandstones to mostly shales. However, the Tuscarora Sandstone and Medina Group maintain an Early Silurian age because of isotope and/or fossil evidence.

WHEN FOSSILS TELL A DIFFERENT STORY. What happens when isotope or fossil evidence disagrees with the previously established age of the rock units? Then we must change the age to agree with the new data. This happened recently in Pennsylvania. An increasing number of new fossil discoveries indicate that certain formations currently considered to be Early Mississippian in age are actually Late Devonian in age. Although there are no isotope data to absolutely dispute or substantiate the new claim, the data from fossils carry enough weight to require us to reset the traditional boundary between the Mississippian and Devonian in Pennsylvania and adjacent states.

Geologists traditionally place the boundary between the Mississippian and Devonian Periods at the base of the Cussewago Formation of northwestern Pennsylvania and its equivalents throughout the state (Figure 1). However, the position of this boundary "has provided much lively controversy during the last 100 years" (deWitt and McGrew, 1979, p. 15). Early in this century, some geologists considered the Cussewago-equivalent Murrysville sand in the subsurface of southwestern Pennsylvania to be within the Devonian Period, even though the Cussewago maintained its status as a Mississippian-age formation. At other times, geologists considered the boundary to lie several hundred feet below the Murrysville. Most of this confusion resulted from poor correlation of strata thousands of feet below the surface, encountered only in scattered areas of oil and gas well drilling and known only through chips of rock taken from the hole by the driller. Considering the techniques available at the time, it is amazing how much our geological predecessors accomplished.

In the 1960's, it became evident that some of the rocks assigned an Early Mississippian age in Ohio and Michigan might be Devonian in age, based on fossil plant spores. One spore with the unwieldy name of *Hymenozonotriletes lepidophytus* Kedo (Figure 2A) occurs in rocks ranging from the upper part of the Ohio Shale, traditionally considered Late Devonian in age, through the lower part of the Mississippian Cuyahoga Formation. Some controversy ensued when one geologist claimed that this fossil indicated a Devonian age for all of the rocks in the sequence and another argued that other data contradicted that claim (deWitt, 1970). Further investigation of the total spore content of these rocks led Eames (1974) to conclude that the Mississippian/Devonian boundary should be placed at or near the top of the Berea Sandstone (Figure 1). Because the Berea lies stratigraphically higher (i.e., is geologically younger) than the Cussewago and its equivalents, the Cussewago and its equivalents logically must be of Devonian age as well.

More recent evidence for raising the roof on the Mississippian/Devonian boundary is from brachiopod and arthropod fossils. It has been known for many years that the Berea-equivalent Corry and Knapp Formations of northwestern Pennsylvania and parts of the Price Formation of West Virginia contain fossils of the brachiopod *Cyrtospirifer* (Figure 2B), called "*Spirifer disjunctus*" in almost all pre-1950's publications. It also occurs in the "Cussewago Sand-

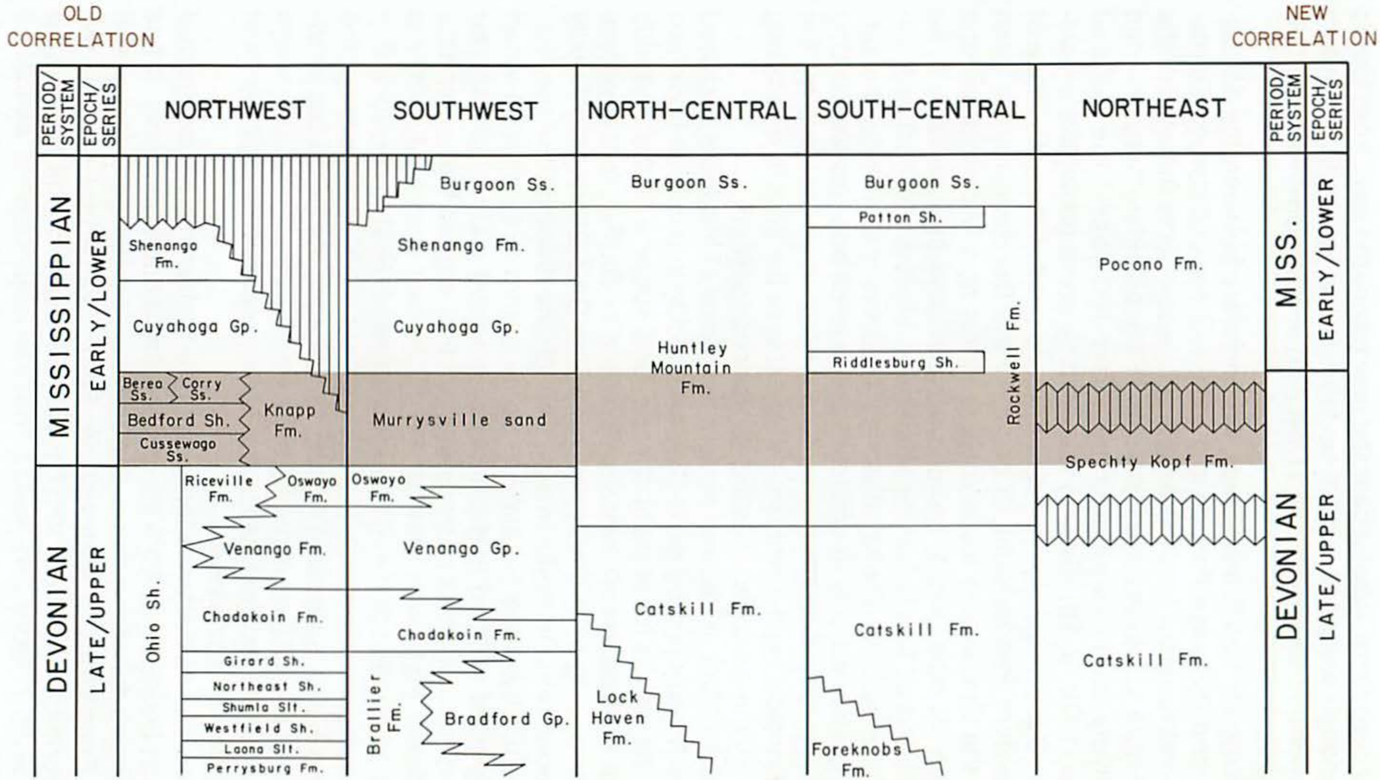

Figure 1. Correlation chart of some rock units of Late Devonian and Early Mississippian age in Pennsylvania. The highlighted area indicates the part of the stratigraphic record for which the geologic age has been changed recently.

stone" of some authors in southwestern Pennsylvania (actually the Murrysville sand) in the few outcrops that can be found along Chestnut Ridge in Fayette and Westmoreland Counties. Carter and Kammer (1990), following the practice of global biostratigraphers, unequivocally consider *Cyrtospirifer* an indicator of Devonian age. They point out that all evidence for the existence of this brachiopod genus in the Mississippian or Early Carboniferous throughout the world has been contradicted by other available data. In fact, according to one author cited in their paper, it may not even range as far as the end of the Devonian Period. In addition, Feldmann and others (1992) recorded the presence of the crustacean *Echinocaris randallii* Beecher (Figure 2C) in the Corry Sandstone at Drake Well Museum in Venango County. This fossil, a kind of bivalved shrimp, occurs elsewhere in rocks generally acknowledged to be Late Devonian in age, lending credence to the concept that the Corry is Devonian in age.

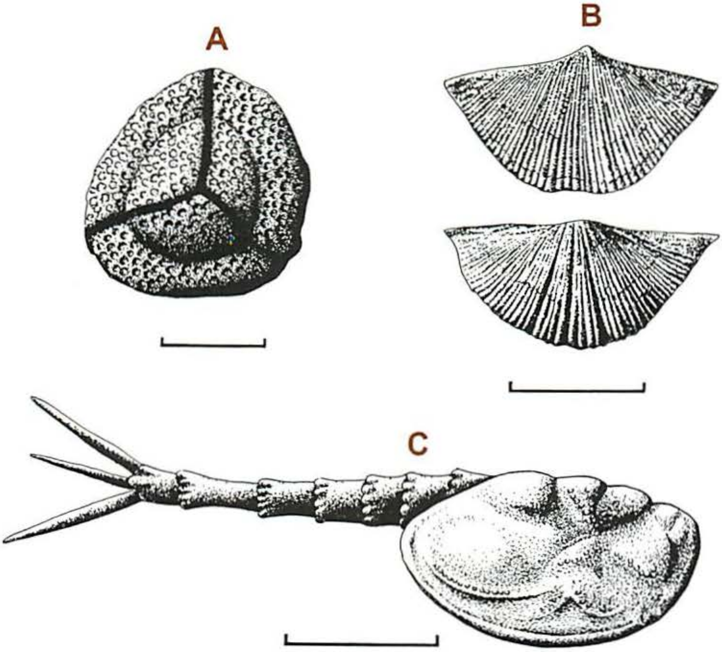

Figure 2. A, *Hymenozonotriletes lepidophytus* Kedo, a Late Devonian and Early Mississippian plant spore. Scale is 50 microns. B, *Cyrtospirifer sulcifer* (Hall), a typical species of the Devonian brachiopod genus. Top view shows pedicle valve, and bottom shows brachial valve. Scale is 25 mm. C, Partial reconstruction of *Echinocaris randallii* Beecher, a Late Devonian bivalved shrimp. Scale is 1 cm.

CHANGES ACCEPTED BY THE PENNSYLVANIA GEOLOGICAL SURVEY. The fossil evidence is indisputable. The Berea, Corry, and Knapp Formations are Late Devonian in age, and therefore the rocks beneath them, previously considered to be Mississippian, are Devonian as well. The first inarguable Mississippian-age rocks in the Commonwealth include the Cuyahoga Formation of northwestern Pennsylvania and, by correlation, the Riddlesburg Shale of south-central Pennsylvania (Figure 1).

The Pennsylvania Geological Survey recognizes and accepts the nature and importance of this change. Although we cannot revise all of our previously published reports and maps to reflect the change, certain expected revisions, such as future editions of the geologic map (Berg and others, 1980) will incorporate the new boundary. The most recent reprinting of the Pennsylvania stratigraphic correlation chart (Berg and others, 1986; reprinted in 1993) includes a written addendum concerning this boundary change. Readers should be aware of the changes when consulting the geologic literature of Pennsylvania.

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ANNOUNCEMENTS

Pennsylvania—A National Leader in the Production of Industrial Minerals

Within the past year, the U.S. Bureau of Mines held the "1992 Industrial-Mineral-Production Awards Ceremony," and Pennsylvania came away with some top honors. The Commonwealth led the nation in the production of crushed stone in 1992 and ranked among the top four states in cement and lime production. Overall, Pennsylvania ranked thirteenth in the nation for value of nonfuel minerals, accounting for 3 percent of the United States total value. This is not a new development in the long history of nonfuel mining in Pennsylvania.

Why are nonfuel minerals important to the citizens of Pennsylvania? In addition to the fact that the 1992 nonfuel-mineral production represents an estimated cumulative value of almost $865 million (the value of crushed stone, alone, represents appproximately 45 percent of this value; see Table 1), the availability of abundant industrial minerals helps

Table 1. ***Nonfuel Mineral Production in Pennsylvania***[1]
(from U.S. Bureau of Mines, 1993; quantities are in thousand short tons unless otherwise indicated)

Mineral	1990 Quantity	1990 Value (thousands)	1991 Quantity	1991 Value (thousands)	1992[e] Quantity	1992[e] Value (thousands)
Cement:						
Masonry	303	$22,594	[e]253	[e]$18,975	249	$18,675
Portland	5,621	286,185	[e]4,881	[e]248,931	4,675	238,425
Clays[2] (metric tons)	840,646	2,900	701,399	2,890	669,463	3,556
Gem stones	NA	5	NA	5	NA	1
Lime	1,626	92,557	1,695	95,328	1,741	97,914
Peat	18	730	10	207	W	W
Sand and gravel (construction)	20,883	97,348	[e]18,300	[e]87,800	18,000	88,000
Stone:						
Crushed[3]	[e]95,800	[e]502,700	70,334	362,306	72,700	385,700
Dimension (short tons)	[e]43,952	[e]9,898	38,493	10,077	41,728	10,822
Combined[4]	XX	15,125	XX	17,482	XX	19,535
Total	XX	1,030,042	XX	844,001	XX	862,628

e, estimated. NA, not available. W, withheld to avoid disclosing company proprietary data; value included with "combined value" data. XX, not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including comsumption by producers).
[2]Excludes certain clays; kind and value included with "combined value" figure.
[3]Excludes certain stones; kind and value included with "combined value" figure.
[4]Includes clays (fire [1990], kaolin), mica (scrap), sand and gravel (industrial), stone (crushed granite [1990], crushed limestone, dolomite, and quartzite [1991], crushed unidentified [1992]), tripoli, and value indicated by symbol W.

Pennsylvania's citizens maintain and expand the state's infrastructure, including highways, bridges, airports, railroad beds, and commercial and residential buildings. In addition to their use in construction, lime and limestone are used in steel making and glassmaking processes. Environmental applications of these carbonate products, such as acid neutralization, water purification, and capturing sulfur emissions, increase each year.

But what is so special about producing aggregates? Although many regions of the United States produce these commodities, it is important to realize that most construction aggregates are low-unit-price, high-volume commodities. Generally they cannot be transported more than 30 miles from their source of origin before transportation costs cause their value on a per-ton basis to double, and construction costs then become significantly higher. It may help to illustrate this point if we consider that for every citizen of Pennsylvania, approximately 45 pounds of industrial minerals are consumed daily at a cost of less than 20 cents per day! These mineral products appear to be one of the last true bargains of the century, costing less than a penny per pound. Furthermore, they are made from all-natural ingredients and can be recycled.

REFERENCE

U.S. Bureau of Mines (1993), *Mineral industry surveys—The mineral industry of Pennsylvania in 1992*, Washington D.C., 2 p.

Maria Crawford Receives MacArthur Fellowship

Maria Louisa (Weecha) Crawford, Professor of Science and Environmental Studies and Professor of Geology at Bryn Mawr College, has received one of 31 MacArthur Fellowships awarded in 1993. Since 1981, money from the John D. and Catherine T. MacArthur Foundation of Chicago has been distributed to exceptionally gifted individuals to spend as they choose. Dr. Crawford was awarded $320,000 to be paid over the next five years.

The money will support Dr. Crawford's site-specific research on mountain belts. This research, which has taken her to British Columbia and Alaska, may one day shed new light on the mechanisms and timing of convergent plate movement.

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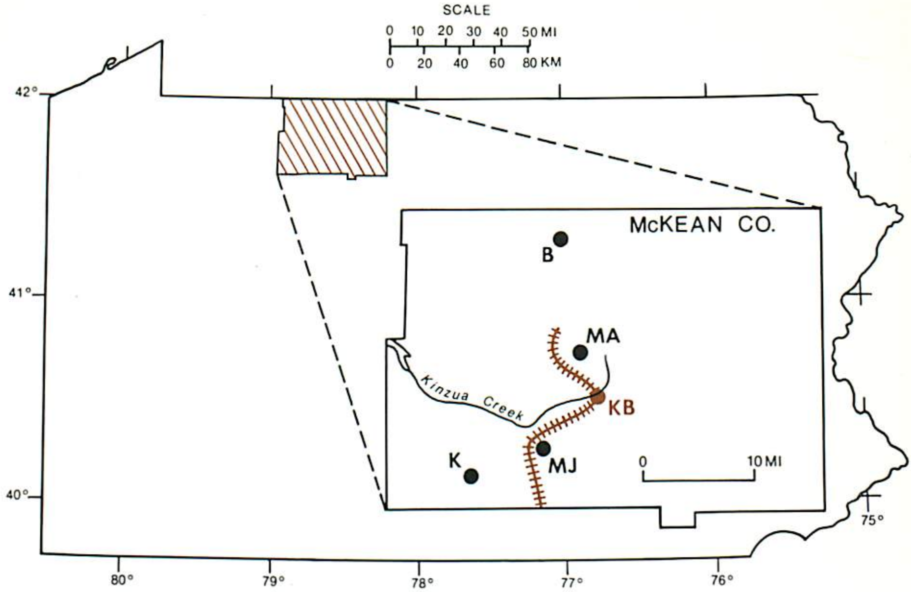
IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY
TOPOGRAPHIC MAPPING
GROUNDWATER-RESOURCE MAPPING

SITE OF THE KINZUA VIADUCT

(see article on page 2)



EXPLANATION

Trackage of the New York, Lake Erie and Western Railroad

B	Bradford	MA	Mount Alton	KB	Kinzua Bridge
K	Kane	MJ	Mount Jewett		

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Department of Environmental Resources
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Address Corrections Requested

DER #103-11/93