Ohio Geology

Ohio Department of Natural Resources, Division of Geological Survey • 2010, No. 1

New Coastal Erosion Maps Continue a Legacy of Coastal Research in Ohio

By D. Mark Jones

Permanent settlement of Ohio's Lake Erie coast began with the founding of Cleveland in 1796. The settlers' problems with coastal erosion began soon after. Geologist Charles Whittlesey, in his 1867 book, *Early History of Cleveland, Ohio*, noted that in "comparing the surveys of 1796 and 1842 there had been a general encroachment of *two hundred and five* (205) feet" (Whittlesey's italics). Figuring Cleveland lost about 4.5 feet per year of land during that span, he told of a man who chained his team of oxen to a tree at the top of a bluff beside the lake, went home for lunch, and came back to find the animals missing. The bluff had collapsed 20 to 30 feet during his break, taking the tree and oxen with it. The animals were found unharmed and "quietly chewing their cuds."

The consequences of erosion are not always so innocuous. From 1972 to 1976, an estimated $61 million—about $300 million in today's money—in erosion-related property damages and losses occurred along the Ohio shore. Since the Ohio Geological Survey recently released a new set of Lake Erie coastal erosion maps, now is a good time to consider coastal erosion in Ohio and the Geological Survey's role in studying it.

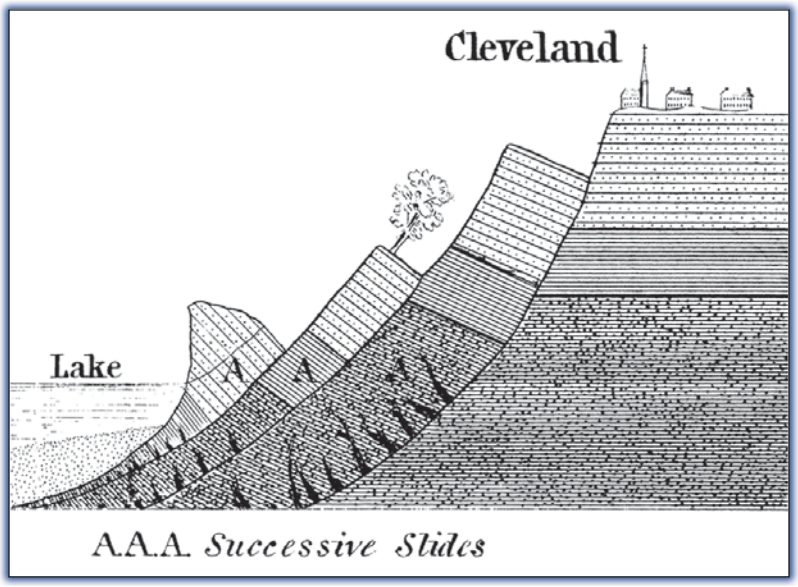
The phrase *coastal erosion* may invoke images of pounding hurricane surf in the Carolinas or towering seaside cliffs in California, but the shores of the Great Lakes are affected as well. Parts of the Ohio coast have receded hundreds of feet over the last century. Erosion threatens not only private property but also public interests, such as infrastructure and utilities (e.g., roads, water intakes, and sewer outfalls). In a state where only 13 percent of the lakeshore is publicly accessible, public parks are some of the properties most susceptible to erosion because there may be few funds in local budgets for their protection.

Rapid erosion also affects lake water quality, harming fish habitat to the detriment of Ohio's sport and commercial fishing economies. Erosion of or near harbors, parks, and beaches affects the shipping industry and recreation and tourism economies. Erosion damage to private properties increases insurance premiums and decreases local tax revenues by destroying taxable property. Erosion can also be dangerous, being blamed for three fatalities in Ohio in recent decades.

Faced with erosion and having little knowledge of its cause, some property owners may respond with measures that are poorly designed for the task, creating safety hazards or worsening erosion problems on adjoining properties or their own.

The Coastal Erosion Area Program

Given the risks to residential, economic, and environmental interests, management of coastal zones has been recognized as a legitimate public concern. The State of Ohio has officially studied



A profile drawing of slumps at Cleveland, from *First Geological Survey of Ohio* (Mather, 1838), shows that bluff erosion in the young city of Cleveland was an original concern of the Ohio Geological Survey.

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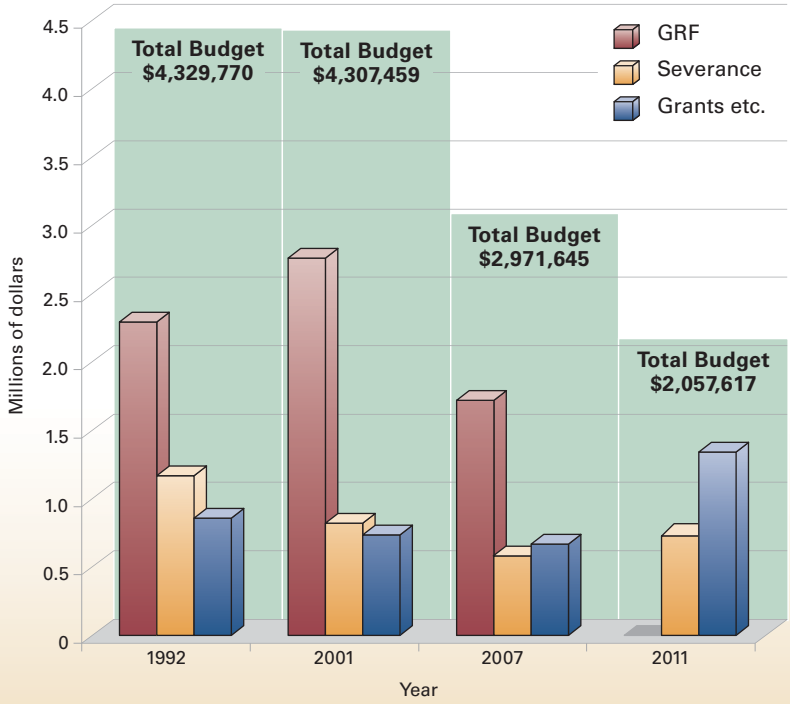
OHIO ROCKS!

Larry Wickstrom,
Division Chief and State Geologist

Many who support the Ohio Geological Survey may not be aware of our organization's current financial situation, so I thought it appropriate to provide an update here. The big news is that general revenue funding (GRF) for the Survey has been eliminated from our budget for the next fiscal year, starting July 1. This development occurred very late in the biennial budget legislative process (mid-June 2009) in response to the worsening economy and the reality that Ohio's tax revenues were worse than previously thought; so most state agencies were given fairly severe eleventh-hour budget reductions for the FY10–11 biennium. Within ODNR, GRF budgets for the Division of Natural Areas and Preserves and the Division of Geological Survey were eliminated for FY11. Facing either elimination or being parted out to other agencies, we proposed to attempt to replace GRF with other funding sources, and the administration agreed.

First, a little background may be useful to our readers. Until 1983, when the Survey began receiving a small percentage of mineral severance taxes, GRF funding was nearly the Survey's sole source of revenue. Then in the late '80s we began attracting research grants, mostly from federal agencies. But through the 1990s and early 2000s, mineral and fuel production decreased; severance income steadily declined; and GRF income fluctuated, with an overall downward trend. As the graph below illustrates, the Survey's total budget during the same period decreased from over $4 million annually to currently just over $2 million. Also during this time, Survey staff levels fell from nearly 70 in 1989 to 25 today. But despite funding and personnel cuts, eliminating several program areas, and closing our Sandusky field office, our dedicated staff continues to find new ways to be more efficient and cost effective, doing more and more with less and less.



Total budget amounts are adjusted to 2008 dollars and do not include the Survey's Publications Fund (non-salary).

With numerous states now facing large deficits, many are calling for reduced spending, eliminating government programs, or finding alternative funding mechanisms. I do believe that government at every level needs to be reinvented. We cannot continue to endlessly fund all government levels, programs, and agencies as we have in the past. But, I am confident that an efficient state geological survey is a necessity and produces more benefits to the citizenry, environment, and industry than the revenues it consumes because of the high value of our products and services, which are used over and over by many interests.

A recent study by Illinois economists showed that the Kentucky Geological Survey's bedrock mapping program returned a 23:1 cost benefit. Our recent bedrock-mapping program cost much less than Kentucky's, and Ohio has a larger population and more development and industry. Thus, I would project our benefit-to-cost ratio is even higher. Similarly, Survey data and publications are basic elements used by the extractive industries to find new reserves and develop existing ones. Collectively, these industries produce over $3 billion annually; if even 1/10 of 1% ($3 million) of this productivity can be ascribed to Survey data and services—and I think that is a

very conservative number—then we are returning a very large benefit-to-cost ratio (we had been spending $1 to 1.5 million annually in this area).

Damages from geologic hazards will continue to mount in Ohio as our infrastructure ages and development continues expanding. We conservatively estimate Ohioans pay for about $100 million/year in damages from various geologic hazards (erosion, karst, mine subsidence, earthquakes, etc.), yet we do not have an overall program in place to map and analyze these phenomena statewide. As this issue's lead story demonstrates, the Coastal Erosion Area Program has significantly contributed to reducing property damage caused by wave energy along Ohio's north coast. Mine subsidence is another area where we have been the primary source of data for decades, specifically with abandoned underground mine maps. We think this program can easily be shown to have saved the state, local communities, and private citizens well above $10 million over just the last decade while having spent at most $2 million on it over that time—another example of great benefit versus cost. These two successful programs need to be duplicated for all geohazards in the state.

The Survey suffers from not having a large enough public image, and too few people realize all we do to benefit the state and its citizens. I firmly believe these were the reasons for the elimination of our GRF funding; it was *not* a judgment on the agency's effectiveness.

I am happy to report that our efforts to secure additional non-GRF funding have been successful (see our grants and partnerships table below). Therefore, the Survey can maintain current staffing and work levels, at least through the current biennium. More importantly, we've bought time to continue reinventing ourselves and address the need for a higher profile while also forging new partnerships and relationships. The cost-effective services of the Ohio Geological Survey are needed, but we must work with state and industry leadership to seek innovative solutions to our long-term funding. We welcome input from *Ohio Geology* readers.

Grants and partnerships pending and/or awarded to the Ohio Geological Survey as of February 1, 2010

Source	Title/Description	Duration	Total ($)
U.S. Department of Energy (DOE)	Simulation and Regional Framework for Injection Operations within the Mt. Simon Sandstone along the Arches Province of Midwest United States	3 years, beginning spring 2010	198,886.00
	Geothermal Characterization of Ohio	3 years, beginning spring 2010	300,000.00
	Midwest Regional Carbon Sequestration Partnership (MRCSP) Phase III.[1]	March 2010–August 2011	224,098.00
U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement	Continue creating & georeferencing high-resolution scans of Ohio's abandoned underground mine (AUM) maps.	July 2010–June 2011	26,538.00
United States Geological Survey (USGS)	National Cooperative Geologic Mapping Program (STATEMAP)—Assistance to the state for creating surficial geology maps.	Current through August 2010	107,000.00
		September 2010–August 2011	114,000.00
	National Geological and Geophysical Data Preservation Program—Assist with preservation of data, samples, and cores and to provide computerized inventories of the collections.	July 2010–June 2011	20,000.00
	National Coal Resource Data System	Current through June 2010	15,000.00
		July 2010–June 2011	65,000.00
Great Lakes Geologic Mapping Consortium[2]	Develop three-dimenional mapping & products of surficial geology.	Current through September 2010	114,000.00
Federal Emergency Management Agency (FEMA)[3]	Ohio Seismic Network equipment (no salaries).	July 2010–June 2011	20,000.00
Ohio Mine Subsidence Insurance Underwriting Association (OMSIUA)	Gather existing geologic information on subsidence complaints.	Current through December 2010	68,995.00
	Gather mine subsidence data/maps from multiple agencies; create new AUM Web site.	Current through December 2010	349,035.00

[1]Funding will be negotiated beyond 2011. [2]Funding through the USGS. [3]Funding through Ohio EMA.

New *Ohio Geology* EXTRA Feature Now Online

We've expanded our Web site to include more of the latest information about Ohio's geology and Survey activities. Log on to our home page and click the "News" link on the left side of the page to reach our *Ohio Geology* EXTRA feature and check out the latest on what's happening at the Geological Survey and around the state.

www.ohiodnr.com/geosurvey

COASTAL EROSION continued from page 1

Lake Erie-related erosion since about the 1930s, then under the Division of Beach Erosion, within the Department of Public Works. That group, later renamed the Division of Shore Erosion, joined the Ohio Department of Natural Resources (ODNR) as one of its seven original divisions, before becoming absorbed by the Division of Geological Survey. However, the modern era of erosion studies in Ohio began in 1988 when the state legislature created the Ohio Coastal Management Program (OCMP). The OCMP has several focus areas, one of which is erosion. Under the OCMP, the Coastal Erosion Area Program was created to study and map erosion along the Ohio coast, attempt to prevent property loss and infrastructure damage, and improve safety by making information on erosion publicly available and encouraging development outside the most erosion-prone zones.

Under the program, the ODNR identifies and maps coastal erosion areas (CEAs), defined as "land areas anticipated to be lost by Lake Erie-related erosion within a thirty-year period if no additional approved erosion control measures are completed within that time" (Ohio Administrative Code 1501-6-10).

Ohio law has special requirements for owners of residential land under a CEA designation. First, those property owners who wish to build on their land must take measures to protect it from erosion. Second, they must disclose the CEA designation to a buyer if they sell the land. These requirements reflect the Coastal Erosion Area Program's goals of encouraging development outside the most erosion-prone areas and increasing public awareness of erosion.

One means of accomplishing these goals is mapping those areas along the Ohio coast that are most prone to erosion. With over a half-century's worth of expertise and data in erosion-related matters, the Geological Survey was a logical choice for creating the maps that define designated coastal erosion areas.

Mapping Ohio's coastal erosion areas

Mapping Ohio's coastal erosion areas is a complex and lengthy process that consists of measuring recession—the landward retreat of a bluff or beach crest. By comparing the past shoreline to a more recent shoreline, the Geological Survey can determine the rate of shoreline recession and project the extent of future recession. (*Shoreline* here refers to the line, in aerial view, defining the crest of the slope above the lake or, in the case of a low-lying coast, the crest of a sand spit or beach.) A finished CEA map consists of the base map (at a scale of 1 inch to 200 feet) overlaid with the recent shoreline; the historical shoreline; and the 30-year anticipated recession distance of the shoreline—essentially, how far the shoreline is predicted to recede 30 years from its current position. Land between this line and the water is said to be in a designated coastal erosion area. Because the base map is an aerial photograph, a person with no technical experience needs only to find a familiar landmark to identify his or her property on the map and determine whether it falls within a designated CEA.

In 1996, 200 years after the first survey of the Ohio shoreline at Cleveland, the first CEA maps were released in preliminary (draft) form. The maps used aerial base photographs from 1990 and reflected recession that occurred from 1973 to 1990. After a period of revision, they were finalized in 1998.

Preparation for an update to the 1998 final maps began in 2004 with the acquisition of a new set of high-resolution, color aerial photographs. The updated maps, released in January 2010 in preliminary form, are based on recession that occurred from 1990 to 2004. Although the methodology for determining past and anticipated recession has not changed, technological advancements have improved the mapping process, yielding maps that are more legible and more quickly produced. For the first time, the maps are also viewable online.

Below: Detail of a 2010 Coastal Erosion Area map.

Changing trends

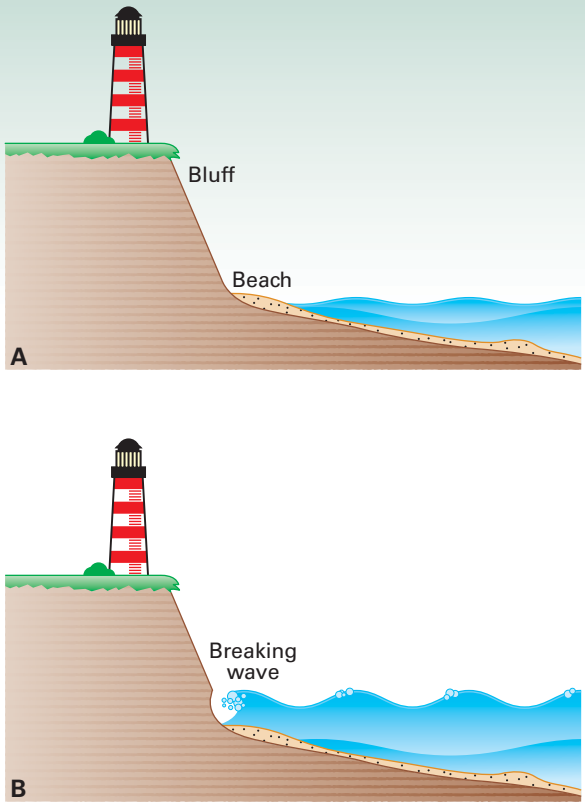
Comparing the 1998 maps with the 2010 maps yields interesting results.

	First release	Second release
Map release date	1998 (final)	2010 (preliminary)
Years of recession measured	17 (1973–1990)	14 (1990–2004)
Average recession rate	1.4 feet/year	0.4 feet/year
Amount of shore in a coastal erosion area	95 miles (36% of Ohio shore)	32 miles (12% of Ohio shore)

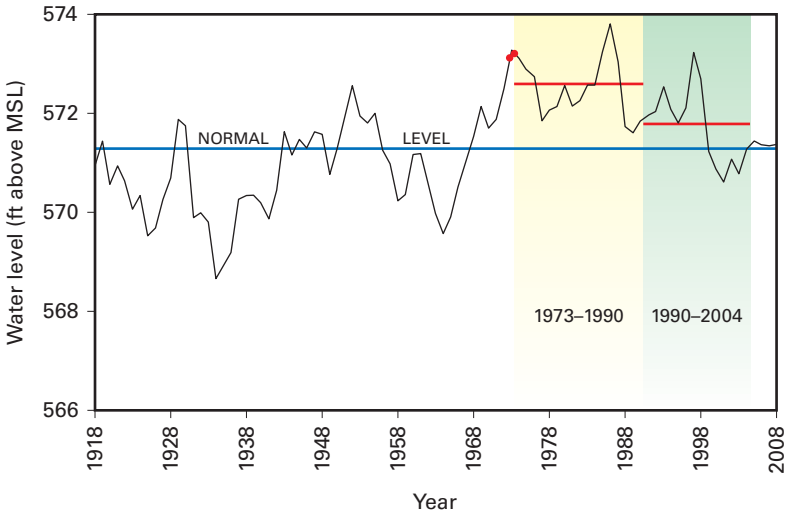
As the table shows, there has been a significant decrease in recession rates and in the amount of Ohio shore under a CEA designation, with both decreasing by about two-thirds. Because the updated maps are in preliminary form, they are subject to change before being finalized; however, the average recession rate and shore length affected are not expected to change significantly.

Understanding why the recession rate was greater during 1973–1990 than 1990–2004 requires understanding why erosion occurs. Most Lake Erie coastal erosion is a result of wave action. Shores accommodate wave energy by developing a profile or cross section that allows waves to break against a low slope (often, but not always, a sandy beach), dissipating wave energy. During periods of normal or near-normal water levels, this profile limits erosion by limiting wave attack on the upland. However, during periods of higher water levels, storms can bring waves higher up the shoreface to inundate beaches and attack the base of the upland directly. Such wave attack destabilizes the bluff and promotes erosion. This process is especially prevalent where bluffs consist of glacial till, as in Ashtabula and Lake counties where coastal erosion area designations affect up to 35 percent of the shoreline. However, bedrock bluffs are also prone to wave attack.

Given this background, a possible clue to changing recession rates emerges. Between 1973 and 1990, Lake Erie experienced two periods of record-high water levels. Each period would have been accompanied by higher waves. As an aggravating factor, two severe nor'easter storms struck the south shore of Lake Erie in the early 1970s. The first occurred in November of 1972, when for two days winds of up to 60 knots drove waves up to 12-feet high towards the lakeshore. Contemporary estimates put damages in Ohio at $22 million. Shortly after, in April of 1973 another storm struck. Both of these events occurred before aerial photographs used to map



A typical cross-shore profile under (**A**) normal water levels and (**B**) high water levels. Storm waves during high water levels can inundate the beach and attack the base of the upland.



Lake Erie hydrograph (water level plot) for 1918–2008. Red lines are the short-term averages for each period. Blue line is the long-term average ("normal" level). From 1973 to 1990, water levels were well above normal, and nearly a foot higher on average than the 1990–2004 levels. Also note the two storms (red dots) that struck the southern Lake Erie coast while water levels were high in the early 1970s. These factors led to faster recession rates for the 1973–1990 period. Water levels are in feet above mean sea level (MSL) per International Great Lakes Datum, 1985.

the 1973 shoreline were taken. However, bluffs that had been battered during the storms probably continued to fail for some months afterward, so that recession initiated by those storms would have been detected when comparing the 1973 shoreline with a later shoreline.

In contrast, water levels for 1990–2004, although still above the long-term average, were lower than 1973–1990, and only one violent nor'easter storm is thought to have struck the south shore during that period, in April 1998. Rather than bluff erosion, that storm's greatest impact was to flood low-lying coasts, and it was followed by a long period (about three years) of steadily dropping water levels. These factors are thought to be responsible for slower shore recession during 1990–2004 than 1973–1990.

As long as gravity and water exist, erosion will continue and lakefront interests will benefit from the Survey's efforts to measure and predict it.

Another likely factor in changing recession rates is shore armoring—the use of structures (e.g., seawalls, breakwalls, and the like, usually made of concrete, stone, or steel) to protect the bluff from wave energy. A Geological Survey study classifying the degree of shore armoring as either sparse, moderate, or dense found that the amount of densely armored shore increased from 24 percent in the 1970s to 78 percent in the 1990s. This was largely due to increasing urbanization, with nearly every new lakefront house being accompanied by its own shore protection structure. Since armoring protects against wave energy, recession rates decreased, on average, during 1990–2004. (Shore armoring, however, is not a perfect solution; it can prevent the formation of beaches and otherwise alters natural coastal processes.)

The Future

By law, future rounds of coastal erosion mapping will occur about every ten years. Almost certainly, advances in technology will speed the mapping process, increase accuracy, and improve map delivery to the public. Less certain are future trends in erosion itself. Further large decreases in recession rates are probably unlikely. In fact, a rise in lake levels on the order of that seen in the 1980s could reaccelerate erosion rates. However, with so much of the Ohio coast now developed, the incentive to protect lands from loss is greater than ever. As the shore approaches 100 percent armoring, wave-induced erosion may become less important and other factors may come to the fore, such as slope failures due to freeze-thaw cycles or groundwater seeps.

The character of development may also be important. Before World War II, much of the Ohio coast was devoted to farming and modest summer cottages. Erosion was tolerated to an extent because few large investments were threatened. Post-war, the coast experienced year-round residential development, with more effort put into armoring the shore against loss. In the same way, future trends in development or changes in how we see our relationship with the coastal environment may alter development patterns further, with unforeseen effects on recession rates. The one certainty is that as long as gravity and water exist, erosion will continue and lakefront interests—residential, economic, and environmental—will benefit from the Geological Survey's efforts to measure and predict it.

Editor's Note: Further information about the Coastal Erosion Area Program, including a fact sheet and a link to the maps themselves, is available online at **www.ohiodnr.com/CEAm.**

Further Reading

Fuller, Jonathan, 1987, "High Water Creates Problems on Lake Erie Shore": *Ohio Geology*, Spring 1987, p. 5–6.

Fuller, Jonathan, 1988, "Storm-Induced Water-Level Changes in Lake Erie": *Ohio Geology,* Spring 1988, p. 6.

Hansen, Michael, 1994, "Lake Erie Bluff Collapse": *Ohio Geology,* Summer 1994, p. 5.

Whittlesey, Charles, 1867, *Early History of Cleveland, Ohio*: Cleveland, Ohio, Fairbanks, Benedict & Co., 487 p.

2008 Report on Ohio Mineral Industries Now Available

The annual *Report on Ohio Mineral Industries* reveals that Ohio's geology produced commodities valued at more than $3.29 billion in 2008, a 29 percent increase from 2007. The free electronic version of the 2008 report and its interactive map are available through the "Interactive Maps" page of the Ohio Geological Survey's Web site. Using the "Identify" tool, interactive map users can obtain mining information about specific mines, including permit numbers, geologic commodities produced, and tonnage produced or sold during the calendar year. The report also will be available on a limited number of CD-ROMs ($10 plus sales tax and $2.50 in shipping). See ordering information on page 8.

Survey Inspects a Rare Ohio Geohazard

On December 16, 2009, Survey geologists Mark Jones, Glenn Larsen, and Erik Venteris, along with Huron County Engineer Joseph Kovach and Administrative Assistant Carl Essex, visited the site of a shale fire along the West Branch of the Huron River in Huron County. The fire occurred in an outcrop of the Late Devonian Huron Shale Member of the Ohio Shale along River Road, northeast of the town of Monroeville in Ridgefield Township.

The Huron County Engineer's Office was notified of the fire in November; however, it may have been burning as early as August, possibly longer. The fire appears to have started at the base of the debris slope and worked its way up to the shale cliff face. Trees on the slope were burned from the roots up, evidence of the fire's duration and heat intensity. The local fire department tried to put the fire out with water but to no avail. And on December 18, 2009, the *Norwalk Reflector* reported that the fire was still burning.

At the time of inspection, geologists were uncertain of the cause. However, such fires have been known to be caused by spontaneous combustion. In oil-shale and coal bed fires elsewhere around the world, such as the southern coast of England, spontaneous combustion occurs during the ignition of a substance as a result of internal oxidation processes, without the application of an external source of heat. Shale fires are thought to be the result of oxidation of iron pyrite within debris slopes of weathered rock faces. Iron pyrites are composed of one iron atom and two sulfur atoms. Moist air decomposes the pyrite. The decomposition process generates heat and if the heat is not vented sufficiently, the sulfur ignites. Once the sulfur ignites, the organic-rich shale provides the fuel to keep the fire burning. Debris slopes provide a good environment because of the high surface area per unit volume of shale, along with trapped moisture and pore space to allow a good flow of oxygen.

While this was the first shale fire reported to the Geological Survey, there are rumors of fires that occurred near the Pontifical College Josephinum, in northwest Columbus, and in Delaware and Morrow counties. One possible explanation for there being so few occurrences is that the organic content in Ohio shales is generally not high enough to sustain combustion. However, any organic-rich black shale may be prone to such events, for example the Cleveland Shale Member of the Ohio Shale, the Sunbury Shale, and the marine black shales associated with coal beds in eastern Ohio.

According to the Huron County Engineer's office, as of February 25, 2010, the shale fire was still burning; with an indefinite amount of oil-rich shale to fuel it, the fire may continue to burn for weeks or even months. Investigators are still trying to determine the cause of the fire.

Further Reading

West, Ian, 2008, Burning Beach, Burning Cliffs and the Lyme Volcano—Oil-Shale Fires, *in* Geology of the Wessex Coast: Southampton, England, Web site hosted by Southampton University Information System Services, < www.soton.ac.uk/ ~ imw/kimfire.htm > .

By Glenn E. Larsen

Smoke rises from an outrcrop of the Huron Shale outside Monroeville, Ohio. The orange debris, called *clinker,* are similar to shards of broken pottery and remain after the organics have been burned out of the shale fragments. The clinker here reveals the fire moved steadily up the slope.

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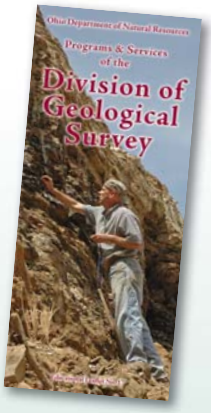
New Educational Leaflet 17 Released



If you're curious about the Survey's role in supporting Ohio industry and commerce or want to know more about our advanced energy and educational outreach efforts, then our new Educational Leaflet—EL 17: *Programs and Services of the Division of Geological Survey*—is a good place to start. Available for free from the Geologic Records Center and online, EL 17 offers a chance to get familiar with the Survey's key programs, services, and research initiatives. Educational Leaflet 17 and other ELs can be found in the "Educational Resources" section of the Survey's Web site at **www.ohiodnr.com/geosurvey**.

New Study Reassesses Stage's Pond

A recent Ohio Geological Survey study offers a new interpretation of how Stage's Pond, in Ashville, Ohio, was formed. Analysis of glacial sediments surrounding the area will be particularly useful to environmentalists, glacial geologists, citizens interested in the geological history of Stage's Pond, and those concerned with how existing and future water wells drilled nearby may impact the pond's ecosystem. Information Circular 62 is available for $8 (plus sales tax and shipping). Please see ordering information at left.