Ohio Geology

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Geologic Maps are Essential Tools for Fish Management

by Erik R. Venteris and Cassandra May

Regular readers of *Ohio Geology* are familiar with the central role that geology plays in our society. From energy production to earthquake hazards, the benefits of geologic studies and maps are well established. The utility of geology extends across many scientific disciplines; well-known examples include the role of geologic sedimentary records in assessing past climates and weather and the contribution of the fossil record to understanding biological concepts, such as evolution. However, some applications of geology are not immediately obvious.

The Ohio Geological Survey recently was asked to help map bottom sediments on Hoover Reservoir, a 2,818-acre impoundment northeast of Columbus. Recent collaborative studies between The Ohio State University, Aquatic Ecology Laboratory and the ODNR Division of Wildlife have shown that walleye and saugeye prefer to live in areas of hard, gravelly sediment rather than soft clay and muck bottoms. Therefore, maps of bottom types can be used by fisheries managers to inventory the amount of available habitat and to help fishermen locate the most promising sites. In addition, bottom sediments are a critical part of the primary productivity in reservoir ecosystems. A significant portion of nutrients available to phytoplankton are derived from organic matter that washes in from the surrounding landscape and eventually sinks to the lake bottom. The nutrients are made available to phytoplankton from the digestion of bottom sediment detritus by gizzard shad, which also are an important food for sport fish. Hence, knowing the location and extent of both coarse sediments and organic-rich bottom sediments is essential for understanding the complex workings of the reservoir's ecosystem.

Natural and Human History of Hoover Reservoir

Documenting the history of Hoover Reservoir is important to accurately mapping its bottom sediments. The story of the reservoir begins with the deposition of Devonian-age shales about 400 million years ago, when Ohio was covered by an epicontinental sea. These shales were buried and lithified during the formation of the Appalachian sedimentary basin and were reexposed to the surface more than 2.5 million years ago, before the current ice age. Before the glaciers arrived, these rocks were subjected to soil formation and drainage development. The terrestrial surface was the site of glacial erosion and deposition during the advances and retreats of numerous Pleistocene ice sheets. The final ice sheet cycle in the Late Wisconsinan left behind tills that are generally less than 15 feet thick in the narrow, southern portion of Hoover Reservoir but are up to 100 feet thick in the wide, northern portion. After the glaciers retreated, about 15,000 years ago, organized drainage redeveloped (the present day Big Walnut Creek and its tributaries) that incised the till and shale deposits and left behind a valley with an alluvial flood plain at its base. In this valley grew a forest, and associated

Photograph of the east shoreline of Hoover Reservoir, just south of the Sunbury Road bridge, during the 2008 drawdown. The foreground shows a typical gravel and cobble deposit left behind by wave action; the background shows an eroding till cliff ranging from 15 to 20 feet in height.

continued on page 3

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Larry Wickstrom,
Division Chief and State Geologist

The recession. Ohio's fiscal crisis. The Ohio Geological Survey's budget dilemma. I'm sure everyone is tired of hearing about these issues. Unfortunately, in reality we must cast everything we do within the current economic context. Through all of this, a large issue that receives little attention is the huge loss of experienced, dedicated staff members that are leaving public service and not being replaced because agencies are unable to fill most positions. Here at the Survey, and at many other government agencies, budget reductions have undermined transition planning, which is critical to the future success and stability of any professional organization.

The timing of the recession and state budget reductions is detrimental for all when we consider the staffing side of the equation. Many companies and agencies alike now have what is referred to as an aging workforce, meaning most current workers were originally hired in the late 1970s and early '80s, the tail end of the "baby boomer" generation. Since September of last year, the Survey has lost six key staff members (24 percent of total staff), including four geologists. And a large percentage of those remaining will be eligible to retire over the next 3–4 years. In a proper transition the Survey would be able to hire new, younger staff members to be trained and mentored by more experienced, senior employees, prior to those senior staff members retiring. Such transitioning is vital to continuation of consistent quality and is actually cost-effective. Without this type of transition, new hires are slower to develop into fully effective, productive employees than if mentored by senior staff members and many technical items may never be discerned on their own.

Additionally, our society is also now very used to workers changing jobs many times during their careers. As a result, we now have the makings for the "perfect storm" in government agencies—shedding our most experienced, dedicated workers and either not replacing them or finding ourselves in a constant hiring cycle.

The Survey's small, dedicated staff has worked hard over the last eighteen months to reinvent how we do business, while maintaining the highest quality service and products. I am very proud and thankful to work alongside an enthusiastic group of professionals that continuously looks for ways to get the Survey's business done in faster, more cost-effective ways. Our staff supervisors and I are working hard to manage this looming transition problem to ensure the long-term viability of this agency—one that is so important to economic development of the state.

Changes in how the Survey is funded also bring a change in the way we hire and retain young professionals. But from crisis comes opportunity, and I believe those that innovate will be rewarded for thinking of new ways to solve budget shortfalls and staff transitioning. And those hardy young staff members that persevere through these economic times will be the stalwart pillars for our agency's future.

New Survey Web Address

You may have noticed in this issue of *Ohio Geology* the use of a new Web address for the Ohio Geological Survey Web site: **www.OhioGeology.com**. As part of our efforts to improve the Survey Web site—and to shorten the Web address and make it easier to remember—we recently acquired the rights to the new URL. You will also see this address used in future publications. Rest assured, our old address (www.ohiodnr.com/geosurvey) still works. But we encourage you to use the new address and to be on the lookout for more updates to the Survey Web site in the coming months.

continued from page 1

soils developed until the land was cleared for agriculture in the early 1800s.

The reservoir was constructed as a water supply project for the city of Columbus, with flooding beginning in 1955, and was named for brothers Charles and Clarence Hoover—long-time employees for the City of Columbus Waterworks—not the past U.S. president of the same last name.

Now flooded, the valley is subject to several important sedimentary processes. Sediment is continually transported into the reservoir by tributaries, the most important being Big Walnut Creek. In addition, wave action works on the shorelines, creating dramatic cliffs in the glacial till and winnowing out fines, a process that leaves a layer of coarse gravel at the surface.

Making the Map

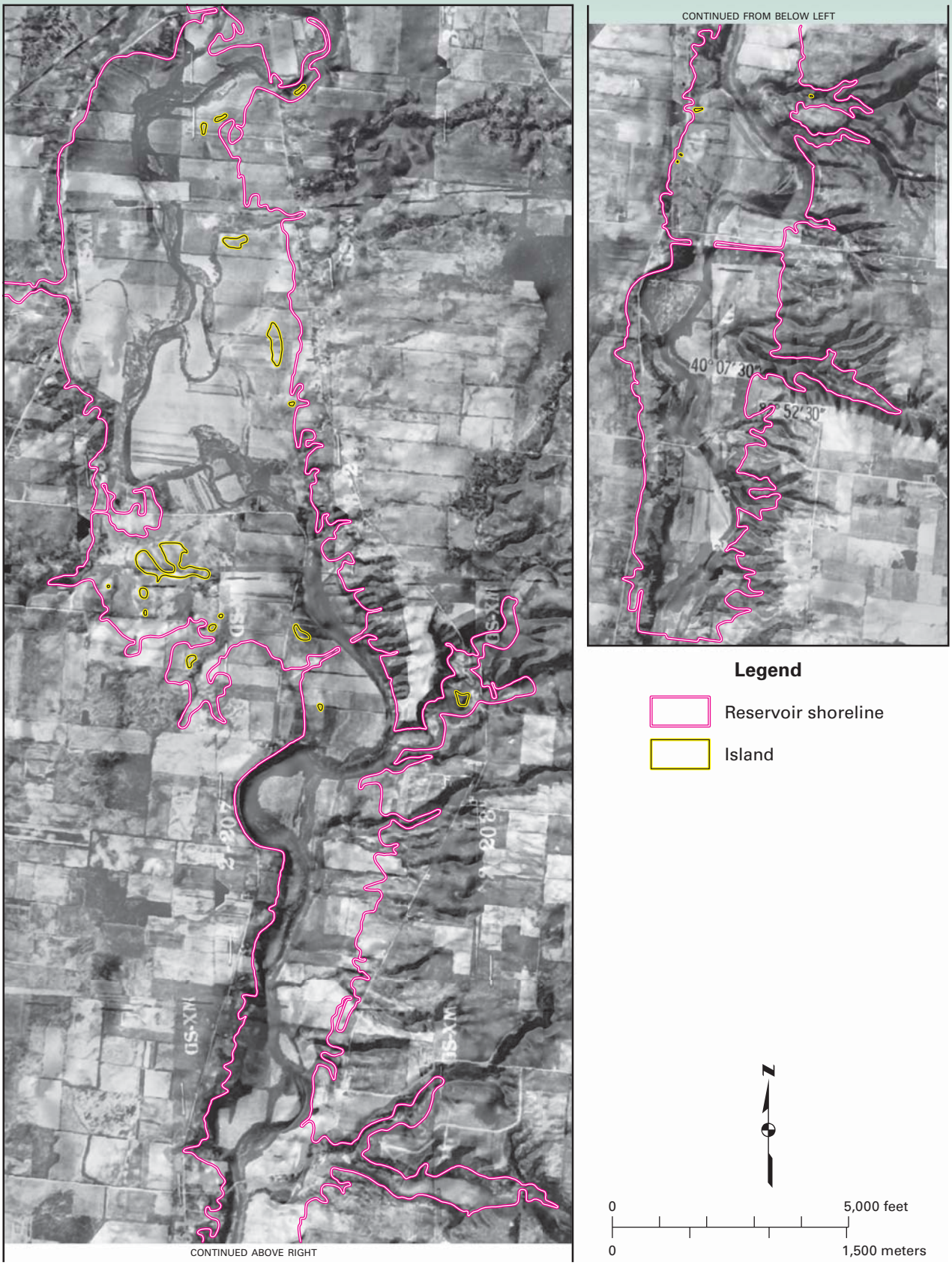
We initially intended to map bottom sediments using vertical sonar and by grabbing samples of bottom sediment, collected by boat in 2006. Theoretically, bottom sediments can be identified by analyzing the way sound waves bounce off them. The sonar echo gives information on the hardness and roughness of the bottom, which is at least partly related to sediment type. However, because there was partial overlap in the sonar signatures between sediment types, our initial comparisons of the sonar data and sediment samples showed that we could only determine areas where coarse sediments (gravels) were unlikely. Sonar could not be used as a simple "bottom type detector." The sonar provided very useful information, but because of the ambiguity in the relationship between sediment type and sonar returns, we needed additional data to make an accurate map of the Hoover Reservoir bottom. Landscape processes that occurred before flooding, during construction, and after flooding of the reservoir may all influence the distribution of its bottom sediments. Therefore, we considered the reservoir's entire history when looking for additional data.

Several sources aided in mapping Hoover Reservoir. We looked at water fluctuation data, as the reservoir is drawn down an average of 12 feet every year, which exposes a portion of the shoreline to wave action every autumn. We also compared a preflood elevation model to the current bathymetry (water depth) map to detect sedimentation and material removals and additions during construction. We then inspected aerial photography collected before the flood to check for relationships between objects in the preflood landscape and the sonar returns. In addition, a geologic map of near-surface materials was made. While the other data sets provided some help in understanding sediment patterns, the most complete and useful information was provided by the geologic map.

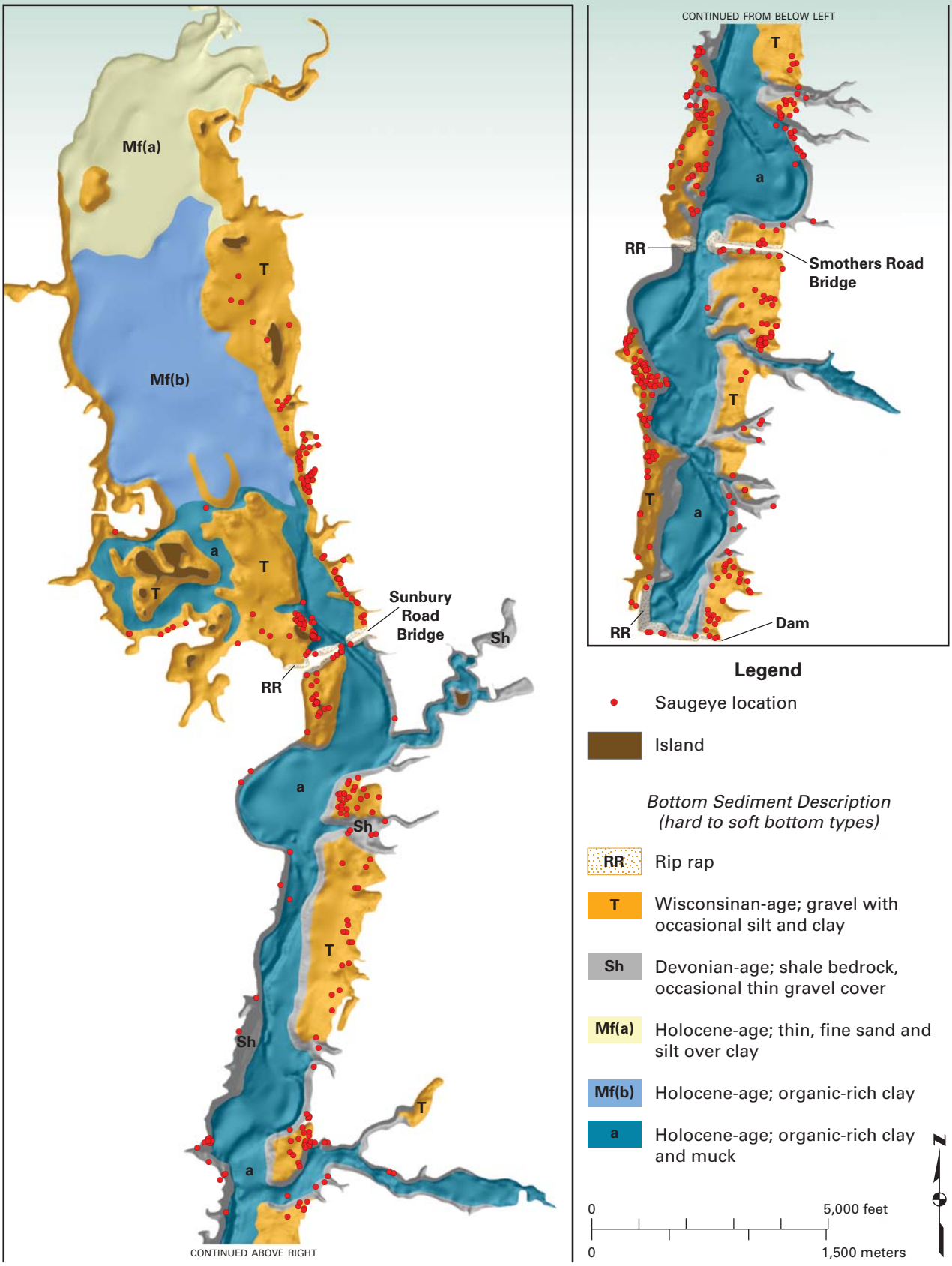
We based geologic mapping of Hoover Reservoir on field work and interpretation of landforms from the bathymetry map, sonar, and sediment sample data. The reservoir was drawn down to an unusually low level in 2008, which provided us an excellent opportunity for field investigation. In all, five individual geologic units were identified and mapped. The geologic map delineates the major surficial deposits—unconsolidated sediments within a meter of the surface—and bedrock outcrops in the basin. The reservoir can be divided into two distinct geomorphic units: an upper portion, north of the Sunbury Road bridge, and a lower portion, south of the bridge (see map on p. 5). The upper portion—the mudflat mapping units, **Mf(a)** and **Mf(b)**—is a wide (1.0 km), relatively shallow valley with gradual slopes. While postflood sedimentation certainly occurs here, it is not the underlying cause of the shallowness of this portion of the reservoir. Here the till is relatively thick, and bedrock is not exposed or near the surface, so lateral erosion was not constrained by bedrock. These features contrast with the lower portion, where the bedrock base of the valley is narrow (0.5 km); the till is thin, pinching out towards the valley center; and shale outcrops are prevalent. Here the valley floor contains a distinct, narrow, relatively flat floodplain filled with alluvial (silty) sediments.

Through statistical investigations using the sonar and sediment data, we were able to establish a strong relationship between bottom sediment type and the geologic map. The map of bottom types shows that each geologic mapping unit has a corresponding bottom sediment type. The physical processes behind the correlation between the surficial geology map and bottom sediment types are likely related to both bathymetric position and geologic parent material. The upland areas are mainly poorly sorted gravel composed of rounded rock washed from the glacial till or angular shale fragments derived from the bedrock or till. The coarse portion of the sediment is concentrated at the surface as a lag deposit, which was left behind as sand, silt, and clay that were winnowed out by wave action and currents and carried out to deeper portions of the reservoir. In contrast, the organic and clay-rich deposits in the alluvial

As biologists study the behavior of fish and how aquatic ecosystems function, it is increasingly clear that geology is an important factor.



A 1953 preflood aerial photograph with the Hoover Reservoir shoreline superimposed and shaded relief in the background. Lighter-shaded areas are mainly agricultural fields on relatively flat ground, whereas much of the darker-shaded areas are forested ravines. Photo source: U.S. Geological Survey.



Final map of bottom sediment type superimposed on a bathymetric shaded relief map of Hoover Reservoir. For each geologic mapping unit, there is a corresponding bottom sediment type as typically the rock type changes with changing formations. The red dots represent saugeye locations recorded from telemetry. The fish clearly prefer coarse bottom sediments, which are largely derived from till (**T**) and shale (**Sh**).

lowlands are mainly related to their position in the depositional system of the reservoir. They occupy the central, deep, low-energy portion of the reservoir, where fine-textured sediments (silt and clay) and organic materials accumulate. The source material for these sediments does not come from underlying alluvial deposits but rather from the reservoir's tributary streams and from sediment eroded from the banks through wave action. We also found anomalies in the sonar data that suggest there are gasses (most likely methane) trapped in the organic-rich sediments of the reservoir.

Geology and Fisheries Management

The combined results between fisheries studies and geologic mapping have significant management implications. Stocking numbers were once determined by overall surface area of the reservoir, neglecting the actual amount of appropriate habitat. For Hoover, only 50 percent of the reservoir has bottom types appropriate for saugeye. Even then, not all of the gravel bottom area is good habitat because of additional factors, such as temperature and available oxygen. Nonetheless, the significance of the bottom sediment map to saugeye behavior is readily apparent. Telemetry (electronic tracking using radio tags) conducted on saugeye showed that they clearly preferred locations with gravel substrate.

Selecting locations for future reservoirs is a complex process, but one factor that should be considered is how the geology of the flooded area will influence the quality of the fishery that the flooded landscape will support. Hoover Reservoir has a good reputation for sport fishing in part because of the material available to produce hard substrates from the till and shale. Conversely, reservoirs located on the sites of old glacial lakes and swamps have little coarse material available to form hard bottoms. While suitable for species less sensitive to bottom sediment type (e.g., bullheads, crappie, and bass), such sites provide little ideal habitat for saugeye and walleye, except where riprap is emplaced for shoreline protection or the construction of dams and causeways. In sum, as biologists study the behavior of fish and how aquatic ecosystems function, it is increasingly clear that geology is an important factor.

Further Reading

Hansen, M.C., 2008, *The Ice Age in Ohio:* Ohio Department of Natural Resources, Division of Geological Survey Educational Leaflet No. 7.

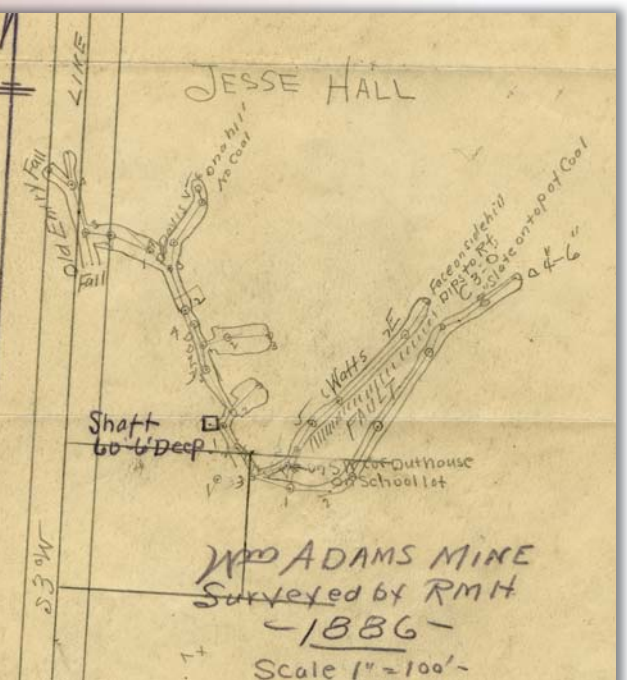
May, C.J., 2008, *Habitat Mapping and Predator-Prey Dynamics in Ohio Reservoirs:* The Ohio State University, M.S. Thesis.

About the Authors

At the time of this study, Erik R. Venteris, PhD., was a senior geologist at the Ohio Geological Survey. He currently is a Research Engineer at Pacific Northwest National Laboratory.

At the time of this study, Cassandra May was a master's student at The Ohio State University (OSU), she is currently pursuing her Ph.D. in aquatic ecology, also at OSU.

Survey Seeks Historic Mine Maps and Well Logs



As we move deeper into the Information Age, the Ohio Geological Survey's search for geologic data and archiving of that data becomes more and more diverse. We still explore field sites; but we also search for historic documents that contain geologic information about Ohio and then use the latest digital technology to analyze, map, and archive the information. Many documents are loaned or donated to us from business and industry, and occasionally we receive them from private citizens. Currently, we are seeking historic abandoned underground mine (AUM) maps and geophysical logs for oil and gas wells for our archives.

Recently, the Geological Survey received funding from the Ohio Mine Subsidence Insurance Underwriting Association (OMSIUA) to investigate and compile data sources, including mine maps, to make the Geological

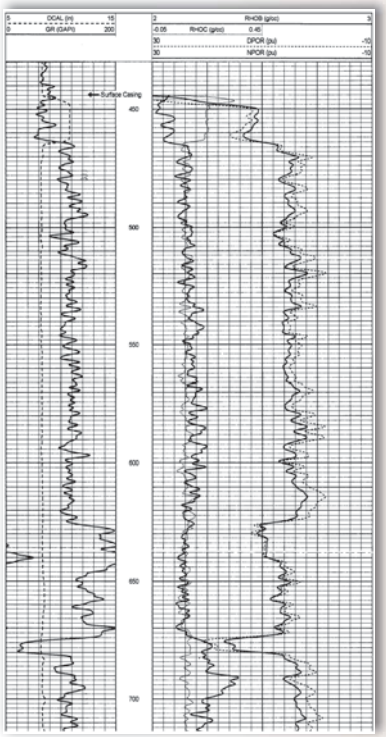
Abandoned underground mine maps commonly depict the workings of coal mines (e.g., rooms and pillars) and have reference features found on the land surface above the mine. Left: A map loaned to the Geological Survey by Professor Ann Harris, Youngstown State University.

Survey's inventory of mine lands as complete as possible. AUM maps are used to identify locations of abandoned mines, which can cause subsidence at the ground surface and potentially damage homes and buildings, roads, and other infrastructure. Data gathered from AUM maps will aid the OMSIUA in reviewing and assessing claims filed with the Mine Subsidence Insurance Fund. The data also will be used to update the *Ohio Abandoned Mine Locator*, an interactive map administered by the Geological Survey.

Similarly, geophysical logs for oil and gas wells provide valuable information to geologists for exploration and characterization of Ohio's deep subsurface. Currently, the Geological Survey has nearly 200,000 well logs archived at our Geologic Records Center.

In 2010 the Geological Survey's search for additional geologic information continues, but we need your help in our effort to improve our library. If you have historic mine maps or geophysical logs that you are willing to donate or perhaps loan to us for scanning and archiving, please contact our Geologic Records Center using the information on page 8.

Information about the OMSIUA, including eligibility and coverage guidelines for the Mine Subsidence Insurance Fund, can be found at the OMSIUA Web site: **www.ohiominesubsidence.com**. The *Ohio Abandoned Mine Locator* interactive map is available to the public via the Geological Survey Web site: **www.OhioGeology.com**.



Geophysical logs are paper printouts, commonly several inches wide and many feet long, that feature well information, such as depth, natural properties of the rock, and how the rock reacts to electrical stimulation.

Analysis of Huron River Shale Fire Minerals Reveals Two Specimens New to Ohio

Cluster of sal ammoniac crystals. Photo by David Waugh.

While oil shale fires are not common in Ohio, one has been burning in a cliff along the east side of the West Branch of the Huron River in Huron County, Ohio, for more than a year. The site is north of Monroeville, near the intersection of River Road and Lamereaux Road in Ridgefield Township. The rock at the site is the Late Devonian Huron Shale, which contains disseminated pyrite, beds of pyrite nodules, highly organic laminae of shale with over ten percent disseminated organic matter. The site was investigated by geologists of the Ohio Geological Survey in December of 2009 and by Will Shewfelt, a colleague, beginning in March of 2010. The area of the fire is about 300 feet long, and probes operated by Will Shewfelt and Huron County engineers recorded temperatures as high as 800°F at a depth of 1.5 feet.

Vent minerals of the Huron River oil shale fire were collected by Will Shewfelt. Minerals found include: anhydrite ($CaSO_4$), gypsum ($CaSO_4 \cdot 2H_2O$), halotrichite [$Fe^{+2}Al_2(SO_4)_4 \cdot 22H_2O$], sal ammoniac ($NH_4Cl$), orthorhombic sulfur (S), and tschermigite [$(NH_4)Al(SO_4)_2 \cdot 12H_2O$]. Two of these minerals, sal ammoniac and tschermigite, have not been previously identified in Ohio. The vent minerals are all sulfates, with the exception of sal ammoniac, which is a halide, and sulfur, which is a native element, occurring on fragments of shale. The sulfur of the sulfates and the native element comes from the oxidized pyrite. Sal ammoniac occurs in colorless cubic crystals up to 2 millimeters on an edge. The tschermigite is vitreous and present as colorless to yellowish-orange granular aggregates, individual crystals averaging 0.4 mm in diameter. The yellowish-orange color is due to staining by iron oxide powder. The ammonia of the sal ammoniac and tschermigite presumably was derived from the vegetation caught up in the fire.

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SG-2 Series Glacial Geology Maps Released

The Ohio Geological Survey recently released its SG-2 series of detailed maps that identify and describe Ohio's glacial deposits and summarize the state's glacial geology from the land surface to the top of bedrock.

Materials shown on the maps include sand and gravel, fine-grained sediments, clay, organic materials, and even bedrock. Consequently, glacial geology maps will benefit many users and industries, including aggregate and mineral producers, community and regional planners, solid-waste disposal companies, construction professionals, engineers, soil and water resource specialists, and researchers.

While the SG-2 series does not represent the entire state—only about 60 percent of the state was glaciated—the mapping to date accounts for nearly 80 percent of Ohio's glaciated areas. Exceptions include northwestern Ohio and unglaciated eastern and southeastern portions of the state.

The SG-2 maps are available for free download at the Ohio Geological Survey Web site: **www.OhioGeology.com**.

New Multimedia Library

A multimedia page has been added to our Web site. The new Multimedia Library features numerous video and audio files with loads of information about the Survey's history and Ohio's geology, including fossils, geohazards, and natural wonders. Log on to **www.OhioGeology.com**, and click the "Multimedia Library" icon to explore what's available.