Ohio Geology

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Geology of a Rare Gem: Salt Fork State Park

By Mark E. Wolfe

Most of us consider a gemstone as rare, beautiful, and durable with exceptional brilliance. The Salt Fork State Park area in Guernsey County can be considered a gem because it has long been known for its natural beauty and geologic bounty. The name "Salt Fork" was probably derived from local natural salt springs that were first used by prehistoric migrating animals, such as mastodons, and later by bison, elk, and other wildlife. These natural concentrations of game animals also attracted Native American hunters that established well-worn hunting and trading routes. Salt was also a valuable and essential commodity to early settlers in Ohio. In the 1870s, salt was produced from brine wells 450-feet deep in the heart of what is now Salt Fork State Park. Two operators produced 11 barrels per day of salt, which sold for two dollars per barrel. In 2009 dollars, that would be a total of more than $385 per day, likely a lucrative small business.

In nineteenth century Ohio Geological Survey publications, geologists noted additional regional mineral resources, such as coal, clay, oil and gas, sandstone, and iron ore, as well as numerous springs. A staff geologist in 1874 provides details of a large spring in the easternmost portion of what is now Salt Fork State Park as an important gathering place for local citizens: "The spring is unfailing, and yields so large a quantity of water that when the annual camp-meeting is held on this property, several thousand persons being present, all the people and horses are supplied from this spring without lessening the amount of water in the reservoir."

As the area has for generations, Salt Fork State Park annually attracts thousands of people that appreciate the natural environment and local geology. The Ohio Geological Survey also continues an active interest in the area, compiling geologic information on economic geology and geohazards, such as landslides and abandoned underground mines.

Geomorphology of Salt Fork State Park

Salt Fork State Park and the adjoining wildlife area occupy 20,181 acres in east-central Ohio. Salt Fork is the largest by area of Ohio's 74 state parks and is located east of I-77 and northwest of U.S. 22. Cambridge, the Guernsey County seat, sits approximately 10 miles to the southwest.

The geographic area encompassing Salt Fork State Park is considered part of the unglaciated Allegheny Plateau physiographic region and is characterized by moderately high relief of approximately 300 feet. Elevations range from 780 feet above sea level (ASL) downstream from the Salt Fork dam to over 1,100 feet ASL in the eastern highlands. Moderately steep stream gradients dissect the region, which includes flattened ridgetops and generally narrow valleys. The topography is strongly influenced by the underlying geology of interbedded siltstones, sandstones, and shales of the Pennsylvanian-age Conemaugh and Allegheny Groups. The Conemaugh contains thin-bedded coal, limestone, and clay, while coal and associated clays are generally thicker and more widespread in the Allegheny. Secondary influences of the Pleistocene glaciation are recognizable by outwash terraces and lacustrine deposits in the larger stream valleys west of the park. Historic and active landslides developed in the Conemaugh red-to-green shales ("red beds") and have altered the natural landscape. Thick-bedded sandstone or conglomerates overlay less-competent siltstones, clays, coals, and shales that are more easily eroded, resulting in the formation of shelter caves and small waterfalls in the secondary drainages. The differential erosion also causes the formation of detached sandstone blocks that topple and slide downslope due to gravity.

The earthen Salt Fork dam, completed in 1968, created an approximately 3,000-acre lake

continued on page 3

OHIO ROCKS!

Larry Wickstrom,
Division Chief and State Geologist

John Bryan State Park

Our wonderful state is blessed with many natural resources, but for picturesque beauty, we are fortunate to have 74 great state parks located throughout Ohio. Our lead article discusses some of the geology of the largest and one of the most popular state parks, Salt Fork in Guernsey County. Salt Fork State Park captures the beauty of the local geology and the early settlement history of the area while providing some of the best recreational opportunities anywhere.

From the limestone and dolomite cliffs of the Lake Erie Islands State Park (S.P.) to the sandy beaches of Headlands S.P., through the sandstone gorges of Hocking Hills and south to the unglaciated Ohio River Valley coal-bearing richness of Forked Run, Ohio's State Parks showcase our state's geologic diversity. Unfortunately, the Survey has not expended sufficient resources on these gemstones in the past. Very few of our publications explain the geology found within our parks. Those that do usually are not published with average park visitors in mind, so they may not aid visitors in understanding more of what they see around them. It has been a desire of mine for years to start a program to address this need and two years ago we initiated efforts, albeit small, to do so.

This past year we attended the state park managers' annual meeting and received an enthusiastic response—many state parks will start selling and distributing our popular publications, leaflets, and brochures in park gift shops and stores to help spread knowledge of Ohio's fascinating geology. A number of park managers requested our geologists to work with them to create geologic maps, displays, field trips and more for their parks. Recently, Senior Geologist Greg Schumacher started a course to help train park naturalists in the Ohio Certified Volunteer Naturalist program in Greene (John Bryan S.P.), Clark (Buck Creek S.P.), Warren (Caesar Creek S.P.), and Montgomery (Sycamore S.P.) counties. The training was very well received and we'd love to expand it to other areas.

I believe that bringing more of Ohio's geologic wonders to a wider audience, such as the millions of annual visitors to its state parks, should be a mid-level priority for the Survey. Sadly, we started these efforts just as our state and nation entered one of the gravest economic downturns in decades. With reluctance, we've had to shelve our modest plans to bring more accessible geologic information to our state park visitors in order to direct our dwindling resources to the more dire needs of the state, such as geohazards (note the article in this issue about the recent Bellevue flooding) and projects that directly assist in economic development—these are the highest priority items for which a state geological survey exists. We are continually looking for greater efficiencies and, as our staffing and funding reduce with the economy, we must all do everything in our power to maintain our priority services and assist in the turnaround. In the meantime, we will try to provide Ohioans with information about our parks and natural areas whenever possible.

About the *Ohio Geology* Masthead

The photograph in the *Ohio Geology* masthead on the front page was taken looking north on the U.S. Route 33 bypass at Lancaster near State Route 193. The final portion of the bypass opened on October 26, 2005, and cuts through hillsides exposing the Black Hand Member of the Cuyahoga Formation, a massive-bedded, resistant sandstone unit shown in the photograph. The Black Hand Member resists erosion, which permits steep but stable road cut slopes. Shale units in the Cuyahoga Formation and the glacial till are less stable and require a shallower angle on the road cut. The vertical lines in the rock are the remains of blasting holes drilled during the road cut excavation.

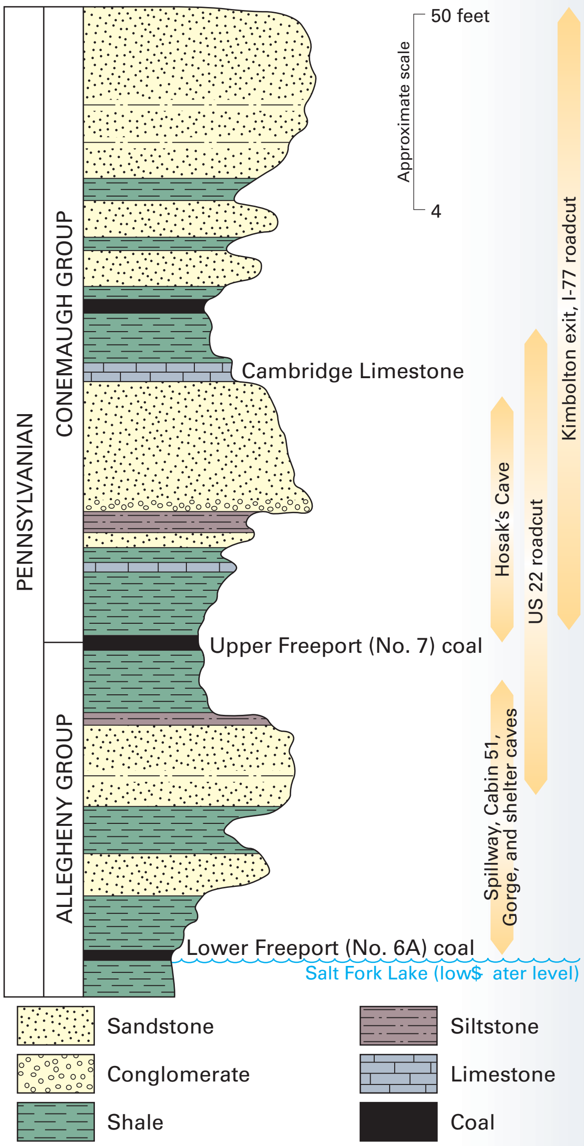
continued from page 1

by impounding the waters of Beeham Run, Coon Run, Rocky Fork, Brushy Fork, Sugar Tree Fork and numerous unnamed tributaries of Salt Fork. The resulting lake has 74 miles of undulating shoreline with numerous coves. Seldom more than 1,200-feet wide, Salt Fork Lake features heavily forested land and occasional rock outcrops steeply rising more than two hundred feet above the lake's surface. Visitors will find areas of quiet solitude and exposed geology either by hiking or boating.

Geologic tour of Salt Fork

Today, Salt Fork State Park visitors arrive via Interstate 77 and can glimpse the multifaceted geology of the surrounding area as the highway cuts through numerous hillsides. The area reveals several examples of the complex geology associated with deltaic deposition during the Pennsylvanian (approximately 300 million years ago). In Pennsylvanian time, multiple large deltas formed in a shallow sea that covered most of Ohio; sediments shed from the newly formed Appalachian Mountains into northward-flowing streams. Just a few of the geologic features that can be seen in I-77 road cuts to the south of Salt Fork are massive sandstones with undulating contacts that are interpreted to be offshore sandbar deposits; extremely fossiliferous limestones and shales that represent the most widespread transgression of the shallow inland seas during the Pennsylvanian; and interbedded red and green shales and mudstones hundreds of feet thick that are thought to have been deposited in floodplains of northward-flowing streams. Many examples of landslides and slumping can be observed along the highway. These earth movements are caused by surface water infiltration and swelling or slaking of incompetent shales, resulting in movement at the weathered bedrock contact.

More spectacular geologic features lie north of Salt Fork along I-77. Near the dam, a coal bed of the Allegheny Group overlies an interesting exposure of lenticular sandstone. Extremely variable in thickness, the coal probably represents a swamp that was periodically inundated with fresh or marine water from a distributary channel in a deltaic environment. Thicker and more consistent coal beds—such as those that can be seen at road level near the I-70/I-77 interchange or near lake level north of the dam (during periods of low-water only)—likely represent swamps that existed for longer periods of time without



Geologic section illustrating rock units encountered at Salt Fork State Park, Guernsey County, Ohio. The section was compiled using field observations, measured sections on file at the Ohio Geological Survey, and from Condit (1912).

major influxes of sediments, allowing plant debris (the raw ingredient for coal formation) to accumulate in greater thickness. Plant fossils, such as *Calamites,* 60-feet-tall "horsetail" trees, are often found in these Allegheny Group rocks.

Approaching Salt Fork State Park from the south on U.S. 22, a road cut west of the park entrance that is partially obscured by vegetation exposes a 110-feet-thick section of rocks from the Conemaugh Group. The exposure represents much of the bedrock geology in the park. A thin limestone bed at the top acts as a stratigraphic marker to geologists, useful for geologic mapping. The underlying thick-bedded, fine-to-coarse-grained sandstones and gray

Looking north from the interior of Hosak's Cave, located in the northern portion of Salt Fork State Park. The large sandstone shelter cave and waterfall is one of many caves, waterfalls, and gorges found throughout the park.

shales with carbonaceous zones, along with thin, shaly, coals and underlying clays, extend to the base of the highway. Sandstones represent more than 40 percent of the section. Some sandstone beds exhibit prominent cross-bedding and contain quartz pebble conglomerates. These sandstones likely represent the upper portion of a distributary river channel within the deltaic environment. Coals are almost non-existent and indicate swamp development was very limited during this period of geologic time at this location.

Hosak's Cave and associated waterfall, located in the northern portion of Salt Fork State Park, offers a scenic area that owes its beauty to the local geology. Here a visitor can keenly observe geologic relationships without the hazards associated with a busy highway. The shelter cave and waterfall were formed by the undercutting of the thick-bedded to massive sandstones and conglomerates that overlay more easily eroded coals and thick shales. Note not only the erosional effects of water striking the plunge pool at the base of the falls, but also the small flow of water that travels underneath the sandstone ledge, leading to additional erosion of the underlying beds. The cross-bedded sandstones become coarser-grained downward; the underlying poorly sorted, quartz pebble conglomerate is cemented with hematite. A thin, flinty limestone is visible within the cave, as well as a thin-bedded, fine-grained sandstone. Just as cleavage and fracture control the faceting of a gemstone, prominent joints trending N 40° E contributed to the formation of both the cave and the large, detached sandstone blocks. These huge sandstone boulders or "float blocks" drift downslope under the effects of gravity.

Shelter caves and massive sandstone ledges exist throughout the park. Noteworthy places to explore include the rocky gorges, caves, and cascades of the cottage area west of the golf course and along the shoreline and hillsides near the water treatment plant and McCleary Cemetery. Many of the early dated headstones at the cemetery were carved from locally derived, fine-grained sandstone and are better preserved than the white marble markers, which were brought in from out-of-state sources, and are more susceptible to dissolution from low-pH rainfall.

Thick-bedded to massive sandstone layers dominate the rocks exposed by the excavation of the emergency spillway. Closer inspection reveals large-scale cross-bedding and slop-

Massive sandstone slump blocks, such as this one located at Cabin 51 (looking northwest), are found throughout Salt Fork State Park.

ing contacts indicating a fluvial depositional environment, possibly associated with a point bar. Lateral and vertical variations in bedding thickness and grain size illustrate the complex interactions of river channel migration and changes of sea-level on the upper deltaic plain. On a north slope at the west end of the spillway is an active earthflow (shallow, slow-moving landslide) represented by exposed red soils and low scarp development. More than 190 historic landslides are delineated on maps that include Salt Fork State Park produced by the United States Geological Survey in 1978. The dynamic and surface-altering effects of landslides, often characterized by hummocky ground, are important factors to consider when assessing the long-term stability of the landscape.

The Kennedy Stone House is a fine example of utilizing local building-stone to construct a home with eye-catching appeal and unusual longevity. Benjamin Kennedy purchased the land in 1837 and built the house in 1840 using sandstone quarried nearby. Examples of the local sandstone in outcrop can be seen along the entrance road northwest of the house. The Kennedy house is forty-feet-long and eighteen-feet-wide. Builders used sandstone blocks up to nine-feet-long and fourteen-inches-thick. The building exhibits fine workmanship of skilled stone masons similar to that of an experienced jeweler; tight-fitting, well-dressed stones were used for the front, and slightly less-detailed stone work is evident in the sides and rear. The sandstone used is light-to-medium brown, medium-grained, and well-sorted. Some faint laminations, probably from small amounts of hematite, add distinctive color to the stone. The Kennedy Stone House was recently restored to its original condition and is open for tours.

View (looking south) of the front of the Kennedy Stone House at Salt Fork State Park. Note the tight-fitting blocks of locally quarried sandstone.

Evaluating Ohio's priceless gem

A gemologist evaluates size (carats), clarity, cut, and color to determine the value of a gemstone. The same "4 Cs" can be used when considering the geologic attributes of Salt Fork State Park. The large size of the park exposes a variety of landforms that were influenced by the local geology. The clarity or beauty of the region is evident in the development of steep gorges, shelter caves, waterfalls, and rock ledges. Slight imperfections can be related to landslides common to Conemaugh Group rocks. Man-made improvements such as the construction of the sapphire blue lake and myriad recreational opportunities can be compared to the jeweler's faceting of a gemstone. Seasonal changes affect the area's color: crystal-clear ice formed at a waterfall in winter sparkles like a diamond; amethyst-hued redbud and gypsum-white dogwood trees scattered on rocky hillsides bloom brightly in spring; and emerald green, ruby red and a multitude of other colors shine throughout the park in fall. In the final evaluation, Salt Fork State Park is a priceless gem to be cherished by the people of Ohio.

Editor's Note: Highway road cuts should be observed while driving the posted speed limit. It is illegal to stop along the highway, except in an emergency. For your safety, please stay on marked trails when exploring the rim of Hosak's Cave and when enjoying the geology of the park. For more information about Salt Fork State Park, visit the Ohio State Parks Web site at <www.ohiodnr.com/parks>.

Salt Fork State Park annually attracts thousands of people that appreciate the natural environment and local geology.

Further Reading

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Contending with Karst: The 2008 Bellevue Flood and Beyond

On March 18, 2008, ground-water levels in the Bellevue, Ohio, area rose to a 30-year high. Sink holes that typically accept surface water acted like springs, as surface and near-surface geologic conditions combined with unique increases in precipitation to cause extensive flooding of fields, roadways and residences due to a lack of surface drainage.

The Ohio Geological Survey, along with the ODNR Division of Soil and Water and Division of Water, investigated the extent and causes of the flooding and found that ground water flooded existing closed basins and sinkholes, caverns, and underground streams—collectively called *karst*—and drained slowly over the course of months.

Detailing the flooding

In a typical year, precipitation recharges the aquifer in the Bellevue and Flat Rock vicinities through a labyrinth of karst features and man-made drainage wells. This water eventually discharges down gradient to the north (in the vicinity of Castalia) through a series of springs locally referred to as "blue holes."

Sinkholes in the southern area serve as a source of ground water for the aquifer system extending to the north. Excessive rainfall and snowmelt from October 2007 culminated with near-record rainfall in March 2008. The excessive precipitation combined with the abundant ground-water recharge from the south to cause water levels in the Bellevue area to rise rapidly to the ground surface and begin flowing out of the karst features, which flooded residences, roads, and fields that are typically dry. In the area north of Bellevue, ground water actually flowed out of the sinkholes and water wells. Similar episodes of excessive precipitation and widespread flooding have been reported in the past, most recently in 1937 and 1969.

Karst flooding in the Bellevue area damaged homes and forced road closings, such as State Rte. 269 shown here (looking north). Photo courtesy of ODOT, District 3.

In May 2008, the Ohio Department of Transportation collected high-resolution aerial photography and LiDAR (Light Detection and Ranging, similar to radar) data for the Bellevue area. Survey personnel reviewed the data sets to help delineate all of the flooded areas. Rings of debris (primarily cornstalks) surrounding the sinkholes were used to determine the maximum extent of the flooding in areas where the waters had receded. Division of Water and Geological Survey personnel concluded that in the southern part of the study area, sinkholes were flooding because of slow drainage caused by surface debris clogging the sinkholes. In contrast, sinkhole flooding in the northern part of the study area was caused by ground water upwelling to the surface. Using the results of the investigations, the Geological Survey helped the Division of Water compile a report on the flooding, which has been released to a number of local officials and agencies.

Karst in Ohio

The term *karst* comes from a limestone-rich region of Yugoslavia known as Krš, where these features are spectacularly developed. Ohio's karst features are primarily associated with the Devonian Columbus and Delaware Limestone formations that run in a north–south band through central Ohio. The high-calcium nature of these units makes them vulnerable to mildly acidic precipitation. Specifically in the Bellevue vicinity, these bedrock formations lack the protection of overlying thick glacial till and instead are covered by sandy, permeable beach deposits. Acidic rainwater passes through the overlying deposits, dissolves the bedrock, and over time, results in karst formation.

If not accounted for during planning, karst can cause severe damage to infrastructure projects, such as highways and sewer lines. However, it is probably best recognized as providing a pathway for contamination of Ohio's limestone aquifers. As ground water rapidly moves through karst solution features, it bypasses the natural filtration aspects of other geologic media, allowing contaminants to move through the aquifers. Examples of such contamination caused by karst include long-term ground-water quality issues in the Bellevue vicinity and the spread of E. coli bacteria throughout South Bass Island in the summer of 2004.

The Survey's role

Participation in the study of the Bellevue area's karst-related flooding marks the Geological Survey's long-term commitment to studying and mapping such features. The Geological Survey produced Map EG-1, *Known and Probable Karst in Ohio,* in 1997, which has since been revised a number of times. The original evaluation of Ohio's karst areas was done in conjunction with determining suitable areas for the disposal of low-level radioactive waste in Ohio.

More recently, the Geological Survey has been preparing a large-scale, full-color map, *Karst Flooding in the Bellevue, Ohio, Area—2008* (Map EG-5), which will feature expanded accompanying text and figures that document the Bellevue flooding. Karst maps aid local planners, administrators, and decision makers in delineating flood-prone terrain and restricting continued development in such areas.

In the spring of 2009, the Geological Survey began a study to do detailed karst mapping in western Delaware County. The study is being done in association with the Delaware Soil & Water Conservation District and a number of other local agencies. As the region continues its rapid population growth, the study will help locate karst and address concerns about contamination from karst features impacting the water quality of the Scioto River—an important source of drinking water. Karst could also create problems for area development, including construction, drainage, and agriculture.

The study of karst features is just one part of the Geological Survey's program to address potential geohazards across Ohio. Currently, staff geologists are investigating other geohazards, including shoreline erosion along the Lake Erie coast, the presence of abandoned underground mines in eastern Ohio, and problems with landslides occurring in many portions of the state. Such studies are important steps in mitigating the effects of geohazards on Ohio's citizens and industry.

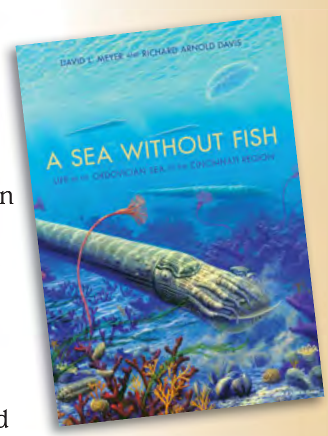
By Mike Angle

Karst Reporting Form Now Available

To support its efforts to investigate, identify, and map karst features across Ohio, the Geological Survey has created a reporting form for Ohio citizens to fill out and submit if they are aware of such features. While primarily concerned with the karst feature known as *sinkholes*, we welcome any information on karst caverns or caves. The form can be filled out and submitted online, or a hard copy may be printed and mailed from the Geological Survey's Web site, < www.ohiodnr.com/geosurvey/ > .

Exploring Cincinnati's Ordovician Graveyard

A Sea without Fish: Life in the Ordovician Sea of the Cincinnati Region
By David L. Meyer, Richard Arnold Davis, and Steven M. Holland
Indiana University Press, 2009, 368 pp.



Underlying the Cincinnati region is a massive graveyard of countless fossils that lived between 452 and 445 million years ago. *A Sea without Fish*, written by David Meyer, Richard Davis, and Steve Holland, is intended for the general public and amateur geologists and describes the fossils preserved in this graveyard. Professional geologists and paleontologists interested in the geology of the Cincinnati Region and Late Ordovician fossils will want this book in their libraries.

The introductory chapters of *A Sea without Fish* explain how fossils are formed, named, and classified by paleontologists; the concepts of geologic timescale; how the Cincinnati Region's Late Ordovician rocks were formed and why they occur in repeating cycles. The

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authors also provide a very interesting overview of the pioneering geologists and paleontologists who first studied the fossils and rocks of the Cincinnati region.

Ten of the book's sixteen chapters describe the great variety of organisms buried in this Late Ordovician graveyard. The discussion begins with a description of single- and multi-celled algae and ends with the description of graptolites and conodonts that may be the ancestors of vertebrate animals. Intervening chapters discuss many strange and often extinct organisms, including sponges, corals, bryozoans, brachiopods, mollusks, worms, trilobites and other legged creatures, and echinoderms, such as starfish, brittle stars, edrioasteriods, crinoids, and cystoids. The final two chapters provide the reader with information about what Earth looked like in the Late Ordovician and how these Late Ordovician animals lived and interacted over the millennia.

Each chapter is lavishly illustrated with figures and photographs. A comprehensive glossary defines much of the science terminology used. The authors also provide a full-color gallery of 14 plates that illustrate spectacular fossil specimens collected over the centuries, informative maps, and Late Ordovician seafloor dioramas, including a new and updated depiction by John Agnew. The extensive reference list is most useful for those who want to learn more.

A Sea without Fish is a must-read for those interested in the geology and fossils of the Cincinnati Region.

By Gregory A. Schumacher

A Sea without Fish: Life in the Ordovician Sea of the Cincinnati Region is available for purchase from the Ohio Geological Survey for $32 (plus sales tax and shipping). Please see ordering information at left.

Amphilichas halli