The 52nd Forum on the Geology of Industrial Minerals

Rolling on the River: Industrial Minerals in the Midwest

Program with Abstracts and Field Trips

August 21–25, 2016

The Clarion Hotel and Conference Center–Louisville North, Clarksville, Indiana

Zakaria Lasemi, Program Editor
Mark E. Wolfe and Nelson Shaffer, Co-Chairs

Open File Series 2016-1   2016

ILLINOIS STATE GEOLOGICAL SURVEY
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Front cover: *Sand and gravel being loaded onto a barge near Racine, Ohio. The Ohio River is an important transportation option for industrial mineral operations. Photograph courtesy of the Ohio Division of Geological Survey.*

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CONTENTS

ANNUAL MEETINGS OF THE FORUM ON THE GEOLOGY OF INDUSTRIAL MINERALS

1st	1965	Columbus, Ohio
2nd	1966	Bloomington, Indiana
3rd	1967	Lawrence, Kansas
4th	1968	Austin, Texas
5th	1969	Harrisburg, Pennsylvania
6th	1970	Ann Arbor, Michigan
7th	1971	Tampa, Florida
8th	1972	Iowa City, Iowa
9th	1973	Paducah, Kentucky
10th	1974	Columbus, Ohio
11th	1975	Kalispell, Montana
12th	1976	Atlanta, Georgia
13th	1977	Norman, Oklahoma
14th	1978	Albany, New York
15th	1979	Golden, Colorado
16th	1980	St. Louis, Missouri
17th	1981	Albuquerque, New Mexico
18th	1982	Bloomington, Indiana
19th	1983	Toronto, Ontario, Canada
20th	1984	Baltimore, Maryland
21st	1985	Tucson, Arizona
22nd	1986	Little Rock, Arkansas
23rd	1987	North Aurora, Illinois
24th	1988	Greenville, South Carolina
25th	1989	Portland, Oregon
26th	1990	Charlottesville, Virginia
27th	1991	Banff, Alberta, Canada
28th	1992	Martinsburg, West Virginia
29th	1993	Long Beach, California
30th	1994	Frederickton, New Brunswick/ Halifax, Nova Scotia, Canada
31st	1995	El Paso, Texas
32nd	1996	Laramie, Wyoming
33rd	1997	Québec, Canada
34th	1998	Norman, Oklahoma
35th	1999	Park City, Utah
36th	2000	Bath, England
37th	2001	Victoria, British Columbia
38th	2002	St. Louis, Missouri
39th	2003	Reno, Nevada
40th	2004	Bloomington, Indiana
41st	2005	Istanbul, Turkey
42nd	2006	Asheville, North Carolina
43rd	2007	Boulder, Colorado
44th	2008	Oklahoma City, Oklahoma
45th	2009	Delaware, Ohio
46th	2010	Middletown, Pennsylvania
47th	2011	Champaign, Illinois
48th	2012	Scottsdale, Arizona
49th	2013	Kingston, Jamaica
50th	2014	St. Andrews, Scotland
51st	2015	Minneapolis, Minnesota
52nd	2016	Clarksville, Indiana/ Louisville, Kentucky

SCHEDULE OF EVENTS

Sunday, August 21, 2016

5:00 PM–7:00 PM
Registration, reception at Falls of the Ohio State Park Interpretative Center, and poster setup at the Clarion Hotel

Monday, August 22, 2016

Technical Sessions

8:30 AM–9:00 AM
Indiana's Dimension Stone Legacy: The Indiana Limestone Photograph Collection, *Todd A. Thompson, Licia A. Weber, Robin L. Nolin, and Barbara T. Hill, Indiana Geological Survey, Bloomington, Indiana*

9:00 AM–9:30 AM
Transportation of Industrial Minerals on United States Inland Waterways, *Waylon Humphrey, U.S. Army Corps of Engineers, Louisville District, Louisville, Kentucky*

9:30 AM–10:00 AM
Industrial Mineral Resources of Oklahoma, *Stanley Krukowski, Oklahoma Geological Survey, Norman, Oklahoma*

10:00 AM–10:30 AM
BREAK

10:30 AM–11:00 AM
Petrology and Mineralogy of Alkaline Ultramafic Rocks, Western Kentucky Fluorspar District, *Warren H. Anderson, Kentucky Geological Survey, Lexington, Kentucky*

11:00 AM–11:30 AM
Application of Cathodoluminescence Microscopy (CLM) to the Identification of Industrial Minerals in Carbonatites, *Richard D. Hagni, Department of Geosciences and Geological and Petroleum Engineering, Missouri University of Science and Engineering, Rolla, Missouri*

11:30 AM–12:00 AM
A Quantitative Analysis of Red Mud Contamination Through Aeolian Processes in Manchester, Jamaica, *Jullian C.B. Williams and Sherene A. James-Williamson, Department of Geography and Geology, The University of the West Indies, Mona, Kingston, Jamaica*

12:00 AM–1:30 PM
LUNCH (on your own)

1:30 PM–2:00 PM
Broken Stone: The Underground Mining of Crushed Stone Aggregates in the Chicago Area, *Donald G. Mikulic, Illinois Geological Survey, Champaign, Illinois, and Joanne Kluessendorf, Weis Earth Science Museum, Menasha, Wisconsin*

2:00 PM–2:30 PM
Resource Assessment, Evaluation, and Distribution Economics of Central Texas Industrial Sand, *Brent A. Elliott and Rahul Verma, The Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas*

2:30 PM–3:00 PM
Subsidence Monitoring in Underground Gypsum Mining, *Brandon Wright, United States Gypsum Company, Chicago, Illinois*

3:00 PM–3:30 PM
BREAK—Bates Scholar Recognition

3:30 PM–4:00 PM
The Future of Ohio Dimension Stone and Statewide Derivative Resource Mapping, *James Stucker, Ohio Department of Natural Resources, Division of Geological Survey, Columbus, Ohio*

4:00 PM–4:30 PM
The Oldest Stone House of Lakewood, Ohio: A Rare Remaining Example of the Use of Siltstone from the Ohio Shale for House Construction, *Joseph T. Hannibal, Cleveland Museum of Natural History, Cleveland, Ohio, and Gordon C. Baird, State University of New York at Fredonia, Fredonia, New York*

4:30 PM–5:00 PM
The Industrial Minerals Investment Arena—What We Learned from the Mega-cycle but Already Knew Before That, *Vanessa Santos, Agapito Associates Inc., Grand Junction, Colorado*

Posters

Reevaluating the Potential for Uranium Resources of Texas, *Brent A. Elliott, The Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas; Mark J. Mihalasky, Geology, Minerals, Energy, & Geophysics Science Center, U.S. Geological Survey, Denver, Colorado; and Susan M. Hall, Central Energy Resources Science Center, U.S. Geological Survey, Denver, Colorado*

Study of Rare Earth Element (REE) Potentials in Highly Altered Tuffs Occurring in the Davraz Mountain Region, Isparta (Southwest Turkey), *Murat Budakoglu, M. Sezai Kırıkıoglu, Ali Tugcan Unluer, Zeynep Doner, and Huseyin Kocaturk, Department of Geological Engineering, Faculty of Mines, Istanbul Technical University, Istanbul, Turkey; and Amr Abdelnasser, Department of Geology, Faculty of Science, Benha University, Benha, Egypt*

And Now for Some R & R (Reclamation & Reuse): Ariel-Foundation Park, Mount Vernon, Ohio, *Mark E. Wolfe, Consultant, Utica, Ohio*

Cement: Exploration, Raw Materials, and Chemistry, *Tom Newman, Holcim (US) Inc., LafargeHolcim Inc., Fort Collins, Colorado*

MONDAY EVENING BANQUET AND SILENT AUCTION

Banquet to be held at the Clarion Hotel and Conference Center–Louisville North

(Banquet fee applies)

6:30 PM *Cash Bar and Silent Auction Bidding* **7:00 PM** *Dinner* **8:00 PM** *Presentation by Alan Goldstein*

Mining History of the Southern Illinois and Western Kentucky Fluorspar District, *Alan Goldstein, Interpretive Naturalist, Falls of the Ohio State Park, Clarksville, Indiana*

ABSTRACTS

MONDAY, AUGUST 22, 2016

Technical Sessions

8:30 AM–9:00 AM

Indiana's Dimension Stone Legacy: The Indiana Limestone Photograph Collection, *Todd A. Thompson, Licia A. Weber, Robin L. Nolin, and Barbara T. Hill, Indiana Geological Survey, Bloomington, Indiana*

A previously unknown and irreplaceable collection of approximately 26,000 architectural photographs has been rescued by the Indiana Geological Survey. These photographs were hidden for decades in a dilapidated house on the outskirts of a quarrying operation in southern Indiana. Depicting buildings from across the country, this collection showcases the important legacy that Indiana limestone played in the architectural and social history of the United States.

The photographs, taken in the early 1900s, were used by the Indiana Limestone Company, one of the largest limestone quarriers and fabricators in North America, for marketing purposes and to illustrate architectural styles and uses. They feature completed buildings, in-progress construction, and details of decorative carvings and finishings. The 7.5- by 9.5-inch black and white photographs are mounted on linen with labels attached to the backing. These labels provide a significant amount of information on the location, owner, date of construction, builder, architect, and other aspects of the building, such as quarrier and stone quantity. The photographer's name or company is often noted on the front of the photographs. Remarkably holistic in scope, these images show the urban transformation of our nation and reflect the extensive use of Indiana limestone in commercial, municipal, institutional, and residential building projects in nearly every state, and in cities such as Chicago, New York, and Washington, DC.

The collection of photographs is being inventoried, catalogued, scanned, and archived at the Indiana Geological Survey. A portion of the digitized photographs are currently available online through Indiana University Library's Image Collections Online. Future plans for the collection include compilation in a comprehensive geographic information system and interactive website. This proposed geospatial interface will allow users to view photographs and the location of each building, as well as to search the metadata by fields such as date, architectural style, limestone type, or building use. This digital interface will enable in-depth analysis of the photographs and associated data, which documents the pervasive use of Indiana limestone through time and across the country.

9:00 AM–9:30 AM

Transportation of Industrial Minerals on United States Inland Waterways, *Waylon Humphrey, U.S. Army Corps of Engineers, Louisville District, Louisville, Kentucky*

9:30 AM–10:00 AM

Industrial Mineral Resources of Oklahoma, *Stanley Krukowski, Oklahoma Geological Survey, Norman, Oklahoma*

Oklahoma is a region of complex geology, where several major sedimentary basins are set among mountain ranges and uplifts. Because of its geologic history, Oklahoma has abundant mineral resources that include petroleum (crude oil and natural gas), coal, metals (lead, zinc, and copper), industrial minerals (limestone, granite, sand and gravel, silica sand, gypsum, and iodine), and water. The value of Oklahoma's petroleum, coal, and industrial-minerals production averages between \$11 and \$12 billion, making the mineral industry the greatest source of revenue in the state in recent years. Industrial minerals alone account for about \$500 to \$600 million annually. Oklahoma typically ranks about 30th in mineral production each year.

Nonmetallic minerals are widely distributed in Oklahoma and are mined for local, regional, national, and international markets. Crushed-stone (aggregate) and building-stone resources include limestone, dolomite, and granite; other major construction resources are cement and the extensive sand and gravel deposits along modern and ancient rivers. High-purity silica sand (industrial sand) is used for glassmaking, foundry sands, ceramics, and abrasives. Enormous reserves of gypsum in the western part of the state are mined for use in wallboard, in plasters, as a retardant in portland cement, in the food and pharmaceutical industries, and as a soil conditioner. Thick layers of rock salt underlie most of western Oklahoma at depths of 30–3,000 ft, and natural springs of salt water emit brine to several salt plains in the region. Iodine is produced from deep oil-field brines (7,000–10,000 ft deep) by three companies in northwestern Oklahoma. The state is the sole domestic producer of iodine; the state's production of 1,570 metric tons in 2005 (the last data available before being withheld by producers for proprietary reasons) was about 20% of the United States' needs. Other important nonmetallic minerals in Oklahoma include clays and shales (to make brick and tile) and tripoli and volcanic ash (abrasives, absorbent materials, or both).

The latest data available from the U.S. Geological Survey ranked Oklahoma first in gypsum and iodine production in 2011. Oklahoma ranked sixth in common clay production in 2011. In 2011, Oklahoma rose from 13th to 12th in the production of crushed stone. Oklahoma continued to rank fourth among six Grade A helium-producing states in 2010; however, Grade A helium was not produced in Oklahoma in 2011. Oklahoma ranked 11th among masonry-cement-producing states, and 13th of 16 salt-producing states. The state's production of industrial sand and gravel managed to rank it eighth in 2011. Tripoli production was last reported in 2009, and feldspar was withheld as proprietary.

10:00 AM–10:30 AM

BREAK

10:30 AM–11:00 AM

Petrology and Mineralogy of Alkaline Ultramafic Rocks, Western Kentucky Fluorspar District, *Warren H. Anderson, Kentucky Geological Survey, Lexington, Kentucky*

The igneous intrusive complex in the Western Kentucky Fluorspar District indicates a diverse and complex mantle-derived igneous rock, historically described as lamprophyre and mica peridotite. Minerals in igneous groundmass and phenocrysts in core indicate a polyphase fractionated facies of an alkaline silicate magma, from which the dikes formed. Unusual minerals in dikes, determined by X-ray diffraction, include (a) titanium garnets, (b) astrophyllite, (c) rare earth element (REE)-bearing perovskites, (d) villiaumite, (e) natrite, (f) spodumene, (e) niobium rutile, (f) fluoro-phosphates, (g) wüstite, (h) molybdenite, (i) fluoro-tetraferriphologopite, and (j) fluocerite, an REE-bearing fluorescent mineral. These REE-bearing fluoride complexes were within the dike or breccia facies, and are usually associated with carbonatites in other areas of the world. Several of these rare minerals have never been described in the Western Kentucky Fluorspar District, and their occurrence suggests a more complex ultramafic facies petrogenesis.

Whole-rock elemental analysis of the dike material shows variable major element content, suggesting polymodal facies, whereas high titanium, niobium, and zirconium suggest mantle-sourced enriched intrusives. Rare earth element analysis of the dikes suggests light REE enrichment, and high La/Yb ratios suggest a metasomatized intrusive. Fluorite mineralization in the district was also analyzed for REE content, suggesting a bimodal fluid, one enriched in light REE and another enriched in a middle REE.

The rare dike mineralogy and enriched REE content suggest a fractionated and metasomatized igneous intrusive complex in the Western Kentucky Fluorspar District.

11:00 AM–11:30 AM

Application of Cathodoluminescence Microscopy (CLM) to the Identification of Industrial Minerals in Carbonatites, *Richard D. Hagni, Department of Geosciences and Geological and Petroleum Engineering, Missouri University of Science and Engineering, Rolla, Missouri*

Most of the industrial minerals that occur within carbonatites can be readily recognized and conveniently studied by using cathodoluminescence microscopy (CLM). Cathodoluminescence microscopy utilizes a defocused beam of electrons to incite minerals to give off light of various colors. Although the color of cathodoluminescence (CL) shown by a given mineral is a function of its trace element content (especially minor transition and lanthanide elements), typically a mineral contains sufficient amounts of those trace elements for their CL response to be characteristic of the mineral. Some minerals, however, exhibit intrinsic CL that is independent of their trace element contents.

The principal mineral of most carbonatites, calcite, typically emits distinctive bright yellow CL. Less abundant dolomite emits a distinctive bright orange CL that makes it readily distinguishable from calcite.

Fluorite, a common mineral associated with carbonatites, has been recovered as an industrial mineral from some carbonatites, such as those at Okorusu, Namibia. Fluorite typically exhibits a characteristic deep purple to blue CL that lends itself to ready recognition and study by CLM. The intensity of CL and colors of various growth bands in fluorite conveniently outline internal zoning and growth patterns within individual fluorite crystals.

Apatite is an important industrial mineral recovered from some carbonatites, such as the Jacupiranga carbonatite at the Cajati apatite mine in Brazil. Although apatite shows intrinsic CL, its CL also is commonly influenced by various trace element contents. Thus, it may show a variety of CL colors, including yellow, blue, purple, and white. At the Cajati mine, CLM has been used to study the apatite, reveal internal apatite zoning, and examine mill recovery of the apatite.

In contrast, when apatite occurs in a fluorspar concentrate from carbonatites, which commonly is the case, apatite is considered a deleterious mineral if the fluorite concentrates are intended for use in the steel industry. Cathodoluminescence microscopy has been shown to be a very effective tool for determining the character of the apatite crystals in fluorspar concentrates at the Okorusu mine. Specifically, apatite can clearly be shown to be present either as free particles or as locked particles of apatite-fluorite in the fluorspar concentrates.

Cathodoluminescence microscopy should be a routine tool for the microscopic study of industrial minerals in carbonatites and their mill products.

11:30 AM–12:00 AM

A Quantitative Analysis of Red Mud Contamination Through Aeolian Processes in Manchester, Jamaica, *Jullian C.B. Williams and Sherene A. James-Williamson, Department of Geography and Geology, The University of the West Indies, Mona, Kingston, Jamaica*

Red mud, the by-product of bauxite processing, is commonly stockpiled through various methods. These methods include lagooning, dry-stacking, and, most recently, dry-caking. Jamaica has recently transitioned from the use of the lagooning waste disposal method to a dry-stacking method, which features dewatering of the existing lagoon or "red mud lake." The Battersea Red Mud Lake located in the parish of Manchester, Jamaica, has made similar adjustments with its bauxite waste product. The dehydration of red mud waste may allow the removal of unconsolidated material. This airborne material is then transported to neighboring communities within the parish.

Radioactive particles present within the red mud would be transported with the unconsolidated material via wind. Alpha particles associated with radium and radon, which are damaging to human tissue, particularly the respiratory and gastrointestinal systems, have been found in varied concentrations in bauxite, soil, and red mud waste. Therefore, the transportation and deposition of unconsolidated red mud particles and subsequent inhalation of radioactive elements from the same may be cause for concern regarding health effects from prolonged exposure.

This paper provides results from a preliminary study of radiation in bauxite red mud waste, its transportation mechanism, and potential exposure by persons within the community. The results from this study can be used to inform best practices for mining rare earth elements from red mud waste as well as post red mud waste deposition management.

12:00 AM–1:30 PM

LUNCH (on your own)

1:30 PM–2:00 PM

Broken Stone: The Underground Mining of Crushed Stone Aggregates in the Chicago Area, *Donald G. Mikulic, Illinois Geological Survey, Champaign, Illinois, and Joanne Kluessendorf, Weis Earth Science Museum, Menasha, Wisconsin*

The Chicago region has long been one of the largest producers and consumers of crushed stone aggregates in the United States. Chicago's "broken stone" production began in the mid-19th century to supply material for macadamizing city streets. One of the first patents for a "stone-breaking" machine to make macadam was issued to a Chicago group in 1859. From about 1820 to 1900, however, aggregates were only a minor stone product of the Silurian dolomite quarries in northeastern Illinois. During this time, huge quantities of building stone ("Athens Marble") were quarried at Lemont and Joliet for the construction of building foundations, load-bearing walls, sidewalks, and many other structures. Chicago quarries were famous for their large-scale production of lime used for mortar.

The stone industry changed rapidly during the 1890s following the introduction of inexpensive portland cement, and by 1900, aggregate had become the dominant stone product of the region. Marking the start of the modern stone industry was the replacement of building stone with concrete, which requires large volumes of aggregates. After 1900, the Good Roads Movement also increased the demand for aggregates as the old macadamized and paving block roads were replaced with pavements made with portland cement and asphalt. These changes caused a large number of quarries in the region to close, especially those producing building stone.

For the next 70 years, the remaining quarries were able to meet most of the Chicago area's greatly expanding aggregate needs. By the 1970s, however, many of these quarries had depleted their reserves of Silurian dolomite available via surface quarrying. Urban expansion already had covered most of the undeveloped aggregate sources located close to the city, forcing the industry to explore for new sites far from Chicago. Significantly, however, the potentially greater transportation costs of stone from these more distant sources made underground mining for aggregates locally an economically viable possibility.

In the early 1980s, the Elmhurst-Chicago Stone Company decided to target Ordovician carbonates via underground mining beneath their depleted Silurian dolomite quarry in Elmhurst, Illinois. With the success of this first mine, other producers began to plan and open additional underground mines in the Ordovician rocks of the region. Currently, seven mines are operating and one is under construction in the Ordovician rocks of northeastern Illinois, although the original mine at Elmhurst has closed. Of the operating mines, five are located in depleted Silurian quarries, one is in a depleted gravel pit, and one is at a never-quarried old industrial site. Numerous other potential sites in the area, most already owned by aggregate producers, have been evaluated for future mining of Ordovician rocks. Ordovician strata are more uniform in thickness and character than local Silurian strata, which are depositionally complex because of numerous ancient reefs, and are increasingly truncated by erosion going from east to west through the region. Therefore, Ordovician carbonates are a more uniform target for mining throughout nearly the entire region, with the only significant variable being depth of burial. In addition, in areas near the eastern portion of the region, thick deposits of Silurian rocks have never been quarried because of thick deposits of overlying Quaternary sediments, but these could also be extracted by underground mining.

Most operating mines have been developed on properties already owned by aggregate producers, which helps solve the problem of prospecting for and permitting new sites. However, important issues have emerged even with producer-owned potential sites for underground mining. Many depleted sand and gravel operations, as well as depleted stone quarries, have been sold off for other uses, and this practice was continued even after the opening of the Elmhurst mine. In many cases, the mineral rights needed for underground mining have not been retained and these potential reserves have been lost. In addition, other proposed uses have competed for the potential mine sites. In the 1980s to 1990s, the Ordovician reserves at the two largest quarries in Cook County, Vulcan's McCook Quarry and Material Service's Thornton Quarry, could have been lost because they faced at least partial condemnation for use as large public works sanitary reservoirs. The loss of Ordovician reserves at these sites could have exceeded 500 million tons, which at the time would have represented up to 60% of crushed stone reserves in the county. Eventually, this loss would have caused dramatic increases in transportation costs to bring aggregates from more distant areas, and taxpayers at all levels would have carried much of the burden of these increases. Fortunately, other solutions were found and the reserves have been preserved for the future.

2:00 PM–2:30 PM

Resource Assessment, Evaluation, and Distribution Economics of Central Texas Industrial Sand, *Brent A. Elliott and Rahul Verma, The Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas*

The Cambrian-age Hickory sand in the Llano Uplift has had steady production over the last decade and remains a viable and cost-effective proppant resource for the petroleum industry of Texas. A recent study has analyzed more than 2,000 well logs in the central Texas region to assess the near-surface accessibility of the Hickory sandstone and create a block model for the distribution of sand resources and overburden throughout the region (Elliott et al. 2016). The important resource characteristics have been evaluated with proximity to transportation facilities, among other salient factors, to calculate the most favorable sites for establishing new extraction facilities.

The compressive strength of Hickory sand, compared with other proppant material, limits its applicability to certain stratigraphy and depths in basins in Texas. On the basis of the quality of the sand, US Silica (2016) and Santrol (2016) claim the Hickory sand to be applicable in fracture closure stress of 2,000–6,000 psi, Benson and Wilson (2015) claim applicability in the range of 0–4,000 psi, and compressibility tests by Kullman (2011) and Economides (1992) show a sharp decrease in conductivity at pressures greater than 6,000 psi.

An assessment of the complex network of highways and railroad infrastructure in the supply chain between product and market shows the most economic means of utilizing industry proppant in Texas. The transportation and handling cost can be as high as $56 per ton depending on the distance and means of transportation, almost 31–46% of the final cost of $120–$180 per ton for sand (Sider 2014). The transportation distance between the product and market identified in this study is already much lower than for some of the other alternatives, such as Northern White sand from Minnesota and Wisconsin, and analysis for the means or mode of transportation in this study attempts to provide a holistic solution for the utilization of proppant (from both in-state and out-of-state sources) in Texas. An intermodal transportation network is created with highways and railroads, and least-cost routes are identified for several locations in the Permian, Barnett, and Eagle Ford basins, where Hickory sand can be sufficiently utilized to the appropriate basin strata pressure(s).

References

Benson, M.E., and A.B. Wilson, 2015, Frac sand in the United States—A geological and industry overview: U.S. Geological Survey, Open-File Report 2015-1107, 78 p., http://dx.doi.org/10.3133/ofr20151107 (accessed August 8, 2016).

Economides, M.J., 1992, A practical companion to reservoir stimulation: Amsterdam, Elsevier Science, Developments in Petroleum Science 34, 87 p.

Elliott, B.A., R. Verma, and J.R. Kyle, 2016, Prospectivity modeling for Cambrian-Ordovician hydraulic fracturing sand resources around the Llano Uplift, Central Texas: Natural Resources Research, v. 25, no. 4, p. 389–415, doi:10.1007/s11053-016-9291-6.

Kullman, J., 2011, The complicated world of proppant selection: Rapid City, South Dakota School of Mines and Technology, http://images.sdsmt.edu/learn/speakerpresentations/Kullman.pdf (accessed on August 8, 2016).

Santrol, 2016, Texas Gold frac sand: Sugar Land, Texas, Santrol, http://fairmountsantrol.com/wp-content/uploads/2014/08/13-FMS-0161-TexasGold-Data-Sht-lores.pdf (accessed on August 8, 2016).

Sider, A., 2014, Fracking sends sand sales soaring: The Wall Street Journal, http://blogs.wsj.com/corporate-intelligence/2014/04/30/fracking-sends-sand-sales-soaring/ (accessed August 8, 2016).

US Silica, 2016, 30/50 Premium Hickory: Houston, Texas, US Silica, http://www.ussilica.com/sites/ussilica.com/files/Premium-Hickory-3050-2.pdf (accessed August 8, 2016).

2:30 PM–3:00 PM

Subsidence Monitoring in Underground Gypsum Mining, *Brandon Wright, United States Gypsum Company, Chicago, Illinois*

The United States Gypsum Company (USG) has operated underground mines for gypsum for more than 115 years. Currently, three underground mines are active. An inactive mine is located beneath an active manufacturing plant. Three underground mines have been permanently sealed and flooded by groundwater.

The minability of gypsum is highly dependent on the presence or absence of groundwater. The solubility of gypsum in fresh water is 150 times greater than that of limestone. Too little water and a gypsum deposit will be contaminated by anhydrite. Too much water and the gypsum will be subjected to erosional and solution processes. Shallow underground mine workings often intersected solution-enlarged fractures, providing direct pathways for the infiltration of surface water, groundwater, or both, resulting in soil piping and the formation of surface sinkholes. The presence of porous zones resulting from the dissolution of gypsum porphyroblasts, thin beds, or veins in dolomite strata overlying a gypsum mining seam seriously affected mine roof stability and the potential for inflows of water.

Over the years, USG has experienced numerous subsidence events at the inactive and flooded underground mines. Thus, USG has gained considerable experience in the detection, monitoring, measurement, and mitigation of surface subsidence and underground water inflows in gypsum mines. The deepest gypsum mine in the world, USG's Plasterco, Virginia, mine, used stope mining methods to extract gypsum from 16 levels, extending to a depth of about 1,500 ft. A major subsidence event in 1984 resulted from the long-term degradation of the mine structure.

This presentation will highlight various types of subsidence features in USG's underground mines and the technologies that have been used for ongoing monitoring and mitigation. The technologies include

- Time-domain reflectometry (TDR),
- Airborne laser imaging (LiDAR),
- Downhole TV and 3-D laser scanning,
- Precise level and remote prism surveying,
- Hydraulic backfilling, and
- Cementitious grouting.

3:00 PM–3:30 PM

BREAK—Bates Scholar Recognition

3:30 PM–4:00 PM

The Future of Ohio Dimension Stone and Statewide Derivative Resource Mapping, *James Stucker, Ohio Department of Natural Resources, Division of Geological Survey, Columbus, Ohio*

Historically, the Ohio dimension stone industry has consisted of western Ohio limestones and eastern Ohio sandstones, with sandstone being the dominant rock type quarried for dimension stone in Ohio today. Ohio dimension sandstone resources rank as some of the highest quality and most heavily quarried in the United States, and they have maintained their relative popularity for decades.

Growing competition and other economic factors, such as rising transportation costs, have curtailed dimension stone production in Ohio. The future of the industry likely will be determined not by geologic properties of the rocks, but by market competition and local business decisions.

To aid dimension-stone and industrial-mineral producers in Ohio, the Ohio Department of Natural Resources, Division of Geological Survey conducts a statewide derivative mapping program that aims to provide general reconnaissance maps of potential bedrock and sand-and-gravel resources. These maps allow for preliminary resource tonnage calculations and aid in exploration and zoning for potentially mineable stone and sand-and-gravel resources. Derivative maps of potential mineral resources are based on the Division of Geological Survey three-dimensional surficial geology maps that are completed or in progress for 27 of the 34 30 × 60-minute quadrangles in Ohio. The current process of derivative mapping employed by the Division of Geological Survey is statewide and allows for greater scalability and more accurate resource descriptions than previous quadrangle-specific mapping techniques.

4:00 PM–4:30 PM

The Oldest Stone House of Lakewood, Ohio: A Rare Remaining Example of the Use of Siltstone from the Ohio Shale for House Construction, *Joseph T. Hannibal, Cleveland Museum of Natural History, Cleveland, Ohio, and Gordon C. Baird, State University of New York at Fredonia, Fredonia, New York*

The Oldest Stone House in Lakewood, Ohio, is a rare remaining example of a house constructed using siltstone from the Ohio Shale. Built circa 1834, it is one of the oldest stone houses in northern Ohio. The siltstone blocks used in its construction were mostly between 4 and 12 cm in thickness, with rippled tops and flatter bottoms containing trace fossils and current markings.

Most of the stones are placed in the building horizontally, parallel to their position in nature. But many are placed upside down and some are set vertically. Plumose structures (tectonic stress feathering) along exposed vertical surfaces (mainly joint faces within the siltstone layers) suggest that the stone was also naturally split, not sawed. A number of lintels and windowsills are also composed of this siltstone. Weathering of the stone has greatly accentuated its sedimentary structures, especially toward the tops of the beds, and remnant pyrite at the base of some vertically placed blocks has caused staining when beds have been set horizontally.

Additional stone houses once existed in Lakewood; photos of one of these indicate that the same type of stone was used in its construction. Similar siltstone was also used for the older foundations of the circa 1816 Joseph Cahoon House, located above Cahoon Creek in Bay Village, Ohio, about 7 miles west of the Lakewood house. Outcrops below the Cahoon House along Cahoon Creek, not far above the level of Lake Erie, contain similar siltstone layers within a rock sequence most similar to those of the Chagrin Member of the Ohio Shale and in some ways similar to the Olmsted bed of the superjacent Cleveland Member. The siltstone beds are usually upward fining. They are composed mostly of quartz, with some mica and a small amount of carbonate. The stone used for the Lakewood Oldest Stone House may have been from the Cahoon Creek locality of the Rocky River valley, where similar siltstone crops out from outcrops along Lake Erie, or from now-covered outcrops in Lakewood itself.

4:30 PM–5:00 PM

The Industrial Minerals Investment Arena—What We Learned from the Mega-cycle but Already Knew Before That, *Vanessa Santos, Agapito Associates Inc., Grand Junction, Colorado*

The industrial minerals (IM) investment arena varies from the metals sector—a lot! Historically, margins have been thinner in the IM sector and market, so transportation and product consistency are keys to success. The introduction of new thinking can make this segment attractive.

Exploration methodology varies greatly, and deposits vary greatly as to geologic origin, depth or shallowness, and solid or brine composition. Project lead time, market entry, and competition are a few of the challenges to success. Existing players may define the game, but explorationists and engineers are redefining techniques for identifying and evaluating mineral deposits, and adapting technologies for production and process. Efficiencies are introduced to the IM sector by modern resource estimation, mine planning, and adaptive exploration technologies. In the potash and trona sector, this includes solution mining, angled exploration and production drilling, adaption of 3-D and downhole geophysical techniques from the oil industry, and alternative mineral species production.

Posters

Reevaluating the Potential for Uranium Resources of Texas, *Brent A. Elliott, The Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas; Mark J. Mihalasky, Geology, Minerals, Energy, & Geophysics Science Center, U.S. Geological Survey, Denver, Colorado; and Susan M. Hall, Central Energy Resources Science Center, U.S. Geological Survey, Denver, Colorado*

The Tertiary depositional sequences of the Texas Gulf Coast host numerous uranium deposits (Eargle et al. 1971). These deposits are typically found in sandstones and are some of the most prolific uranium deposits in the United States. Deposits in the Texas Coastal Plain region are estimated to contain the third largest domestic sandstone-hosted uranium resource after the Colorado Plateau and Wyoming Basin regions. Undiscovered uranium resources associated with sandstone-hosted roll-front deposits in the Texas Coastal Plain were estimated for geologic units with known uranium occurrences: the Eocene Claiborne and Jackson Groups, the Oligocene Catahoula Formation, the Miocene Oakville Sandstone, the Pliocene Goliad Sand and Willis Formation, and the Pleistocene Lissie Formation. Sandstone facies that host mineralization were deposited in mixed marine-coastal-fluvial facies (Claiborne and Jackson Groups) and by dominantly fluvial systems (Catahoula Formation, Oakville Sandstone, Goliad Sand, Willis and Lissie Formations; Fisher et al. 1970). The more than 150 known mines in the region have produced more than 40 thousand tons of U_3O_8, with reported in-place uranium resources of about 30 thousand tons of U_3O_8. Ore bodies are typically narrow and long, with strike lengths ranging from tens of meters to kilometers.

Geologic sedimentary units known to host uranium deposits were used to delineate three geographic regions (tracts) permissive for undiscovered uranium deposits: (1) the Claiborne-Jackson tract, (2) the Catahoula-Oakville tract, and (3) the Goliad-Willis-Lissie tract. The tracts represent groups of stratigraphic sequences that were deposited in broadly similar depositional environments. The tracts are geographically subdivided into the Rio Grande Embayment sub-tract (the southwestern region, with more known occurrences and higher mineral potential) and the Houston Embayment sub-tract (the northeastern region, with fewer known occurrences and lower mineral potential), forming a total of six sub-tracts. More than 100 undiscovered sandstone-hosted uranium roll-front deposits contain a calculated mean total of 110 thousand tons of recoverable U_3O_8, encompassing all six permissive sub-tracts in the Texas Coastal Plain. This represents nearly 1.6 times the amount of uranium that has already been identified or produced from the region.

References

Eargle, D.H., G.W. Hinds, and A.M.D. Weeks, 1971, Uranium geology and mines, south Texas: University of Texas at Austin, Bureau of Economic Geology Guidebook 12, 59 p.

Fisher, W.L, C.V. Proctor Jr., W.E. Galloway, and J.S. Nagle, 1970, Depositional systems in the Jackson Group of Texas—Their relationship to oil, gas, and uranium: Gulf Coast Association of Geological Societies Transactions, v. 20, p. 234–261.

Study of Rare Earth Element (REE) Potentials in Highly Altered Tuffs Occurring in the Davraz Mountain Region, Isparta (Southwest Turkey),* *Murat Budakoglu, M. Sezai Kırıkoglu, Ali Tugcan Unluer, Zeynep Doner, and Huseyin Kocaturk, Department of Geological Engineering, Faculty of Mines, Istanbul Technical University, Istanbul, Turkey; and Amr Abdelnasser, Department of Geology, Faculty of Science, Benha University, Benha, Egypt*

In this study, we investigate the potential in situ enrichment of rare earth elements (REE) in highly altered alkaline tuffs located in the Davraz Mountain district of Isparta, southwest Turkey. The highly altered tuffs in this region are related to the Quaternary Golcuk Volcano located in the Isparta region. This volcano is an example of the well-known postcollisional, Afyon-Isparta potassic-ultrapotassic volcanic province in southwestern Turkey. The volcano consists augite-trachytes, porphyry trachytes, and tephriphonolite dikes that are formed in several eruptive cycles. Pyroclastic occurrences of this volcano can be observed in various locations beneath the Isparta angle. The tuffs in our study field can be described as mafic crystal metatuffs, which predominantly consist of plagioclase with actinolite, clinopyroxene, hornblende, K-feldspar, and quartz set in a microcrystalline tuffaceous matrix of microcrystalline aggregates of kaolinized and sericitized feldspar, tremolite-actinolite, biotite, quartz, and dusty iron oxide. The results indicate high values for the light REE (LREE) elements such as La (350–400 ppm), Ce (600–650 ppm), and Sc (70–80 ppm), as well as relatively high values for Th (70–80 ppm). The average LREE content of samples is ~1,200 ppm. These results are compatible with the samples from the Golcuk Caldera in terms of LREE (La and Ce values of 400–500 ppm and 500–600 ppm, respectively).

*This research was supported by The Scientific and Technological Research Council of Turkey (TUBITAK) project (CAYDAG-114Y646; Prof. Dr. M. Sezai Kırıkoglu, principal investigator).

And Now for Some R & R (Reclamation & Reuse): Ariel-Foundation Park, Mount Vernon, Ohio, *Mark E. Wolfe, Consultant, Utica, Ohio*

Geologists who interact with the public should constantly stress that mining is a short-term land use that provides both present and future economic value. Numerous examples can be found across the United States of abandoned mines that have been reclaimed and are being used for housing, office buildings, retail development, and even concert venues. An important use of reclaimed land is for recreation. Industrial mineral operations are often located near urban centers and, when depleted, become valuable as publicly accessible open space. Many locations in Ohio of formerly mined land are now being used as parks. Ariel-Foundation Park is a visionary rejuvenation of an abandoned glass plant and adjacent sand and gravel operation into a public space that celebrates that industrial heritage. The urban park is located on 250 acres of reclaimed land less than 1 mile from downtown Mount Vernon, Ohio. Ariel-Foundation Park allows for low-impact recreation, such as fishing, hiking, biking, birdwatching, concerts, and picnics. Several former Pittsburgh Plate Glass (PPG) window-glass manufacturing buildings have been repurposed as a performing arts pavilion, a museum that details the site's industrial heritage, and an event center. An observation platform offering panoramic views of the area was constructed on the former PPG smokestack. Three lakes covering an area of nearly 100 acres have been reclaimed from former sand and gravel pits. A local rails-to-trails bike path bisects the park, allowing access to a nearby restored train station used as a welcome center; a restored 1872 wrought-iron bow-string truss bridge; the state-recognized, scenic Kokosing River; downtown Mount Vernon; and two local universities.

Cement: Exploration, Raw Materials, and Chemistry, *Tom Newman, Holcim (US) Inc., LafargeHolcim Inc., Fort Collins, Colorado*

Cement has a unique language for the industrial minerals geologist. This presentation is tailored to those interested in a deeper knowledge of the cement manufacturing process. Emphasis will be given to the geologic exploration methodology and targets for cement, including what raw materials are required, what qualities to look for, and what to avoid. The complex chemistry of cement is clearly presented, from raw materials to clinker production.

FIELD TRIPS

Introduction

The Louisville (Kentucky) and Jeffersonville (Indiana) area is an old, long-settled area on the Ohio River. Development began in part because of resistant beds of Devonian Age carbonate rocks in the bed of the Ohio River that caused a large change in elevation and the Falls of the Ohio—a natural route across the river.

Abundant natural geologic resources helped support the cities. Carbonates and shales of Paleozoic Age provided raw materials for aggregate, lime, cement, ceramics, and other essential products. Large deposits of sand and gravel were deposited during Pleistocene time, especially along the Ohio. The Ohio River also provided an excellent transport route to move large amounts of raw materials all along the river. Locks are essential for river transport of raw materials, grains, fuel, and finished products.

Indiana, Kentucky, and, to a lesser extent, Illinois and Ohio have many industrial minerals on or near the Ohio River. Indiana has one cement plant, 15 crushed stone quarries, seven sand and gravel pits, and one currently inactive specialty sand mine. Kentucky has one cement plant, 11 crushed stone quarries, 20 sand and gravel pits, and one ceramic operation near the Ohio. Illinois has five crushed stone quarries and a number of now-closed Mississippi Valley Type fluorite, sphalerite, and galena mines. We will visit a few of these operations and look at the river itself. Wishing you a great trip!

—Nelson Shaffer

Guest Field Trip, August 22, 2016

Louisville Areas Sites

A guest trip will be conducted to sites in southern Indiana and northern Kentucky. In Indiana, stops will be made at historic Corydon, Little Wyandotte Cave, and the Overlook Restaurant. In Kentucky, stops will be made at the Kentucky Derby Museum/Churchill Downs and Museum Row, both in Louisville.

Post-Meeting Field Trip 1, August 23, 2016

Essroc Cement Corp.
Louisville Mega Cavern
Rogers Group, Inc., Jefferson County Stone
McAlpine Locks and Dam

Essroc Cement Corp., Clark County, Sellersburg, Indiana

This plant is part of the Italcementi Group, which operates 60 plants and 15 grinding operations around the world. It occupies a site larger than 3,500 acres and has ample rail transport. This plant also produces a line of mortars in a number of colors. Cement is made mostly from pure Devonian and Silurian carbonate rocks. The quarry has produced excellent fossils, especially from the so-called Coraline Zone.

Louisville Mega Cavern, Jefferson County, Louisville, Kentucky

The original limestone quarry was started by Ralph Rogers in the 1930s and continued production through the early 1970s. An area of about 100 acres was mined underground to about 90 ft thick. Large pillars (233, each numbered) hold up the roof. The mine underlies part of the busy Watterson Expressway and the Louisville Zoo. More than 17 underground road miles serve a number of businesses, storage areas, a civil defense station, and recreation facilities. The quarry features underground ziplines, bike trails, tram tours, and other adventure activities. It also hosts a very popular subterranean light display at Christmas. The mine was backfilled with recyclable materials, so rooms are about 30 ft high. It stays at 58 °F year round and has large air conditioners to control moisture. It is classified as a building, and as such, it is the largest in the state.

Rogers Group, Inc., Jefferson County Stone, Louisville, Kentucky

A large underground limestone mine has been operating since the early 2000s. It is located on the site of an earlier surface mine, active beginning in the 1960s. The mine is about 1,000 ft deep and takes stone from the Silurian Age Louisville and Camp Nelson Limestones. Deep mining is possible because of the beneficial location of the site.

McAlpine Locks and Dam, Jefferson County, Louisville, Kentucky

The Falls of the Ohio was a great impediment to river transport, and several efforts were made to eliminate the problem. A small Louisville and Portland Canal was built by a Kentucky company in 1825–1830. This was upgraded in 1872, and the U.S.

Army Corps of Engineers assumed jurisdiction in 1874. A dam was completed in 1881, and a wicket dam was made in 1910. A new dam and hydroelectric operation was built in 1925–1927. During 1958–1961, a large lock 1,200 × 600 ft was constructed. A second lock was built during 1996–2009. The locks serve hundreds of barge tows each year and is essential to river transport throughout the Midwest, especially the 981 miles of the Ohio.

Post-Meeting Field Trip 2, August 24–25, 2016

DAY 1

Irving Materials, Inc., Corydon Stone
Corydon Capitol State Historic Site
Wyandotte Cave System
Mulzer Crushed Stone, Inc., Cape Sandy Quarries
Mulzer Crushed Stone, Inc., Griffin Plant
New Harmony State Historic Site

Irving Materials, Inc., Corydon Stone, Harrison County, Corydon, Indiana

The Corydon Crushed Stone mine has very pure limestones of Mississippian Age. Some St. Louis Limestone is the base, but it contains chert and so is not as attractive as the overlying Ste. Genevieve Limestones. Almost 105 ft of Ste. Genevieve contains several white beds of oolites. Some Paoli Limestone is taken at the top and some St. Louis Limestone at the bottom.

Several quarries mine the same section in the area. Most of the carbonate rocks have been subjected to weathering resulting in the Mitchell Karst Plain. Karst features often affect mining. At Corydon, a large sinkhole was encountered during mining. It is connected to a large horizontal cave that runs diagonally across the middle bench of the quarry. Ground-penetrating radar studies have been used to address karst issues. The cave is mostly filled with a sticky orange clay. Karst features also affect drainage and water retention.

Corydon Capitol State Historic Site, Harrison County, Corydon, Indiana

Indiana is celebrating its bicentennial this year (2016). The first state capitol was convened at Corydon in Harrison County. The first statehouse was built there in 1816. It is built of local Ste. Genevieve Limestone collected from local streams. One can contrast the almost white, tight Ste. Genevieve Limestone with the well-known porous, sparse-grained, brown to gray Indiana Limestone mined in Lawrence and Monroe Counties. Indiana or Salem Limestone is the country's most important building stone.

Wyandotte Cave System, Crawford County, O'Bannon Woods State Park, Indiana

South-central Indiana has an extensive karst system—the Mitchell karst—that provides many caves and karst structures. Karst features not only adversely affect quarrying, but also offer opportunities for tourism. Four such show caves operate in the Corydon region. We will visit a cave called the Little Wyandotte Cave that is also known as the New Cave and was originally called Sibert's Cave, after its finder. It was discovered in 1850 but had long been known and used by the Native Americans. A larger cave called Wyandotte or the Historic Cave lies nearby. Both caves began to form during the Pliocene as Mississippian Age Ste. Genevieve Limestone was dissolved. The system was once considered one of the longest in the United States and is a well-known tourist site. Caves are cool, staying at about 52 °F. Very large passages and huge rooms, some with large breakdown "mountains" as well as evidence of aboriginal mining, attract many visitors.

Mulzer Crushed Stone, Inc., Cape Sandy Quarries, Crawford County, Indiana

Ste. Genevieve Limestone is a thick, pure unit that is mined at many sites in southern Indiana. Well-washed carbonate with little chert or clay makes up most of the unit. Well-cemented oolitic units even provide building stone, but most is mined for construction aggregate, cement making, or chemical raw material. Easy access to relatively inexpensive barge transport on the Ohio allows movement of stone over extreme distances. Three mines are located at this site. Caves Sandy 1 and 2 are open pit operations that expose the entire 200+ ft section of Ste. Genevieve Limestone. An underground mine also operates on the site.

Mulzer Crushed Stone, Inc., Griffin Plant, Posey County, Indiana

Much sand and gravel in this region comes from dredging in the Ohio River channel. We will stop at an on-land pit near Griffin. This pit also exposes paleoliquefaction features formed during large earthquakes in the past. A number of studies have looked at earthquakes, some of which have used the liquefaction features (see brochure).

New Harmony State Historic Site, Posey County, New Harmony, Indiana

New Harmony is a very old town that lies on the Wabash River. It was founded in 1814 by George Rapp as a fundamentalist utopian colony. It was sold to a wealthy Scottish industrialist, Robert Owen, in 1825. The colony became a center of intellectual development on the frontier. Noted scientists included geologist William McClure. Robert's geologist son, David Dale Owen, started a geologic reconnaissance based in New Harmony in 1837, which grew into the Indiana Geological Survey. Expeditions from New Harmony also explored much of the Northwest Territories for the U.S. Geological Survey. The Owen geological laboratory and a large storage granary still exist in New Harmony. The Wabash River is meandering toward the town, and the U.S. Army Corps of Engineers has constructed several projects to save the town.

DAY 2

Vulcan Materials Company, Reed Quarry
Ben E. Clement Museum
Hastie Mining & Trucking

Vulcan Materials Company, Reed Quarry, Livingstone County, Lake City, Kentucky

Opened in 1950 by the Clyde Reed Trucking Company, the quarry was operated for many years by the Reed Crushed Stone Company. Vulcan Materials Company purchased the operation in 1990. Located near Paducah, Kentucky, Reed Quarry is one of the largest and deepest single crushed stone quarries in the country. Crushed stone has been produced from three Mississippian formations (in descending order): the Salem Limestone, Warsaw Limestone, and Fort Payne Formation. Current production is mostly from the Fort Payne Formation, a dark gray, fine to very fine grained, siliceous limestone. Reed Quarry ships most of its production by barge, 15% by rail, and 10% by truck. The Gulf Coast region is the destination for most of the stone that is transported by barge.

Ben E. Clement Museum, Crittenden County, Marion, Kentucky

http://www.clementmineralmuseum.org/about.html

Hastie Quarry, Hardin County, Cave-in-Rock, Illinois

Hastie Quarry is located in Hardin County northeast of Cave-in-Rock, Illinois, along Illinois Route 146. At the Hastie Quarry, limestone is being quarried from the Ste. Genevieve Limestone (Msg) and the St. Louis Limestone (Msl). The limestone quarry is located in an area of fluorite mineralization, and underground workings can be seen in the highwall of the quarry. The Lower Chesterian units (Bethel Sandstone, Downey's Bluff Limestone, and Yankeetown Formation) are removed and wasted or spoiled. The Aux Vases Sandstone is mined for a specialty "nonskid" aggregate. In this region, the fluorite is contained within the Renault Limestone. As the quarry advances into the hillside, the fluorite that was previously left in the underground workings is being extracted and sold. Minerals that are commonly found at the Hastie Quarry include fluorite, galena, sphalerite, calcite, and barite. Individual fluorite crystals and banded "coontail" ore may be collected. The ore is primarily bedding replacement ore, which was first mined along the surface in open pits. Once the surface ore was extracted, the miners followed the ore into the hillsides, employing a modified room-and-pillar underground mining method.

DAY 2

The following will be visited only if time permits
Cave-in-Rock State Park
Rosiclare Fluorspar Museum
Garden of the Gods

Cave-in-Rock State Park, Hardin County, Cave-in-Rock, Illinois

Cave-in-Rock State Park is located east of the village of Cave-in-Rock along a bluff overlooking the Ohio River. The cave entrance is about 55 ft wide, and the cave extends northerly under the bluff. This particular cave has a very colorful history. River pirates utilized the cave, and violent events unfolded within the cave throughout the late 1700s and into the early 1800s. At least three bloodthirsty gangs have utilized the cave as a store or saloon to draw travelers along the river into a trap. The travelers would be robbed and almost always murdered. The lore of this particular cave was fodder for a scene with Jimmy Stewart in the 1962 movie *How the West was Won*. The cave is developed within the St. Louis Limestone.

Rosiclare Fluorspar Museum, Hardin County, Rosiclare, Illinois

Pell's Landing was settled in 1832 by William Pell, Jr. The settlement eventually became known as Rose Clare, and later as Rosiclare. The Rosiclare Fluorspar Museum is located adjacent to the Rosiclare Vein at the old Rosiclare Lead and Fluorspar Mining Company office. The Rosiclare vein, also called the Good Hope or Fairview Vein, was one of the most prolific veins in the Illinois-Kentucky Fluorite District. Dozens of shafts were sunk along the vein over the years. The maximum vein width was 30 ft (10 m). The vein was mined to depths of more than 700 ft (210 m) in places. The Rosiclare Vein was mined for several miles in length from the Ohio River northward to Illinois Route 146. Many beautiful fluorite specimens can be found in the museum, along with mining artifacts, and a small gift shop is on-site.

Garden of the Gods, Saline County, Herod, Illinois

Garden of the Gods is a scenic trail that overlooks the Eagle Valley Syncline. This site is located within the Shawnee National Forest near the junction of Saline, Hardin, and Gallatin Counties in southeastern Illinois. No collecting will be allowed here because this is part of the Shawnee National Forest. The lower Pennsylvanian Age Caseyville Formation is very well exposed on steep bluffs through which the trail traverses. The Caseyville Formation lies on top of the Kaskaskia-Absaroka unconformity. The thickness of the Caseyville is highly variable, primarily because it was deposited on an erosional surface with moderate relief. The Caseyville is present only in the southeastern part of Illinois and a small outlier in northwestern Illinois. The Eagle Valley Syncline is thought to be the western extension of the Moorman Syncline, which trends east–west across western Kentucky. The syncline is terminated to the west by the Rough Creek-Shawneetown Fault System. The gentle structural dip to the north at the Garden of the Gods is probably due to the influence of Hicks Dome, which is located a few miles to the south. Hicks Dome is part of a regional Permian Age ultramafic igneous complex that extends from northwestern Kentucky into southeastern Illinois.

AUTHOR INDEX

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