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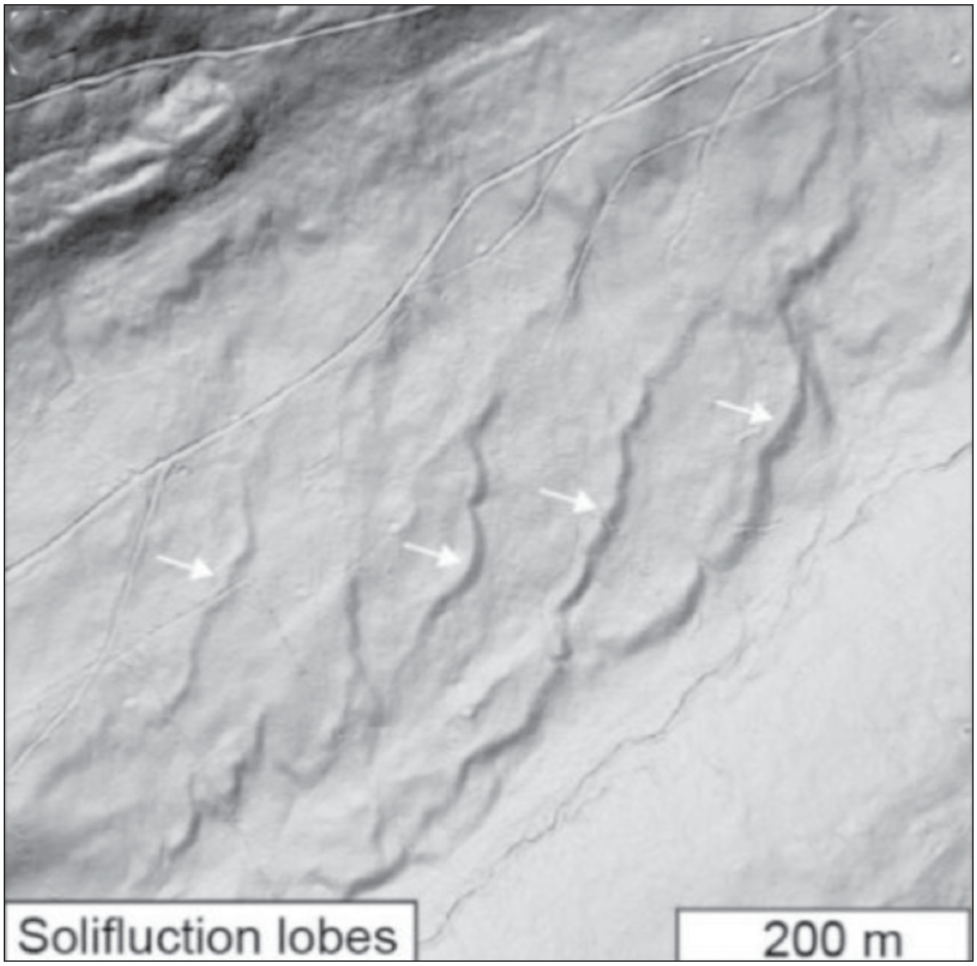

Solifluction lobes (resulting from the slow downward flow of saturated sediment) on Tussey Mountain at Garner Run (from DiBiase and others, 2017) (see article on page 3).

EDITORIAL

Our One Hundredth Anniversary Is Coming!

Gale C. Blackmer, State Geologist
Pennsylvania Geological Survey

The year 1919 was a big one: Edsel Ford took over as head of the Ford Motor Company, Prohibition started, Congress approved the Nineteenth Amendment to the Constitution that guaranteed women the right to vote, and the Fourth Geological Survey was commissioned in Pennsylvania. Happy 100th anniversary to us! But wait, you say. Don't I recall celebrating the 150th anniversary of the Bureau back in 1986? True. The Survey has actually had four incarnations. The First Survey (1836–58), Second Survey (1874–89), and Third Survey (1899–1919) were commissioned for finite periods of time with a mandate to map the state, focusing on energy and mineral resources. The nineteenth century was a time of great industrial and economic expansion, and understanding the coal, iron, and mineral resources in the state, and eventually oil and gas resources, were critical to the advancement of Pennsylvania as an economic power. The Fourth Geological Survey was commissioned as an ongoing agency in 1919. Our mission has broadened to include geologic hazards, groundwater resources, and public education and outreach, to name just a few of the services we provide. The Fourth Survey has always been a bureau within a larger department, moving around as state government reorganized: Internal Affairs, Forests and Waters, Internal Affairs again, State Planning Board, Environmental Resources, and finally Conservation and Natural Resources. The Bureau has also had many physical homes, the most problematic being the lower floors of a building on Cameron Street in Harrisburg, which it occupied only weeks before the Agnes flood in 1972. So many of our files and notebooks were damaged in that event that we are perhaps the only state geological survey that uses "pre-flood" to refer to part of our archives.

Over the years, much has changed, but much remains the same. The early reports illustrated with beautiful lithographs gave way to modern typesetting and color separates, and now to digital publication. While creating geologic maps of the surface and subsurface remains the "bedrock" of our work, databases and digital datasets have also become important and popular products. Although lidar-derived base maps, GPS units, drones, and handheld electronic devices are now necessary elements of field equipment, geologic observations still start with a geologist in front of an outcrop or a core sample, using his or her trained eye to discern its characteristics. If you are a careful reader of the last page of this magazine, you will have noticed that our name has also changed. Long known outside of state government as the Pennsylvania Geological Survey, our official name within the state hierarchy is now Bureau of Geological Survey. The parallelism of those two names should reduce ambiguity about our identity as an agency.

There is a lot more to be said about the Bureau's history. Stay tuned for an article in the next issue of this magazine, and keep an eye out for an announcement to join us in celebrating our anniversary in early December.

Gale C. Blackmer

The Late Pleistocene-Early Holocene in Central Pennsylvania

Charles E. Miller, Jr.
State College, Pennsylvania

INTRODUCTION

In Earth's long history, there have been at least five ice ages. Some date back hundreds of millions of years or more. The most recent—the Pleistocene Ice Age—began approximately 2 million years BP (before the present) and ended about 10,000 years BP. This ice age is familiar to most of us in Pennsylvania because it directly affected about one third of the state (Figure 1), leaving indelible evidence that we see today (see photograph on page 20).

During the Pleistocene, there were multiple glacial advances into the state. Interglacial periods, with much warmer temperatures, separated each advance. Most geologists believe we are in an interglacial period now. Figure 1 shows the southern limits of ice sheets in Pennsylvania. Of particular note are the locations of Lock Haven (red dot) and Williamsport (red triangle), 51.5 km (32 miles) and 88.5 km

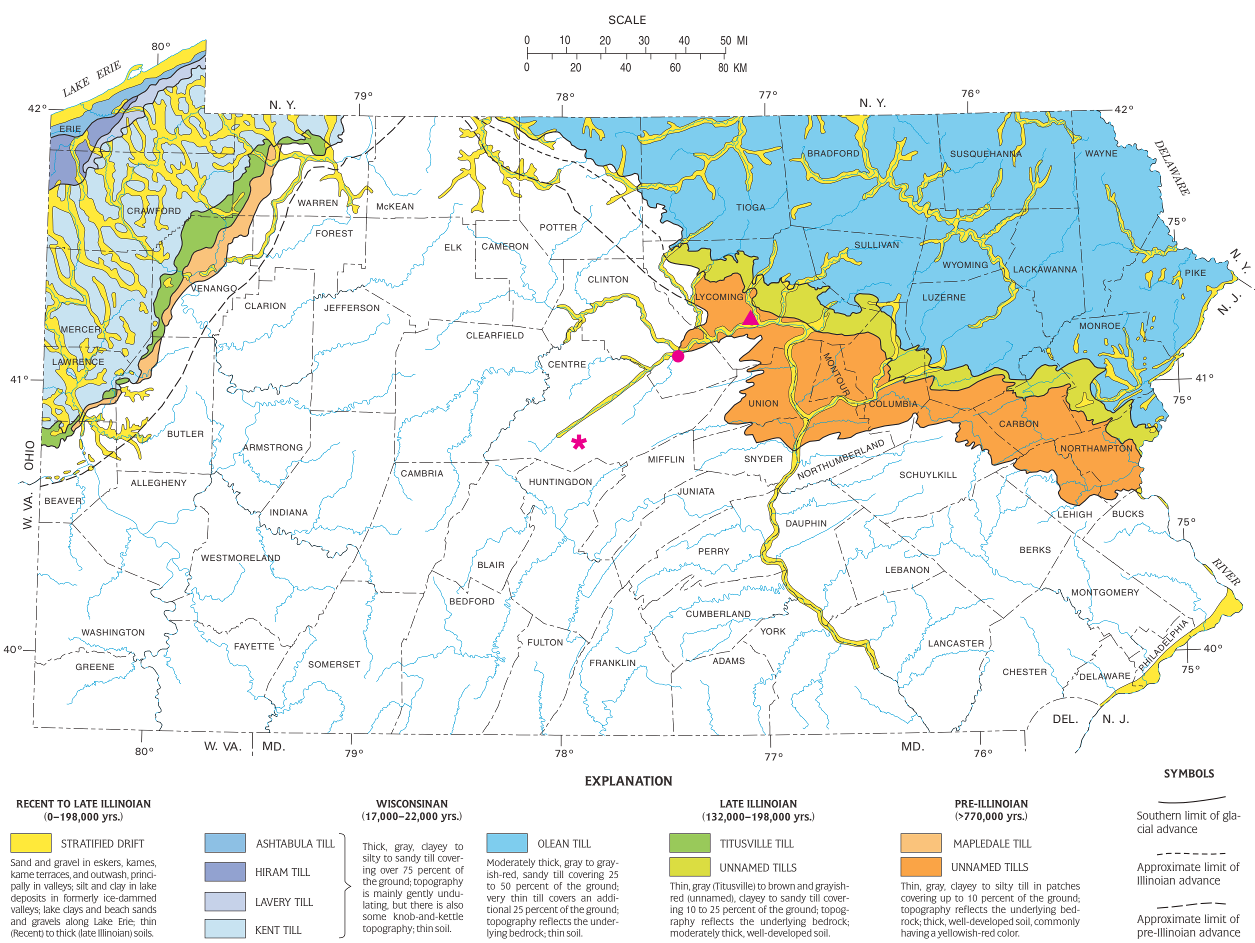

Figure 1. Map showing glacial deposits and glacial advances into Pennsylvania during the Pleistocene Epoch (Sevon and Braun, 1997). Red star, State College; red dot, Lock Haven; red triangle, Williamsport. See text for discussion.

(55 miles), respectively, from State College (red star). These two communities are frequently mentioned as being at or near the southernmost glacial advance into central Pennsylvania.

In this article are described the general paleoecology and more conspicuous Ice Age features in central Pennsylvania in late Pleistocene and early post-Pleistocene time. Most of this area was south of the glacial advances and, therefore, unglaciated. Because there are so few glacial deposits (till and other types of drift) in this part of the state, clues are found in indirect ways.

The last glacial maximum (Late Wisconsinan) occurred in Pennsylvania at about 20,000 BP (Sevon and others, 1999). At that time, vegetation distribution in the central and eastern United States was approximately as shown in Figure 2 (Flint, 1971). Characteristic vegetation in part defines climates because plants adapt to specific ecological conditions. As those conditions shifted northward (glacial retreat) and southward (glacial advance), so did vegetation. This association assists in determining vegetation/climate distributions during the recent Ice Age.

Immediately south of the ice sheet at the last glacial maximum was a narrow (50–150 km) tundra belt across north-central Pennsylvania, roughly paralleling the glacial front (Figure 2) (Guilday and others, 1964; Flint, 1971; Braun, 1989) and extending southward along higher mountains (Flint, 1971;

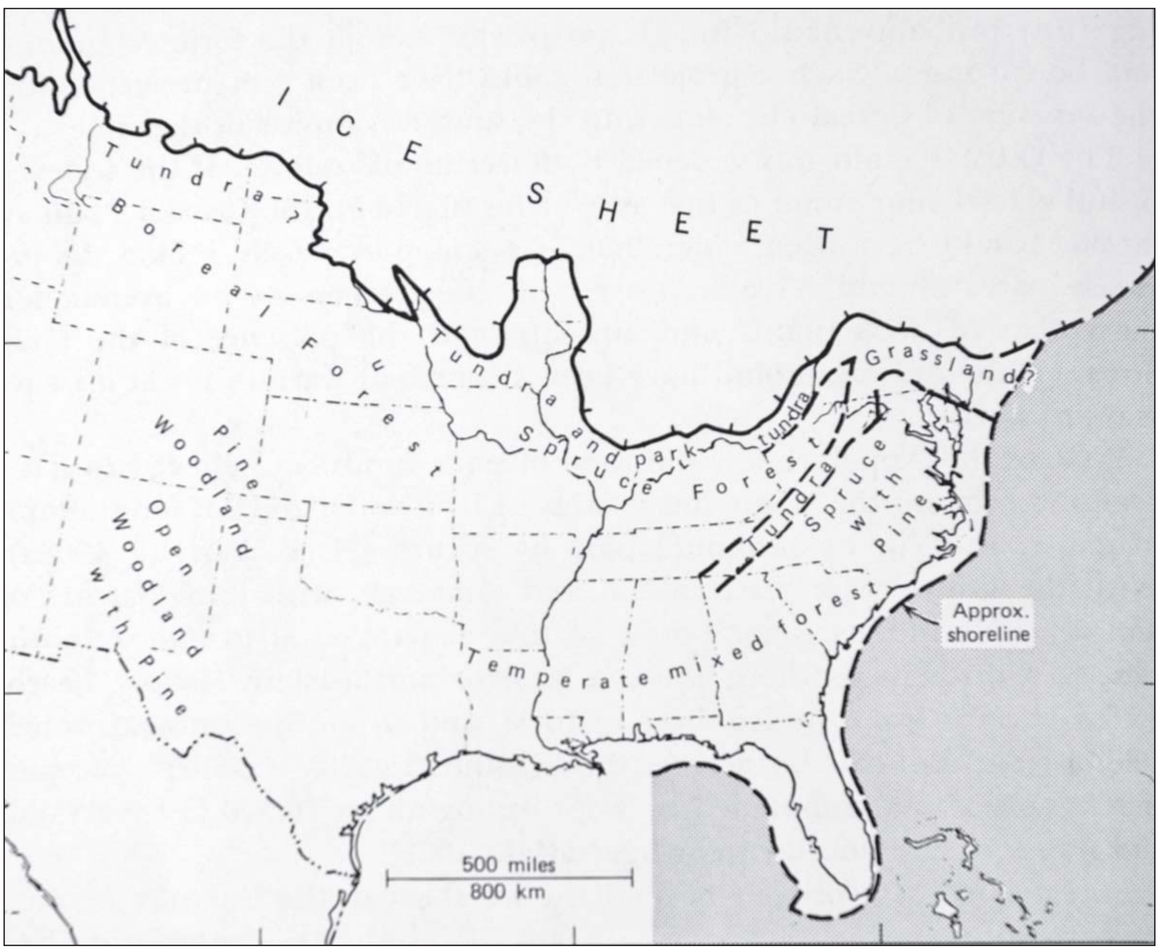

Figure 2. Vegetation distribution in the central and eastern United States at the Late Wisconsinan glacial maximum approximately 20,000 BP (Flint, R. F., 1971, Glacial and Quaternary geology, John Wiley and Sons, p. 510; copyright © 1971 by John Wiley and Sons, Inc.; used with permission).

Watts, 1979). That distribution included parts of central Pennsylvania (Figure 2). Today, tundra is restricted both to altitudes above the tree line and to high latitudes.

Tundra consists of short shrubs, grasses, mosses, lichens, and limited spruce trees adapted to much lower temperatures. Those temperatures produce permafrost—permanently frozen soil that, today, is restricted to polar areas and elevations above the tree line. Permafrost is due to temperatures low enough to sustain frozen soil year round and can occur in any climate having those temperatures. Continuous permafrost occurs in places with mean annual air temperatures (MAAT) less than approximately –6°C to –8°C. The MAAT for discontinuous permafrost is approximately –0.5°C to –2°C. In comparison, the MAAT in State College is about 10°C. This means that if continuous permafrost existed in central Pennsylvania, since the Pleistocene the MAAT has increased by 17°C (30.6°F) (Clark, 1992).

South of the tundra belt (Figure 2), but still in central Pennsylvania, temperatures moderated so that spruce and pine replaced grasses and shrubs as the dominant vegetation. This was the boreal forest, or taiga, usually relegated to higher latitudes and altitudes. Transition from tundra to boreal forest was probably not a sharp, well-defined boundary. More likely, in the transition zones, coniferous forests had tundra intervals. This conclusion is based on palynological work (the study of pollen and spores) at New Paris (Bedford County) (Guilday and others, 1964).

PERIGLACIAL FEATURES AND PROCESSES

Associated with permafrost are periglacial features and processes. They are the product of cold temperatures adjacent to glaciers, where frost action and intense freeze/thaw cycles exist. Some periglacial processes no longer operate in central Pennsylvania because temperatures are too warm. Others, such as frost heaving and ice wedging, still occur, but not with the same intensity or pervasiveness as in glacial advances. Landforms associated with permafrost in this part of the state are relics of the Pleistocene.

In central Pennsylvania, boulder fields (also called scree or felsenmeers) are ubiquitous on mountain slopes and ridges (Figures 3A and 3B). These features are the most widespread and conspicuous Ice Age relics in this part of the state. The boulder fields are periglacial features, largely from frost weathering (frost riving)—which is water freezing in rock fractures or other discontinuities. When water freezes, it exerts pressures sufficient to split rock, creating boulders.

At times, boulders and soil moved imperceptibly downslope due to gelifluction and/or solifluction—periglacial processes involving water-saturated soils resting on frozen (permafrost) and/or unfrozen ground, respectively (Potter and others, 2014). Freeze and thaw cycles cause downslope movement, producing lobes—a distinctive feature in much colder climates. Ice-wedge casts (discussed later) are the best indicator of permafrost (Potter and others, 2014), and their presence in Centre County indicates that continuous permafrost existed here at that time.

Solifluction features are widespread on nearly all slopes in central and south-central Pennsylvania (Merritts and others, 2014). However, in these parts of the state, dense forests cover the lobes, making them virtually invisible to the unaided eye. Resolution is gained through lidar, a surveying technique using pulsed laser light. The cover photograph shows lidar-detected solifluction lobes on the slope of Tussey Mountain at Garner Run (DiBiase and others, 2017). The lobes indicate that permafrost affected this region, and the MAAT during glacial maxima must have been less than 0°C (Merritts and others, 2014).

Frost weathering (frost heaving) also produces patterned ground (Figure 4), another periglacial feature. Examples consist of stones, fissures, and vegetation forming polygons, rings, or stripes. These

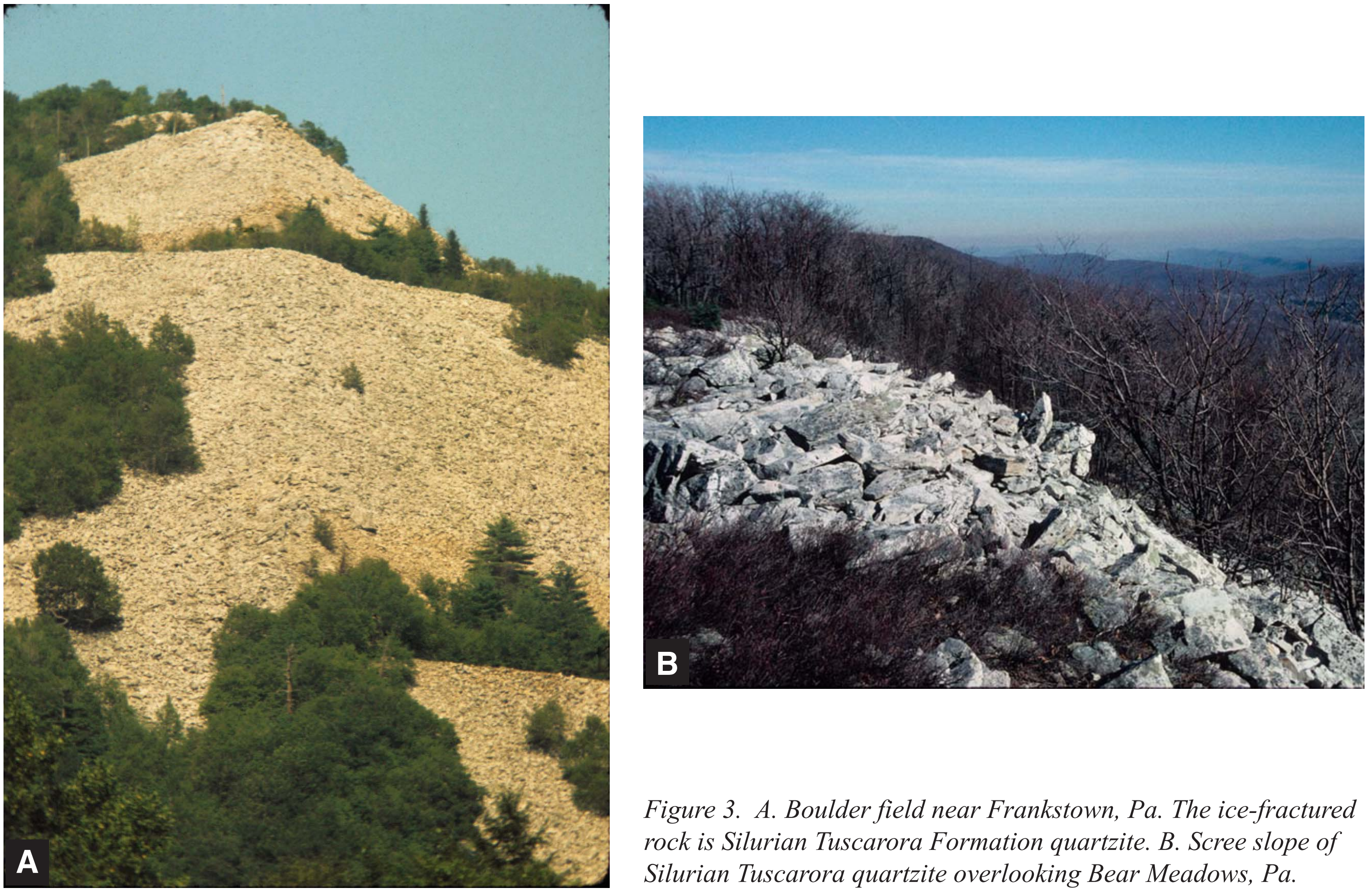

Figure 3. A. Boulder field near Frankstown, Pa. The ice-fractured rock is Silurian Tuscarora Formation quartzite. B. Scree slope of Silurian Tuscarora quartzite overlooking Bear Meadows, Pa.

features are due to repeated freezing and thawing. Expanding ice crystals in soil push stones into such patterns. The role of frost action in pushing rocks in soil is appreciated if one considers the plight of farmers in New England. Many parts of those states are covered with glacial deposits. Each year, freeze and thaw cycles bring new rocks to the surface. Farmers regularly remove rocks, placing them in stone fences. In central Pennsylvania, patterned ground is found in Centre County (Hodgson, 1967; Roman DiBiase, personal communication, 2019), Huntingdon County (Troutt, 1971), and Union County (Marsh, 1999). Due to thick vegetation that makes identification difficult, patterned ground may be more common than realized.

Ice-wedge casts represent another class of periglacial features in central Pennsylvania. These consist of former ice wedges formed when ice developed in open contraction cracks in soil or relatively soft rock, increasing in size with each annual freeze-thaw cycle. After melting, the resulting mold filled with sediment to form a cast of the original ice wedge. Figure 5 is a drawing of an ice-wedge cast near Tusseyville, Centre County (Crowl and Sevon, 1999). Figure 6 shows a soil/ice wedge in a shale pit at Potters Mills, Centre County (Clark, 1992). Ice-wedge casts are conclusive evidence of permafrost (Merritts and others, 2014), indicating a MAAT in this area of –5°C to –10°C (Clark, 1992).

Pingos (Figure 7) are large, soil-covered frost mounds, sometimes 30 to 50 m high and up to 600 m in diameter, associated with periglacial conditions. They are conclusive evidence of permafrost (Merritts and others, 2014) and form from hydrostatic pressure in or below permafrost, creating closed and open forms. Closed-system pingos form where the mean annual air temperature is about –5°C or lower. Open-system pingos may develop in continuous or discontinuous permafrost. Those in discontinuous

Figure 4. An example of stone rings, a type of patterned ground (Scoresby Sound area of East Greenland) (photograph by Richard B. Alley, The Pennsylvania State University).

permafrost may form in areas where the MAAT is as high as –2°C or –1°C (Washburn, 1980). In central Pennsylvania, pingo scars are known from Raymond B. Winter State Park (Union County) (Marsh, 1987) and Rothrock State Forest (Centre, Huntingdon, and Mifflin Counties) (Kubina and Chamberlain, 2014).

Loess is a periglacial eolian (wind-blown), fine-grained, highly sorted soil consisting mostly of silt. In central Pennsylvania, loess has been reported in Northumberland, Clinton, Dauphin, Juniata, Perry, Snyder, and Union Counties (Clark, 1992; Hershey and Pollok, 1995). This type of loess largely originates with rocks being ground under glaciers, producing very fine grained sediment known as glacial flour. That sediment is transported downstream, clouding the stream with a milky color. The water is said to contain glacial milk. Eventually, the fine-grained sediment is deposited along the sides of streams in outwash plains. Upon drying out during long, cold winters, intense winds commonly generated near glaciers carry the fine sediment and deposit it as loess.

PALEONTOLOGY STUDIES

Additional insight into central Pennsylvania's environment during the late Pleistocene and early post-Pleistocene is from paleontology. Plants and animals are linked to particular climates. As the climate shifted northward and southward due to glacial retreat and advance, plants and animals followed, staying in the environment to which they were adapted. Some plant and animal species are proxies to a particular climate. Their identification provides a clue to determining the paleoclimate at that time. For example, the New Paris fauna (Figure 8) corresponds to a present-day geographic distribution in eastern Canada at approximately 50° north latitude and in central Canada west of Hudson Bay at approximately 57° north latitude (Guilday and others, 1964).

In central Pennsylvania, paleontological studies at Frankstown (Blair County); Hosterman's Pit, Oak Hall, and Bear Meadows (Centre County); New Paris (Bedford County); Saltillo (Huntingdon

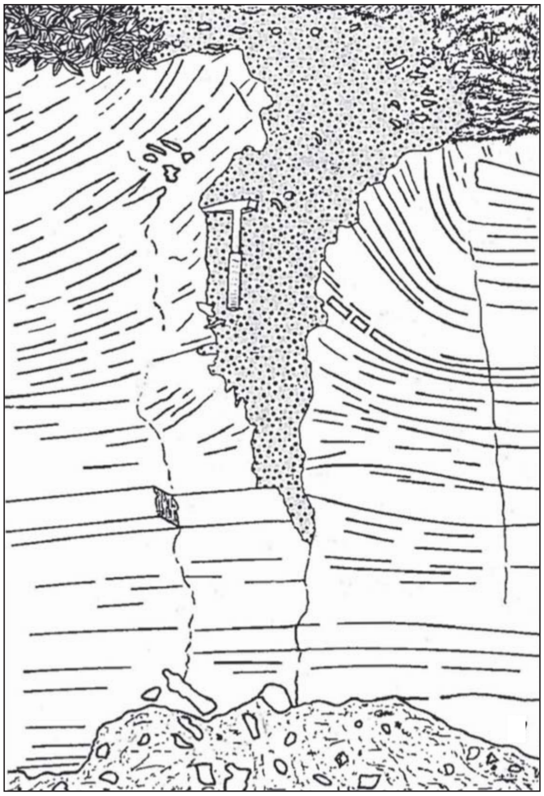

Figure 5. Ice-wedge cast in Ordovician Reedsville Shale near Tusseyville, Centre County, Pa. (Crowl and Sevon, 1999).

Figure 6. Soil wedge in shale in the Tom Swank (Musser) shale pit, Centre County, Pa. (Clark, 1992).

County); Crider's Pond (Franklin County), and Kings Gap Pond (Cumberland County) contribute to interpreting the paleoecology during the referenced time period (Figure 8). Except for Oak Hall and Saltillo, these demonstrate plant and/or animal transitions related to climate change (Figure 8). Paleontological data from all the sites complement previous discussions concerning much colder conditions in this part of the state.

More than 9,300 fossils, representing 71 species of Pleistocene animals (of which 52 are mammals), have been reported from a fissure-cave complex at Frankstown (Holland, 1907; Cuffey and others, 1976; Fonda, 2003). Figure 9 depicts the landscape around the cave when those plants and animals lived, about 12,000 years ago. The climate was cold temperate, halfway between the full glacial or "boreal" of several thousand years earlier and the mid-temperate climate of today. Of particular note are fossils of mastodon, caribou, collared lemming, and musk ox.

Intermittently from 1932 to 1963, sinkhole excavations at New Paris yielded more than 2,700 Pleistocene animals. In 1935 and 1997, the remains of a Pleistocene mastodon were described from Saltillo. In the 1960s, paleontological studies at Hosterman's Pit yielded at least 20 animals, representing 13 species, ranging in age from 11,300 BP to 9,290 BP. Mastodon, musk ox, and caribou are among the animals excavated. Hosterman's Pit fauna reflect a change from a boreal to a temperate mammal fauna over 2,000 to 4,000 years (Figure 8). This implies a rapid climate change of warming temperatures following periglacial conditions in the Pleistocene (Guilday, 1967). Colder temperatures of the preceding tundra and boreal-forest conditions were replaced with significantly moderated temperatures.

Figure 7. An example of a pingo (https://indianapublicmedia.org/amomentofscience/icy-pingos/).

Hosterman's Pit local fauna represent the earliest known date for a Recent fauna in northwestern North America (Guilday, 1967). More recently, possibly in the late 1990s, a Pleistocene mastodon tooth was found along Spring Creek near Hanson's Oak Hall quarry.

Of the aforementioned studies, mastodon, caribou, musk ox, and collared lemming are proxies to a colder climate in central Pennsylvania during the Pleistocene. Of these, mastodons generally inhabited areas farther south of the ice front than the others, even as far south as Florida. Mastodon tooth morphology is suited for forest browsing. Close to the ice front where tundra conditions persisted (Figure 2), trees were uncommon. Farther south, temperatures moderated and a boreal forest developed. This was the setting most suitable to mastodons. In central Pennsylvania, mastodons are known from Frankstown, Saltillo, and Oak Hall. Palynological data suggest that these locations were, at that time, in boreal forest.

Mammoths, the other well-known Pleistocene elephant species, have been found in Pennsylvania. They generally lived along the glacial ice front and had teeth adapted to a harsh grass-grinding diet characteristic of tundra grasses.

Complementing the faunal work are palynological studies at Bear Meadows, Crider's Pond, Frankstown, Kings Gap Pond, and New Paris (Figure 8). The study of pollen helps to identifiy plant species and, therefore, the climate in which they grow. Figure 8 is a composite of time intervals for the sites, reflecting climate change through time for central Pennsylvania. In general, there is a warming trend from the late Pleistocene into the Holocene, beginning with tundra, transitioning to boreal forest, and eventually to temperate deciduous vegetation. Of the five sites, tundra is identified only at Kings

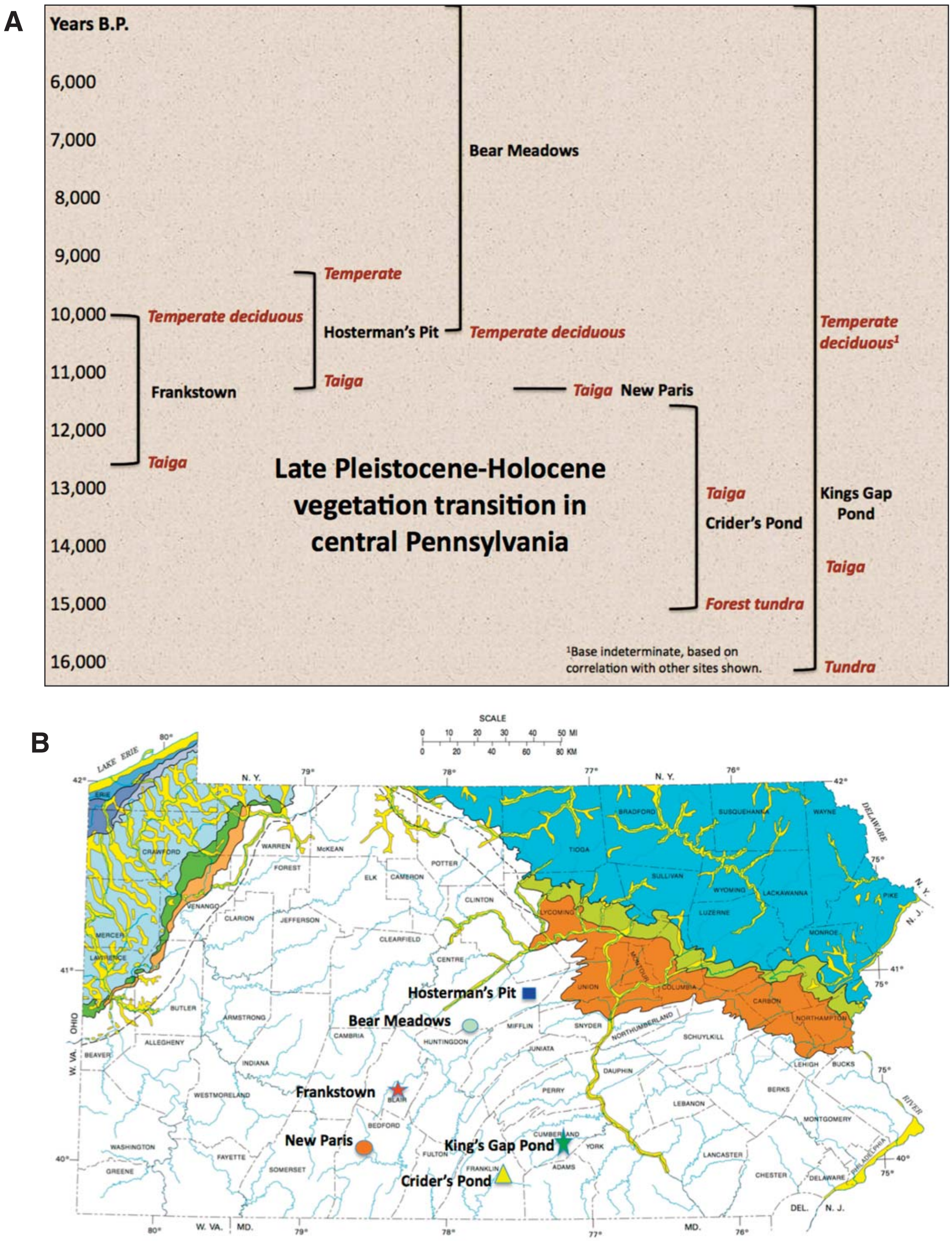

Figure 8. A. Late Pleistocene-Holocene vegetation transition in central Pennsylvania. Based on paleontological data from six sites (B). See Figure 1 for map explanation.

Gap Pond. Variation in the timing of vegetation transitions at individual sites may reflect local factors such as elevation and topographic features that created isolated pockets.

Palynological work at Bear Meadows during the 1950s and 1960s yielded data back to 10,320 years ago (Kovar, 1964) (Figure 8). Recently, workers from Penn State began a new initiative at Bear

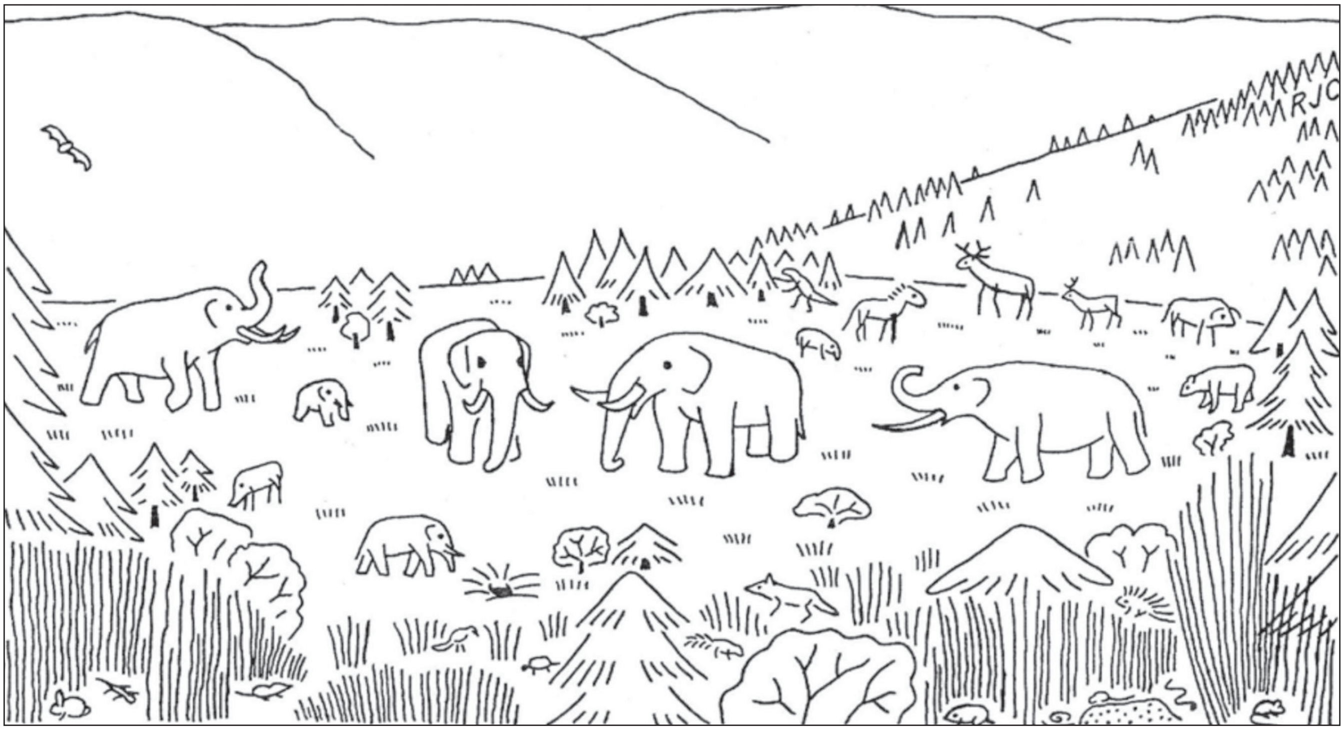

Figure 9. Reconstruction of a latest Pleistocene environment, including both animals and plants, on top of a hill containing the Frankstown cave (small black hole in front of juvenile mastodon, below and left of center of image) (Cuffey and others, 1976; Fonda, 2003).

Meadows. As of 10,320 years ago, this part of the state already had a somewhat complex forest cover, having rebounded from the previous colder climate. The palynological record at Crider's Pond ranges from 15,210 to 11,650 years BP, indicating a transition from forest tundra to boreal forest (Figure 8A). This transition reflects climate change as temperatures warmed. At Frankstown, between 12,700 to 10,000 years BP, boreal coniferous forest transitioned into temperate deciduous forest (Figure 8). Kings Gap Pond sedimentation extends from 16,080 years BP to the present. Tundra persisted from 16,080 to approximately 14,450 years BP. That transitioned to boreal forest, and eventually to temperate deciduous. At New Paris, pollen studies agree with fauna collected there, identifying boreal forest environments at approximately 11,300 years BP. The boreal forest included conifer, fir, white oak, birch, juniper, sedge, lichen, and moss. A boreal forest reflects temperatures warmer than the preceding tundra conditions.

CONCLUSION

During the late Pleistocene, approximately 20,000 BP, tundra that was 50–150 km wide covered part of central Pennsylvania immediately south of the ice sheet and extended southward along higher mountains. Associated vegetation included grasses, shrubs, mosses, lichens, and limited spruce trees. In general, it was a treeless plain with low biotic diversity. This was the setting of mammoth, musk ox, caribou, and collared lemming, which are proxies to a colder climate. Fossils of these mammals have been found in central Pennsylvania. A MAAT of –5°C to –10°C produced permafrost. South of the tundra in central Pennsylvania was boreal forest of spruce with pine. Here, too, was permafrost. With somewhat moderated temperatures, typical animals of the boreal forest in this part of the state included mastodon, black bear, deer, elk, porcupine, and vole. Low temperatures associated with these climates at that time produced a litany of periglacial features, including ice wedges, pingos, boulder fields, patterned ground, solifluction lobes, and loess.

At about 12,700 BP, boreal forests in central Pennsylvania began transitioning to temperate deciduous forests in which hardwood deciduous trees (maple, oak, birch, magnolia, sweet gum, and beech) dominated. By 10,320 BP, the State College area already had a complex forest cover as temperatures from the Ice Age continued moderating.

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BUREAU NEWS

Bureau Staff Volunteer Judging at Capital Area Science and Engineering Fair

Staff geologists Victoria Neboga, Zachary Schagrin, and Antonette Markowski had the pleasure of category judging Physical Science projects with 150 other judges at the 62nd Capital Area Science and Engineering Fair (CASEF) on March 4–7, 2019. This is the second year the event was hosted by Harrisburg Area Community College. The fair expanded its service to 346 aspiring young scientists from 68 schools in 14 counties, where they exhibited 274 independent and 32 team projects, according to CASEF Director Valerie Knowles (personal communication, 2019).

Neboga and Markowski judged eight senior projects where students showcased their creativity and knowledge in areas such as parachute design, soil erosion, the effect of a magnet's shape on energy production, the amount of electromagnetic field radiation emitted from a laptop, and how to minimize light pollution. Neboga recommended one project, "Starlight, Starbright, Can I See Stars Through the Skyglow Tonight?" for the Dr. George Hayword Love, Sr., judges' award. The student studied the amount of skyglow by comparing images of the sky taken at night from different directions. Another project won this award ("The Shape of a Parachute Decides Its Drop Velocity"). Markowski recommended first prize and the Dr. George Hayword Love, Sr., judges' award to three projects, "Starlight, Starbright, Can I See Stars Through the Skyglow Tonight?," "The Effects of Different Materials on Soil Erosion," and "The Shape of a Parachute Decides Its Drop Velocity" (team project) based on design, execution, and interview ability.

New staff geologist Zachary Schagrin eagerly joined the ranks of CASEF volunteers by judging nine junior projects where students demonstrated their skills through projects touching on rocketry, medicine solubility, and the physics of tennis. The students also showed an ability to convey knowledge of their projects through presentations to the judges during a question-and-answer session. Schagrin recommended five projects for the Dr. George Hayward Love, Sr., judges' award, including "The Effects of Liquid Nitrogen on Synthetic Rubber." In this study, the student submerged rubber balls in liquid nitrogen for different amounts of time and recorded the height each ball bounced.

In a second round of judging, Markowski teamed with four other judges to evaluate seven Senior Grand Champion projects out of 204 total senior students. The top five finalists advanced to the 70th Intel International Science and Engineering Fair in Phoenix, Ariz., on May 12–17, 2019 (Figure 1). Topics included the following: "Aerodynamic Bicycle," "Beetles Beware: Effects of Various Biopesticides on *Callosobruchus maculatus* Behavior," "Developing and Simulating Self-Driving Car A.I. Without Need for Traffic Lights" (team project), and "Taking a Step Toward Solving the Foot Crisis: Reducing Joint Impact with Magnetic Levitation." The alternate Grand Champion presented

"Planariidae as a Model System for Studying Neurological Aspects of Allergy Response: Year Three of an Ongoing Study." The students applied strong analytical and critical thinking to offer solutions and alternatives to real-world problems.

Other judges selected three Junior Grand Champions as national semifinalists for Broadcom MASTERS in Washington, D.C., on October 25–30, 2019 (Figure 2). This national science competition is affiliated with the Society for Science and the Public and features the top 10 percent of United States middle school students.

Harrisburg University and other partner organizations sponsored $730,000 in prizes and scholarships awarded to CASEF students. This includes 85 four-year scholarships for participating juniors (142) and seniors (204). Eighty-three scientific, professional, industrial, educational, and governmental organizations also offered 264 special awards at the fair (Valerie Knowles, personal communication, 2019).

New judges, special awards, and sponsorships are always welcome—especially welcome is a sponsor for the judging portion of the fair. Please consider joining the Bureau staff at next year's category judging on Tuesday, March 10, and/or Grand Champion judging on Wednesday, March 11. Anyone interested should contact Valerie Knowles (CASEF Director) at director@casef.org or 717–580–3812. For further information about the CASEF, see https://www.casef.org/ or e-mail casef@hacc.edu. The future of science and engineering is fueled by students' curiosity, passion, critical thinking skills enabled by effective communication, and a healthy dose of self-discipline to reach a conclusion on schedule despite obstacles.

Figure 1. Senior Grand Champion finalists at the Phoenix, Ariz., Intel International Science and Engineering Fair, in front of the Wall of Fame, where every finalist's name is listed. Left to right: Christian Gasdaska, 11th grade (Susquenita High School); Liam Douglas, 11th grade, team project with Alec Warren (Harrisburg Academy); Dev Lochan, 10th grade (Cumberland Valley High School); Adele Shirmer, 12th grade (Susquenita High School); and Alec Warren, 12th grade, team project with Liam Douglas (Harrisburg Academy). Alternate Grand Champion, not pictured, is Cheyna Warner (Central Dauphin High School) (https://www.casef.org/ and confirmation from Valerie Knowles, CASEF Director).

Figure 2. Junior Grand Champion finalists. Left to right: First runner-up—Parimala Rajesh, 8th grade (Cumberland Valley Good Hope Middle School); Second runner-up—Varnika Udhayakuma, 8th Grade (Cumberland Valley Good Hope Middle School); and Grand Champion—Julia Toyer, 8th grade (Harrisburg Academy) (https://www.casef.org/ and confirmation from Valerie Knowles, CASEF Director).

Celebrating Earth Day at the Governor's Residence

Staff geologist Antonette Markowski represented the Economic Geology division of the Pennsylvania Geological Survey by presenting a poster in celebration of Earth Day at the Governor's Residence in Harrisburg, Pa. Acknowledgments go to Brian Dunst and Kristin Carter of our Pittsburgh office for slides used in this poster highlighting the division's timely work on "Carbon Capture, Utilization, and Storage" (CCUS). Highlights from the poster are shown in Figure 1.

The Secretary of the Department of Conservation and Natural Resources, Cindy Adams Dunn, stopped by and enthusiastically requested that the poster be used at a senior staff meeting and also for a Deep Decarbonization Panel. A commonwealth photographer took pictures, and news coverage was available at https://www.abc27.com/news/local/energy-saving-measures-at-governor-s-residence-unveiled-for-earth-day/1945610500 (accessed July 26, 2019). Other news channels were also present. The Governor and First Lady announced a light-emitting diode (LED) initiative and other energy-saving devices recently implemented at the residence.

About 50 or 60 students and teachers from schools around the state attended. Markowski greeted around 15 people with free materials and contact information at a table shared with Bureau of Forestry staff. Students from a Greene County school expressed interest in environmental science and meteorology careers. Markowski reminded them about the role of the other science beneath their feet. Tamara Peffer (Environment and Ecology Content Advisor, Department of Education) seemed very interested in a fact sheet or informational piece on carbon capture and storage (CCS) and CCUS for school curricula.

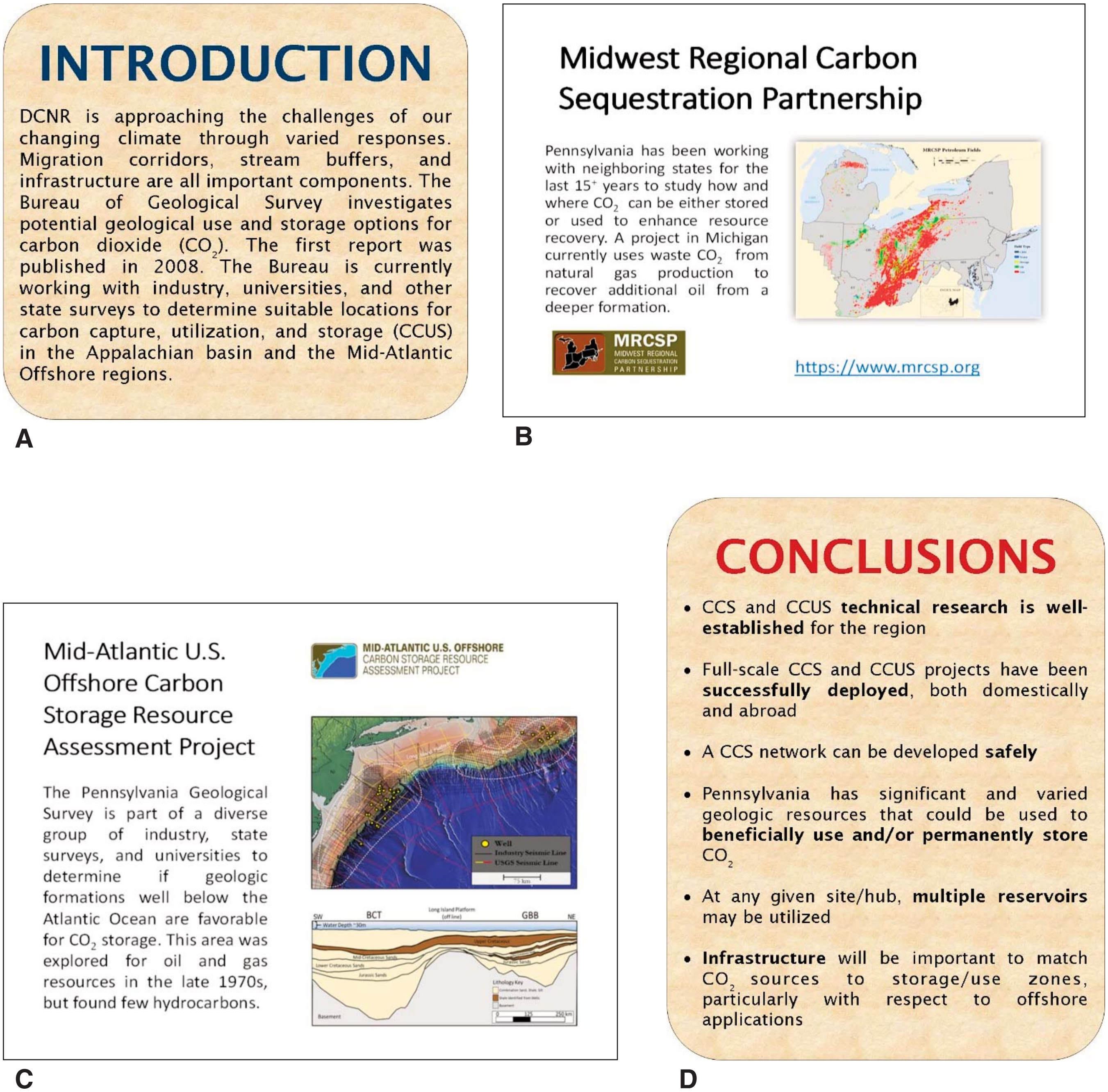

Figure 1. Highlights from the poster that was presented at Earth Day 2019 at the Governor's Residence in Harrisburg, Pa. The Bureau of Geological Survey is participating in multi-state studies to determine how carbon dioxide can be used and/or stored so that it does not accumulate in the atmosphere. CCS, carbon capture and storage; CCUS, carbon capture, utilization, and storage.

This was a unique opportunity to showcase the work of the Bureau of Geological Survey and an honor to meet Governor Tom Wolf and First Lady Frances Wolf. Markowski discovered that one of their two daughters is a remediation geologist in Boston. Selected photographs from the event are included below (Figures 2, 3, and 4).

Make every day an Earth Day!

Figure 2. Governor Wolf and the First Lady celebrate Earth Day with Markowski at the Governor's Residence (photograph by Maria Neboga, Department of Conservation and Natural Resources—Pennsylvania Outdoor Corps).

Figure 3. Markowski explaining the critical role of CCUS (carbon capture, utilization, and storage) in climate mitigation and various storage opportunities in our state and offshore (photograph by a commonwealth photographer).

Figure 4. Students from one of many schools observing Earth Day, shown with Governor Wolf (photograph by a commonwealth photographer).

BUREAU NEWS

New Staff Member

Ellen Fehrs graduated from the University of Pittsburgh with a B.S. in geology and a certificate in Geographic Information Systems (GIS). She later headed west to get her M.S. in geology at the Colorado School of Mines, which she finally finished in April 2019. She likes any kind of geology that involves fancy tech toys: for her M.S., she was lucky enough to operate an FE-SEM (field emission scanning electron microscope) with an EDS (energy dispersive X-ray spectroscopy) unit to help characterize the evolution of dolomite and the formation of secondary porosity in her study site. She has done some chemostratigraphic work with an XRF (X-ray fluorescence) unit, and is still proud of herself for having successfully smuggled an X-ray gun through airport security . . . twice!

Before, during, and after her graduate school adventures, Ellen has been taking additional GIS coursework through The Pennsylvania State University. This interest in geospatial work led her to joining the Bureau's Geologic and Geographic Information Services Division in July 2019. She thinks the coolest part about GIS is the intersection between science, art, and (again) fancy tech.

Ellen spends her free time reading, painting, watching Animal Planet, and exploring Pennsylvania bike trails. She lives in Grantville with her cat, Misty.

A Look Back in Time

This photograph was taken by former State Geologist (from 1919 through 1946) George Ashley on July 31, 1930. The photograph was taken three miles northwest of Northeast, Pa., in Erie County, and shows Lake Warren sands in the upper right-hand corner. The rest of the outcrop is Wisconsinan till. For more information about the Ice Age in Pennsylvania, see the article on page 3.

To see more photographs from the Bureau's archives, please visit the library's Historical Photographs Collection page.

RECENT PUBLICATIONS

Open-File Miscellaneous Investigations **(August 2019)**

- Water Depth of Prompton Lake—Prompton State Park, Wayne County, Pennsylvania (ZIP)
- Water Depth of Hickory Run Lake—Hickory Run State Park, Carbon County, Pennsylvania (ZIP)
- Water Depth of Gouldsboro Lake—Gouldsboro State Park, Monroe and Wayne Counties, Pennsylvania (ZIP)

Calling All Authors

Articles pertaining to the geology of Pennsylvania are enthusiastically invited.

Pennsylvania Geology is a journal intended for a wide audience, primarily within Pennsylvania, but including many out-of-state readers interested in Pennsylvania's geology, topography, and associated earth science topics. Authors should keep this type of audience in mind when preparing articles.

Feature Articles: All feature articles should be timely, lively, interesting, and well illustrated. The length of a feature article is ideally 5 to 7 pages, including illustrations. Line drawings should be submitted as CorelDraw (v. 9 or above) or Adobe Illustrator (v. 8 or above) files.

Earth Science Teachers' Corner: Articles pertaining to available educational materials, classroom exercises, book reviews, and other geologic topics of interest to earth science educators should be 1 to 2 pages in length and should include illustrations where possible.

Announcements: Announcements of major meetings and conferences pertaining to the geology of Pennsylvania, significant awards received by Pennsylvania geologists, and other pertinent news items may be published in each issue. These announcements should be as brief as possible.

Photographs: Photographs should be submitted as separate files and not embedded in the text of the article.

Submittal: Authors may send their article and illustrations as email attachments to RA-pageology@state.pa.us if the file sizes are less than 6 MB. For larger sizes, please submit the files on CD–ROM to the address given below. All submittals should include the author's name, mailing address, telephone number, email address, and the date of submittal.

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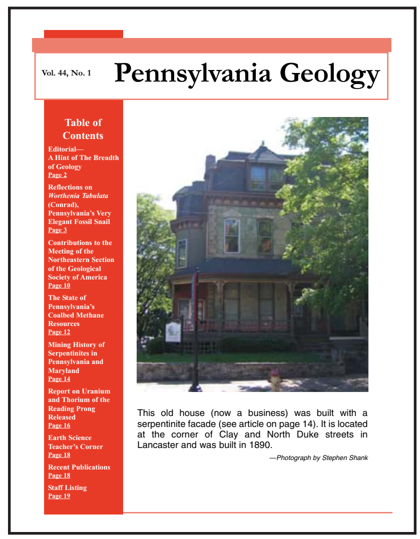
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This old house (now a business) was built with a serpentinite facade (see article on page 14). It is located at the corner of Clay and North Duke streets in Lancaster and was built in 1890.

—*Photograph by Stephen Shank*

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Contributed articles are welcome.

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