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Pennsylvania Geology

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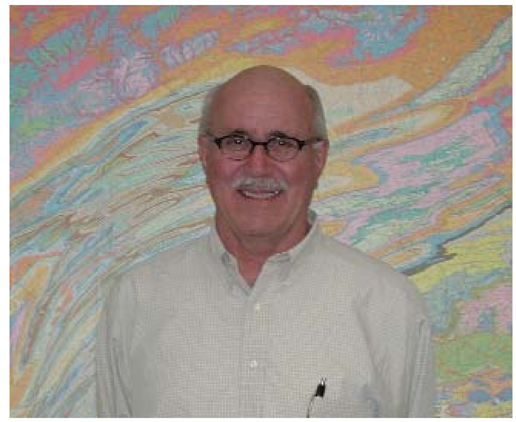
Exotically sculptured Jurassic diabase has been eroded into intricate, almost alien-looking forms at Conewago Falls on the Susquehanna River in northwestern Lancaster County, Pa. This geologic feature is exposed only when the water level is very low.

—Photograph by Victoria Neboga, July 2012

EDITORIAL

On to the Future!

George E. W. Love, State Geologist
Pennsylvania Geological Survey



What a world we live in! Technology has gone beyond what I personally could have imagined back in the fall of 1963 when I went off to college. I was trained to perform many functions on a slide rule—multiply, divide, take square roots, find logs, and determine trigonometric functions that I can now hardly pronounce. I recall the spring of 1964, when a fellow physics major showed me his handheld electronic calculator. It could "only" add, subtract, multiply, and divide. We, his fellow students, laughed at him. He had wasted more than $200, a princely sum in those days, and we all agreed he could have gotten a top-of-the-line circular slide rule with greater accuracy for $30, and no need for batteries.

Now that I have clearly established myself as a product of the middle of the last century, let me share with you what I see happening with the bureau, and what I hope you will see as a step forward in our effort to share information and knowledge. The announcement on page 16 in this issue, written by Caron O'Neil with a mischievous glint in her eye, informs us of the sea change in how our publications and data will be distributed—online and for free! Yes, I too love the library; I too find solace in the quiet comfort of the stacks; I too delight in seeing the printed words and colorful maps laid out before me. BUT, for the bureau, this is driven by both budget and technology. We can no longer afford to print copies of publications and then house them until they are purchased. On the up side, the data that are the basis for our reports and maps are readily available to everyone. With freely available software, users can extract parts of maps for their use, and can access our PAMAP data of orthoimages and lidar to create specific images to meet special needs. And of course, when you wake up at 2:30 on a Saturday morning with that gnawing question about…, well, you know what I mean.

And the future described by Caron—the ability to search all bureau data banks by positioning the cursor over a map location—is nothing short of amazing!

Things do change rapidly. And some are not so nice, depending where you stand. We have "lost" two more of our stalwarts, folks whose knowledge and nature were part of the image the bureau tries to foster. John Harper and Joe Kunz, both of our Pittsburgh office, have retired. Their service to the bureau and the public will be missed. With time, we will add staff to fill the seats they occupied. We will come to know and appreciate the skills of these new people, and we will realize what great new colleagues we have. And sadly, with time, we will come to realize that we never adequately said thank you John and Joe for your work, your dedication, and most importantly, your friendship.

Potential for CO_2-Enhanced Oil and Gas Recovery, Southwestern Pennsylvania

John A. Harper
Pennsylvania Geological Survey, Retired

A Lot of Hot Air

According to the Intergovernmental Panel on Climate Change, climate change is the most significant environmental problem facing the world today (Core Writing Team and others, 2007), threatening our environment, our economy, public health, and even our way of life. Scientific consensus suggests that this phenomenon is due to the atmospheric buildup of anthropogenic greenhouse gases (GHGs), heat-trapping emissions of carbon dioxide (CO_2) and other gases exuded from power plant flues and vehicle exhaust pipes. The DOE (U.S. Department of Energy) estimated that the amount of CO_2 emitted by human activity, primarily from burning fossil fuels, has expanded from 0.028 percent of air before the industrial revolution to 0.037 percent today (Harper, 2004). They estimated that it will continue to rise as global energy use expands into the future unless we change the way we produce and use energy.

Pennsylvania's energy, transportation, and industrial sectors produce more greenhouse gas than 105 developing countries combined, emit one percent of the Earth's anthropogenic GHGs, and place the state third in the nation in contributing GHGs to global warming (Pennsylvania Department of Conservation and Natural Resources, 2008) (Figure 1). The USEPA (U.S. Environmental Protection Agency) estimated that Pennsylvania's contribution to GHGs is 274.3 million metric tons annually (U.S. Environmental Protection Agency, 2012).

In addition, Pennsylvania is the fourth largest coal-producing state in the nation. More than 50 percent of the state's electricity is coal-fired, and 30 percent of the energy generated is exported to other states and countries. In effect, we are generating huge amounts of GHGs while not deriving any benefit from it.

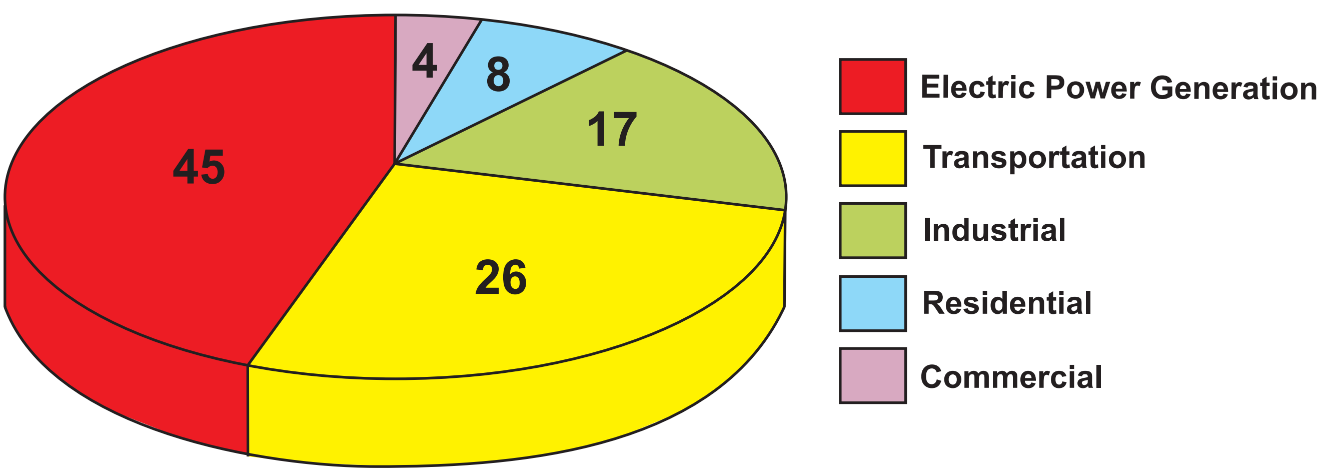


Figure 1. Pie chart illustrating the percentage of total annual greenhouse-gas emissions in Pennsylvania by source (data from U.S. Environmental Protection Agency, 2012).

So, what can we do about this?

For more than a decade, the geological community has been addressing the problem with one idea in mind—carbon capture with sequestration (CCS). As described previously (Harper, 2004), this involves capturing CO_2 at its source, pressurizing and cooling it to a liquid, and then pumping it underground and storing it for millions of years in porous and permeable rocks called "saline formations" (i.e., rocks containing some concentration of brine). Saline formations generally occur below potable water zones; for example, in western Pennsylvania, the brine-bearing sandstones of the Pottsville Formation (Figure 2) typically lie at an average depth of 1,600 feet (488 m), about 1,000 feet (305 m) below the deepest potable water zones. Drillers call these the Salt sands because of the amount of salt water contained in them. Rocks of this type have a long history of being used for waste-fluid disposal, and have been shown to be suitable for CO_2 sequestration in other parts of the world. The potential should be good in Pennsylvania—many of the state's deeper brine-bearing rocks, such as the Lower Devonian Oriskany Sandstone (Figure 2), occur in places where they have the reservoir characteristics necessary for storing huge quantities of CO_2 without much worry that it could escape to the surface for millions of years. The only problem is that those very good reservoirs are currently being used by the oil and gas industry to store natural gas.

There is another way to help solve this problem that offers great promise—carbon capture and utilization with sequestration (CCUS). Where CCS is the capturing and storing of carbon, CCUS includes sequestration and some potential benefit. What potential benefit can we derive from what the USEPA has termed a pollutant? We can use it to produce crude oil and natural gas AND store CO_2 in producing or depleted reservoirs—if they have all the proper reservoir characteristics, that is.

Rockin' Around the CCUS

In order to maximize sequestration volumes in subsurface formations, CO_2 must be compressed into a supercritical phase (i.e., above its critical temperature and pressure). In this phase, CO_2 has qualities of both a liquid and a gas, yet occupies much less volume than it does in its gaseous phase. Based on DOE guidance, geologic sequestration targets must occur at depths in excess of 2,500 feet (762 m) to ensure that enough pressure is maintained to keep the injected CO_2 in its supercritical phase, and to provide as much overlying cap rock (confining layers) as possible to act as a geologic seal for the sequestration reservoir (Battelle, 2005). Burruss and others (2009), however, recommended a minimum storage depth of 3,000 feet (914 m) to ensure that the CO_2 remains in its supercritical phase.

For example, if we were interested in deep saline formations for CCS, we know that the Oriskany Sandstone, Lower Silurian Lockport Dolomite, Lower Silurian Medina Group and equivalent Tuscarora Sandstone, and Upper Cambrian Gatesburg Formation (Figure 2) occur in the subsurface of western Pennsylvania because we have records and logs from numerous wells that penetrate those formations. Even so, only a limited amount of useful reservoir data (e.g., porosity, permeability, and injectivity) exist in the public sector for formations below the Oriskany Sandstone. It is highly unlikely that anyone would spend the kind of money that would be necessary to drill a test well much deeper than the Oriskany to test its reservoir properties. As such, these deeper formations are probably beyond the depth of an economically viable sequestration project.

More Bang for the Buck

Three other types of geologic carbon sequestration can add value beyond merely removing CO_2 from the atmosphere and storing it underground. It is potentially possible to use CO_2 to assist with the recovery of natural gas and crude oil from coal, shale, and oil and gas reservoirs through enhanced

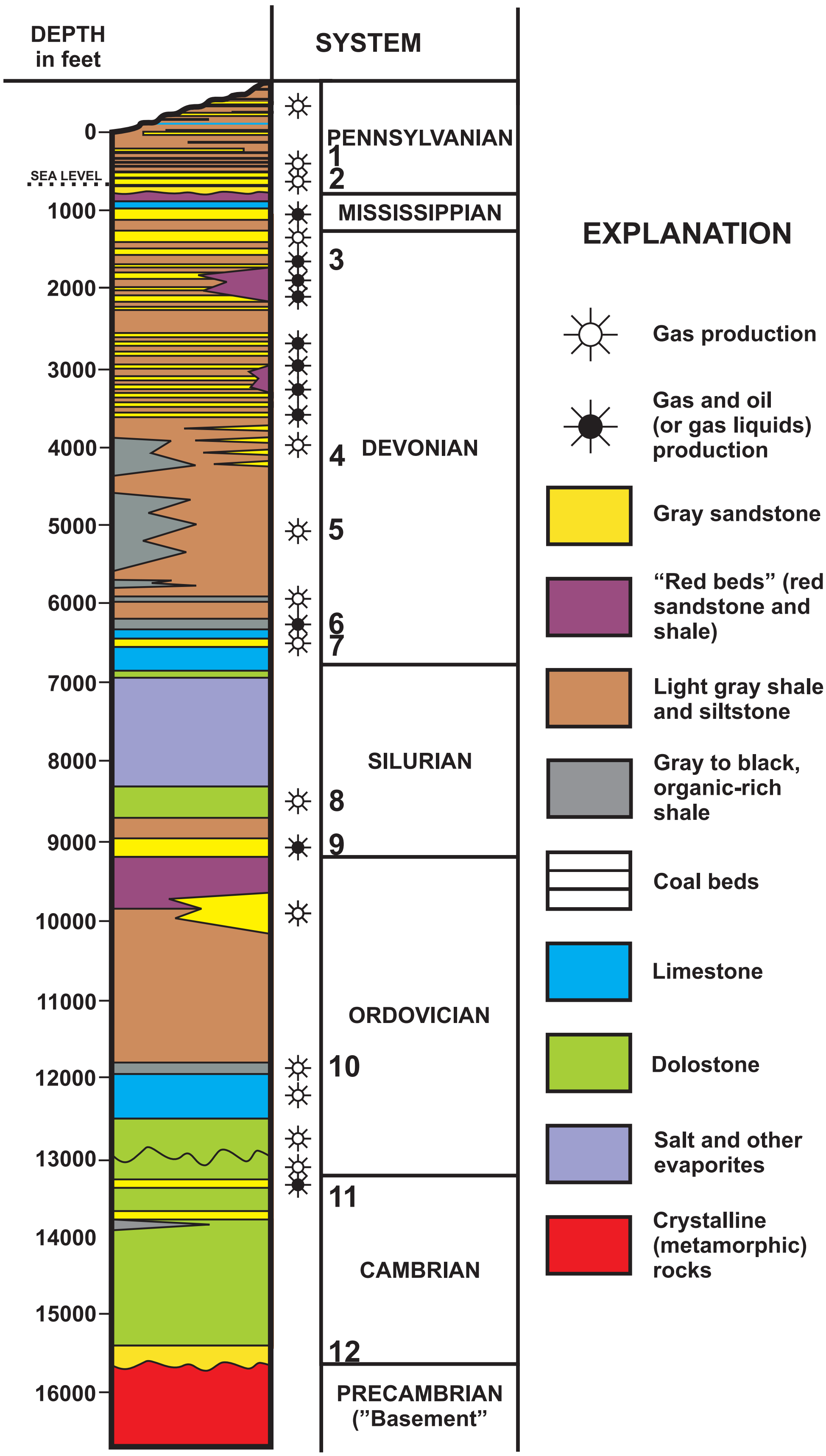


Figure 2. Generalized stratigraphic column of rocks in southwestern Pennsylvania. Numbers indicate geologic units referred to in this article: 1, Pennsylvanian and Permian coal beds; 2, Pottsville Formation Salt sands; 3, Venango Group oil sands; 4, Huron Shale; 5, Rhinestreet Shale; 6, Marcellus Formation; 7, Oriskany Sandstone; 8, Lockport Dolomite; 9, Medina Group and equivalent Tuscarora Formation; 10, Utica Shale; 11, Gatesburg Formation sandstones; and 12, Potsdam Sandstone.

recovery operations. Below is a rundown of some of the potential for producing more oil and natural gas through the use of CO_2-enhanced recovery.

Deep Unmineable Coal Seams. CO_2 has a greater affinity for coal than does methane (CH_4). Therefore, when injected into a coal seam, CO_2 should displace the CH_4 adsorbed onto the organic matrix of the coal and provide enhanced gas recovery. Additionally, this adsorption mechanism means that the injected CO_2 will, theoretically, adhere to the coal matrix, effectively sealing it in the coal and keeping it from leaking into adjacent units or to the surface (Greb and others, 2010). The adsorption rate for CO_2 in bituminous coals is at least twice that of CH_4 (Burruss, 2003) (Greb and others [2010] reported that adsorption ability varies with gas type, rank, coal type, and moisture content; CO_2/CH_4 ratios have been reported as high as 5.3:1 in Illinois and may be higher than 10:1 for lignites). This means that at least twice the volume of CO_2 should be able to be sequestered in the same space originally occupied by CH_4 once the CH_4 has been produced. And industry should be able to produce a lot of CH_4 because the bituminous coals of western Pennsylvania generally have fairly high coalbed-methane contents (Figure 3). Many of them have CH_4 contents greater than 100 scf/ton (standard cubic feet per ton), which is the amount considered to be commercially viable (Markowski, 2001).

Because CO_2 theoretically bonds with the organic matrix of the coal through adsorption, rather than just filling pore space as in a saline formation, it would not have to be in a supercritical phase. It could thus be sequestered at depths much shallower than 2,500 feet (762 m), an additional factor that makes CCUS in coals an attractive concept. Because the Pennsylvanian and Permian coal beds in western Pennsylvania (Figure 2) generally lie less than 1,500 feet (457 m) below the surface, this makes unmineable coals even more attractive as targets for sequestration, with or without enhanced gas recovery. (I should point out that "unmineable" is primarily an economic definition and varies from com-

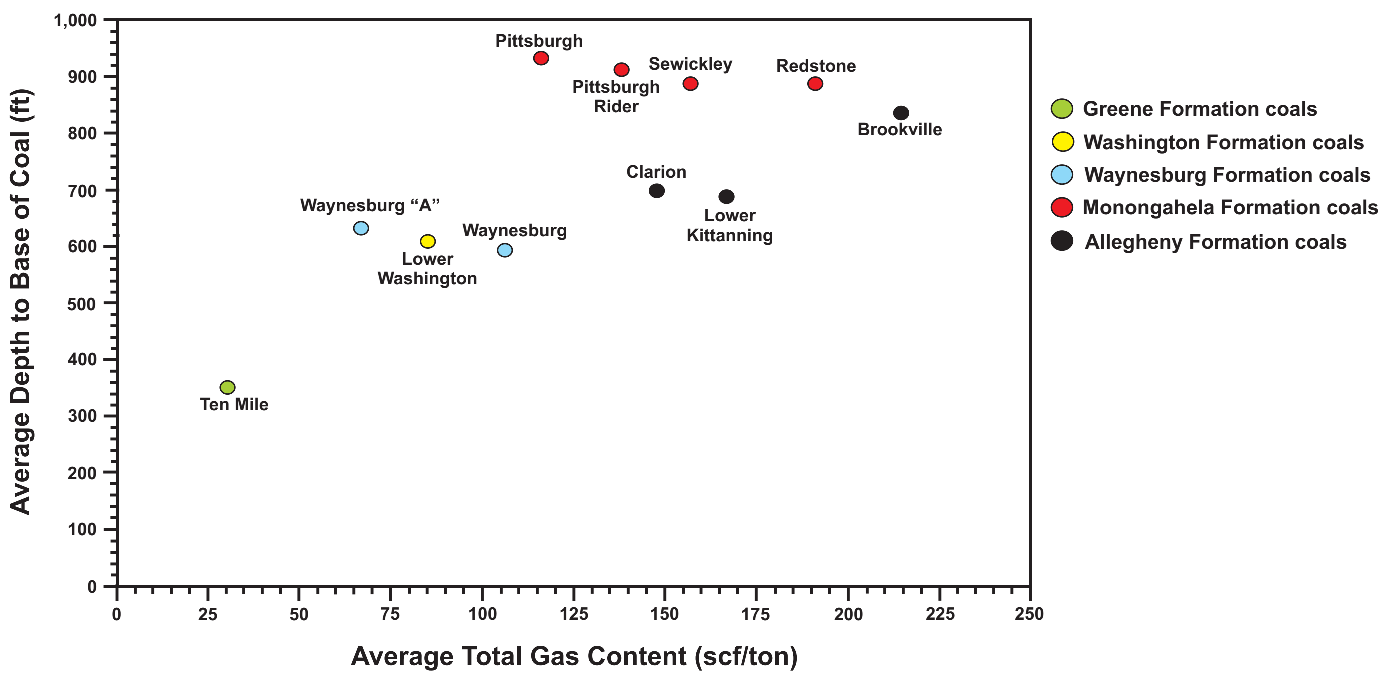


Figure 3. Graph of the coalbed-methane content in scf/ton (standard cubic feet per ton) of selected coals from western Pennsylvania (based on data from Markowski, 2001).

pany to company. Some people even maintain that there is no such thing as an "unmineable" coal. Although I can't imagine why anyone would spend the money to dig up a six-inch-thick [15-cm-thick] coal at a depth of 1,500 feet [457 m], this point of contention could drastically affect the potential for CCUS in Pennsylvania's coal beds.)

Organic-Rich Shale. Theoretically speaking, CO_2 injection into organic-rich shales, such as the Middle Devonian Marcellus Formation (Figure 2), could be used to promote production of CH_4 from these rocks. Geochemical studies have shown that such organic-rich shales are the source of the oil and natural gas found in Pennsylvania's traditional reservoir rocks (Laughrey and Baldassare, 1998), and they also act as prolific hydrocarbon reservoirs themselves (Harper, 2008). Assuming that sequestration in organic-rich coal is an analog for sequestration in organic-rich shale-gas reservoirs, CO_2 should adsorb onto the organic matrix of the shale, thus permitting sequestration while enhancing gas production. Although displacement and storage efficiency data are not available for shales, Nuttall's (2010) calculations may mean that the deeper and thicker Devonian shales in the Appalachian basin have a storage capacity of 2.3 billion metric tons of CO_2. If, in fact, the Devonian shales have storage efficiencies similar to coal, these rocks might be able to sequester as much as 29.68 billion tons of CO_2 (Nuttall, 2010) and produce prodigious quantities of CH_4 in the process. The use of shale for CO_2 sequestration and enhanced gas recovery on a commercial scale will be determined by future economic factors, including a low price for CO_2 and a concomitant high price for natural gas (Nuttall, 2010). It is also possible that CO_2 could be used to artificially fracture the shale. If such technology could be sufficiently developed and accepted by the petroleum engineering field, it would provide a much-needed respite from the use and disposal of water during hydraulic fracturing.

Enhanced Oil Recovery (EOR). For the past 40-plus years, the oil and gas industry has been demonstrating around the world that CO_2 can enhance the production of oil and natural gas when injected into "depleted" or abandoned reservoirs (Westrich and others, 2002). Supercritical CO_2 floods the pore space within the reservoir rock, reducing the viscosity and displacing hydrocarbon molecules, which then can be swept with the injected fluid to the borehole to be produced (Figure 4). Some of the variables that control the sequestration potential of depleted oil and gas reservoirs include the volume of the reservoir, permeability, injectivity, pressure, reservoir integrity, water/brine chemistry, the nature of the cap rock or reservoir seal, and the history of production (Reichle and others, 1999).

The process of CO_2 EOR assists in the recovery of crude oil in one of two ways: (1) immiscible CO_2 flooding repressurizes the reservoir, thereby displacing and driving the remaining oil to a recovery well; and (2) miscible CO_2 flooding mixes and chemically interacts the CO_2 with the remaining oil as it pushes the oil to the recovery well (Figure 4).

CO_2 mixes with oil, but it mixes more readily with water. Water, on the other hand, doesn't absorb as much CO_2 as does an equal amount of oil. As a result, miscible CO_2 EOR is a two-step process. When CO_2 is first injected into a reservoir, it preferentially mixes with and displaces the water near the borehole, leaving the more viscous oil remaining in the pore spaces. After some time, when most of the water has been displaced, the CO_2 will begin to mix with the oil in the pore spaces. This can take up to four weeks (Boomer and others, 1999), so the EOR project operator will shut in the well to allow the CO_2 to "soak" into the other fluids. Eventually the CO_2 becomes miscible with the oil, reducing its viscosity and allowing it to flow from the higher-pressure reservoir to the lower-pressure well bore. The CO_2 then can be captured at the surface and reused. It will eventually begin to remain in the reservoir, occupying the pore space vacated by the oil. Thus, CO_2 EOR has the dual benefit of helping produce oil and sequestering CO_2.

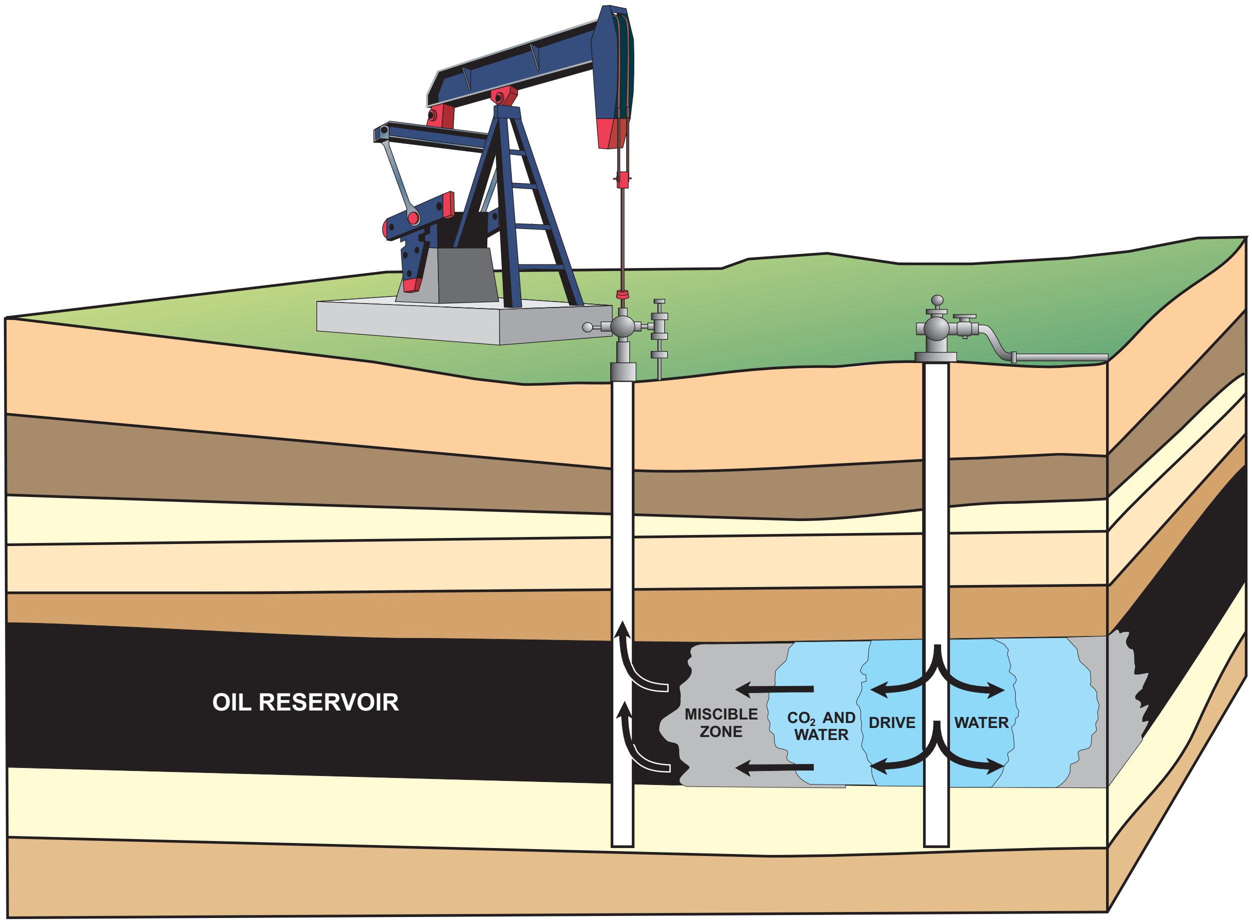


Figure 4. Cartoon of a typical CO_2-enhanced oil recovery project. Supercritical CO_2 and water enter the oil reservoir through the well on the right, chemically mix with and reduce the viscosity of oil in phases, and flush the oil to the production well on the left. The water/CO_2 mixture is separated from the oil at the surface, reinjected, and circulated through the reservoir. Over time, the CO_2 occupies the vacated pore spaces and is locked in the reservoir, a form of geologic sequestration.

Pennsylvania has many oil fields and pools, but relatively few of them lie below the sequestration depth of 2,500 feet (762 m) (Figure 5). Therefore, any attempt at miscible CO_2 flooding will be limited by the characteristics of the particular reservoir.

How Greene Was My County

During an analysis of Pennsylvania's potential to store CO_2, primarily on state-owned land (Pennsylvania Department of Natural Resources, 2008, 2009), it was determined that southwestern Pennsylvania might be an interesting place to try a pilot sequestration project. Greene and Washington Counties have good examples of the types of geologic storage opportunities needed for both CCS and CCUS—deep saline formations for CCS, and deep unmineable coals, organic-rich shales, and "depleted" (or "depleting") oil and gas fields for CCUS. A well drilled about 8,500 feet (2,591 m) deep to test Pennsylvania's sequestration potential would encounter all of these reservoir types. In addition, there are numerous large industrial sources of CO_2 within a reasonable distance of Greene and Washington Counties that could supply the gas for a pilot project (Figure 6).

Greene and Washington Counties have the largest bituminous coal reserves in the state (Socolow and others, 1980), and that is only the "mineable" coals (seams 28 inches [71 cm] thick or greater). With coal seams occurring in every Pennsylvanian and Permian formation, southwestern Pennsylvania also has a wealth of unmineable coal seams. Therefore, this area would be an ideal location to test the sequestration potential of both mineable and unmineable coal seams and to test the use of CO_2 in enhancing the production of coalbed methane.

According to the last census of oil reserves done Pennsylvania (Lytle, 1950), the oil fields in Greene and Washington Counties that are deep enough for CO_2 EOR had estimated OOIP (original oil in place) of 53,042,000 bbl (barrels) at an average depth of 2,981 feet (909 m) (Figure 7 and Table 1). Of this amount, 1,200,000 bbl were deemed recoverable by primary methods (that is, flowing and pumping). At the time of Lytle's (1950) report, secondary recovery (air/gas injection or waterflooding) had been tried on only a few of these fields, mostly without success. Only the great Washington-Taylorstown field and the much smaller Lagonda field (numbers 1 and 2 in Figure 7) had undergone successful air/gas injection by that time. Waterflood operations by Pennzoil Corp. on the western edge of the Washington-Taylorstown field in the 1980s greatly improved production there. Unfortunately, complete, modern production data are hard to come by. Although reporting of production in Pennsylvania was required under the 1984 Oil and Gas Act, many operators did not begin submitting production data to the state until 1991. Most waterfloods in the state have shut down, and Pennzoil has ceased to exist as an independent company. So we really don't know the total effect waterflooding had on the Washington-Taylorstown field.

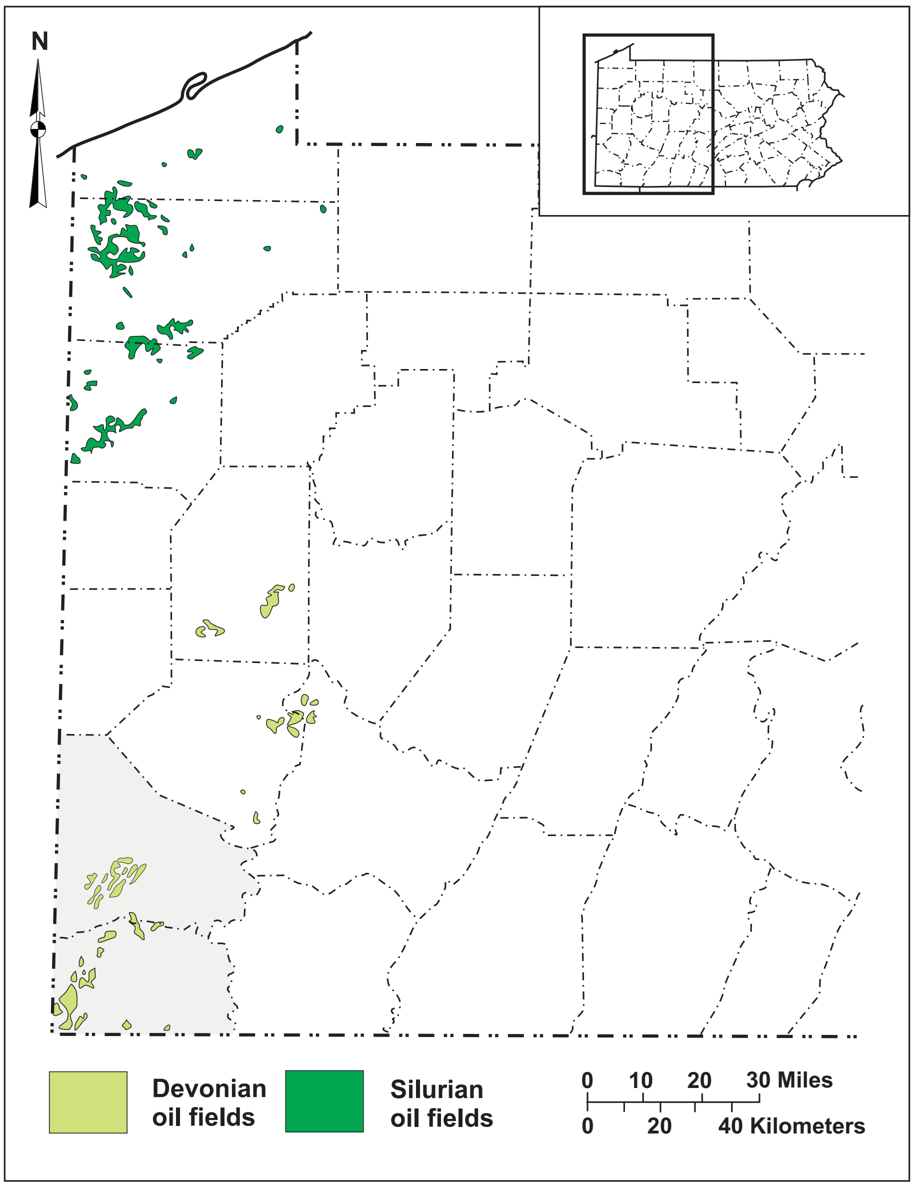


Figure 5. Map of the western Pennsylvania oil fields having average depths of 2,500 feet (762 m) or greater. These are the only oil fields in Pennsylvania that would respond to miscible CO_2 flooding. The area shaded in gray is shown in more detail in Figure 7.

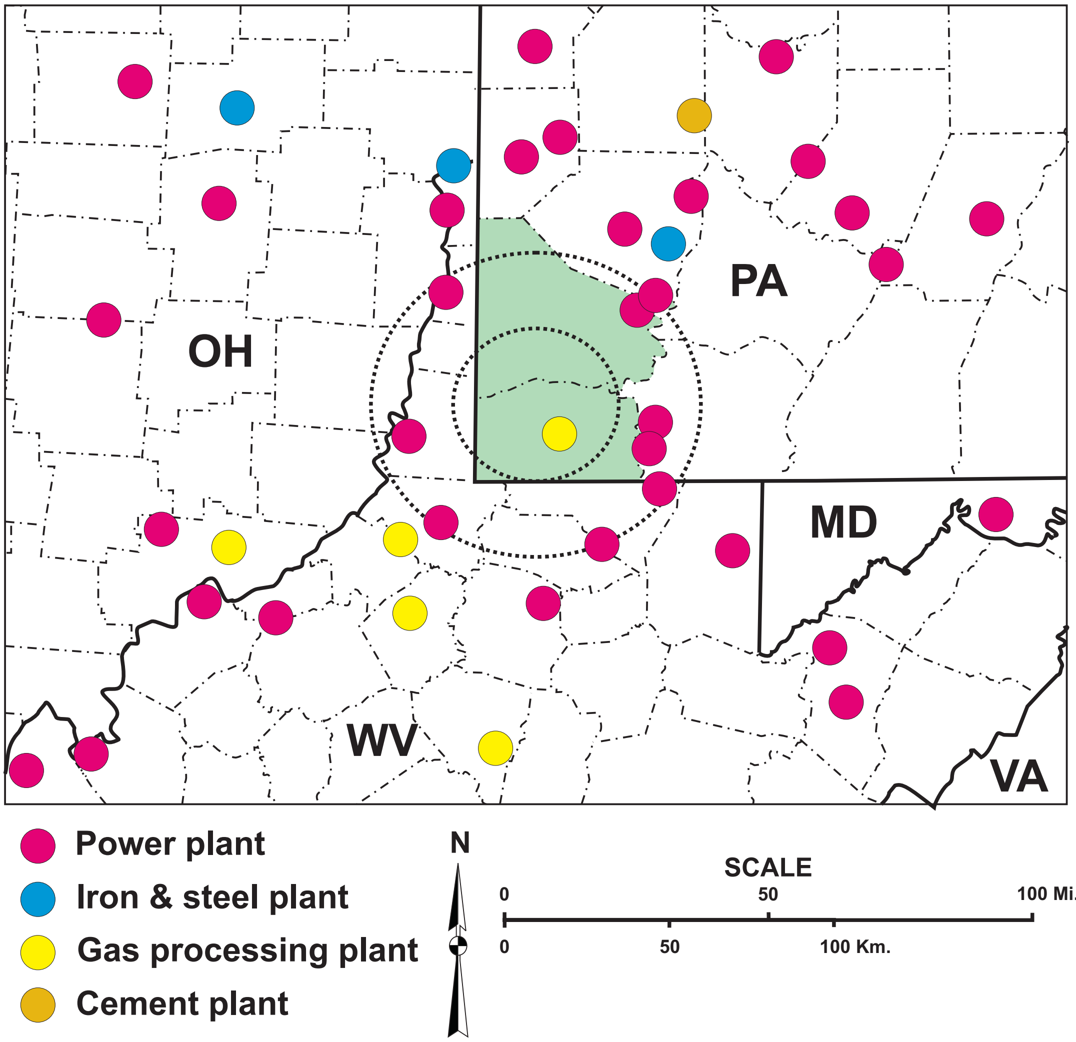


Figure 6. Map of southwestern Pennsylvania and adjacent states showing the locations of large point sources of CO_2 (modified from Battelle, 2005). Greene and Washington Counties are shown in pale green. Dotted circles indicate distances of about 30 and 60 miles (50 and 100 km) from the approximate center of the oil-producing area within these two counties.

We know for certain that most of these old oil fields are still producing (Table 2), but an accurate accounting of total production to date remains elusive. In all likelihood, all of the fields are now larger in area and have larger OOIP amounts than when Lytle's (1950) data were collected in the 1940s. It is also unlikely that more than 10 or 20 percent of the producible crude oil has been removed, leaving 80 or 90 percent yet to be recovered. Perhaps many, if not most, of these old fields do not have the proper reservoir characteristics for CO_2 EOR. Comments by Lytle (1950) indicated that many of the reservoirs are tight, but an analysis should be undertaken based on whatever information can be gotten from existing wells.

Be forewarned—trying a CO_2 EOR project in most of these old fields will require a huge amount of time and expense. It will require, at a minimum, the following: (1) the acquisition of the oil and gas rights to at least a portion of the field; (2) an accurate accounting and location of every well ever drilled in the area; (3) evaluation of each well to determine which, if any, are in good enough shape to be used in a project of this sort; (4) abandonment and complete plugging, and sometimes replugging, in compliance with DEP's oil and gas regulations of all wells not being used; (5) reconditioning any wells

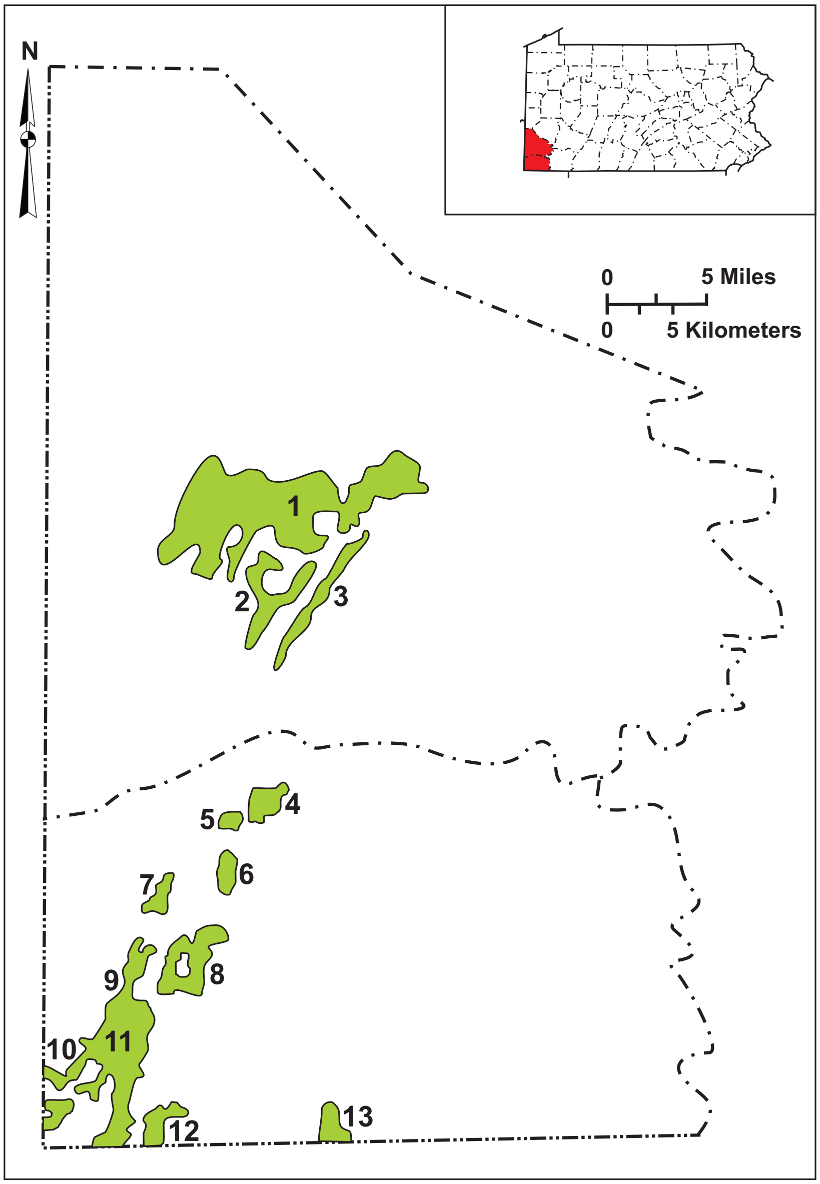


Figure 7. Map of the oil fields in Greene and Washington Counties that are deep enough for miscible CO_2 flooding. See Table 1 for data and explanation of numbers. Because of the lack of reservoir information, it is uncertain whether the physical characteristics of the reservoir rocks would actually allow CO_2 EOR in most of these fields.

that can be salvaged; and (6) drilling new wells as needed. And that's just for starters. Cores will need to be taken of the reservoirs in order to determine the porosity, permeability, oil and water saturations, potential injectivity, oil recovery factor, and a myriad of other reservoir characteristics needed to establish whether the rock is even capable of enhanced recovery.

Now, there's a job for someone with a lot of time on their hands and very deep pockets, not to mention a high tolerance for exasperation!

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Table 1. Crude Oil Production and Reserves of the Deeper Oil Fields of Greene and Washington Counties, Pennsylvania
(From Lytle, 1950)

Map no.	County	Field name	Average reservoir depth (feet)	Original oil in place (Bbl[1])	Recoverable by primary methods (Bbl[1])	Remaining oil in place (Bbl[1])
1	Washington	Washington-Taylorstown	2,600	37,600,000	805,000	36,795,000
2	Washington	Lagonda	2,675	3,257,000	89,000	3,168,000
3	Washington	Point Lookout	2,725	183,000	5,000	178,000
4	Greene	Nineveh	2,925	901,000	23,000	878,000
5	Greene	Rutan	2,925	809,000	20,000	789,000
6	Greene	Grays Fork	2,950	498,000	13,000	485,000
7	Greene	Wright Run	3,000	704,000	18,000	686,000
8	Greene	Bristoria	3,200	2,765,000	69,000	2,696,000
9	Greene	Aleppo	3,000	1,043,000	26,000	1,017,000
10	Greene	Board Tree	3,300	1,454,000	36,000	1,418,000
11	Greene	New Freeport	3,300	3,092,000	78,000	3,014,000
12	Greene	Garrison	3,200	169,000	4,000	165,000
13	Greene	Lantz	2,950	567,000	14,000	553,000
		Totals:		**53,042,000**	**1,200,000**	**51,842,000**

[1]Bbl, barrels.

Table 2. Minimum Amount of Crude Oil Produced Since 1990, and Known Secondary Recovery Operations
(From Pennsylvania Geological Survey, 2012)

Map no.	Field name	Minimum oil produced since 1990 (Bbl[1])	Secondary recovery operations
1	Washington-Taylorstown	522,996	Air/gas, waterflood
2	Lagonda	27,897	Air/gas, waterflood
3	Point Lookout	7,489	Probably none
4	Nineveh	255	Probably none
5	Rutan	5,537	Probably none
6	Grays Fork	3,469	Probably none
7	Wright Run	7,805	Probably none
8	Bristoria	5,305	Probably none
9	Aleppo	7,762	Probably none
10	Board Tree	N/A	Probably none
11	New Freeport	48,297	Probably none
12	Garrison	7,594	Probably none
13	Lantz	N/A	Probably none
	Total	**644,406**	

[1]Bbl, barrels.

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RETIREMENTS

John A. Harper

After 35 years of working in a job he loved, John Harper retired on December 28, 2012. Thanks to some saved-up vacation time, John's actual last day in the office was December 21, which was the day of the purported Mayan apocalypse. As you might have noticed by now, the world DIDN'T end after all.

John Harper and friend at Disney's Animal Kingdom Park (John is the one on the left).

John was born in Sewickley, Pa., and grew up in Coraopolis and the area around the Greater Pittsburgh Airport. His early interests included natural history and classical music. But it was the set of toy dinosaurs he got for Christmas one year that set him on his course to being a paleontologist and geologist.

John received his undergraduate degree at Indiana University of Pennsylvania, spent two years in the U.S. Army as a terrain-intelligence analyst, and earned graduate degrees at the University of Florida and the University of Pittsburgh. While at Pitt, studying Paleozoic snails, John spent two summers interning at the Pittsburgh office of the bureau, working on the Pittsburgh Regional Environmental Geologic Study and learning about subsurface and petroleum geology. Serendipitously, a position opened up at the Pittsburgh office following John's graduation in 1977, and he jumped at the chance to work with his former mentors.

John's first project was working on the Eastern Gas Shales Project (funded by the U.S. Department of Energy), which included the Marcellus Formation, and learning subsurface geology. By mid-1980, all of the senior geologists in the office had left to work in industry or academe, leaving John in charge. There was a steep learning curve, but with the encouragement of former State Geologists Art Socolow and Don Hoskins, and the invaluable assistance of his Pittsburgh office colleagues, he was able to grow in the job. In 2009, after 29 years as head of the Pittsburgh office, he was promoted to Chief of the Mineral Resources Division, which includes the Mineral Resource Analysis Section in Middletown and the Petroleum and Subsurface Geology Section in Pittsburgh.

Over the years, John worked on many projects dealing with subsurface geology and petroleum, including funded cooperative projects with other Appalachian state surveys and universities. These involved studies on topics such as Cambrian reservoirs, geologic carbon sequestration, and the Utica Shale, as well as the compilation of *The Atlas of Major Appalachian Gas Plays.* John also served as the Pittsburgh office's front man for investigations of geologic hazards, fossil collecting, and other geologically related topics in western Pennsylvania. He also did his best to stay current on Paleozoic snails.

John is well-known within the geological community for his cartoons (for example, the one on the next page), which he started drawing as an undergraduate for the university newspaper. He continued drawing them to entertain his army colleagues, graduate school professors and fellow students, and professional colleagues. Many have been "published" by the Pittsburgh Geological Society and the Field Conference of Pennsylvania Geologists, including the one on the cover of the 1980 Field

The infamous Harper "Coat of Arms" (original, 1974; updated, 2012).

Conference guidebook, which was also used as the frontispiece to Part IX, Environmental and Engineering Applications, in *The Geology of Pennsylvania.*

John plans on spending part of his retirement time volunteering with the bureau to finish the ongoing Utica project, part of it working with his beloved Paleozoic snails at the Carnegie Museum of Natural History, and part of it traveling, drawing cartoons and painting, playing guitar, and enjoying watching his grandson and granddogs grow up.

Joseph E. Kunz, Jr.

After a childhood spent in western Pennsylvania, Joseph Kunz joined the U.S. Navy and devoted 4 years to serving our country. In 1984, he took a job with the former Department of Environmental Resources. He worked there for a year, then finally landed at the bureau, where he worked until his retirement on January 25, 2013.

Joe's job with the bureau involved several administrative tasks, including maintenance of the Pittsburgh office's library and state vehicles, procurement of office and field supplies, timekeeping, greeting and assisting visitors, and managing the daily inflow of oil and gas well record paperwork from various regional offices of the Department of Environmental Protection. The most important of these issues, at least from a business management standpoint, was the oil and gas well record handling that Joe coordinated for the PA*IRIS/WIS system, but helping visitors was Joe's favorite activity.

Joe Kunz

He was always a great help and very pleasant to work with. He enjoyed meeting people and enjoyed helping those from all walks of life in their quest for subsurface geologic information. To quote Joe: "It was the best move I've ever made in my life."

In his retirement, Joe plans on continuing his exercise program and being with his friends and family. He also hopes to become a volunteer in his community.

ANNOUNCEMENT

Looking for a Pub?

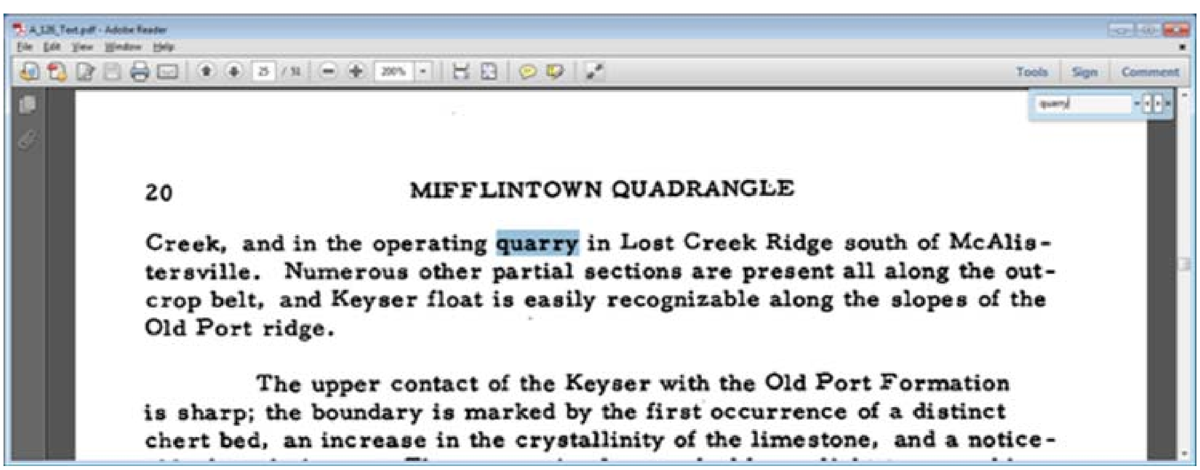
Caron E. O'Neil
Pennsylvania Geological Survey

Saint Paddy's Day may be fast approaching, but I must confess this is not the type of pub I have in mind. I just wanted to get your attention, because we have news that should be of almost as much interest to a Pennsylvania geologist as the brew in the gent's hand above. The way the Survey is distributing publications, including any associated GIS data, has changed: (1) almost all of the reports published by the current (Fourth) Survey are now available on our website, and (2) effective May 1, except for Special Publication 1, *The Geology of Pennsylvania*, the bureau will no longer be selling hard copies of our publications.

In recent years, the Bureau of Topographic and Geologic Survey has been publishing text, maps, and datasets online. As we were able, we scanned and added some of our out-of-print formal reports to the online selection. We recognized the desire of many to have all of our printed publications online, but because of the considerable time it would take to accomplish such a task and the limited number of our staff, this is one job we kept putting off. Then something happened.

We were instructed to upgrade all of our web pages to the department's standard format. The new website structure would mean reorganizing pages and reassigning web addresses. We were going to have to do a lot of work on our publication links. What better time to expand our online publication presence?

Mike Moore, Manager of the Geologic and Geographic Services Division, purchased a wonderful Fujitsu ScanSnap unit that would allow us to quickly batch scan the text of our printed reports into text-recognizable PDF files. Mike's staff dug in and cut apart bound books, scanned oversized maps on our large-format scanner, ran text-recognition software on previously scanned reports, zipped job files together, and worked in harmony to prepare almost all of the available Fourth Pennsylvania Geological Survey publications for the new website. When the dust settled, more than 500 publications had been


20 MIFFLINTOWN QUADRANGLE

Creek, and in the operating quarry in Lost Creek Ridge south of McAlistersville. Numerous other partial sections are present all along the outcrop belt, and Keyser float is easily recognizable along the slopes of the Old Port ridge.

The upper contact of the Keyser with the Old Port Formation is sharp; the boundary is marked by the first occurrence of a distinct chert bed, an increase in the crystallinity of the limestone, and a notice-

Printed publications were scanned and saved as PDF files using text-recognition software. The example to the right shows the first result of a search for the word "quarry" in Atlas 126.

added to the list of publications available for download. The zip archives of these scanned publications are available through the "Publication by Series" pages of our website (dcnr.state.pa.us/topogeo/publications/pgspub).

For now, most of these publications and any associated datasets are downloadable as zip files from their title link in their series' list of titles. The bureau is working on a web-mapping application that (among other wonderful things, which you will learn about in future issues of this magazine) will allow searches for publications by geographic region or geologic topic. When this app is up and running, instead of immediately initiating the download of the zip file, you will connect to a landing page for each publication that summarizes the original publication, provides a suggested citation as well as other pertinent information, and most importantly, includes the link to download the report.

As a result of our recent mass-scanning project, all of our cost publications that are still in print, except for SP 1, are now available online for free as text-searchable PDF files. So, with the exception of SP 1, the bureau will stop selling printed publications effective May 1. If you want to purchase a hard copy of any of our remaining printed formal publications, they can be ordered from the ShopPAHeritage website page for the Department of Conservation and Natural Resources until April 30. If you wish to purchase a printed open-file report from our offices, visit the "Open-File Reports" page of our website before May 1 to see the titles that are still available in that format. Available reports will be identifiable on the web page by a price and a link to ordering instructions, which follows the title. The web addresses of the ShopPAHeritage page and the Open-File Reports series page are listed below.

shoppaheritage.myshopify.com/collections/conservation-and-natural-resources

dcnr.state.pa.us/topogeo/publications/pgspub/openfile

That's it folks. Go ahead and have a geological publication on us, and if you like, print it out and take it with you to read at your favorite pub on Saint Paddy's Day.

RECENT PUBLICATION

Bedrock geology open-file reports **(February 2013)**

Bedrock geologic map of the Troy quadrangle, Bradford County, Pennsylvania

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