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ON THE COVER: The great “whaleback” at the Bear Valley strip mine, 1.8 miles southwest of Shamokin, in Coal Township, Northumberland County. This three dimensionally exposed anticline affects rock strata in the Mammoth coal zone of the Pennsylvanian-age Llewellyn Formation. Photograph by R. P. Nickelsen, Bucknell University.
The Future of Critical Minerals

The modern crisis of availability of critical and strategic minerals may yet make one world in which people will finally be forced to live together in harmony. Or, it may make further global conflict inevitable. If we look at the current spate of conflicts induced by nationalism and cultural vehemence and the inhumane treatment of people by each other and we project this behavior into the future, the scene is not a pleasant one. The unknown factor is whether this our human species can adapt to the finite limitations of natural resources of the earth or can discipline itself to use the earth's systems to sustain civilizations.

One hundred years ago, when minerals began to be extensively developed, the world had 1.9 billion people. Now we have 5 billion. All reasonable projections tell us that we will have 12 billion in the next 100 years. Using currently known resources and technologies, this growth demands that we will have to develop four times the amount of mineral, energy, and water resources as are currently developed. Responsible stewardship also demands that we consider the needs of the civilizations of the centuries beyond.

Citing our own national needs as an example, the U.S. Department of Interior lists as critical and strategic such minerals as the platinum group of metals, chromium, manganese, vanadium, and rutile. For these there are little or none at all to be found within the United States at any reasonable present or projected future cost. Although manganese may eventually be producible from nodules on the sea floor in the U.S. Exclusive Economic Zone, at present this is not economically feasible. Many other nations likewise lack essential mineral resources.

Resource problems are thus no longer national (if they ever were); they are global problems. Many of the largest resources of critical minerals are located in countries whose political behavior is either hostile or repugnant to the United States, such as South Africa. We face the dilemma of either devising ways to cooperate with them or we must change or reduce the standard of living to which we are accustomed. For example, China with its large, geologically unexplored areas is likely to become the major producer of many critical minerals on which we now depend.

We must learn to accept that the finite resources of our planet, such as fossil fuels and minerals, cannot sustain unlimited growth of population. As the carrying capacity of the earth is approached, the quality of life that most Americans enjoy will

(continued on page 16)
IN MEMORIAM
John Oleksyshyn
1901-1987

John Oleksyshyn, educator and research geologist, died of heart failure on December 19, 1987, at the age of 86. He will be fondly remembered by his students and colleagues for his integrity, for his dedication to his work and his family, and for never inching away from his fundamental values and beliefs. His recent work on the Pennsylvanian flora of the Anthracite region made his name familiar to many paleontologists in Pennsylvania and the United States, both professional and amateur, who may yet know little of his extraordinary life.

Ivan (John) Oleksyshyn was born in Chreniv, Austria (Poland since 1923), on September 1, 1901, to a family of Ukrainian descent. During World War I, he served as a second lieutenant in the Ukrainian National Army and became a prisoner of war of the Polish occupation forces. Following his release in 1921, he eventually received his B.S. (1928) and M.S. (1929) in geology from the Jan Kazimierz University in Lvov. After teaching stints at several eastern European universities, he returned to school after World War II and obtained his Ph.D. in geology and mineralogy from Leopold-Franz University in Innsbruck, Austria.

In 1949, John came to the United States as a displaced person and acquired a position as a bacteriological technician at Jefferson Medical College in Philadelphia in 1953. He received his citizenship in 1954. He was finally able to resume his professional career when he was hired as an assistant professor of geology at Boston University in 1955. Within eight years, he had been promoted to full professor. A year after retiring from Boston University in 1967, John returned to Jefferson Medical College as a part-time microbiologist. He continued until 1984, when his health prevented his continued employment.

John Oleksyshyn carried on prodigious paleontologic research throughout his entire adult life. He was especially well known for his work on Miocene invertebrate paleontology of Europe and Carboniferous paleobotany of the northeastern United States. He wrote two landmark paleobotanical reports on the Pennsylvania anthracite fields: *Plant fossils from the anthracite coal fields of eastern Pennsylvania* (published in 1982 and reprinted in 1988) and *Fossil plants from the Abbott coal-bed horizon, Northern Anthracite field of eastern Pennsylvania* (to be published in 1990).

In John Oleksyshyn the geological profession has lost one of its most dedicated and meticulous practitioners—a man of exceptional qualities as a scientist, teacher, and friend.

The Eckley Whalebacks

by Jon D. Inners and Leonard J. Lentz
Pennsylvania Geological Survey

A major problem facing geologists in this era of "on-again, off-again" environmental consciousness is the loss of significant rock exposures and their outcrop data through reclamation of mines and quarries. Many a field geologist has seen his favorite sites destroyed through the mandated (and usually necessary) removal or burial of dangerous and often unsightly highwalls. The Pennsylvania Geological Survey has long had a program of photographing, sampling, and describing ephemeral strip-mine highwalls in the bituminous coal fields (Project TASIC—"Temporarily Available Stratigraphic Information Collection"). The Survey is only now starting similar data collection in the Anthracite region. Since our interest in anthracite strip mines centers as much on the temporarily exposed geologic structures as on the rock strata, we present here a detailed description of some unusual structures recently discovered in a strip mine near Eckley Miners' Village in the Eastern Middle Anthracite field, Luzerne County.

This paper concerns two "whalebacks," both of which were well exposed as late as the spring of 1986. But what, you ask, is a "whaleback"? To the anthracite miner, a whaleback is a broad roll in the "bottom rock" that brings the coal bed closer to the surface and makes strip mining somewhat easier. To the geologist, it is a three dimensionally exposed, doubly plunging, small third-order (wavelength ~100 to 500 feet) anticlinal fold within the floor of a coal stripping. The resemblance to a whale is increased by the dark-gray to black, shaly "seat rock" (bottom rock) that commonly forms the rounded surface of the fold. Best known of the many whalebacks in the Anthracite region is the great Bear Valley leviathan near Shamokin (cover photo), made famous by the detailed geological investigations of Nickelsen (1979, 1983, 1987).

The Eckley whalebacks are located in an abandoned and partially backfilled strip mine on the southwest side of SR 2051, 1.5 miles southeast of Eckley, Foster Township, Luzerne County (40°58'56"N/75°50'11"W, Weatherly quadrangle; Figure 1). They lie near the east end of the Hazleton basin between Buck Mountain subbasins No. 2 (north) and No. 6 (south), approximately 400 feet south of the axis of the Hazleton syncline.
Both structures expose rocks of Middle Pennsylvanian age that lie just below the Buck Mountain (No. 5) coal bed at the base of the Llewellyn Formation. One fold is mantled by dark-gray, rootworked, silty claystone that represents the seat rock of the coal bed; the other exposes the uppermost bedding plane of a light-gray, medium- to coarse-grained sandstone sequence (technically in the Pottsville Formation) that directly underlies the claystone seat rock.

The whalebacks consist of two en echelon (i.e., in steplike arrangement) anticlines—a low "roll" to the west and a higher, partially wooded knob to the east (Figure 2). Both structures have wavelengths of about 275 feet and wave heights of about 150 feet. The western whaleback plunges 8 degrees toward N88°W and 8 degrees toward S85°E (Figure 3a), and the exposed west end of the eastern fold plunges 32 degrees toward S85°W (Figure 3b). This latter plunge is extremely steep and considerably exceeds that of any other whaleback anticline that we have seen in the Eastern Middle field. (The Bear Valley whaleback—in the Western Middle field—plunges only 12 degrees at its well-exposed eastern end.)

Whereas the western whaleback is simply an anticlinal fold exhibiting two approximately perpendicular sets of planar, quartz-
Figure 2. The Eckley whalebacks, as they appeared in April 1986. Looking east. The western fold (in the left foreground) has since been partially covered with spoils. The steep limbs and sharp plunge of the eastern whaleback (in the right background) have caused a peeling off of its original mantle of dark-gray claystone. Note the open fracture on the nose of the latter structure.

Mineralized fractures—one nearly parallel to the strike of bedding and the other parallel to the dip direction (Figure 3a)—the eastern fold is much more complex. Its north limb is locally offset by a subvertical wrench fault that strikes N26°W (Figure 3b), and its south limb is cut by a conspicuous south-directed, folded thrust fault (Figure 4). Straight slickenlines on the wrench fault plunge 36 degrees to the northwest (Figure 3b), and, together with the minute, but distinct, "steps" on the slickensided surface, indicate an oblique right-lateral sense of motion (Figure 5). In addition, the west-plunging nose of the eastern whaleback is split by a ragged tension fracture ("fault") up to 2 feet wide, on which the north side has dropped down about 5 feet.

Figure 6 is a north-south cross section through the area based on mine sections supplied by Beltrami Enterprises and on exposures in a stripping directly to the north that cuts into the north side of the western whaleback (arrow). Note the overturned fold in the rock strata (interbedded dark-gray sandstones and shales) overlying the Buck Mountain coal bed and the broadly arched floor of subbasin
No. 6. The Buck Mountain itself is 15 to 20 feet thick and consists of several benches of low-ash anthracite separated by shaly partings up to 6 inches thick. To the east this thick vein splits into two distinct coal beds up to 10 feet apart (C. Soroka, Beltrami Enterprises, personal communication, 1988).

When and how did these folds, faults, and fractures originate? All of the major structures of the Anthracite region formed during the Alleghanian orogeny, about 250 million years ago, at the climax of the collision between the North American and African continental plates. Like the Bear Valley whaleback, the Eckley folds were probably deformed beneath an overburden of 3 to 5 miles at a temperature of at least 200°C (Nickelsen, 1983; see Levine, 1986).

Of the six stages of the Alleghanian orogeny that Nickelsen recognized at Bear Valley, only two are well represented at Eckley. The prominent thrust fault on the south limb of the eastern whaleback (Figure 4) is probably similar to a Stage IV (pre-folding) thrust seen on the north limb of the Bear Valley whaleback (Nickelsen, 1979, Figure 7). Stage V is represented by the whaleback folds and the synclinal folds forming the subbasins. The planar fractures that cut the folded bedded surfaces of both whalebacks may also belong mainly
Figure 4. Folded thrust fault on the south limb of the eastern whaleback. Looking west. The Buck Mountain footwall on the south side of the basin is barely visible to the extreme left (arrow). The hammer is 11 inches long.

to this stage. Only the right-lateral wrench fault on the north limb of the eastern whaleback does not fit readily into Nickelsen's scheme. It appears to postdate the folding (straight slickenlines), but the movement sense is wrong for it to have formed by Stage VI extension parallel to the fold hinge (see Nickelsen, 1979).

The origin of the wide crack on the eastern whaleback (Figure 2) is unclear. It is probably related in some way to the early underground mining of the Buck Mountain on the north limb of the fold, where

Figure 5. Sketch of slickenlines and "steps" on the quartz-mineralized surface of the wrench fault on the north side of the eastern whaleback, showing the relative movement of rock on either side of the fault.
the sandstone is overturned slightly and overlies the coal bed. If a large mine void were excavated there, settlement of the massive sandstone could create tensional stresses that would rend the nose of the fold.

In only a few years, much of what we can now see in the Eckley strip mine will be covered over and vegetated, and weathering will soon after efface the little that remains above the backfill. No more will the geological investigators of this part of Luzerne County be able to exclaim like Ismael in Melville’s *Moby Dick*: “And lo! close under our lee, not forty fathoms off, a gigantic Sperm Whale lay rolling in the water like the capsized hull of a frigate, his broad, glossy back, of an Ethiopian hue, glistening in the sun’s rays like a mirror.”

With this constant man-made and natural flux in mind, perhaps we should try all the harder to preserve the great whaleback at Shamokin (which is in danger of being covered by spoils when stripping operations resume in nearby areas). In this way, future generations will be assured of having at least one such “window” into the geologic foundation of the once-prosperous Pennsylvania anthracite industry and the past turbulent history of the earth.

We are indebted to Louis Beltrami and Charles Soroka of Beltrami Enterprises, Hazleton, Pennsylvania, and Vince Shikora of Tresckow, Pennsylvania, for supplying information used in preparing this article.

REFERENCES


**COMMEMORATE THE CENTENNIAL OF THE JOHNSTOWN FLOOD**

**at the**

**1989 Field Conference of Pennsylvania Geologists**

The 54th Annual Field Conference of Pennsylvania Geologists will convene in Johnstown, Pennsylvania, October 5–7, 1989, at the site of the famous 1889 “Johnstown flood.” Special features of the 1989 Conference are as follows:

- Float trip (pre-meeting) on the Youghiogheny River between Ohiopyle and Confluence to see Venango Group stratigraphy—limit 40 people.
- Underground Kittanning coal mine (pre-meeting) to see relationship of geology to underground mining problem—limit 20 people.
- Reception and preview of field trips at the Johnstown Flood Memorial Museum.
- Upper Devonian-Pennsylvanian stratigraphy and structure in and around the river gorges through the Laurel Hill and Chestnut Ridge anticlines.
- “Windfall”—songs of the rivers, mountains, mines, and floods following the annual banquet.

Early registration is recommended for the limited spaces on each of the optional pre-meeting trips. Registration information will be sent in early August. If you are not on the current Field Conference mailing list and wish to attend the 1989 Conference, please write to the Field Conference of Pennsylvania Geologists, c/o Pennsylvania Geological Survey, P. O. Box 2357, Harrisburg, PA 17105.
NEW PUBLICATIONS

THE STATE GEOLOGICAL SURVEYS—A HISTORY

This comprehensive volume was published by the Association of American State Geologists in recognition of the major role that the State Geological Surveys have played in geologic mapping and research accomplished in the United States over the past 150 years. Diverse in size, name, and detailed functions, each of the 50 State Surveys has the basic responsibility to delineate the geologic framework and resources of the respective state.

Edited by retired Pennsylvania State Geologist Arthur A. Socolow, this illustrated, hard-covered, 500-page book contains the history, organization, and functions of the 50 State Geological Surveys in individual chapters prepared by the respective Surveys. It is a record replete with scientific achievements, human drama, bureaucratic struggles, and, most important, service to the public.

Geologists in government, academia, and industry, as well as all who are interested in geologic achievements, will find this volume informative and thoroughly readable.

The State Geological Surveys—A History may be ordered from the Geological Survey of Alabama, P. O. Box 0, Tuscaloosa, AL 35486. The price of $20 includes shipping. Checks should be made payable to Association of American State Geologists.

STUDIES OF EARLY MESOZOIC BASINS

U.S. Geological Survey Bulletin 1776, a compilation titled Studies of the Early Mesozoic Basins of the Eastern United States, is now available for distribution. Many of the sections in this 423-page report pertain to the geology of Pennsylvania. One of the more exciting papers concerns a palladium anomaly at Reesers Summit, York County. Based on cooperative sampling by the Pennsylvania Geological Survey and the U.S. Geological Survey through the York Haven Diabase at Reesers Summit, the report contains a description of a 300-foot-thick zone containing an anomalous concentration of palladium. The presence of a confirmed anomaly of a platinum-group element in a
ferrogabbro suggests that significant exploration targets exist within Pennsylvania.

Other interesting papers deal with various types of copper occurrences within the Mesozoic and the sedimentary, stratigraphic, and tectonic aspects of the Mesozoic basins in Pennsylvania. Various interpretations of the fluvial-deltaic-lacustrine sequences are presented. Some of these papers also deal with the petroleum, uranium, and base-metal characteristics and potential in this rift-basin setting.

Bulletin 1776 is available from U.S. Geological Survey, Books and Open-File Reports, Federal Center, Box 25425, Denver, CO 80225. Prepayment of $20 (includes postage) by check or money order payable to the Department of the Interior-U.S.G.S. should accompany each order.

![Figure 1. Distribution of palladium (Pd) and platinum (Pt) in York Haven Diabase, Reesers Summit, York County, Pennsylvania (slightly modified from Gottfried, David, and Froelich, A. J. (1988), Variations of palladium and platinum contents and ratios in selected early Mesozoic tholeiitic rock associations in the eastern United States, in U.S. Geological Survey Bulletin 1776, p. 338).](image-url)
With the publication of Westmoreland County, the 1:50,000-scale county topographic map series of Pennsylvania is complete. Although the series was started in 1973 with the publication of Lehigh County by the Pennsylvania Geological Survey, preparation of the remaining Pennsylvania county maps was assumed by the U.S. Geological Survey as part of its national program of intermediate-scale maps. Pennsylvania is now one of three states (along with Colorado and Connecticut) that have topographic map coverage at the 1:50,000 scale; these three states plus Iowa and Wisconsin are the only states whose county topographic map series are complete.

Nine county maps have been released for public sale in the past 12 months. These are Cameron (part of this map is shown on the following page), Clearfield, Juniata, Lawrence, Somerset, Wayne, Westmoreland, and Wyoming. In addition, Lehigh County, published in 1973, and formerly available as Map 39 of the Pennsylvania Geological Survey, has now been replaced by the 1987 U.S. Geological Survey edition. Copies of each have been distributed to local legislators, county and township commissions, and county planning agencies for examination.
These maps may be purchased from the U.S. Geological Survey, Map Distribution, Box 25286, Federal Center, Denver, CO 80225. The cost of each sheet is $4.50 (if the map is printed on two sheets, the price is $9.00; refer to the index map for the number of sheets in each county). Prepayment is required; make checks payable to U.S.G.S. A $1.00 handling charge should be included on orders of less than $10.00.

For more information, contact the Pennsylvania Geological Survey library, the National Cartographic Information Center (NCIC) Affiliate, telephone 717-783-8077; or contact NCIC Headquarters at the U.S. Geological Survey, telephone 1-800-USA-MAPS.

The next phase of the county map series is the revision of the oldest maps; this phase has been started with a pilot project focused on Montour County. One purpose of the project is to determine the best method for rapid updating and republication of each map. The map information on Montour County dates from prior to 1973, the date of original compilation, and will be revised from modern aerial photography obtained as part of the NAPP (National Aerial Photography Program), which started in Pennsylvania in 1987. In planning for revision of these county maps, we seek comments on their utility and how they might be improved. Please address your comments to State Geologist, Department of Environmental Resources, P. O. Box 2357, Harrisburg, PA 17105.
State Geologist of Ohio Selected from Pennsylvania Geological Survey Staff

Thomas M. Berg, Associate Director of the Pennsylvania Geological Survey, and Chief of the Geologic Mapping Division for the past decade, was selected to become the new State Geologist of Ohio. Tom, who spent 24 years with the Pennsylvania Geological Survey mapping in the bituminous coal fields, the Pocono Plateau, and the Ridge and Valley province, became the 11th State Geologist of Ohio on March 13, 1989, preceded in the position by such eminent geologists as William W. Mather, John S. Newberry, Edward Orton, and George White. The history of the Ohio Geological Survey nearly parallels that of the Pennsylvania Geological Survey. The Ohio Survey began in 1837, one year after the First Survey began in Pennsylvania, and is now in its fourth organizational structure, as is the Pennsylvania Geological Survey.

Tom became well known in Pennsylvania through his compilation work on the 1980 geological map, which significantly improved upon prior editions. As part of this compilation, Tom did extensive field reconnaissance for the north-central part of Pennsylvania. This work evolved into remapping of the bedrock and surficial geology of Warren County, a project that became his final one as a member of the Pennsylvania Geological Survey. This new map will appear as part of a report on the groundwater resources of Warren County being prepared by the Survey's Environmental Division in cooperation with the U.S. Geological Survey.
While a member of the Pennsylvania Geological Survey, Tom also became well known for his work on Archanodon (the upper Paleozoic clam burrow), Upper Devonian and Lower Mississippian stratigraphy, and mapping of glacial and surficial deposits. Important products that resulted from Tom’s lead role in the 1980 geologic map were the first-ever published correlation chart of Pennsylvania rocks and the atlas of preliminary geologic quadrangle maps of Pennsylvania (Map 61), which has been one of the most useful sets of maps in the Survey’s history.

We are very sorry to lose the experience, knowledge, and companionship of Tom, but we are glad that another state has recognized his capabilities and has selected Tom to lead its Survey. We wish Tom all success.

We trust that, much as in the celebratory cake feasted upon on Tom’s last day, there will be no geological or administrative border faults between Ohio and Pennsylvania.

**ADMINISTRATIVE ASSISTANT EARNS ACHIEVEMENT AWARD**

Cheryl L. Cozart, an Administrative Assistant in the Oil and Gas Geology Division in Pittsburgh, received the Secretary’s Award for Outstanding Achievement at the Department’s Employee Recognition Program Awards Luncheon in October 1988. Ms. Cozart was honored for her outstanding work in developing several important data bases on the Division’s Sperry IT/PC computers. These include, but are not limited to, data bases dealing with oil and gas well statistics, oil and gas production, geophysical-log requests, and billing for copying services. Through the hard work of Ms. Cozart, the Division now has an easier task of collecting and disseminating information on oil and gas in Pennsylvania.

Flanking Ms. Cozart is Secretary of Environmental Resources Arthur A. Davis (left) and Deputy Secretary for Resources Management James R. Grace.
Pennsylvania Geologist Receives National Award

The Association for Women Geoscientists Foundation (AWGF) awarded its first Outstanding Educator Award to Dr. Maria Luisa Crawford of Bryn Mawr College. The award was given at a special breakfast on November 2, 1988, during the Geological Society of America National Convention in Denver, Colorado. The award was given by the Foundation in recognition of Dr. Crawford as an outstanding educator who has demonstrated excellence and commitment to the higher education of women students in the field of earth science. The award was doubly significant because it was given at the Centennial celebration of the Geological Society of America.

The AWGF was established by the Association for Women Geoscientists in 1983 to develop and fund innovative programs designed to encourage women to study earth science and to investigate career opportunities and advancement in the geoscience professions.

Dr. Crawford (Weecha to her colleagues) has provided a role model to many young women studying geology and preparing to enter geoscience professions. A researcher of the highest caliber, Weecha Crawford has chaired the Geology Department at Bryn Mawr for 12 years, published more than 80 papers and abstracts, and received more than a dozen National Science Foundation grants for her work. She is truly an inspiration to everyone in her field and has made major contributions to the geology of Pennsylvania.

(continued from page 1)

most probably suffer. This problem demands that our leaders who establish state and national policies understand the complexity and implications of availability of natural resources on which we depend. The State and U.S. Geological Surveys, as well as the U.S. Bureau of Mines, together can assist our state and national leaders by providing the framework for investigating and understanding natural-resource availability.

Donald M. Hoskins
State Geologist
PENNSYLVANIA GEOLOGICAL SURVEY STAFF

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IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY

TOPOGRAPHIC MAPPING
GROUNDWATER-RESOURCE MAPPING
GROUNDWATER LEVELS FOR FEBRUARY 1989

EXPLANATION

Above last year
Below last year
Observation well
Above last year
Below last year
Observation well equipped with data-collection platform
No data
High
Normal range
Low

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