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ON THE COVER
Early Mesozoic fluvial conglomerate in the Newark remnant of the Birdsboro basin, 10 km (6 mi) east-southeast of Reading, Pa. (see article on page 2). The rock consists of subrounded to angular clasts (pebbles to small cobbles) of carbonate in a poorly sorted matrix of grayish-red muddy siltstone and angular grains of carbonate sand. Ballpoint pen for scale. Photograph by Rodger T. Faill.

PENNSYLVANIA GEOLOGY
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VOL. 34, NO. 4 WINTER 2004
STATE GEOLOGIST’S EDITORIAL

Say Hello to TAGIC

As our name implies, we map both the geology and the topography of the commonwealth. I have been pushing the topographic mapping aspect of our mission for the first three years of my tenure. As a result, we have a PAMAP program in place, which has been generously supported by DCNR as well as many other state agencies. This year we have plans to fly 28 of our state’s 67 counties. This means that we will soon have more than half the state done. On a similar note, we have worked with the U.S. Department of Agriculture to upgrade their annual flight of color infrared orthoimagery. The DCNR Bureau of Forestry supplied most of the funding for this upgrade. So as of today, we have a “snapshot” of the commonwealth. This is particularly useful for monitoring land-use change over time.

So, you may say, enough on the air photos already. Well, I have to agree. What are we going to do about mapping those rocks? One step we are taking is to implement a revision of a program started many years ago. The idea is to collect geologic information that is ephemeral, such as from road cuts, before they get grown over, or from open mines, before they are reclaimed.

The Temporarily Available Geologic Information Collection (TAGIC) program will encourage our staff to document sinkholes, road cuts, landslides, and other transient geologic sites and enter the information into our newly emerging, comprehensive database. The results should be that more of our staff will be doing geologic mapping and that fewer items of geologic interest will slip by undocumented. TAGIC should help us do for geology what is in progress for topography. And since we cannot be everywhere, please assist us by bringing these temporary phenomena to our attention.

Jay B. Parrish
State Geologist
INTRODUCTION. A swath of predominantly red rocks crosses southeastern Pennsylvania, weathering into a distinctive red soil. This swath, commonly called the Triassic basin, is part of a long, sinuous belt that reaches from southern New York, across New Jersey, Pennsylvania, and Maryland, and into Virginia. This belt is what remains of a 200-million-year-old sedimentary trough, the Birdsboro basin (Figure 1), which formed prior to the opening of the Atlantic Ocean. The Birdsboro basin (Faill, 2003) began forming approximately 225 million years ago (Ma) at the beginning of the Late Triassic Period, and it gradually enlarged and filled for some 35 million years before being tilted, faulted, and folded in the latter part of the Early Jurassic Period (approximately 180 Ma). Subsequent erosion has left us with four basin remnants: the Newark (New York to Pennsylvania), Gettysburg (Pennsylvania and Maryland), Culpeper (Virginia), and Barboursville (Virginia) remnants (Figure 1, inset map).

The four deformed and eroded basin remnants we see today are quite different from the early Mesozoic Birdsboro basin from which they came. The Birdsboro basin was a single continuous trough. Depositionally, this sinuous, elongate basin was complex. Sediment input by fluvial processes from both sides produced large, near-margin alluvial fans; yet the differences in provenance and stream geometry produced markedly different sediment bodies. In addition, the finer grained fractions of sediment (the muds) were winnowed from these high-energy environments and carried by axial currents to quieter parts of the basin. This pattern pervades all four remnants.

ORIGIN OF THE BIRDSBORO BASIN. About 225 Ma, the Appalachian Mountain system created by the Alleghany orogeny some 25 to 30 million years earlier was still an impressive mountain chain, albeit reduced through erosion from its initial Himalayan-like dimensions. The mountain core, passing just southeast of Pennsylvania, across New Jersey and eastern Maryland, is now largely covered by the Atlantic Coastal Plain sediments. But at the beginning of the Late Triassic, the mountain core still stood exposed some 2 to 4 km (1 to 3 mi) in ele-
Figure 1. Map of the Birdsboro basin in the Central Atlantic Region of Eastern North America showing schematically the drainage into and the depositional environments within the basin (modified from Faill, 2003, Figures 1, 2, 4, and 5). The four remnants of this early Mesozoic basin (see inset map) are as follows: B, Barboursville; C, Culpeper; G, Gettysburg; and N, Newark.
vation, and the streams and rivers on it flowed northwestward across New Jersey, Pennsylvania, Maryland, and Virginia.

At that time, the crust under the Appalachian Mountains began to extend in a northwest-southeast direction, causing the mountain system to slowly descend. But the descent was not even. Unknown crustal inhomogenieties caused accelerated subsidence along a northeast-southwest-trending belt on the northwest side of the mountain core, resulting in a trough at the surface. This trough was the beginning of the Birdsboro basin.

**SOUTHEAST PROVENANCE.** The trough interrupted the flow of the many streams coming off the mountain core, causing the streams to deposit the sand, silt, and mud they were carrying along the southeast edge of the trough. These sediments, originating in granitic terranes to the southeast, were arkosic, being fairly rich in feldspars (Glaeser, 1966). The accumulation of these sediments created subaerial alluvial fans, which, because of the close spacing of the streams, coalesced over time into a single alluvial plain, a bajada. This body of sediment along the southeast side of the Birdsboro basin formed the rocks now called the Stockton Formation (New York, New Jersey, and Pennsylvania), the New Oxford Formation (Pennsylvania and Maryland), and the Manassas Formation (Virginia) (Figure 2).

**NORTHWEST PROVENANCE.** Sediment did not enter the basin only from the southeast. As the accelerated subsidence continued under the trough, the slower subsidence to the northwest produced a broadening upland that became a source of sediment in itself. The absence of granitic terranes to the northwest precluded the presence of feldspars in the southeastward-flowing streams. Another difference lay with the streams. Prior to the formation of the trough, the numerous smaller streams high on the northwest slope of the mountains had coalesced into fewer larger rivers lower on the slope. When the trough formed, these rivers reversed direction and each carried correspondingly more sediment into the basin. This sediment accumulated in large alluvial fans along the northwest margin of the basin. The Hammer Creek alluvial fan in the “narrow neck” of the Gettysburg remnant (Glaeser, 1966) is characteristic. Unlike the alluvial fans on the southeast side of the basin, however, these fewer and more widely spaced fans remained distinct and did not coalesce into a bajada. As the northwest drainage area enlarged with time, the alluvial fans grew larger. Four major rivers produced four regional alluvial fans (Figure 1): the Mahwah, Hammer Creek, Goose Creek, and Cedar Mountain. Strati-
Figure 2. Stratigraphic correlation chart of the Birdsboro basin for each of the basin remnants (modified from Faill, 2003, Figure 3). The upper undulate curve represents the age of the youngest preserved Mesozoic rocks. The lower undulate curve does not simply represent the age of initiation of sedimentation; it is also an estimate of the preserved thickness of the bajada. Variations in this thickness may reflect the areal extent of the bajada environment (wider is thicker) or the persistence of sediment input (longer is thicker).
graphically, these fans correlate respectively with the northeast side of the Passaic Formation in New Jersey, the Hammer Creek Formation in Pennsylvania, the Catharpin Creek Formation in northern Virginia, and the Haudricks Mountain and Cedar Mountain Members of the Bull Run Formation in central Virginia (Faill, 2003; Figure 2).

QUIETER ENvironments WITHIN THE BASIN. The coarse- to medium-grained fluvial sediments (sands and silts) that entered the elongate Birdsboro basin from both sides accumulated in the alluvial fans and the alluvial plain. The finer grained sediments (muds) were winnowed and carried by axial currents from these high-energy environments to low-energy areas. The low-energy areas, dominated by lake and playa environments, lay between the alluvial fans and extended for some distance from the bajada along the southeast margin (Figure 1). The bodies of fine-grained sediments formed rocks found in the present-day Lockatong Formation (New Jersey and Pennsylvania), Passaic Formation (New York, New Jersey, and Pennsylvania), Gettysburg Formation (Pennsylvania and Maryland), and Bull Run Formation (Maryland and Virginia) (Figure 2).

The gray and red shales, mudstones, and argillites that fill the quiet areas exhibit remarkable features. An extensive interlayering exists between the coarser grained rocks of the alluvial fans and bajada and the fine-grained rocks of the playas and lakes. The gradual decrease in grain size in general is a function of distance from input area, but the interlayering reflects climatic changes (predominantly moisture) as well as fluctuation in the volume and content of the incoming sediment. The climatic influence appears to be the more dominant factor because a pervasive cyclicity persists through most of the rocks in the quieter areas (Van Houten, 1964; Olsen, 1986; Smoot, 1991), a cyclicity controlled by the astronomical Milankovitch cycles (Van Houten, 1969; Olsen, Kent, and others, 1996). In the wetter parts of the cycles, the lakes expanded onto the distal margins of the alluvial fans; during the drier periods, the lakes shrank, leaving behind playa conditions.

There are two remarkable aspects of the climatic cycles: (1) the cyclicity persisted for more than 25 million years, and (2) many of the cycles can be traced for over 100 km (60 mi), from one alluvial fan to the next. These two aspects strongly imply that the basin was tectonically quiescent for most, if not all, of its history.

But this seems at odds with the prevailing view of these early Mesozoic basins—they are generally considered to be rift basins formed by active, syndepositional faulting at the down-dip margins (the margins toward which the bedding dips). The primary features used to support
this view are the coarse-grained, poorly sorted fanglomerates found along the basin margins.

**THE FANGLOMERATES.** The fanglomerates are one of the more interesting deposits in the Birdsboro basin. They are small, rarely extending more than 2 or 3 km (1 or 2 mi) from the basin margin. They are commonly no more than 200 to 300 m (600 to 1,000 ft) thick. They contain numerous pebbles and cobbles (rarely more than 10 cm [4 in.] in size) floating in a matrix of (generally) red mud and silt (see front cover). This texture is very different from those of the fluvial deposits found throughout the basin. The large clasts and poor sorting suggest that these deposits formed as debris flows rather than by fluvial processes. These debris flows probably originated in flash-flood runoffs from occasional cloudbursts, runoffs that entrained any colluvial or alluvial material that had accumulated just outside the basin. These slurries of cobbles, pebbles, silt, and mud rushed into the basin, but only for a short distance; the flash floods could not sustain the water flow and energy necessary to spread the larger clasts any farther.

The Birdsboro fanglomerates are of two principal varieties—quartzose and carbonate. The clasts in the quartzose fanglomerates consist primarily of vein quartz, quartzites, and felsic gneisses. The clasts tend to be well rounded, indicating that they have probably traveled a considerable distance (tens of kilometers). In addition, many of the gneisses are not represented in nearby outcrops, further indicating a distant source. In contrast, many of the limestone and dolomite clasts of the carbonate fanglomerates are subrounded to angular, suggesting a more proximal source. Given the arid to semiarid climate of that time, carbonate terranes outside the basin would have been hilly. They would have weathered mechanically, shedding angular fragments that accumulated at the foot of slopes as colluvial deposits and were available for entrainment in the occasional flash floods.

The Leesburg fanglomerate, which is represented today by the Leesburg Member of the Bull Run Formation in Virginia (Figure 2), was an exceptionally large fanglomerate, extending for 55 km (35 mi) along the basin margin and 30 km (20 mi) across the basin (Figure 1). The clasts in this fanglomerate are angular carbonate pebbles, cobbles, and even a few small boulders. It probably originated in a large carbonate terrain away from the major rivers.

**IMPLICATIONS FOR BASIN TECTONICS.** The fanglomerates did not contribute much sediment to the Birdsboro basin, but their presence sheds light on the development of the basin. Most geologists accept the presumption that the presence of fanglomerates indicates syn-
depositional faulting at the margin of a basin—that fanglomerates form only at the foot of a rising fault scarp (e.g., Russell, 1892, p. 83; Barrell, 1915; and Kay, 1951). However, the fanglomerates are present on both sides of the Birdsboro basin, on the updip, nonfaulted southeast side as well as on the downdip northwest side. Clearly, fanglomerates can be produced by some mechanism other than faulting, such as the geomorphic process described at the end of the previous paragraph.

Several other aspects indicate that faulting did not occur during basin filling. First, seismic and drilling data indicate that the basin floor near the northwest margin dips 25 degrees to the southeast, not a steep dip to the northwest as would be expected in a half graben. Second, faults are present along some parts of the northwest margin, but elsewhere the sinuous trace of the margin suggests an overlap relation. Third, the basin floor is exposed next to the northwest margin—in a half graben, the basin floor would be at 5 to 7 km (3 to 4 mi) depth. Fourth, the faults that are present offset and truncate Jurassic rocks and terminate downsection—nowhere can Triassic movement be confirmed. And fifth, the tectonic quiescence implicit from the subtle Milankovitch cyclicity is not consistent with episodic fault movements. These aspects indicate that the Birdsboro basin developed as a nonfaulted trough through simple crustal downwarping (Figure 3A).

**JURASSIC IGNEOUS EPISODE AND SEDIMENTATION.** The Birdsboro basin experienced an episode of igneous activity just after the beginning of the Jurassic Period (note the volcanic layer in Figure 2). The activity was fairly short-lived, lasting for approximately 600,000 years (Olsen, Schlische, and Fedosh, 1996). The igneous rocks were emplaced in three forms: as volcanic rocks on the surface of the basin, as intrusive sills (thick, subhorizontal sheets), and as subvertical dikes (Smith and others, 1975). Igneous rocks are present in one or more of these forms throughout the Newark, Gettysburg, and Culpeper basin remnants, and as dikes through much of the surrounding pre-Mesozoic terranes. The igneous rocks are tholeiitic basalts, similar in composition to coeval igneous rocks to the northeast and southwest along the Central Atlantic margin.

Sedimentation continued in the basin during the igneous episode and thereafter. Coarse-grained sediment entered predominantly from the northwest. Lacustrine conditions persisted throughout much of the basin (the Jurassic climatic cycles are markedly thicker), and fanglomerates accumulated near the basin’s northwest margin. The Jurassic fanglomerates contain basaltic fragments, which suggests that the
A. EARLY JURASSIC

Figure 3. Cross sections through the Newark remnant of the Birdsboro basin along the Delaware River. A. Partially filled basin in the Early Jurassic. B. What remains of the same section after deformation and erosion. Arrow indicates the approximately 15-degree northwestward rotation of much of the basin.
volcanic flows had spread some distance beyond the basin margin and correspondingly that the topographic relief must have been low there. The youngest sediments of the Birdsboro basin, present only in the Newark remnant (Figure 2), are of Sinemurian age (approximately 200 Ma) within the Early Jurassic. The Birdsboro basin may have continued to fill past this time, but no direct evidence of such sediments are preserved.

**POSTDEPOSITIONAL BASIN DEFORMATION.** The four present basin remnants are quite different from the simple downwarp that contained the Birdsboro basin. Clearly, some tectonic activity occurred postdepositionally. The most prominent, widespread structure is the monoclinal tilt of bedding—in each remnant, bedding dips generally to the northwest (Figure 3B). The amount of dip varies between and within each remnant, from as low as 5 or 10 degrees to as much as 60 degrees. Across some parts of the remnants, the dip is constant, from the oldest beds on the southeast margin to the youngest on the northwest. The unconformity along all the southeast margins and the absence of any faulting (excepting a few small cross faults) indicates that the crust under the basin remnants was tilted as well. So the remnant rotation (tilt) reflects a fairly widespread crustal tectonism.

Faults are quite common within the remnants. Some lie along the northwest margin, some cross one or the other margin, and some are intrabasinal. The faults are predominantly of the normal type, although strike-slip and even a few small thrust faults are present. Displacements range from a few meters to more than 3 km (2 mi). Although faults offset the oldest as well as the youngest rocks in the basin, they were not active during sedimentation—the movements were all post-depositional. In addition to the faults, open folds (some with axial-plane cleavage) occur along the northwest margin in the Newark remnant. These folds encompass the youngest preserved rocks.

It is quite evident that all the deformation of the Birdsboro basin was postdepositional, occurring sometime after the early Sinemurian (Faill and Smith, 2003). When one looks for a crustal event that could have caused the tilting, faulting, and folding, the only significant post-Sinemurian event is the opening of the Atlantic Ocean late in the Early Jurassic. It appears that the separation of North America from Africa released the attenuating crustal stresses, producing a crustal rebound that deformed the Birdsboro basin. Erosion since that time (mainly through the remainder of the Jurassic, the Cretaceous, and the Tertiary) has removed a large volume of the original basin, leaving us with the deformed remnants we see today.
SUMMARY. The Birdsboro basin formed as a sinuous, linear trough on the northwest side of the Appalachian orogen through simple downwarping in the Late Triassic. Sediment entered the basin from both the northwest and southeast, creating large alluvial fans and a bajada. The finer grained sediment passed through these higher energy environments and settled in quieter lakes and playas. Late in the Early Jurassic, in conjunction with the opening of the Atlantic Ocean farther to the east, the basin was tilted and deformed by faults and folds. Erosion since that time has left us with the four basin remnants that we see today.

REFERENCES


Pennsylvania’s Master Well Owner Network

by Jay B. Parrish and Kristin M. Carter
Bureau of Topographic and Geologic Survey

Think about this: there are approximately 3.5 million residents throughout Pennsylvania with private water systems,¹ and a majority of these systems fail at least one drinking water standard.

In August 2004, Kristin Carter, a Bureau staff member, took an eight-hour training course offered by the Penn State Cooperative Extension to become a certified Master Well Owner in the state of Pennsylvania. Kristin owns a home in suburban Washington County where no public water supply is available. As a private well owner with a growing family, she was concerned about the quality, condition, and ongoing operation and maintenance of her well.

The training courses offered by the Penn State Cooperative Extension are associated with a program known as the Master Well Owner Network (MWON). This grassroots network was created to train individuals like Kristin, who in turn volunteer their time to educate the public about private water systems. They do this through various means, including work, social, and volunteer connections. The goal of each Master Well Owner is to personally interact with 100 people over a two-year certification period. Your local Master Well Owner can help you sort through the technical aspects of siting, constructing, and maintaining a private water system, answer questions about testing the quality of your water, and offer water conservation tips, among other things.

The MWON is sponsored by the Penn State Institutes of the Environment and is currently funded by the U.S. Department of Agriculture, Cooperative State Research, Education and Extension Service. Project partners include the Pennsylvania Groundwater Association, Pennsylvania Department of Environmental Protection, U.S. Environmental Protection Agency, and Pennsylvania Rural Water Association.

Given current funding, the MWON program can train up to 240 Master Well Owners statewide. Solicitation of new MWON participants

¹Private water systems include wells, springs, and cisterns.
continues even as this issue of *Pennsylvania Geology* is published. Figure 1 shows the number and distribution of Master Well Owners by county. To date, 216 volunteers have been certified as Master Well Owners in 54 counties throughout the commonwealth.

Learning to test well water for potential contaminants, learning about well maintenance, and learning the inputs and outputs of the hydrologic cycle are all part of the training to become a Master Well Owner (Figure 2). It is not a regulatory effort. Kristin’s aim is to help well owners become more aware of where their water comes from, how to keep their private water supply safe from contamination, and how to care for a home water well.

Figure 1. Master Well Owner Network regions in Pennsylvania. The number of certified Master Well Owners as of March 2005 is noted by county.

Figure 2. Kristin Carter tests well water quality for a homeowner in Washington County in September 2004.
So think about the source of your drinking water and seek out a Master Well Owner in your area. Visit the Master Well Owner Network’s home on the web at http://mwon.cas.psu.edu/ for additional information.

ANNOUNCEMENT

Geologic Publications on Sale

Rock-Bottom Prices—Limited Time Only!

A warehouse inventory reduction sale on selected publications of the Pennsylvania Geological Survey is currently in progress. For a limited time, dozens of publications will be drastically reduced in price prior to moving our stock to a new warehouse. A list of sale titles and prices is posted on the Bureau’s web site at www.dcnr.state.pa.us/topogeopub/sale.aspx. The site also contains additional details about the publications, information on ordering, and a special order form that may be used by customers for the period of the sale. All publications are sold through the State Bookstore, Commonwealth Keystone Building, 400 North Street, Harrisburg, PA 17120–0053, telephone 717–787–5109. The Bookstore accepts orders either over the counter or by mail.

The publications vary widely in topic, technical content, geographic area covered, number of pages or maps, and year of publication. For example, the list includes Atlas 144cd, Geology and Mineral Resources of the Allenwood and Milton Quadrangles, Union and Northumberland Counties, Pennsylvania, printed in 1997 (list price $24.00, sale price $4.00), Environmental Geology Report 5, Building Stones of Pennsylvania’s Capital Area, printed in 1977 (list price $1.50, sale price $0.45), and Water Resource Report 67, Groundwater Resources of Cambria County, Pennsylvania, printed in 1998 (list price $11.50, sale price $2.35).

To find the publications that are of interest to you, visit our web site. Keep in mind that the list will be changing. Some titles that are already in low supply will go out of print, and others will be removed from the sale list as they reach their targeted inventory. SO HURRY! Take advantage of these rock-bottom prices and order your publications now!
The Pennsylvania Rock Hound Kit

by Kristen L. Hand
Bureau of Topographic and Geologic Survey

In the editorial of a recent issue of *Pennsylvania Geology* (v. 34, no. 2, p. 1), Jay Parrish announced a new version of the Pennsylvania Geological Survey rock boxes. The column spawned so much interest in our *Pennsylvania Rock Hound Kit* that we decided to give our readers a little more information about this product.

The Pennsylvania Rock Hound Kit is a partitioned box containing 12 samples of Pennsylvania native rocks collected from across the state and 6 open spaces, which we hope the owner of the kit will be inspired to fill with their own special Pennsylvania rock specimens.

The cover insert unfolds to reveal a listing (rock type, unit, and age) of the 12 samples and a geologic map of the state showing the location where each sample was collected (see back cover). The kit also comes with an interactive CD–ROM that contains lesson plans made specifically for the kit, a short film about the Pennsylvania Geological Survey, several of our educational publications and page-size maps, interactive games, georeferenced statewide datasets, and additional general geologic lesson plans and activities. Classroom kits consisting of 30 pieces of each of the 12 specimens and 1 cover insert are also available. The students can make their own rock box out of an egg carton or other materials brought from home and fill it with the rocks from these kits.

So, why are we doing this? That’s easy! Pennsylvania is fortunate to have a variety of wondrous geology and a rich geologic history. Our goal is to try to bring at least 12 little pieces of that into everyone’s home and especially into the classrooms of our children across the state. In order for us to bring the rocks into the classrooms for free, we need to sell the boxes. The program has two major components: (1) hosting teacher workshops across the state to bring Pennsylvania geology into the classroom, and (2) selling rock kits to the public.

The teacher workshops, which vary by host, are partial- or full-day workshops where teachers have the opportunity to assemble their own boxes. A workshop may also include a rock box assembly com-
petition, a geology field trip, and a review of the lesson plans that were developed specifically for the kits. On the field trip, participants learn about local geology—how to bring the geology that is under the grass in their own backyard into their curriculum. Lunch is provided for full-day workshops, and depending on the host, Act 48 credits may be offered. Teachers receive three rock hound kits and one classroom kit. There is normally a small charge to pay for lunch and other related fees. Workshops will be announced on the Bureau’s web site (www.dcnr.state.pa.us/topogeo) as they are offered.

This project was undertaken with the cooperation of the Field Conference of Pennsylvania Geologists, Pennsylvania Department of Education, and Pennsylvania Aggregates and Concrete Association. None of this would have been possible without the assistance and cooperation of all of our partners.

As was mentioned above, we need to sell boxes in order to make the classroom component of the program possible. The proceeds of every individual box sold is directly reinvested into producing more kits to put into classrooms across the commonwealth. Purchasing your new Pennsylvania Rock Hound Kit is simple. You can stop by either one of the two Bureau offices (see inside back cover for addresses) and pick one up for $15. For teachers not attending a workshop, classroom kits are also available for $30. Another option is to order individual or classroom kits and have them mailed to you; just add an additional $4.95 for shipping and handling for each item ordered. Send a check or money order payable to Field Conference of Pennsylvania Geologists and your name, shipping address (no P.O. Box), and items you wish to order to Kristen Hand, Bureau of Topographic and Geologic Survey, 3240 Schoolhouse Road, Middletown, PA 17057. For your convenience, an order form is available through the classroom link on our web site. I am sorry, but we do not accept credit or debit cards. If you have any questions, feel free to contact me at 717–702–2047.

Please join us in our endeavor to bring geology into the homes and classrooms across our geologically rich commonwealth and to help everyone to get to know the geology of the state by looking under the grass in their own backyards. Buy your Pennsylvania Rock Hound Kit today!
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ON THE COVER

Early Mesozoic flanngelurate in the Newark remnant of the Birdsboro basin, 10 km (6 mi) east-southeast of Reading, Pa. (see article on page 2). The rock consists of subrounded to angular clasts (pebbles to small cobbles) of carbonate in a poorly sorted matrix of grayish-red muddy siltstone and angular grains of carbonate sand. Ballpoint pen for scale. Photograph by Rodger T. Faill.

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COLLECTION LOCATIONS OF ROCK KIT SPECIMENS

(See article on page 15.)

EXPLANATION

1. Sandstone (sedimentary)
   Mississippian Pocono Fm.
2. Shale (sedimentary)
   Ordovician Martinsburg Fm.
3. Limestone (sedimentary)
   Ordovician Epler Fm.
4. Diabase (igneous)
   Jurassic age
5. Gneiss (metamorphic)
   Precambrian Baltimore Gneiss
6. Arglilite (metamorphic)
   Triassic Gettysburg Fm.
7. Dolomite (sedimentary)
   Cambrian Ledger Fm.
8. Anthracite coal (metamorphic)
   Pennsylvanian age
9. Metabasalt (metamorphic/igneous)
   Precambrian Catoctin Fm.
10. Serpentinite (igneous/metamorphic)
    Baltimore Mafic Complex (uncertain age)
11. Marble (metamorphic)
    Cambrian Kinzers Fm.
12. River gravel (various rock types)
    Quaternary age

1 Simplified from the insert map for the Pennsylvania Rock Hound Kit, which also shows geologic units in full color.