MARYLAND GEOLOGICAL SURVEY

Kenneth N. Weaver, Director

GUIDEBOOK NO. 2

NEW INTERPRETATIONS OF THE EASTERN PIEDMONT GEOLOGY OF MARYLAND

OR

GRANITE AND GABBRO OR GRAYWACKE AND GREENSTONE

William P. Crowley, Maryland Geological Survey
Michael W. Higgins, U. S. Geological Survey
Tyler Bastian, Maryland Geological Survey
Saki Olsen, Johns Hopkins University

A GUIDEBOOK PREPARED FOR THE 1971 ANNUAL MEETING

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GEOLOGICAL SOCIETY OF AMERICA

FIELD TRIP NO. 4

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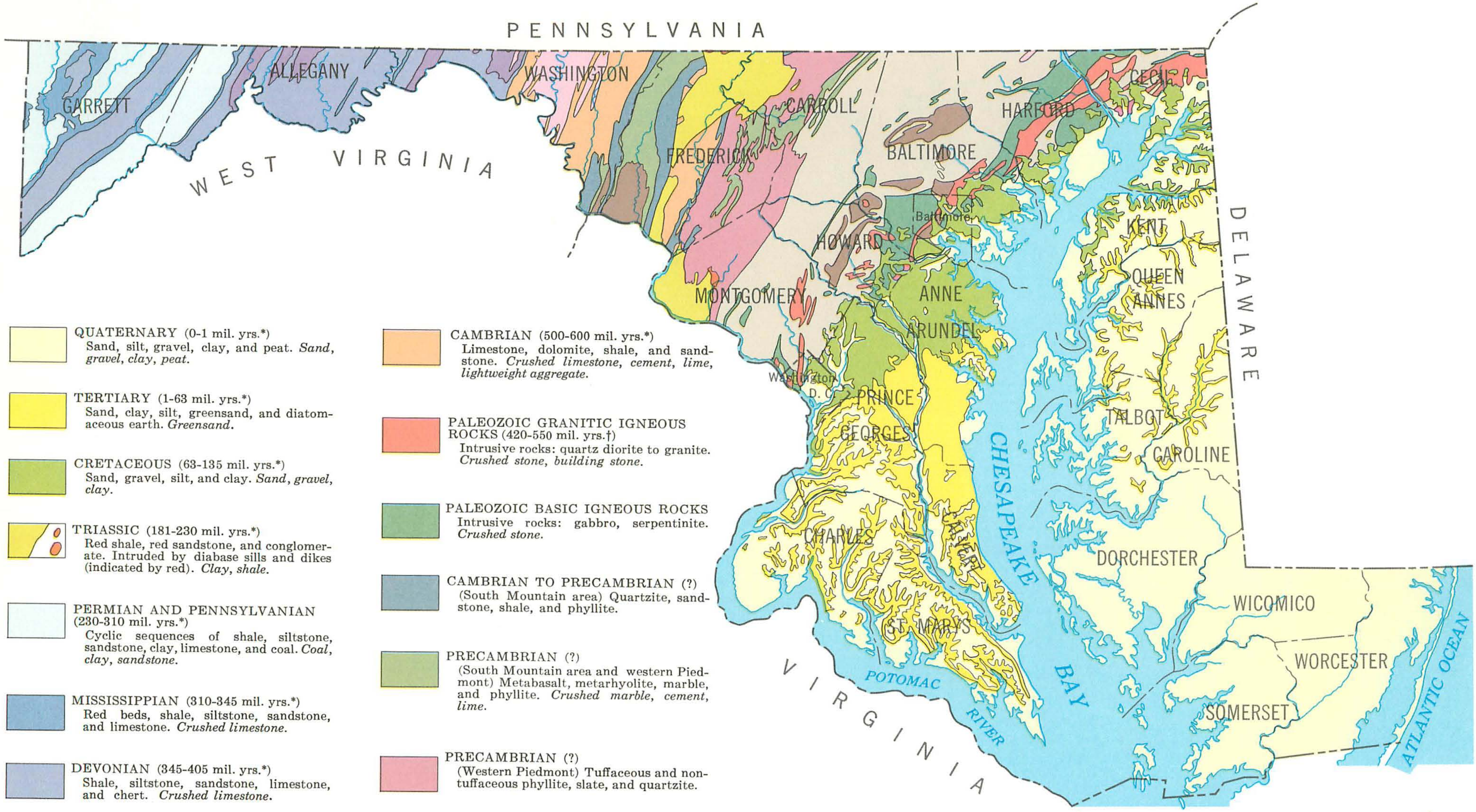
ILLUSTRATIONS



QUATERNARY (0-1 mil. yrs.*)
Sand, silt, gravel, clay, and peat. *Sand, gravel, clay, peat.*

TERTIARY (1-63 mil. yrs.*)
Sand, clay, silt, greensand, and diatomaceous earth. *Greensand.*

CRETACEOUS (63-135 mil. yrs.*)
Sand, gravel, silt, and clay. *Sand, gravel, clay.*

TRIASSIC (181-230 mil. yrs.*)
Red shale, red sandstone, and conglomerate. Intruded by diabase sills and dikes (indicated by red). *Clay, shale.*

PERMIAN AND PENNSYLVANIAN (230-310 mil. yrs.*)
Cyclic sequences of shale, siltstone, sandstone, clay, limestone, and coal. *Coal, clay, sandstone.*

MISSISSIPPIAN (310-345 mil. yrs.*)
Red beds, shale, siltstone, sandstone, and limestone. *Crushed limestone.*

DEVONIAN (345-405 mil. yrs.*)
Shale, siltstone, sandstone, limestone, and chert. *Crushed limestone.*

SILURIAN (405-425 mil. yrs.*)
Shale, mudstone, sandstone, and limestone. *Glass sand, crushed limestone.*

ORDOVICIAN (425-500 mil. yrs.*)
Limestone, dolomite, shale, siltstone, and red beds. Slate and conglomerate in northern Harford County. *Crushed limestone, cement, clay, lime.*

CAMBRIAN (500-600 mil. yrs.*)
Limestone, dolomite, shale, and sandstone. *Crushed limestone, cement, lime, lightweight aggregate.*

PALEOZOIC GRANITIC IGNEOUS ROCKS (420-550 mil. yrs.†)
Intrusive rocks: quartz diorite to granite. *Crushed stone, building stone.*

PALEOZOIC BASIC IGNEOUS ROCKS
Intrusive rocks: gabbro, serpentinite. *Crushed stone.*

CAMBRIAN TO PRECAMBRIAN (?)
(South Mountain area) Quartzite, sandstone, shale, and phyllite.

PRECAMBRIAN (?)
(South Mountain area and western Piedmont) Metabasalt, metarhyolite, marble, and phyllite. *Crushed marble, cement, lime.*

PRECAMBRIAN (?)
(Western Piedmont) Tuffaceous and nontuffaceous phyllite, slate, and quartzite.

PRECAMBRIAN (?)
(Eastern Piedmont) Schist, metagraywacke, quartzite, marble, and metavolcanic rocks. *Crushed stone, crushed marble, building stone.*

PRECAMBRIAN BASEMENT COMPLEX (1100 mil yrs.†)
Gneiss, migmatite, and augen gneiss.

MARYLAND GEOLOGICAL SURVEY
Kenneth N. Weaver, Director

GENERALIZED GEOLOGIC MAP OF MARYLAND‡
1967

10 0 10 20 30 40
1 inch equals 25 miles

Most important mineral products in italics.
* Age ranges from Kulp, J. L., 1961, Geologic time scale: Science, v. 133, no. 3459, p. 1105-1114.
† Radiometric dates made on Maryland rocks.

‡ A detailed Geologic Map of Maryland, 1968 at a scale of 1 inch equals 4 miles, is also available.

NEW INTERPRETATIONS OF THE EASTERN PIEDMONT GEOLOGY OF MARYLAND

INTRODUCTION

by William Crowley

The area to be visited by this field trip is the northeastern Piedmont of Maryland (Fig. 1), chiefly Baltimore and Cecil Counties (Figs. 11 and 2) with one stop in Harford County. The stops in Cecil County were chosen by Higgins to illustrate concepts derived from his recently concluded mapping there. The one in Harford County touches on some of the problems considered by Southwick (1969). Those in Baltimore County deal with the recent work of Hopson (1964), Crowley, and Olsen as well as the earlier work of Matthews (1904), Knopf and Jonas (1929), and Broedel (1937). Some comments on the Piedmont archeology of northeastern Maryland are offered by Bastian at Stop 4.

The first important work in this region was that of Professor George Huntington Williams and his students at Johns Hopkins University. Williams, an igneous petrologist who had studied under Rosenbusch, centered his attention on the gabbro complex west of Baltimore. His students worked on a variety of Piedmont igneous and meta-igneous rocks, ranging from felsic to mafic. The emphasis in all of these studies was an elucidation of the crystallization history of the rocks as deduced from detailed petrographic studies. Conclusions of regional geologic interest were limited for the most part to discussions of cross-cutting relationships. One important result of the work of this period that is relevant to this field trip was the discovery by Bascom (1902), an early student of Williams, that the potpourri of mafic and felsic gneisses in Cecil County included meta-rhyolite and greenstone.

Following Williams' untimely death in 1894 research leadership in Piedmont geology was assumed by Edward Matthews who was elected instructor at Johns Hopkins to offer the courses formerly given by Professor Williams. Although Williams had some concept of stratigraphic relations in the Piedmont, it remained for Matthews (1904) to work out in detail the correct stratigraphic sequence (shown in part in Fig. 12). The complete section is present in Baltimore and westernmost Harford County. In Cecil County only the uppermost part (Wissahickon Formation) crops out; the area there is underlain in large part by felsic and mafic gneisses that did not fit into Matthews' stratigraphic scheme.

By the 30's the emphasis had shifted to structure, and a new crop of geologists returned to the Piedmont armed with Ernst Cloos' concepts of the importance of small-scale planar and linear features in the interpretation of geologic history. A group of papers announcing the results of this new approach were assembled in 1937 into volume 13 of the Maryland Geological Survey. Among those papers that bear on this field trip are Broedel's on the Baltimore gneiss domes, Hershey's on the Port Deposit gneiss complex, and Marshall's on the Cecil County metavolcanics.

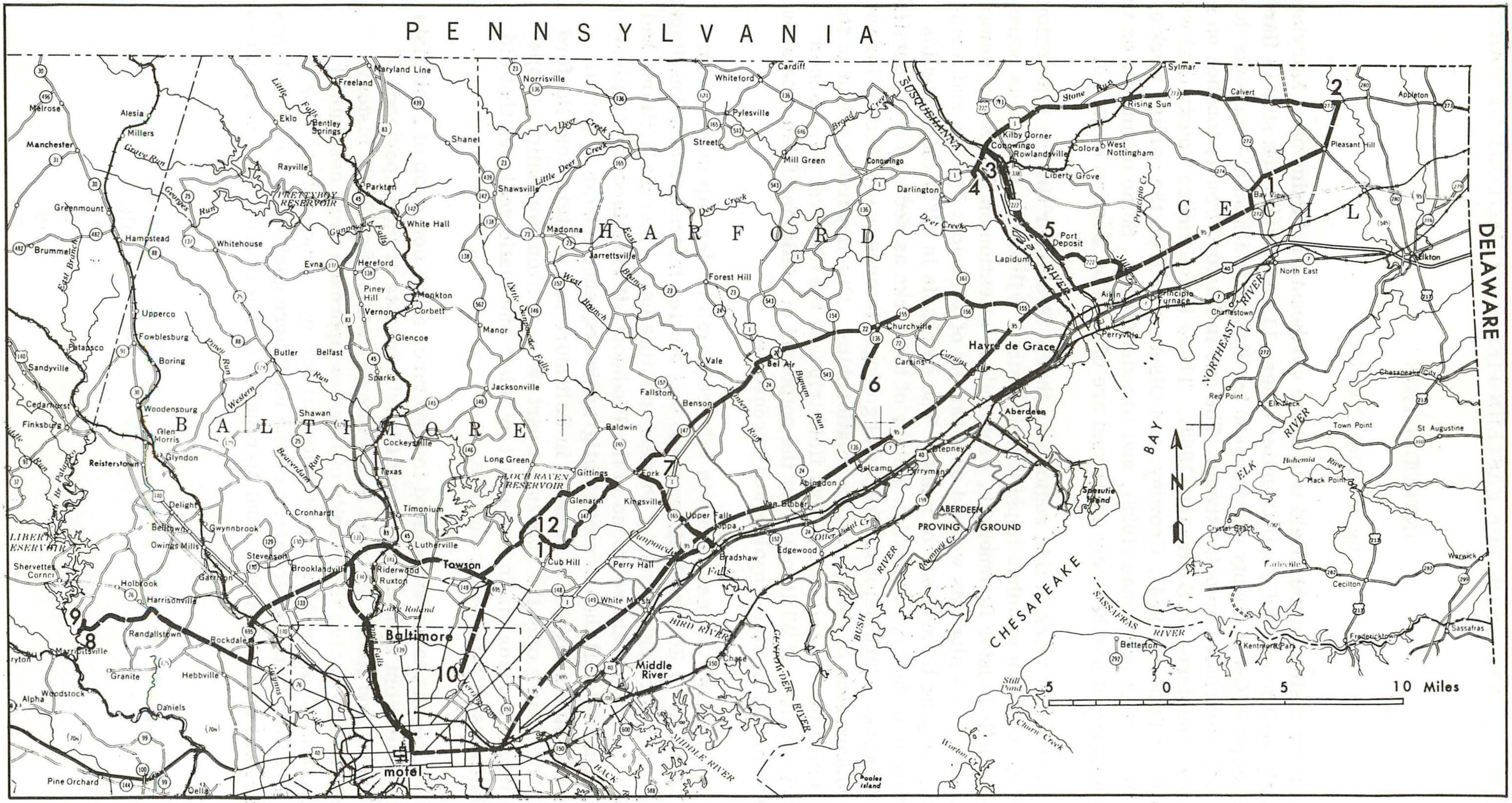


Figure 1. Road map showing field trip route and stops.

Hershey, in his concluding remarks, suggested that stratigraphic-structural evidence indicated a snyclinal geometry for the Port Deposit Granodiorite complex, a conclusion that has also been reached by Crowley farther south in Baltimore County. Recent work by Higgins (1971), however, has shown that what has been called "Port Deposit" includes rock types of diverse origins, and that the truly plutonic "Port Deposit" occupies a much smaller area than had been previously thought (Stops 3 and 5).

Several papers could be cited in the years following the 30's where the germ of an important idea was expressed. Clifford Hopson weaved many of these ideas along with his own very original thoughts into an elegant synthesis that appeared in 1964. Relevant to this field trip are Hopson's interpretation of the "Sykesville Granite" as a submarine slide deposit, an idea that has been extended by Higgins to parts of the Port Deposit Gneiss (Stop 3) and may be even more broadly applicable (Stop 6). Hopson also interpreted as volcaniclastic rocks certain layered gneisses that had been previously assigned to the Baltimore Gneiss, an interpretation subsequently extended by Southwick to similar gneisses in Harford County (Stop 6).

FIELD TRIP INTRODUCTION - FIRST DAY

METAVOLCANIC ROCKS AND EPIZONAL PLUTONS IN THE CECIL COUNTY PIEDMONT, MARYLAND

by Michael W. Higgins

Metavolcanic rocks underlie a far larger part of the Cecil County Piedmont than previously supposed (Fig. 2). These rocks range from basalt to rhyolite in composition, and from pillowed subaqueous flows to ash falls, some of which are mixed with detrital sedimentary material. They grade by increasing grain size and slight mineralogic changes into shallow, coeval plutonic rocks that were probably sources for the volcanic rocks.

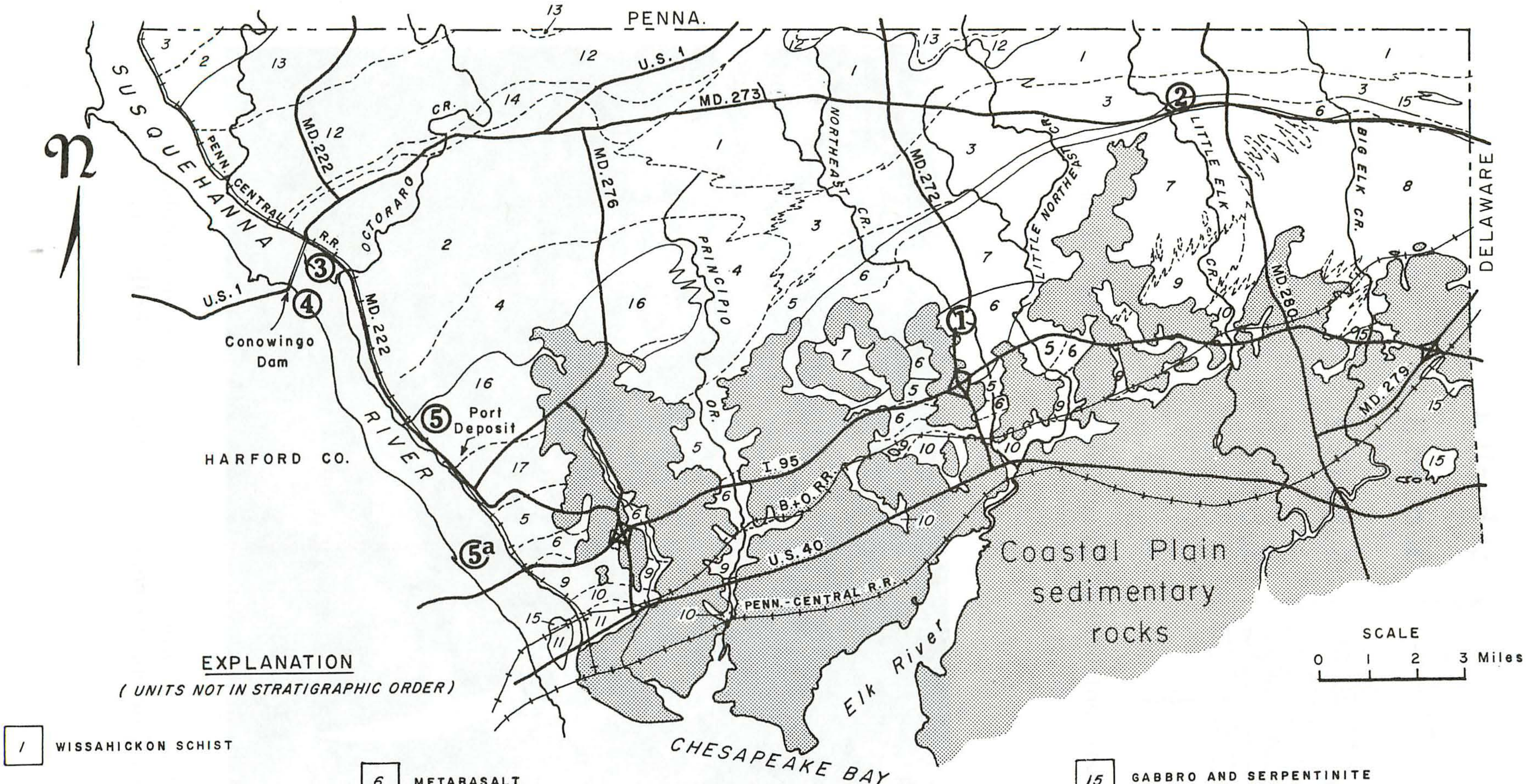
This part of the field trip concentrates on two of the more interesting and accessible examples of parts of this assemblage of volcanic and of plutonic-hypabyssal-volcanic rocks. The first example is a unit of pillow basalt, basaltic tuff, and pillow breccia, metamorphosed and locally sheared into amphibole schist and layered amphibolite. The second is the Port Deposit pluton, including the restrictions made on its size by the recent mapping and the gradation of its south-eastern border into metavolcanic rocks.

Metabasalt unit

Metamorphosed basaltic rocks crop out in a narrow, folded, S-shaped band across Cecil County (Fig. 2). This unit extends southwest into Harford County for an unknown distance, and northeast into Delaware. In Delaware, the meta-basalt blends gradually into amphibolite, and finally into massive, coarse-grained metamorphosed gabbro. The coarse-grained metagabbros at the Fall Line in eastern Cecil County (Fig. 2) probably also represent plutonic equivalents of this same metabasalt unit, although this cannot be proven because of the extent of the Coastal Plain cover.

The metabasalt unit is divisible into four stratigraphic parts, or subunits (Fig. 3), although all four of these are not present in every cross section through the unit. The lowermost of these subunits is composed of massive pillow lava (Fig. 4), with local thin chert beds near its top. The massive pillow lava grades upward into the second subunit composed of isolated pillow breccia (Carlisle, 1963) interlayered with thin beds of basaltic tuff. This second subunit grades upward into a third that consists chiefly of basaltic tuff, with local isolated pillows (Fig. 5), and local lenses of broken pillow breccia (Fig. 6); locally, this third subunit also has a few thin, discontinuous beds of felsic tuff and of volcanic-epiclastic rocks that must have been mixtures of ash and nonvolcanic sedimentary detritus. Near the top of the metabasalt unit, the basaltic tuffs of subunit three grade into coarse-grained basalt flows (?) of subunit four. Locally, subunit four also contains fine-grained volcaniclastic rocks.

Figure 2. PRELIMINARY GEOLOGIC SKETCH MAP OF CECIL COUNTY, MD.



EXPLANATION

(UNITS NOT IN STRATIGRAPHIC ORDER)

Unit	Description
1	WISSAHICKON SCHIST
2	WISSAHICKON DIAMICTITE
3	WISSAHICKON METAGRAYWACKE
4	WISSAHICKON METAGRAYWACKE AND MAFIC METAVOLCANIC ROCKS
5	FELSIC METAVOLCANIC ROCKS
6	METABASALT
7	METARHYOLITE
8	EPIZONAL GRANITE
9	INTERLAYERED MAFIC AND FELSIC METAVOLCANIC ROCKS
10	FELSIC METAVOLCANIC ROCKS AND DIAMICTITE
11	COARSE QUARTZ-RICH GNEISS
12	BALTIMORE GABBRO OF HOPSON (1964)
13	SERPENTINITE
14	MIXED ZONE OF GABBROTIZED DIAMICTITE
15	GABBRO AND SERPENTINITE
16	GRANODIORITE (EPIZONAL)
17	GRANODIORITE AND FELSIC METAVOLCANIC TRANSITION ZONE

——— CONTACT (NOT GRADATIONAL)

- - - - - - - - GRADATIONAL CONTACT

③ FIELD TRIP STOPS

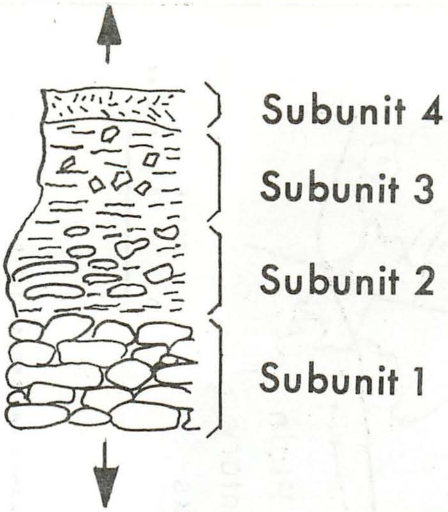


Figure 3. Schematic column to illustrate the four subunits of the metabasalt unit in Cecil County.

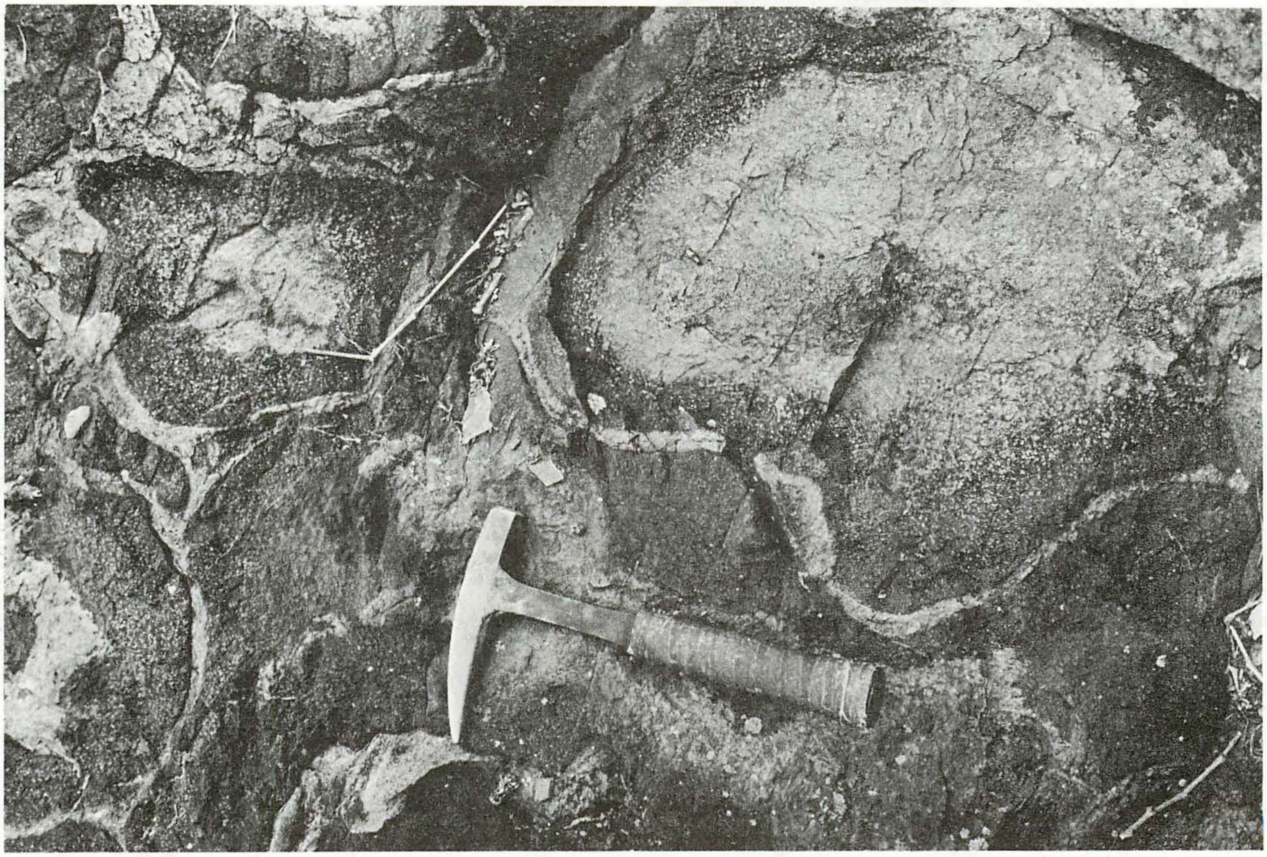


Figure 4. Metamorphosed pillow lavas near the base of the metabasalt unit along Northeast Creek south of Gilpin's Falls, Cecil County.

Figure 5. Isolated pillow and fragment in basaltic tuff of the metabasalt unit along Northeast Creek, Cecil County.

Figure 6. Broken pillow breccia of the metabasalt unit along Northeast Creek, Cecil County.

ROAD LOG -- FIRST DAY
Saturday, October 30, 1971

Departure from the Holiday Inn Downtown, Baltimore at 8:00 a.m. Field trip will follow route shown on Fig. 1.

Mileage	
0.0	Leave Holiday Inn heading east on Lombard St. Get over into left lane.
0.2	Turn left onto Charles St. Keep to the right.
0.7	Turn right onto Mulberry St. (U.S. 40 east).
5.4	Bear right onto entrance ramp of I 95 following sign for BELTWAY, KENNEDY HIGHWAY NORTH.
5.9	Keep right following sign reading NORTH TO I 95.
7.1	Leave Baltimore City, enter Baltimore County.
8.2	Road cuts on both sides expose Potomac Group sediments of Cretaceous age.
16.4	Cross Big Gunpowder Falls.
18.6	Cross Little Gunpowder Falls. Leave Baltimore County, enter Harford County.
22.0	Cross Winters Run.
23.1	Potomac Group sediments on left.
25.3	Cross Bynum Run.
36.4	Descend into the valley of the Susquehanna River. Large roadcut on right exposes metamorphosed volcanic rocks.
36.6	Enter Susquehanna River bridge, leave Harford County. Downstream on right is large inactive quarry of the Arundel Corp. Rock is mapped as Port Deposit Gneiss, but is of probable volcanic origin. Immediately upstream on far side of river is an abandoned quarry in metavolcanics. Farther upstream can be seen the well known quarry at Port Deposit (Stop 5).
37.5	Leave Susquehanna River bridge, enter Cecil County. Metavolcanics on left.

Mileage

38.9	Toll booths.
39.4	Pass under U.S. 222 (also Md. 222).
45.6	Bear right onto exit ramp 8 following sign for RISING SUN, NORTHEAST, 272.
45.9	Bear left following sign for RISING SUN.
46.0	Bear left onto Md. 272.
47.4	Historical plaque on right - "GILPIN'S FALLS COVERED BRIDGE. Built c. 1860, the bridge is one of the few covered ones left in Maryland and the only one on public grounds in Cecil County. The area to the east has been the site of several mills, the earliest Samuel Gilpin's flour mill c. 1735."
47.5	Pull off on right shoulder near entrance to MacGregor Conference Center Boy Scouts of America, disembark, and follow dirt road into Scout camp.

STOP 1. PILLOW BASALT (45 minutes)

Michael W. Higgins

Stop 1 is near the base of the pillow basalt subunit. Here one can see the nearly undeformed nature of the pillows, and can speculate as to top and bottom, based on the Y's of the pillow rims. Chemically, the rock here is a tholeiitic basalt. Just inside the pillow rims is a zone of abundant vesicles (amygdules). Measurements of the maximum size and percentage of these suggest that these pillow basalts were emplaced in fairly shallow water - less than 300 meters (Jones, 1969; Moore, 1965). Figure 7 shows the route of an expanded trip down the creek through the pillow basalt section, the rest of the metabasalt unit, and some of the other metavolcanic rocks.

47.5	Board vehicles and continue northeast on Md. 272.
47.6	Turn right onto Warburton Road.
49.0	Cross North East Creek. Outcrops on right of massive felsic volcanics.
50.7	Cross Blue Ball Road (Md. 545).
50.8	Cross Middle Road.

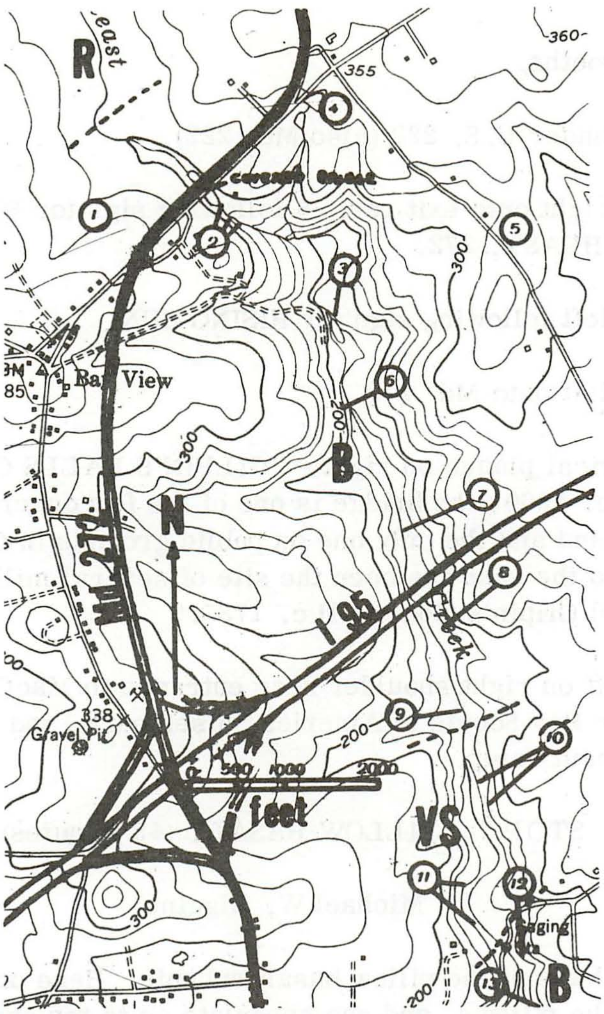


Figure 7. An expanded trip through the pillow basalt section, the rest of the metabasalt unit, and the felsic metavolcanic rocks between the two outcrop belts of the metabasalt unit.

R- metarhyolite; B- metabasalt; VS- volcanic sedimentary rocks.

Localities of interest (by circled nos. above)

1. Large outcrops of pillow lavas.
2. Pillow lavas of Gilpin's Falls.
3. Chert beds in the pillow lava sequence.
4. Large outcrops of pillow lavas.
5. Large outcrops of pillow lavas.
6. Broken pillow breccias and basaltic tuff.
7. Isolated pillows in basaltic tuff.
8. Isolated pillows in basaltic tuff.
9. Coarse grained basalt flow (?).
10. Large outcrops of tuffaceous sandstone.
11. Large outcrops of volcaniclastic rock.
12. Large outcrops of basaltic tuff with some thin beds of felsic volcaniclastic rocks.
13. Basaltic tuff.

Mileage

50.9	Turn left onto Hill Top Road
52.6	Quartz boulders on left.
52.7	Turn right onto Md. 273.
53.2	Turn left onto Rock Church Road. Pull off on left shoulder of road, park, and disembark. Walk up the road to gate that leads into field on right. Climb hill to outcrop, then descend to outcrop at church.

STOP 2. SHEARED PILLOW BASALT (45 minutes)

Michael W. Higgins

Shearing in the basalt unit is extremely erratic, showing immense variation along strike over distances as short as 100 feet; locally, extreme variation can be seen in a single outcrop. Stop 2 illustrates this variation in the effects of shearing and metamorphism. In the outcrop in front of Rock Church (Fig. 8) vesicular basalt with relict, stretched pillow rims and pillow rim material can be seen transformed by shearing into layered amphibolite and amphibole schist, all in the same outcrop. Here also, in a small part of the outcrop, one can see the amygdules in the metabasalt being stretched out until they coalesce to form the felsic layers of the layered amphibolite. About 100-150 feet east along strike from this outcrop (Fig. 8) nearly undeformed pillow lavas are exposed.

About 3 miles east of Rock Church, along Big Elk Creek (Fig. 8, no. 7) coarsely layered amphibolite forms good outcrops. In these, the felsic layers are 2-6 inches thick and the mafic layers 2-10 inches thick. These coarsely layered rocks are directly along strike from, and in the same unit as the metabasalt at Rock Church, and there is a temptation to explain the layering here as a further step in the process seen at Rock Church. However, the lack of continuous exposure between the two localities precludes proof of this possible theory. The coarsely layered amphibolite probably represents interlayered mafic and felsic tuffs.

53.2	Return to Md. 273.
53.3	Turn right onto Md. 273.
55.8	Cross Blue Ball Road. Historical plaque on right - "BLUEBALL TAVERN Established about 1710 on lot no. 35 of 'the Nottingham Lots' by Andrew Job who secured it from William Penn. Job's son, Thomas, married Elizabeth Maxwell, niece of Daniel Defoe who wrote 'Robinson Crusoe.' "

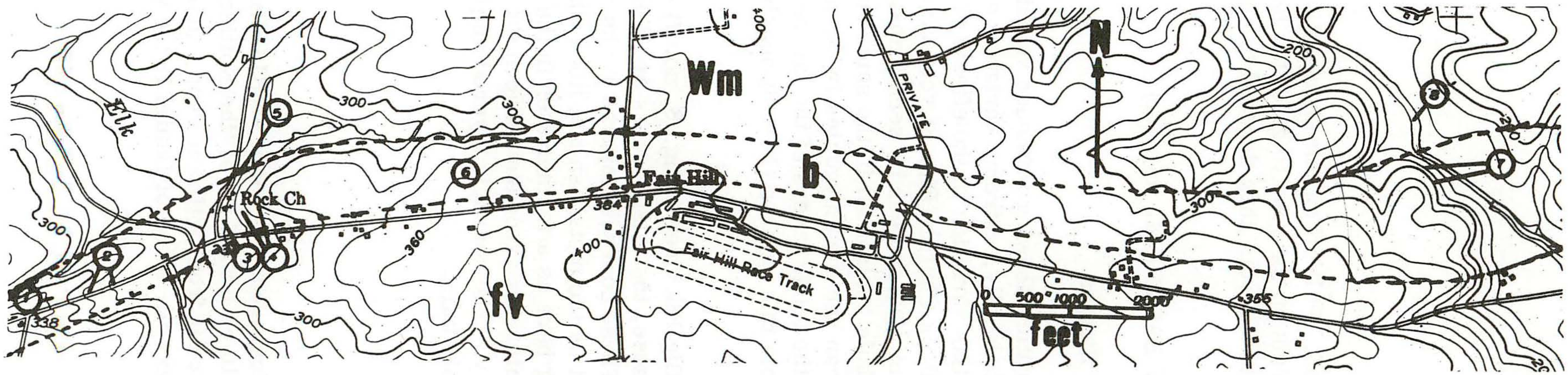


Figure 8. Pillow basalts and layered amphibolites.

Wm- Wissahickon metagraywacke; b- metabasalt; fv- felsic metavolcanic rock.

1. Outcrops of slightly deformed pillow lava.
2. Amygdular basalt with some pillow rims visible.
3. Sheared pillow lava transformed into layered amphibolite.
4. Large outcrops of pillow lava, nearly undeformed.
5. Contact with metagraywacke of the Wissahickon Formation.
6. Metabasalt unit recognizable by float, soil, and rare, scattered outcrop.
7. Large outcrops of coarsely layered amphibolite.
8. Large outcrops (in creek) of Wissahickon metagraywacke.

Mileage

58.3	Cross Md. 272.
61.6	Historical plaque on left - "THE NOTTINGHAM LOTS 37 lots of approximately 500 acres each given by William Penn to his colonists in 1702 although they lay in Maryland and were part of George Talbot's 'Susquehanna Manor' of 32,000 acres granted him in 1680 by Lord Baltimore."
62.9	Cross Md. 274 in Rising Sun.
63.9	Cross Md. 276. Historical plaque on left - "WEST NOTTINGHAM ACADEMY Founded 1744 by Rev. Samuel Finley a Presbyterian minister and a native of Armaugh County, Ireland. He remained in charge of the academy and church until 1761 when he was chosen president of the College of New Jersey, now called 'Princeton.' "
64.4	Jog right to U.S. 1 and continue west.
65.7	Historical plaque on right - "RICHARDS OAK General Lafayette and his Army camped around this tree April 12, 1781. A Civil War cavalry unit later occupied the site. The oak, over 500 years old, was owned by the Thomas Richards family for over a century. A huge limb fell August 1964, splitting the trunk. In 1965 the tree measured 85' in height, 24' in girth and 115' in spread."
66.7	Outcrops on both sides of the road of metagabbro.
69.8	Turn left onto U.S. 222.
70.0	Outcrop on left - diamictite facies of the Wissahickon Formation.
70.5	Turn right into dirt road along high voltage lines.
70.6	Pull off on grass to left of road. Park and disembark. Follow path to river and large water-worn outcrop.

STOP 3. CONOWINGO BRECCIA (45 minutes)

Michael W. Higgins

Previous maps of Cecil County and adjacent areas (Bascom and Miller, 1920; Marshall, 1937; Hershey, 1937; Cloos and Hershey, 1936; Southwick and Owens, 1968; Cleaves and others, 1968) have shown very large parts of the area underlain by Port Deposit Granite, Granodiorite, or Gneiss. My mapping shows that much of the area thus mapped is underlain either by metasedimentary or by metavolcanic rocks.

Of particular interest are outcrops just south of Conowingo Dam (Fig. 2), which were earlier considered the "contact zone of the Port Deposit plutonic complex" (Cloos and Hershey, 1936; Hershey, 1936, 1937), but which Hopson (1964, p. 118) suggested were submarine slide deposits, and Southwick (1969) mapped as boulder gneiss facies of the Wissahickon Formation. These rocks, and the rocks for several miles to the south, belong to the diamictite facies of the Wissahickon Formation (Higgins and Fisher, 1971). They are identical in most aspects with the Sykesville Formation of Hopson (1964).

Stop 3 illustrates the nature of these rocks. The wide variety of sedimentary clasts within the rock and, more important, the clastic nature of the groundmass - relict quartz granules and quartzite pebbles are abundant - show the metasedimentary origin of the rock. Similar outcrops are found along Octoraro Creek (Fig. 2).

The inclusion of this large swath of metasedimentary rocks in the Wissahickon shrinks the Port Deposit pluton considerably.

70.6	Board vehicles, return to U.S. 222, turn left, and retrace route back to U.S. 1.
71.2	Turn left onto U.S. 1 and cross Susquehanna River via Conowingo Dam.
72.1	Turn left onto Shuresville Road.
72.8	Turn left onto Shures Landing Road.
73.6	Enter property of Philadephia Gas and Electric Co.
73.9	Park in designated area and disembark.

STOP 4 (lunch). SOME COMMENTS ON THE PIEDMONT ARCHEOLOGY OF NORTHEASTERN MARYLAND (1 hour)

Tyler Bastian

This stop was selected chiefly for its scenic appeal, as it commands a fine view of the valley of the lower Susquehanna. The park is owned and maintained by the Philadelphia Electric Company and is open to the public.

Conowingo Dam, at the time of its completion in 1928, was the largest steam or hydroelectric development constructed in one step in the history of the power industry. The original 7 generator facility was expanded in 1964 by the addition of 4 more generators which are clearly visible at the north end of the plant. Current annual output averages 1.7 billion kilowatt hours, equivalent to the domestic electrical needs of a city of more than 335,000 homes.

A short distance below the dam on the opposite bank of the river is one of the most important archeological sites in Maryland, and it was decided, therefore, that at this stop it would be fitting to offer some comments on the Piedmont archeology of northeastern Maryland.

Men have lived in the Piedmont area of northeastern Maryland since the end of the Pleistocene epoch when the oceans were still considerably below their present level and Chesapeake Bay had not inundated the ancestral valley of the Susquehanna River. The oldest recognized archeological remains in northeastern Maryland, known as Paleo-Indian, are best characterized by a few isolated finds of stone dart or spear points which are lanceolate in outline and have a diagnostic flute or channel on either face as a result of long flakes having been removed from the base toward the tip. Related forms, referred to as Clovis and Folsom in the West, have been found from Nova Scotia to Arizona in contexts which consistently radiocarbon date between 7,000 and 10,000 B.C.; a comparable age can be attributed to the Maryland specimens on the basis of their typological similarity to the dated artifacts. The fluted points from northeastern Maryland are made of cherts and quartzites derived from local gravels, jasper from prehistoric quarries in Berks and Lehigh counties in eastern Pennsylvania, and rhyolite (metarhyolite, aporhylite) quarried from localized occurrences on South Mountain near Gettysburg in south-central Pennsylvania immediately west of the Piedmont. The environment of Paleo-Indian times included a relatively cool climate, largely coniferous forests, and now extinct animals such as mastodons and mammoths. Although there is abundant evidence that the Western Paleo-Indians hunted mammoth and other large mammals, direct information about the subsistence habits of the eastern Paleo-Indians is lacking.

The post-Pleistocene change to an essentially modern environment, including the extinction of megafauna, is accompanied by notable changes in the archeological record. Increased variety of artifact types and marked regional diversity suggests a shift from economically specialized and wide-ranging small bands to economically diversified and locally oriented groups referred to as the Archaic cultures. The Archaic cultures, which range in time from about 6,000 to 1,000 B.C., subsisted by hunting small game, gathering wild plant foods, and fishing. Most Archaic tools were made by chipping, but an innovation during this period was the manufacture of some tools by battering and grinding. Quartz, rhyolite, quartzite, hornfels, and siltstone were the most common materials used for chipping. Archaic sites are abundant in the Piedmont, but most of them are widely dispersed and appear to have been briefly occupied. In contrast, several large, intensively occupied Archaic sites occur along the Susquehanna River, including one near the Conowingo Dam. The differences between the Archaic sites found in the interior of the Piedmont and those along the Susquehanna Valley is not limited to settlement pattern, but is also apparent in both types of artifacts and the materials from which the artifacts are made. It remains to be determined if the variation is due to the presence of different cultures in the interior and in the valley, or if it is the result of different activities of the same culture. Small rock shelters are common in parts of the Piedmont, and excavations in a few have revealed that they have been used as

temporary shelters since early Archaic times just as they are occasionally used today by sportsmen and Boy Scouts. Unfortunately, the archeological record in many of the shelters has been destroyed by uncontrolled digging for artifacts by various individuals. Vessels made of soapstone are an index marker for the end of the Archaic cultures. Soapstone (or steatite) occurs in small masses associated with serpentine which, in northeastern Maryland, extends in a discontinuous band from Rising Sun near the Susquehanna River to Soldiers Delight northwest of Baltimore. A number of aboriginal quarries have been found. Most of the archeological remains in northeastern Maryland, as well as throughout the Piedmont area, relate to the Archaic period. The popular assumption that most locally found artifacts are types that were in use by the Indians of late prehistoric and early Colonial times is a serious error.

Farming and the use of pottery made from fired clay are hallmarks of the succeeding Woodland cultures from about 1,000 B.C. to A.D. 1550. The earliest pottery retains the distinctive flat-bottomed, straight-sided, lug-handled form of the late Archaic soapstone vessels, and pulverized soapstone is used as grog. Later Woodland potters used sand, crushed stone, or pulverized shell grog. Stamped and impressed decorations become more common and complex through time, but the shape of the vessels remains simple; none of the native pottery in Maryland is painted. A dual economy of hunting and farming is typical of the Woodland period with increased emphasis on farming toward the latter part of the period. Tobacco, sunflowers, corn, beans, pumpkins, and squash were important crops. The bow and arrow first appeared during Middle Woodland times; previously spears and darts were the only thrusting weapons. Early and Middle Woodland cultures participated in wide trading networks as indicated by artifacts made of chert and a few other rock types from as far away as Ohio and New York. By Late Woodland times some fairly large, sedentary villages were located along the Susquehanna River and on Chesapeake Bay. In the Piedmont, however, it appears that life continued much as it had for thousands of years except for the introduction of some new artifact types including pottery. It is not known whether this means that the Piedmont was abandoned by permanent residents and only occupied intermittently by hunters and travelers from the coastal Late Woodland villages, or whether the Piedmont continued to be occupied by nomads who did not participate to any great extent in the more developed cultures along the major waterways. Historical sources tell us nothing about aboriginal life on the Piedmont because the earliest recorded explorations were confined to the major waterways. When the interior was eventually explored and described, its native cultures had been destroyed by disease and migrations indirectly brought about by Euro-American encroachment in the coastal area.

One of the most important archeological sites in Maryland was located on the Susquehanna River a short distance below Conowingo Dam. Exceptionally favorable circumstances resulted in the slow accumulation of flood deposits over an area that

was intensively occupied since middle Archaic times so that a remarkable stratified sequence covering 5,000 years of prehistory was preserved. Severe erosion of the river banks caused by sudden release of water through the gates of Conowingo Dam has almost totally destroyed this unique and valuable site. Remaining portions of the site have been extensively damaged by the uncontrolled digging of individuals searching for Indian relics to place in their private collections or to sell.

Indian petroglyphs (two-dimensional rock carvings) in the vicinity of Bald Friar were submerged by the Conowingo Reservoir. A few of the petroglyphs were removed by the Maryland Academy of Sciences, and casts were made of others.

Maryland has recently initiated a state-sponsored program in archeology as a division of the Maryland Geological Survey. The Division of Archeology has the dual function of conducting research and attempting to reduce future loss of the limited and irreplacable archeological data which still remain in Maryland. Both site preservation and systematic salvage of non-preservable sites are being attempted.

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73.9	Leave Stop 4 (retrace route back to U.S. 1).
74.9	Turn right onto Shuresville Road.
75.7	Turn right onto U.S. 1, and recross Susquehanna River via Conowingo Dam.
76.6	Turn right onto U.S. 222.
77.5	Historical plaque on left - "A SUSQUEHANNOCK INDIAN FORT located at this point was an important factor in the boundary line controversy between Lord Baltimore and William Penn in 1683."
77.6	Cross Octoraro Creek.
78.5	Historical plaque on right - "THE PROPRIETORS OF THE SUSQUEHANNA CANAL. The corporate title of the company authorized in 1783 to build one of the first inland waterways in America. The bed of this canal and some of its stone locks are still visible near this road."
80.9	Historical plaque on right - "In 1609 Captain John Smith ascended the Susquehanna River until stopped by the rocks. On his map he calls this point 'Smyths Fales,' marking it by a + which he explains as meaning 'hath bin discovered what beyond is by relation.' " Just beyond the plaque turn left into entrance of Port Deposit Quarry.
81.0	Disembark and walk to quarry face.

STOP 5. THE PORT DEPOSIT QUARRY (30 minutes)

Michael W. Higgins

Port Deposit Gneiss, the plutonic-appearing phase of the "Port Deposit pluton" is confined to a relatively small outcrop band around the Port Deposit quarry (Fig. 9, stop 5), a short distance north of the town of Port Deposit (Fig. 2). This quarry is the type locality of the gneiss which here is massive, coarse grained, and foliated, and has the appearance of a metamorphosed plutonic rock.

Evidence for the origin of the Port Deposit Gneiss (as restricted here) is equivocal. Chemically, the gneiss plots in the sedimentary field of a q-or-ab diagram (Fig. 10), and mineralogically it has too much modal quartz in comparison with modal feldspar for a magmatic rock. On the other hand, its outcrop appearance, its fair degree of homogeneity, and the fact that its zircons give radiometric ages approximately the same as the volcanic rocks of the area (Steiger and Hopson, 1965; Davis and others, 1965; Tilton and others, 1970; A. K. Sinha, M. W. Higgins, and W. S. Kirk, unpub. data), suggest an igneous origin.

There is, however, an alternative origin for the Port Deposit Gneiss that fits perfectly with the field relations and petrography, and seems to reconcile the apparent contradictions of the other evidence. The hypothesis, suggested elsewhere (Higgins, 1971), and advanced here, is that the Port Deposit was a shallow, surface-breaking pluton that was a source for some of the volcanic rocks.

81.0	Leave Port Deposit quarry. Turn left onto U.S. 222.
81.3	Enter village of Port Deposit. Historical plaque on left - "ROCK RUN MILL Built c. 1725. Owned by John Steel, this grist mill was in successful operation as early as 1731. At the same period a ferry was operated about one-half mile downstream at a crossing known as Upper Ferry."
83.3	Entrance to Bainbridge Naval Training Center on left.
85.2	Stay on U.S. 222 by turning right at the intersection with Md. 275.
85.4	Bear right onto entrance ramp of I 95 southbound.
86.0	Toll booths.
87.4	Enter Susquehanna River bridge.

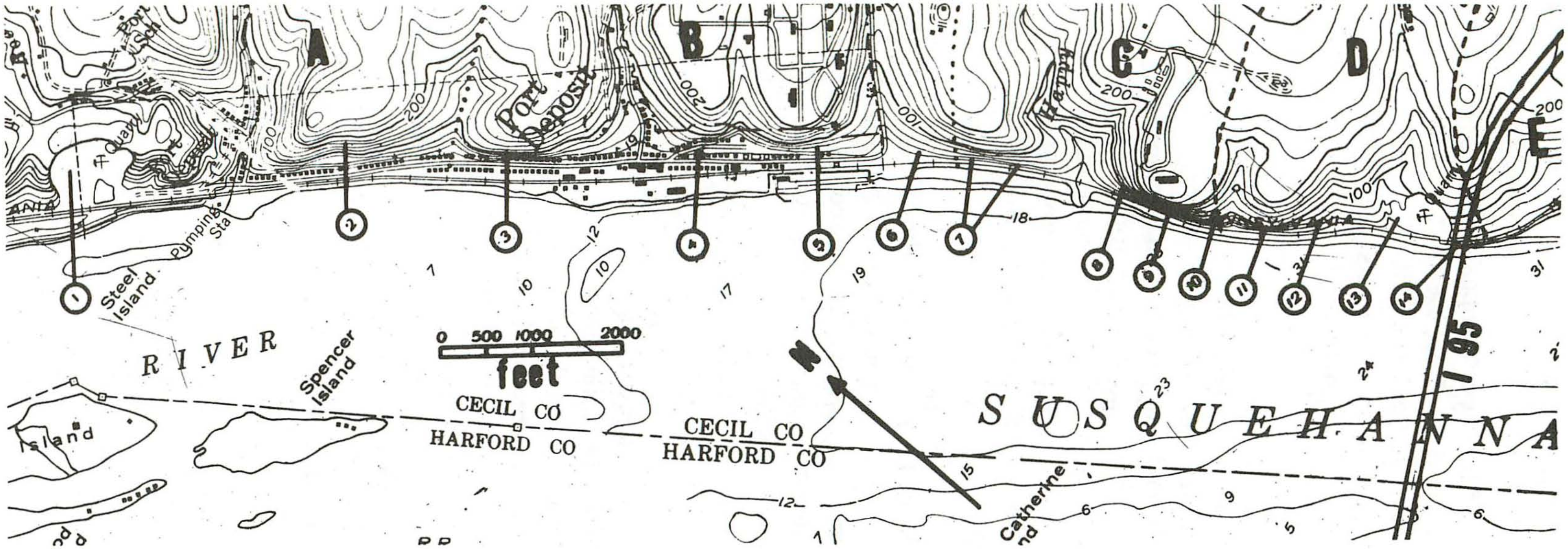


Figure 9. The nature of the Port Deposit Pluton

Unit A--Port Deposit plutonic (epizonal) phase; Unit B--Port Deposit intermediate phase; Unit C--Port Deposit-James Run supracrustal phase; Unit D--James Run basalt; Unit E--mixed James Run mafic and felsic volcanic rocks. All contacts gradational; all units metamorphosed.

1. Port Deposit quarry: gneiss here is massive, coarse grained, foliated, and plutonic-appearing.
2. Gneiss in this area (in cliff behind houses) is distinctly finer grained and less well foliated than at quarry.
3. Gneiss here is much finer grained than at quarry.
4., 5., and 6. Good outcrops of the finer grained "hypabyssal (?)" gneiss.
7. Gneiss here has many features of the metavolcanic rock. Layers of metabasalt occur here--some of these are dikes.
8. Large outcrop of transitional (hypabyssal-volcanic) gneiss. Also good outcrops of metabasalt dikes with chilled margins.
9. Fresh spalls show fine grained, felsic gneiss with textures suggestive of a metavolcanic origin.
10. Pyroclastic texture (some pumice blebs) well displayed here.
11. Sheared basaltic tuff with some thin felsic tuff interbeds.
12. Basaltic tuff.
13. Abandoned quarry with excellent outcrops of sheared metabasalt (probably basaltic tuff).
14. Under bridge, good outcrops of pyroclastic basalt and pyroclastic felsic interbeds. Good cleavage-bedding relations seen here.

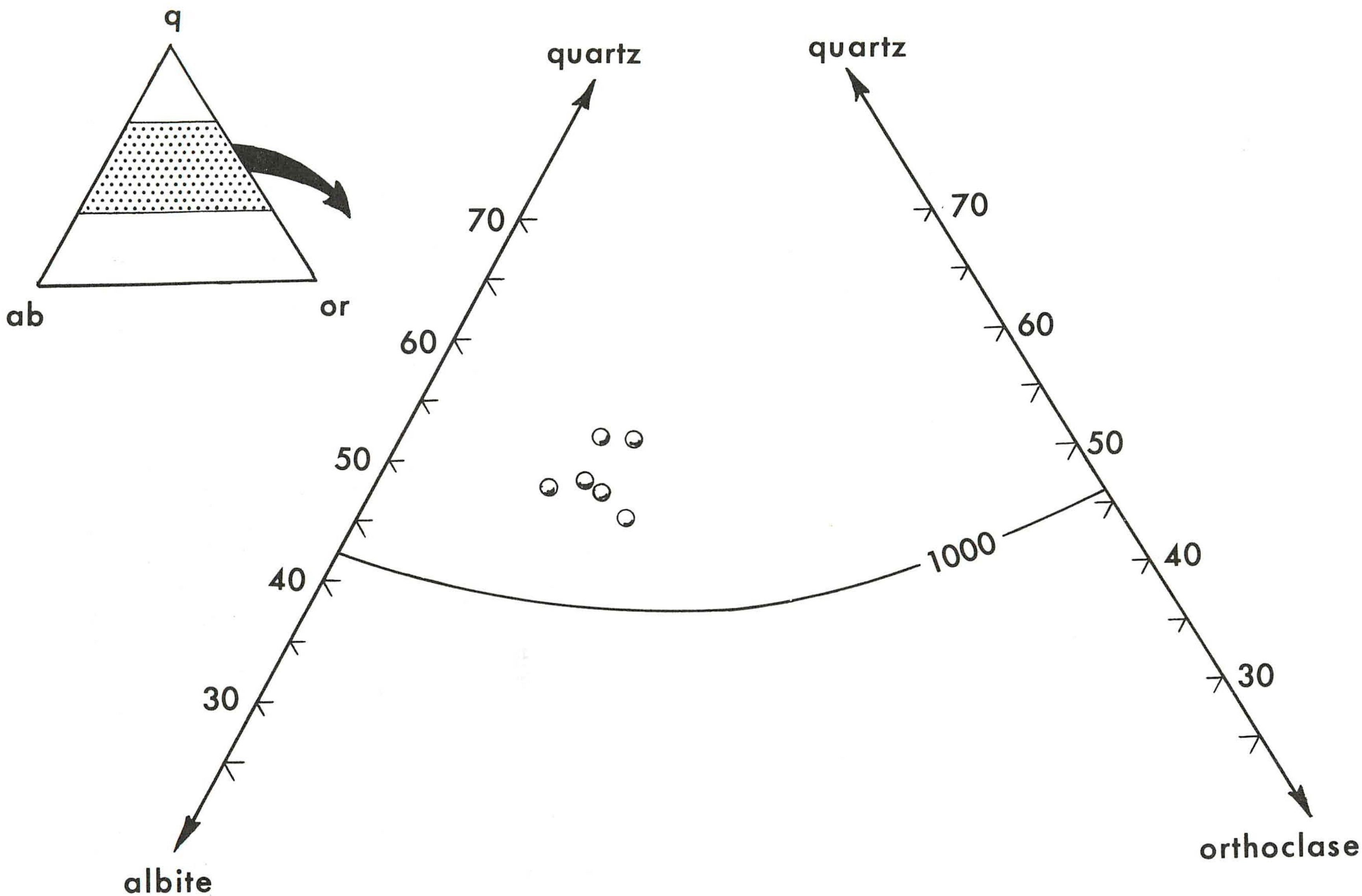


Figure 10. Normative q-or-ab ratios of the Port Deposit Gneiss. Plot after Hopson, 1964. Analyses by U.S. Geological Survey -- Higgins, unpub. data. 1,000-bar projection of synthetic granite minimum shown.

Mileage

88.4	Leave Susquehanna River bridge.
89.5	Bear right onto exit 6 for Md. 155 and Havre De Grace.
89.9	Bear right onto Md. 155 westbound following sign for Bel Air and Churchville.
91.5	Pass thru intersection of Md. 462.
91.8	Pass thru intersection of Md. 156.
92.5	Pass junction of Md. 161.
95.3	Exposed on both sides of the road is layered amphibolite saprolite of the James Run Gneiss, a metavolcanic unit that will be seen at the next stop.
96.3	Turn right onto Md. 22 and then immediately left onto Md. 136.
98.5	Turn left into entrance of Gatch Crushed Stone Company. Park in designated area and proceed into quarry.

STOP 6. THE GATCH QUARRY (60 minutes)

William Crowley

The Gatch Quarry was first opened in 1922 under the ownership and management of the Gatch family. The rock is crushed for use in the construction industry throughout most of Harford County and parts of adjacent Baltimore County.

The Gatch Quarry is the only operating quarry that will be visited during the course of the field trip. As quarry development progresses, various small scale features are exposed from time to time only to be destroyed during subsequent operations. Thus the geology can be described only in very general terms. Exposed in the quarry is the James Run Gneiss, a layered rock ranging in composition from amphibolite to leucocratic quartz-plagioclase gneiss. According to Southwick (1969), "Near perfect layering distinguishes the James Run Gneiss from other gneisses of generally similar builk composition in the region. Individual layers range from less than 1 inch to more than 20 feet in thickness; they have knife-sharp contacts, and even thin layers can be traced for several tens of feet before they gradually lense out." Important features of the chemistry of the James Run Gneiss are the large excess of Na_2O over K_2O even in very siliceous rocks, and the variable amounts of CaO in the mafic layers. Southwick concluded that neither normal lavas nor graywacke are a likely parent material for the James Run, but followed

Hopson (1964) in noting that there a class of altered marine volcanic sediments whose chemical composition does closely match the James Run Gneiss. These are the albitized and zeolitized volcaniclastic rocks of intermediate to silicic composition. Such marine volcanic sediments commonly resemble the James Run Gneiss in structure as well as composition, forming massive to thin-bedded deposits with interstratified mafic material.

Zircon data (Tilton and others, 1970) are compatible with an age of 550 m.y. for the James Run Gneiss assuming loss of lead by continuous diffusion. Underlying the James Run is a sequence of rocks similar to the lower Glenarm Series and Baltimore Gneiss. Granted that this similarity implies correlation of the two rock sequences, then the age of the lower Glenarm Series is Cambrian.

98.5 Reboard vehicles and leave Gatch quarry.

98.6 Turn right onto Md. 136 and retrace route back to Md. 22.

100.7 Turn left onto Md. 22.

102.7 Harford Junior College off to the right. Historical plaque on near right - "MEDICAL HALL two miles north of this point. Birthplace and home of Dr. John Archer, 1741-1810. First graduate of medicine in America. Signer of Bush Declaration March 22, 1775. Member of Congress 1802. One of the founders of the medical and chirugical faculty of Maryland. Father of five physicians."

104.2 Pass through intersection of Md. 543.

106.3 Entering Bel Air. Turn left onto Md. 24 and then immediately right onto U.S. 1.

106.4 Historical plaque on left - "THE HAYS HOUSE circa 1711. A dwelling of the type owned by a family of moderate means, soon after the frontier reached this area. Occupied by seven generations of the Hays - Jacobs family. Moved from its original site in 1960 by the Historical Society of Harford County and now its headquarters.

108.5 Outcrop of Port Deposit Gneiss on left, largely weathered to a grus.

108.9 On the left - a cut in mafic saprolite of the Baltimore Gabbro Complex.

109.0 Continue straight through intersection and onto Md. 147 following sign for FORK.

Mileage

109.1	Massive metagabbro on the right.
110.1	Pass through intersection of Md. 152.
110.8	Note boulder strewn field on right, a feature typically developed on massive mafic rocks.
111.7	Outcrops on right of felsic augen gneiss that forms a thin zone in the Gabbro Complex.
111.8	Turn left into entrance of Little Gunpowder Quarry, park on apron along right side of road, disembark, cross bridge, and proceed into quarry.

STOP 7. LITTLE GUNPOWDER QUARRY (60 minutes)

William Crowley

Striking northeastward along the Fall Zone of Baltimore, Harford, and Cecil Counties is a broad zone of felsic and mafic rocks (see frontispiece map) long considered to be of plutonic origin. The felsic rocks - the Port Deposit Gneiss - have been observed at two earlier stops where they were shown to be of diverse origin, including supracrustal as well as plutonic rocks.

The mafic rocks - the Baltimore Gabbro - are equally diverse in genesis. Along the Susquehanna River the Gabbro Complex is chiefly massive hypersthene gabbro and serpentinite, presumably plutonic. Some twenty miles directly on strike to the southwest along Gunpowder Falls (just northeast of Baltimore City) the Complex is largely dark and light hornblende gneiss or amphibolite of volcanic and volcaniclastic origin. The contact between these two contrasting mafic assemblages lies somewhere in the vicinity of Bel Air, 12 miles southwest of the Susquehanna, in an area of few outcrops. The relationship of the gabbro to the volcanics is consequently obscure.

The internal relationships of rock masses in the Gabbro Complex are not only unclear on a regional scale but on an outcrop scale as well, as illustrated at Stop 7. The overall impression here is one of mafic blocks floating in a felsic mass, and the conclusion that this is a magmatic breccia seems inevitable. The host rock is a dark, dense, generally fine-grained amphibolite of volcanic aspect intruded by hornblende-plagioclase-quartz gneiss of dioritic aspect.

The quartz content of the dioritic gneiss averages about 40%, a rather high value for a diorite. Alternatively, one might postulate a sedimentary origin for the dioritic gneiss and consider the melange a mixture of volcanic and volcani-

clastic rocks. This interpretation is more consistent with the regional geologic picture since the Gabbro Complex in this area is composed chiefly of layered dark and light hornblende gneiss of volcanic origin identical to the dark and light gneiss of the quarry. One is then led to ask why the volcanics are chaotically mixed here in contrast to their regularity of layering elsewhere. The explanation is very likely the same as that proposed at Stop 3 for the Conowingo breccia, and for that matter for many other areas of chaotically mixed rocks in the Piedmont, namely, that shortly following their deposition the volcanics and volcanic sediments were locally ripped up and incorporated into slide masses and turbidity currents that swept down the continental slope depositing the chaotically mixed material on the ocean floor. Later tectonism may also account in part for the chaotic aspect, as in places several layers show parallel deflections.

111.9	Return to Md. 147 and turn left.
112.0	Cross Little Gunpowder Falls, enter Baltimore County.
112.3	The stream on the right which parallels our route marks the approximate contact of the Gabbro Complex with the Wissahickon Formation.
113.5	Turn left onto Sunshine Avenue.
114.4	Historical plaque on left - "ISHMAEL DAY'S HOUSE When one of Harry Gilmor's Confederate cavalrymen (on July 11, 1864) pulled down his Union flag Day shot him and then escaped to the woods. They burned his house and barn."
115.5	Pass through intersection of U.S. 1.
115.6	Pass through intersection of Jerusalem Road.
117.8	Cross over Kennedy Highway and immediately turn right onto unnamed road.
118.6	Pass through intersection of Md. 7 (Old Philadelphia Road).
119.1	Cross B&O railroad tracks.
119.3	Turn right onto Pulaski Highway (U.S. 40).
123.4	White Marsh sand and gravel operation of the Campbell Corporation on the right.
135.0	Turn left onto Eutaw St.
135.2	Turn left onto Lombard St. and pull up in front of Holiday Inn Downtown.

INTRODUCTION TO FIELD TRIP - SECOND DAY

by William Crowley

The theme of the second day's excursion is the general geology of the Baltimore gneiss domes. Our route (Figs. 1 and 11) will take us through three of the domes, with stops scheduled in two of them. The stratigraphy of the area is shown in Fig. 12.

The existence of gneiss domes in the Maryland Piedmont went unrecognized until the appointment of Edward B. Matthews as instructor in the Department of Geology at Johns Hopkins in 1894. Prior to that time, the chief emphasis in the Piedmont around Baltimore had been on the petrology of the igneous rocks, particularly the Baltimore Gabbro. Matthews not only worked out the stratigraphic succession in the Baltimore area, but also recognized the unconformity at the base of the Setters Formation (see Fig. 12), and on the State geologic map of 1906 accompanying volume 6 of the Maryland Geological Survey, the gneiss domes are clearly shown for the first time. They are described in a later publication (Matthews, 1907).

A detailed structural study of the gneiss domes was published by Broedel in 1937. Paralleling Matthews' discovery of a stratigraphic unconformity at the base of the Setters Formation was Broedel's discovery of a structural unconformity at the base of the Cockeysville Marble. He noted that the basement surface and overlying Setters are broadly folded and comparatively free from minor folds (Stop 12) whereas the overlying Cockeysville Marble and Wissahickon Formation are tightly folded (Stop 9) and display a map pattern that is much less dependent than the Setters on the configuration of the basement surface.

Broedel also recognized what he considered to be primary (pre-Glenarm) structures (Stop 10) in the Baltimore Gneiss and showed that the map patterns of the domes were strongly influenced by these structures - a semicircular arrangement of primary elements, as in the Texas dome, resulted in round domes; a linear arrangement, as in the Chattolanee dome, resulted in long, anticlinal domes.

It is of interest to note that in his doctoral dissertation (1935) Broedel was of the opinion that the Wissahickon is allochtonous and was thrust over the Baltimore Gneiss and lower Glenarm Series, his only evidence being the great variations in thickness of the Cockeysville. The thrust idea was subsequently ignored, but in modified form has been revived by both John Rodgers (1970) and George Fisher (personal communication), the two arriving at the hypothesis from different lines of reasoning.

In 1946 Pentti Eskola visited Maryland briefly and concluded that the Baltimore gneiss domes had had a history similar to that of the Finnish domes, a history that is elaborated upon in his well known 1949 paper. Part of Eskola's theory holds that the basement rocks are activated by migmatization and become so mobile that not only do they dome up the overlying cover but in places even intrude it. According to Hopson (1964) the intrusive Gunpowder Granite was derived from partial melting of the Baltimore Gneiss in just such a manner (Stop 11).

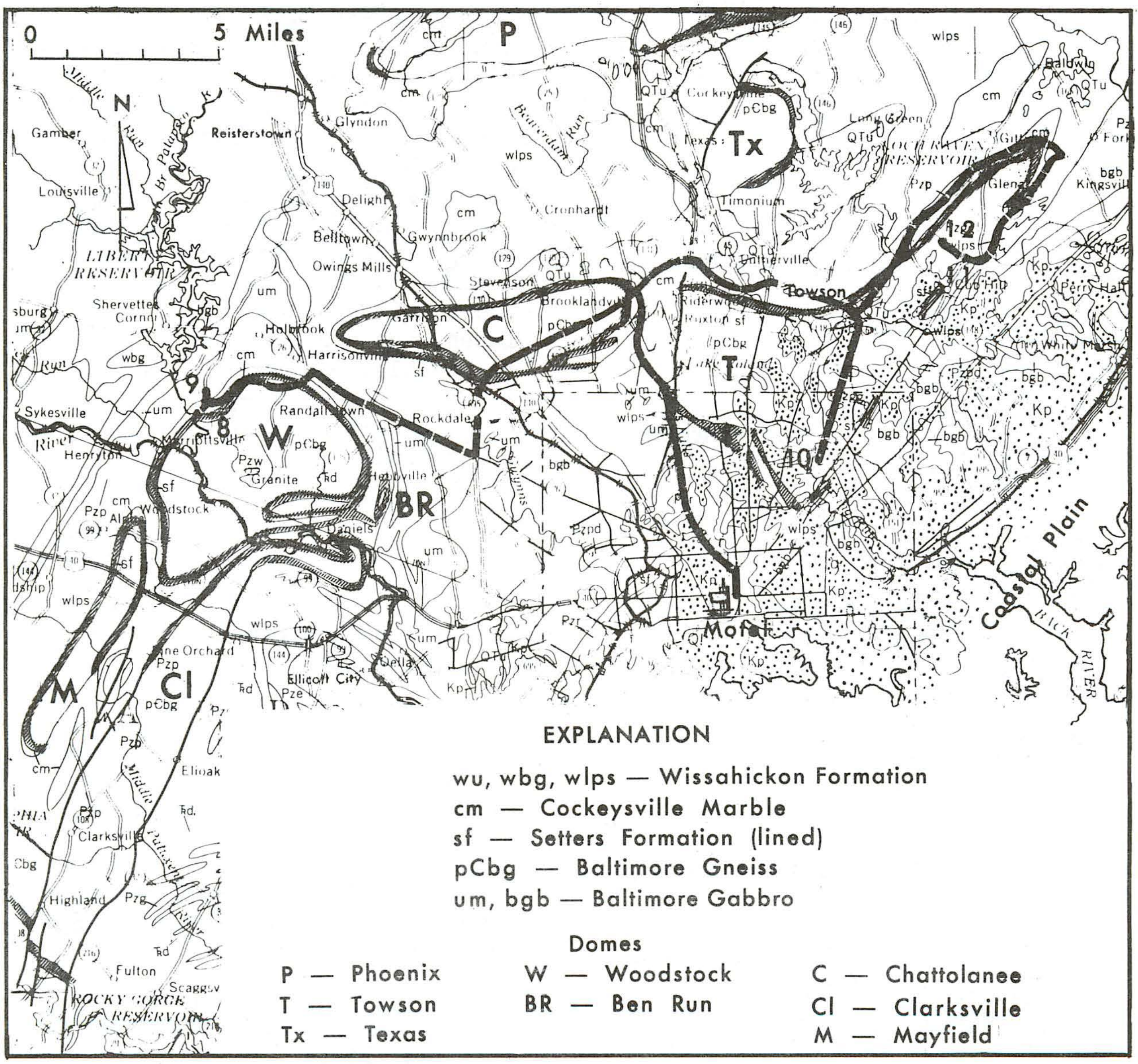
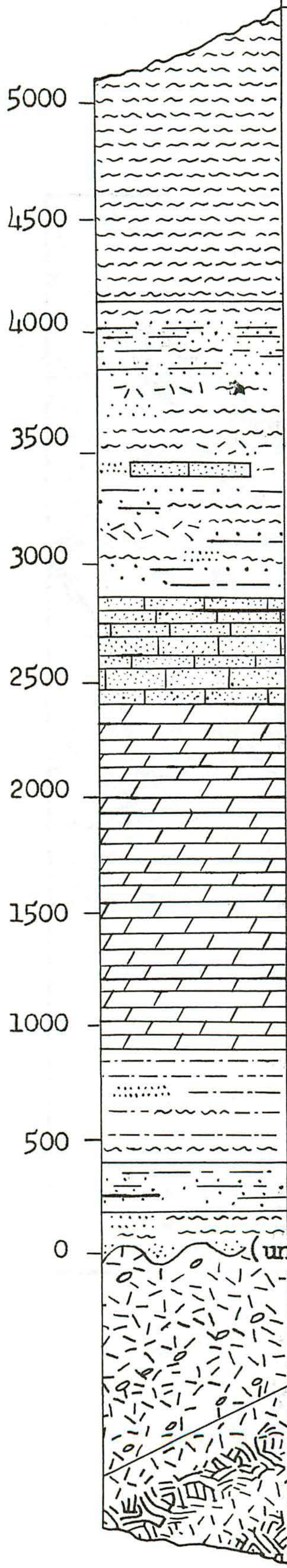


Figure 11. Geologic map showing second day's field trip route and stops.

Figure 12. Columnar section showing stratigraphic units exposed on northwest flank of Towson dome.



Series	Formation	Unit	Description
GLENARM SERIES	Wissahickon Formation	Uniform Schist Member	Medium- to coarse-grained, uniform biotite-muscovite-quartz schist with lenticles and pods of vein quartz. Garnet very common but not ubiquitous. Staurolite and kyanite locally abundant; sillimanite very restricted
		Basal Member	Fine-grained biotite-feldspar-quartz gneiss, biotite-quartz schist and muscovite-biotite-quartz schist, locally with interlayered quartzite. Finely disseminated pyrite common throughout. Conformable layers of epidotic amphibolite in a few places, and a 25 ft. thick bed of impure calcite marble in one place
	Cockeysville Marble	Upper Member	Impure phlogopitic calcite marble (calcschist)
		Lower Member	Medium-grained, uniform metadolostone with minor tremolite
	Setters Fm.	Upper Member	Chiefly mica gneiss, with subordinate quartzite and schist, generally bearing conspicuous tourmaline
		Middle Member	Thin bedded, slabby muscovite-microcline quartzite and massive muscovite-microcline quartzite
		Lower Member	Medium-grained biotite-microcline-quartz-muscovite schist with interlayered quartzite
	Baltimore Gneiss	Augen Gneiss Member	Pinkish biotite-quartz-feldspar augen gneiss, uniform biotite-quartz-feldspar gneiss, and pinkish, weakly gneissic to massive quartz-feldspar rock
		Layered Gneiss Member	Layered dark and light biotite-quartz-feldspar gneiss

ROAD LOG -- SECOND DAY
Sunday, October 31, 1971

Departure from the Holiday Inn Downtown, Baltimore at 8:00 a.m. Field trip will follow route shown on Fig. 11.

Mileage	
0.0	Leave Holiday Inn heading east on Lombard St. Get over into left lane.
0.2	Turn left onto Charles St. Keep to the left.
1.2	Bear left onto entrance ramp of Jones Falls Expressway (I 83) North.
4.1	Woodberry Quarry on left, outcrops on right - felsic gneiss and massive amphibolite of the Baltimore Gabbro Complex.
5.3	Mafic gneisses of the Gabbro Complex on right.
6.5	Baltimore City limit. Enter Baltimore County.
7.3	Passing through the Bare Hills, a serpentine barrens of historic importance as the first chromite mining district in the U.S. Although undergoing urbanization, the characteristic features of a serpentine barrens still persist - thin soil, bare patches, and a general lack of hardwoods.
7.7	Pass out of the serpentine barrens and down section into the lowermost Wissahickon Formation.
8.2	Wissahickon schist exposed on both sides of highway. Descending into valley underlain by Cockeysville Marble.
9.2	Bear left following sign for BELTWAY PIKESVILLE.
9.6	Bear right onto entrance ramp of BELTWAY following sign for PIKESVILLE.
12.9	Baltimore Gneiss on right.

Mileage

15.0	Pass under Western Maryland Railroad. This is approximate contact between Setters Formation and Cockeysville Marble on southwest flank of the Chattolanee dome. We are driving up section and after passing through the Cockeysville and a thin zone of lower Wissahickon will be in Baltimore Gabbro.
15.4	Passing from Cockeysville into Wissahickon.
15.7	Pale-green-weathering serpentinite at base of Baltimore Gabbro on left side of highway.
16.7	Bear right onto exit ramp 18 - WEST RANDALLSTOWN 26.
21.6	Turn left onto Marriottsville Road. We are now driving directly down section through Wissahickon Formation towards the Woodstock dome.
22.0	Road bears right. Housing development in shallow valley on left is underlain by Cockeysville Marble.
22.2	Road bears left, crosses first Cockeysville, then over an inconspicuous ridge of Setters and into Baltimore Gneiss.
23.6	Baltimore Gneiss on right.
24.2	Quarry in Setters Formation on left. Marriottsville quarry #2 in Cockeysville Marble on forward right.
24.8	Turn left onto road leading into #1 quarry (permission to visit quarry must be obtained from quarry superintendent).
25.2	Disembark at beginning of descent into quarry and walk the descent road down into quarry.

STOP 8. MARRIOTSVILLE QUARRY IN COCKEYSVILLE MARBLE (60 minutes)

William Crowley

The Marriotsville quarry was first opened in 1953 under the ownership of Samuel Pistorio. Annual production averaged around 200,000 tons. In 1958 Campbell acquired the business and boosted production to 1,000,000 tons. In 1964 operations were shifted largely to the newly opened quarry on the north side of Marriotsville Road. The major product of both quarries is crushed stone for the construction industry.

The quarry is located in Cockeysville Marble on the northwest flank of the Woodstock dome (see Fig. 11). The Cockeysville here consists of alternating laminae of relatively clean and very phlogopite-rich calcite marble (calc-schist). As such it is typical of the "dirty" marble in the southern part of the Cockeysville outcrop belt, and contrasts markedly with the clean metadolomite and calcite marble of the northern part of the belt. Rodgers (1970) has suggested that this contrast between a northern and southern facies may be due to an original contrast in depositional sites - clean carbonates on a northern, shallow-water shelf or bank, and dirty carbonates in a southern, deep-water basin.

The effects of folding are immediately obvious upon entering the quarry. The attitude of layering changes markedly from the east side of the quarry to the west. The hinge of the large fold that effects this change is clearly exposed at the top of the northeast face of the quarry just south of the southernmost dike cutting that face (Fig. 13). This fold plunges approximately N70W at 30° and is paralleled by numerous minor folds and the axes of deformed boudins. These axes are parallel to fold axes and lineations from a larger area surrounding the quarry (Fig. 14). An earlier and more steeply plunging set of northeast-trending folds is well expressed in the southern face of the quarry, but is not evident elsewhere. Large scale refolding in this general area is clear from the map pattern of figure 15 and one might readily hypothesize a correlation between quarry-scale and map-scale folds. Detailed mapping of the Woodstock dome with such an objective in mind, however, remains to be done.

A mafic dike about 6 inches thick runs up the southwest face of the quarry (Fig. 13). Farther north are three wider dikes, all felsic, two of which extend across the quarry, striking about N50E and standing about vertical. Foliation in the dikes parallels the dike walls. The marble has been converted to a talc schist in a thin zone adjacent to the dikes. Dike emplacement obviously post-dates regional metamorphism, but beyond this nothing is known of their age.

25.2	Board vehicles and return to Marriotsville Road.
25.7	Turn left onto Marriotsville Road.
25.9	Turn right onto Wards Chapel Road.
26.0	Pull off onto either shoulder of the road.

STOP 9. WISSAHICKON SCHIST (30 minutes)

William Crowley

WARNING! There is an active firing range a mere 100 ft. west of the road. On disembarking you will note that we are on the northern edge of a broad lowland between two ridges. The distant ridge is underlain by Setters Formation, and the

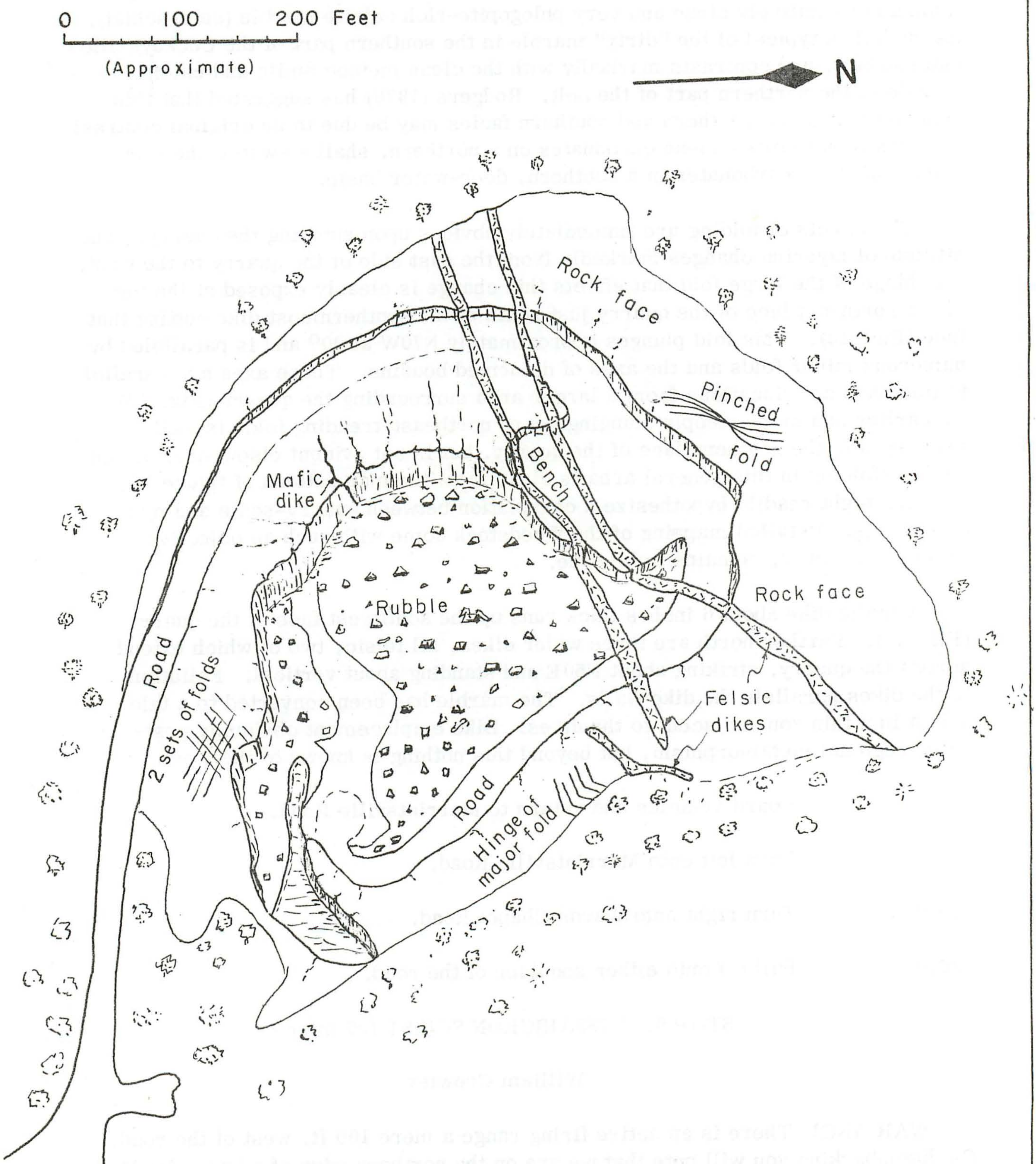


Figure 13. Sketch of Marriotsville Quarry No. I from an oblique airphoto

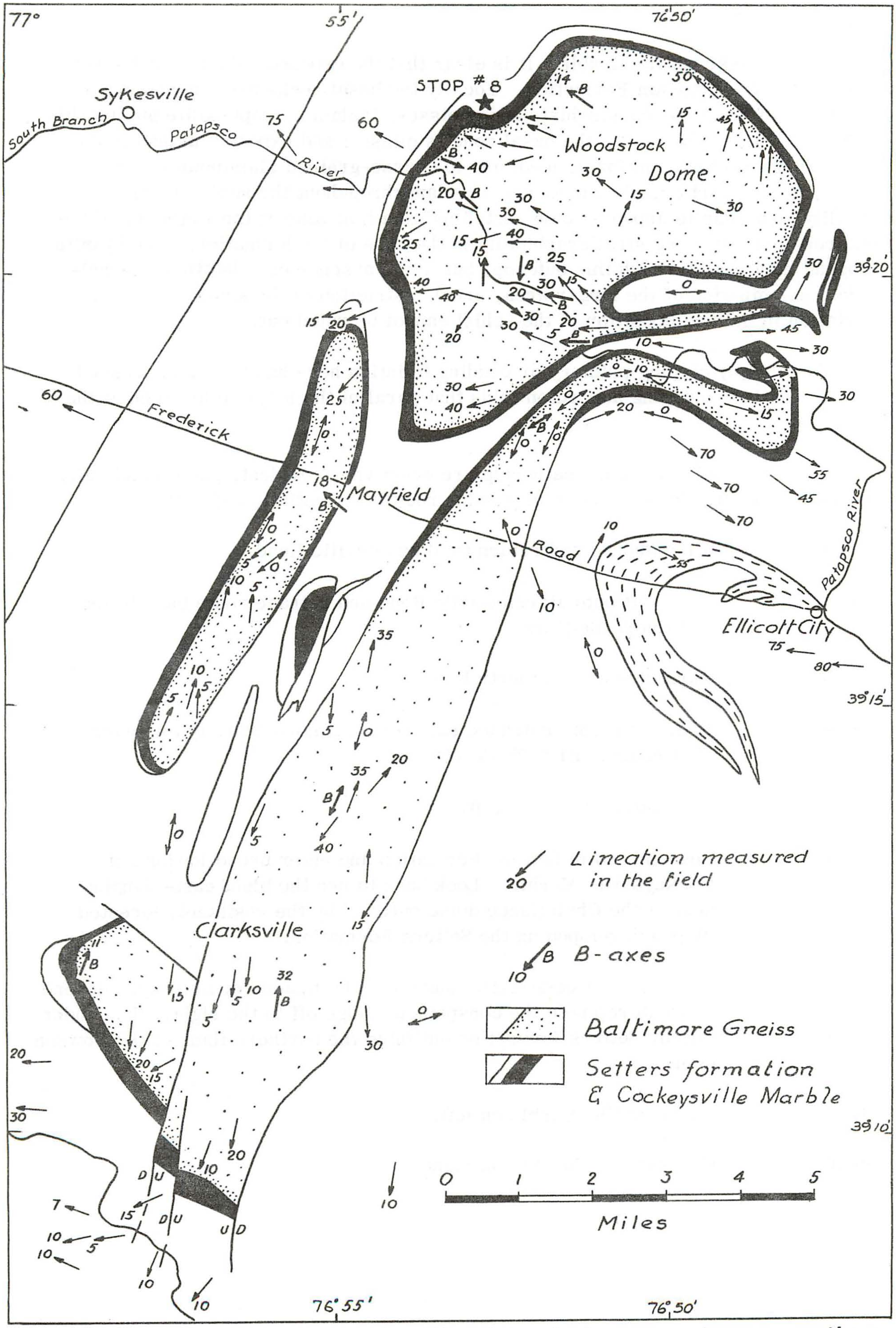


Figure 14. Geologic map of the Woodstock dome and surrounding area.

lowland by Cockeysville Marble. It is clear that the exposed schist is at the very base of the Wissahickon Formation. Locally the basal rocks are a considerable thickness of heterogeneous schists and gneisses, including amphibolite and marble (Fig. 12). Here, however, the basal zone is missing and exposed instead is the more characteristic, uniform, medium- to coarse-grained aluminous schist. Staurolite and particularly garnet are abundant throughout the schist at this locality, but kyanite appears to be restricted to a thin zone at the south end of the outcrop corresponding stratigraphically to the base of the formation. The kyanite isograd may pass through this outcrop, but in the absence of a detailed mineralogical examination of the larger area, areal restriction of the kyanite due to a variation in bulk composition of the schist cannot be ruled out.

The steeply dipping primary or bedding foliation here has been compressed into gently west plunging accordion folds that parallel the major folds seen at the last stop.

The effects of chemical weathering are everywhere evident, particularly along the west trending slope where in places the rock is essentially saprolite.

26.0	Turn around and return to Marriotsville Road.
26.1	Turn left onto Marriotsville Road and retrace route back to the Baltimore Beltway.
29.6	Turn right onto Liberty Road.
34.4	Bear right onto entrance ramp of Baltimore Beltway following sign reading BELTWAY TOWSON.
38.7	Baltimore Gneiss on left.
41.1	Descend hill of Setters Formation and enter broad lowland of Cockeysville Marble. Look back to see the blunt east-plunging nose of the Chattolanee dome outlined by the resistant, forested slopes developed on the Setters Formation.
42.4	Outcrops of Cockeysville Marble on both sides of Beltway. Beyond this outcrop note the conspicuous ridge off to the right. It is underlain by Setters Formation outlining the northern flank of the Towson dome.
45.6	Cockeysville Marble on left.
46.6	Cockeysville Marble on right.

Mileage

47.6	Cockeysville Marble on both sides of Beltway. Directly ahead, the trend of the Towson dome changes from east-west to northeast. The Beltway continues its southeasterly course, thus crossing strike and heading down section.
48.0	Conspicuous dip slope exposure of Setters Formation on right.
48.1	Ascend hill of Setters. Outcrops on right.
48.3	Small outcrop of Baltimore Gneiss on left. Our route now takes us into the Fall Zone where topographic expression of the bedrock geology is subdued by coastal plain deposits.
49.1	Bear right onto exit ramp 30 following sign reading PERRING PARKWAY SOUTH.
49.8	Cross Putty Hill Avenue.
50.5	Cross Taylor Avenue.
50.9	Cross Oakleigh Road.
51.1	Folded Baltimore Gneiss in stream on left adjacent to Perring Parkway shopping center.
51.4	Cross McClean Blvd.
51.9	Mount Pleasant Municipal Golf Course on right. Wildly folded Baltimore Gneiss in stream channel to right of road.
52.6	Cross Herring Run.
53.4	Potomac Group gravels on left.
53.5	Perring Parkway becomes Hillen Road. Turn left at break in concrete median strip, drive into Morgan State campus, disembark and proceed down into stream valley on left. Examine outcrops all the way downstream to Cold Spring Lane bridge. Buses will continue straight on through the college, cross Cold Spring Lane and park in unpaved area adjacent to the stream.

STOP 10. MORGAN STATE COLLEGE (BALTIMORE GNEISS) (50 minutes)

William Crowley

Chartered in 1867 as the Centenary Biblical Institute, Morgan was originally established to prepare young men for the Christian ministry. A generous endowment by Dr. Lyttleton Morgan in 1890 enabled the school to offer collegiate level courses, and in appreciation of Dr. Morgan's gift, the school was renamed in his honor. Since 1939 Morgan has belonged to the higher education system of the State of Maryland. The College assumes as its responsibility the training of students in the liberal arts, and the preparation of students for the professions, with emphasis upon the training of teachers for the public schools of Maryland.

The College is located on a south-jutting appendage of the Towson dome (Fig. 11). The rock here is Baltimore Gneiss and is typical of the migmatitic rocks that compose the interior of the dome. Mineralogically the rocks are quite simple - biotite, quartz, and feldspar, and, associated with pegmatites only, muscovite. The light colored minerals, feldspar and quartz, generally occur in a ratio of about 2 to 1, respectively, but the ratio of biotite to the light minerals can vary between wide limits yielding anything from a jet black biotite schist to a massive quartzo-feldspathic rock. These mineralogical variations, combined with variations in grain size yield a diversity of rock types which at this stop are interlayered, intermingled, and folded on all scales.

The effects of both tectonism and magmatism are very evident at this stop. The chief evidence of the former is an early stage isoclinal recumbent folding accompanied by development of a strong axial plane foliation. Broad warping of this foliation into upright folds defines a later stage folding. Both generations of folds plunge gently southwest. An additional tectonic feature in these rocks are short ductile faults of small displacement.

The chief evidence of magmatism are the numerous dikes of felsic rock ranging from aplite to pegmatite. Textural evidence, moreover, strongly suggests local in situ melting of rock.

54.0	Board vehicles and leave parking area. Turn left onto Cold Spring Lane. Baltimore Gneiss on both sides of road.
54.2	Turn right onto Hillen Road and retrace route back to Baltimore Beltway.
58.7	Turn right onto entrance ramp of Baltimore Beltway following sign for BELTWAY TOWSON.
59.8	Descend hill from Baltimore Gneiss through Setters Formation into valley of Cockeysville Marble. Setters crops out on left.

Mileage

60.2	Bear right onto ramp of exit 29.
60.4	Turn left at stop sign onto Cromwell Bridge Road. This road runs approximately along the contact between Setters Formation in the ridge on the right and Cockeysville Marble in the valley on the left. The ridge beyond the marble valley is underlain by Wissahickon Formation. Our route is taking us northeast along the northwest flank of the Towson dome.
61.4	Bare glimpse of a large quarry in Setters Formation on the right.
63.1	Turn left at stop sign onto Glenarm Road. Our route has now shifted upsection a bit and we are driving through the middle of the Cockeysville. The hilly topography in this belt of Cockeysville is due to an unusual abundance of large pegmatites.
63.4	Pegmatite on left. Actually the rock is a fine- to medium-grained garnet-biotite-muscovite-quartz-feldspar gneiss that grades into pegmatite. This relationship between gneiss and pegmatite has been noted in a few other localities in this belt and raises the possibility that pegmatite emplacement may have predated, or, at latest, coincided with regional metamorphism.
64.7	Conspicuous pegmatite ridge on right.
66.0	Village of Glen Arm from which the Glenarm Series takes its name. Bear right past Koppers Plant on left.
66.3	Cross Long Green Pike.
67.9	Cross hinge of Towson dome.
68.6	Turn right onto Harford Road.
68.9	On the right is a beautiful view of the plunging hinge of the Towson dome, outlined by the steep, forest covered slopes of Setters Formation, and the verdant valley of Cockeysville Marble. Our route now follows the Cockeysville along the southeast flank of the dome.
69.9	Pass junction of Hartley Mill Road. This road cuts directly across the dome exposing magnificent outcrops of the Baltimore Gneiss and Setters Formation.

Mileage

71.1 Pass junction of Long Green Pike. Historical plaque on left - "THE BALTIMORE AND HARFORD TURNPIKE COMPANY. Authorized by the Maryland Legislature in 1816 to open a road from Baltimore City with two branches, one through "Belle Air" to the Susquehanna at Rock Run and the other to Susquehanna Bridge at McCall's Ferry, Pennsylvania."

71.4 Cockeysville Marble has thinned down to the point where it no longer has any influence on the topography.

71.8 Outcrops along road from here to next stop are lowermost Wissahickon Formation with intercalated Gunpowder Granite Gneiss.

72.2 Historical plaque on left - "GUNPOWDER COPPER WORKS 1804 - 1883. Levi Hollingsworth built a mill here to roll and fabricate refined blocks of copper that were shipped to Baltimore from Wales and hauled to the mill by oxcart. The copper used for the roofing of the original dome of the Capitol was rolled and fabricated here." A few feet beyond the plaque on the left just across the river is a well exposed fault bringing lowermost Baltimore Gabbro (actually volcanics here) into contact with Wissahickon Formation and Gunpowder Granite Gneiss.

72.6 Cross Gunpowder Falls.

72.6 Turn right into gas storage facility of the Baltimore Gas and Electric Company, park, and disembark.

STOP 11. GUNPOWDER GRANITE (60 minutes)

Saki Olsen

To provide for wintertime peak consumption of natural gas, the Baltimore Gas and Electric Company augments its regular supply of natural gas with propane that is stored in a rock cavern at this site. Site selection was based chiefly on geological criteria - the uniformity and soundness of the bedrock, the Gunpowder Granite. Excavation was carried out in 1960 resulting in a cavern 410 ft. below ground level with a storage capacity of 6 million+ gallons of liquid propane. Layering in the rocks dips moderately steeply northwest, and in order to avoid the Cockeysville Marble, a probable prolific aquifer, the cavern was excavated sufficiently northwest of the surface outcrop of marble to escape its down-dip extension.

This stop is located on the southeast flank of the narrow, northeasterly-elongated neck of the Towson dome (Fig. 11). A large section of the Glenarm Series is exposed - the Setters Formation, Cockeysville Marble, and lowermost Wissahickon Formation, though all are considerably thinner than usual. Intercalated throughout the section are sheets a few feet to more than several tens of feet thick of homogeneous, fine- to medium-grained gneissic granite, with occasional biotite schlieren, bluish gray on a fresh surface, long known as the Gunpowder Granite. It consists mainly of crystalloblastic quartz, oligoclase (An 14), and microcline (Or 94) with lesser amounts of biotite and muscovite, and in bulk composition is close to that of average calc-alkaline granite. A typical mode is as follows:

Qz	Mic	Plag	Bio	Mus	Chl	Apatite	Cal	Epidote	Sph	Ilmenite
30.8	37.8	22.2	4.9	3.2	0.5	0.2	0.2	Trace	Trace	Trace

Hopson (1964) concluded that the Gunpowder Granite was a rheomorphic offshoot of the Baltimore Gneiss for two reasons. First, although the Granite is relatively uniform here, it becomes less so and begins to take on characteristics of the Baltimore Gneiss as it is traced back into the interior of the dome. Hopson found a complete gradation between the two walls exposed during excavation of the gas storage cavern. Second, the Gunpowder Granite and granitic gneiss of the Baltimore Gneiss are similar in both mineralogy and bulk chemistry. Indeed, in the core drilled at this locality it is often difficult to distinguish the two.

Davis and others (1965) found two types of zircon in the Gunpowder. One is small and euhedral; the second is larger, cloudy and similar to zircons found in the Baltimore Gneiss. The finer fraction yielded a lead-lead age of $500^{\pm}$ m.y. and the coarser fraction an age of 615 m.y. From this they concluded that the euhedral zircons were freshly formed during melting of the gneiss and that the coarser fraction was inherited from the original Baltimore Gneiss, with some loss of lead. The Gneiss itself has yielded a zircon age of 1120 m.y. (Tilton and others, 1958).

The field and geochemical evidence cited above support an anatectic origin for the Gunpowder. But contrary to Hopson's observations, the Gunpowder is a uniform gneissic granite even at the center of the dome, although it occurs there in thinner, more widely separated layers. Contacts with the Baltimore Gneiss, moreover, are quite sharp. The Baltimore Gneiss near the center of the dome in this area consists chiefly of migmatitic biotite gneiss and nebulite with only subordinate granitic and felsic gneiss. If anatexis occurred it must have been at a deeper level than that presently exposed.

Study of rock cores taken at this stop also support an intrusive origin for the Gunpowder. Foliation in the Granite locally is slightly discordant to that in the country rock or to the contact between Granite and country rock. Reaction zones have been noted between the Gunpowder and the Baltimore Gneiss, especially where the latter contains amphibole. A zone of silicified rock with coarse muscovite flakes occurs at the contact of the Granite with the Cockeysville Marble. On a regional scale the occurrence of Gunpowder Granite in stratigraphic units as widely separated in age as the Baltimore Gneiss and the Wissahickon Formation also indicates an intrusive origin.

72.6	Reboard vehicles and leave gas storage facility.
72.7	Turn left onto Harford Road and recross Gunpowder Falls.
72.8	Turn left onto Notch Cliff Road. Outcrops on right are Glenarm Series and intercalated Gunpowder Granite Gneiss, succeeded very shortly by Baltimore Gneiss with Gunpowder Granite Gneiss.
73.7	Bear left onto dirt road that follows river. Proceed as far as road conditions dictate, disembark and walk to large outcrop of augen gneiss.

STOP 12. BALTIMORE GNEISS AND LOWER GLENARM SERIES (60 minutes)

William Crowley

This stop is located approximately one mile directly across strike from Stop 11, on the opposite flank of the dome. Yet the geology here is quite different. Baltimore Gneiss, here a pinkish biotite augen gneiss shot through with pegmatite (Augen Gneiss member of Fig. 12), forms the base of the section. The overlying Setters Formation and Cockeysville Marble are considerably thicker than at the gas storage facility, apparently for stratigraphic reasons, as there is no evidence of repetition of the section by either faulting or folding. Gunpowder Granite is absent from the entire section.

The augen gneiss is identical to and physically continuous with the Hartley Augen Gneiss of Knopf and Jonas (1929), who considered it a pre-Glenarm pluton intrusive into the Baltimore Gneiss. My own mapping indicates that the augen gneiss and its retinue of associated rock types are a distinctive stratigraphic unit and should be considered a member of the Baltimore Gneiss. This leads to a two-fold subdivision of the Baltimore Gneiss in the Towson dome (Fig. 12). The contact between the two members is truncated in several places by the overlying Glenarm Series, thus providing stratigraphic-structural evidence for an unconformity which was previously supported chiefly by radiometric data.

The tripartite Setters Formation is well exposed here as a series of linear ridges extending up the slope that flanks the river. Both Knopf and Jonas (1929) and Hopson (1964) emphasized the exceptionally high K_2O and low $Na_2O + CaO$ content of the Setters, expressed modally by abundant microcline. Hopson rejected an origin due either to development of a residual soil on the Baltimore Gneiss or to granitization to explain this unusual chemistry, and concluded along with Knopf and Jonas that the Setters belongs to a limited class of K_2O-rich sediments such as the Cambrian Cartersville Formation of Georgia and the Ordovician Glenwood Shale of Minnesota, which, like the Setters, generally occur in blanket type deposits with thin, regular bedding. The K_2O of the Cartersville and Glenwood is chiefly in very fine-grained orthoclase of authigenic origin.

A deformed zone in the lower member at this stop is one of the few places where folds have been noted in the Setters. The folds plunge directly down the northwest-dipping bedding in contrast to uniformly southwest-plunging folds in nearby outcrops of Baltimore Gneiss and Wissahickon Formation. Cleavage in the middle member quartzites at this stop is at a small angle to bedding, a feature rarely observed in the highly metamorphosed rocks of this part of the Piedmont.

The stone structure in the vicinity of outcrops of the upper member is the remains of a bridge abutment of the defunct Maryland and Pennsylvania Railroad (the "Ma and Pa"). Beyond it is an enormous pegmatite which cuts out nearly the entire section of Cockeysville Marble in this area.

73.8 Leave Stop 12, retracing route back to Harford Road. Turn right onto Harford Road and drive to the Baltimore Beltway where a choice of routes to Washington, D. C. is available. End of second day completes field trip.

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1. Coastal Plain geology of Southern Maryland, by J. D. Glaser, 1968.................................... $2.75

2. New interpretations of the eastern Piedmont Geology of Maryland, by W. P. Crowley, M. W. Higgins, T. Bastian, and S. Olsen, 1971........................ $1.75

3. Environmental history of the Maryland Miocene, by R. E. Gernant, T. G. Gibson, and F. C. Whitmore, Jr., 1971 .... $2.50

4. Piedmont crystalline rocks at Bear Island, Potomac River, Maryland, by G. W. Fisher, 1971............... $1.00

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