

Guidebook

35TH. FIELD CONFERENCE
OF
PENNSYLVANIA GEOLOGISTS



Baltimore, October 2-3, 1970

Host: Maryland Geological Survey

Guidebook for the 35th Annual Field Conference of Pennsylvania Geologists

October 2-3, 1970

NEW INTERPRETATIONS OF EASTERN
PIEDMONT GEOLOGY OF MARYLAND.
or
GRANITE AND GABBRO OR
GRAYWACKE AND GREENSTONE?

By

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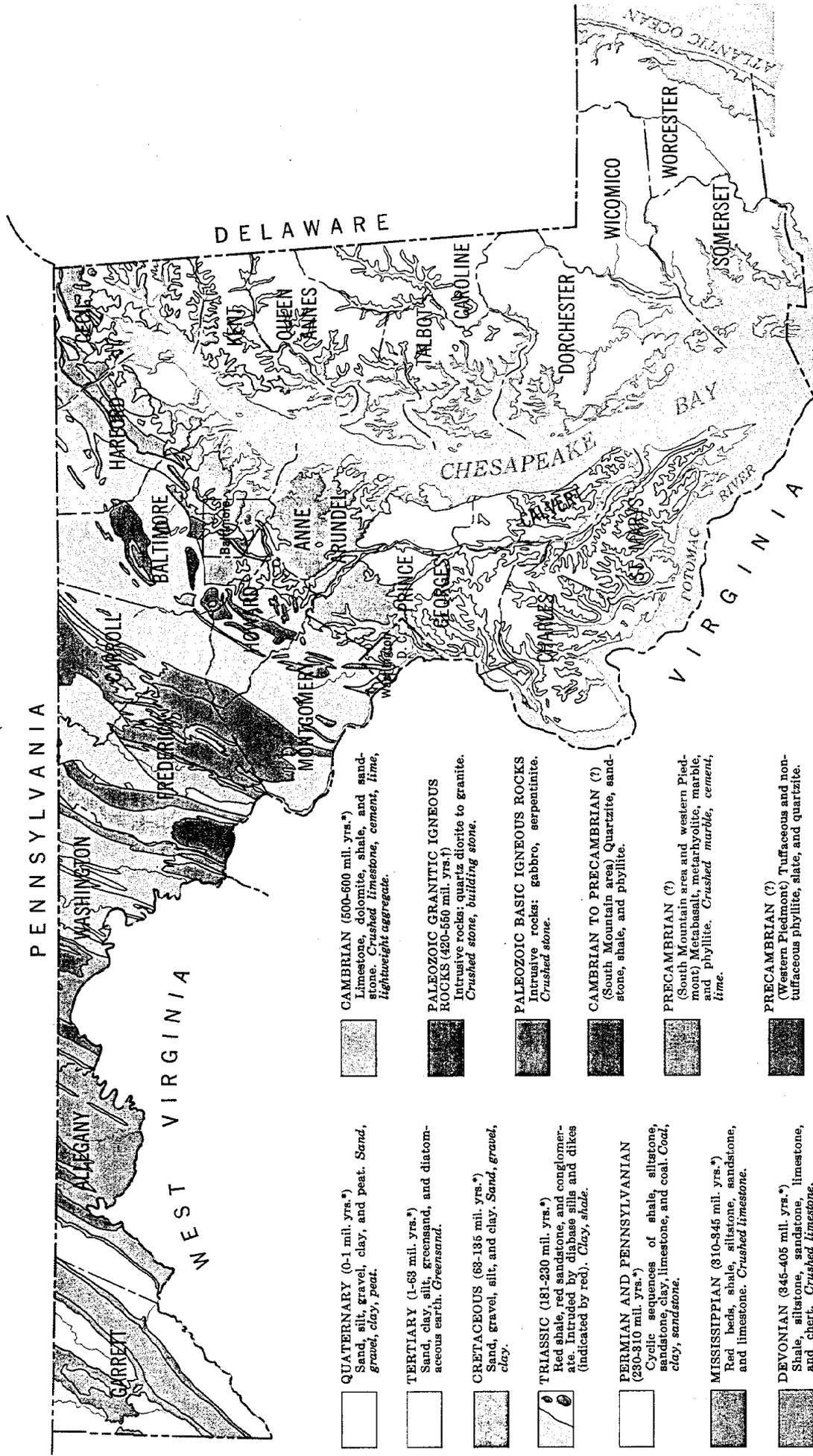
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PENNSYLVANIA



-  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.*

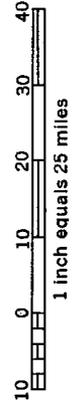
-  GAMBRIAN (500-600 mil. yrs.*)
Limestone, dolomite, shale, and sandstone. *Crushed limestone, cement, lime, lightweight aggregate.*
-  PALEOZOIC GRANITIC IGNEOUS ROCKS (420-550 mil. yrs.)
Intrusive rocks: quartz diorite to granite. *Crushed stone, building stone.*
-  PALEOZOIC BASIC IGNEOUS ROCKS
Intrusive 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, building stone.*
-  PRECAMBRIAN (?)
(Western Piedmont) Tuffaceous and non-tuffaceous 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.

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.

MARYLAND GEOLOGICAL SURVEY
Kenneth N. Weaver, Director

GENERALIZED GEOLOGIC MAP OF MARYLAND

1967



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

INTRODUCTION

by William Crowley

The area to be visited by this year's field conference is the northeastern Piedmont of Maryland (Fig. 1), chiefly Baltimore and Cecil Counties (Figs. 12 and 2) with two stops in Harford County (Fig. 11). The stops in Cecil County were chosen by Higgins to illustrate concepts derived from his recently concluded mapping there. The two in Harford County touch 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, both felsic and 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 year's field conference 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.

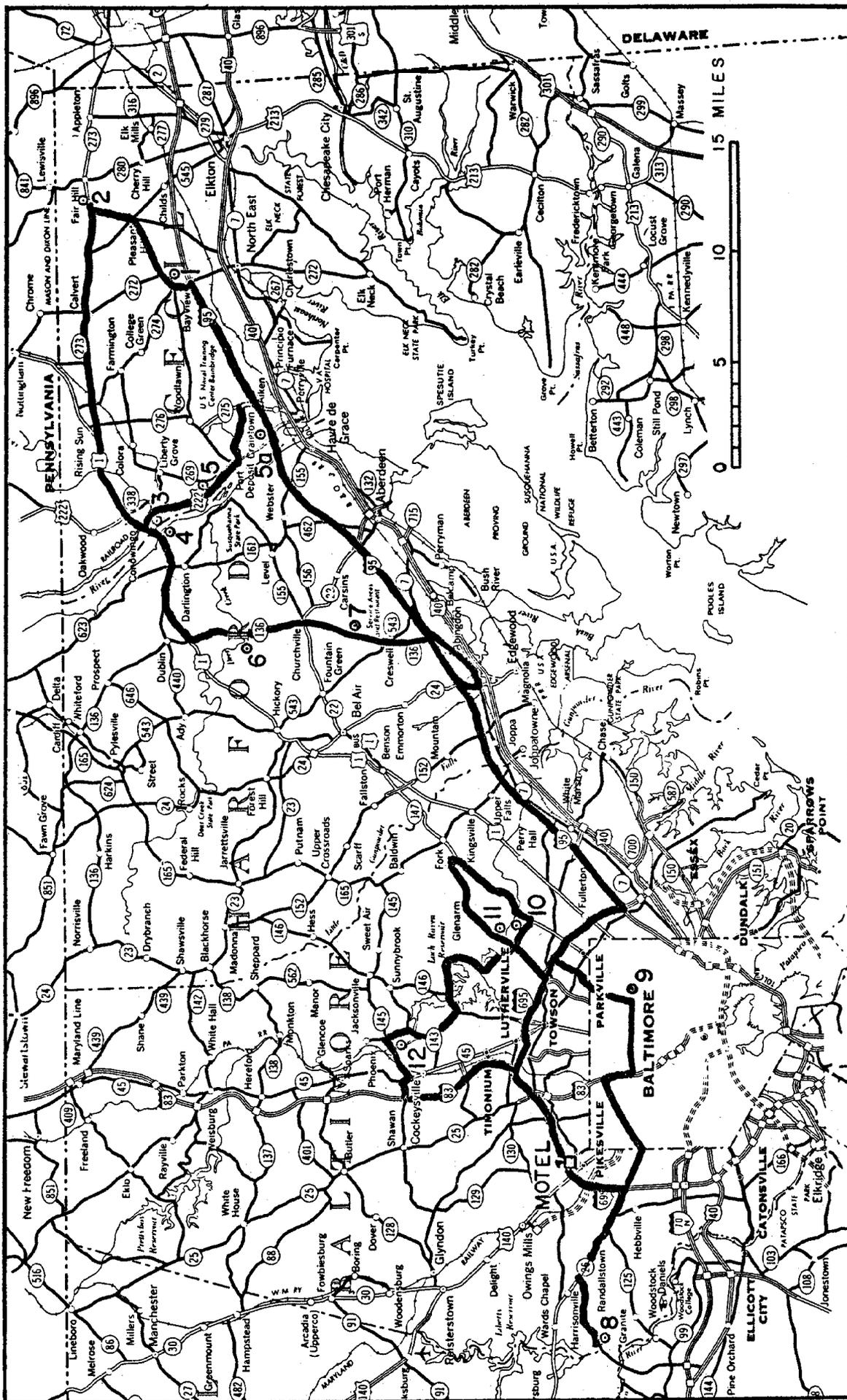


Figure 1. Road map showing field trip route and stops

Probably the most important early contribution to the geology of this area and the one that has been the starting-point for most subsequent studies was that of Matthews (1904), who worked out the stratigraphic sequence of the eastern Piedmont of Maryland (see Fig. 13). The complete section is present in Baltimore County 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 the papers is Broedel's study of the Baltimore gneiss domes, a subject that will be taken up during the second day's trip. Relevant to the first day's trip are papers by Hershey on the Port Deposit gneiss complex, and by Marshall on the Cecil County metavolcanics.

Hershey, in his concluding remarks, suggested that stratigraphic-structural evidence indicated a synclinal geometry for the Port Deposit Granodiorite complex, a conclusion that has also been reached by Crowley in Baltimore County. Recent work by Higgins (in press), 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, 5, and 5a).

Marshall described in some detail the textures of the metavolcanics.

Several papers could be cited in the years following the 30's where the germ of an important idea was expressed. These ideas were developed by Hopson along with many of his own very original ideas and elegantly synthesized in his 1964 paper with the classic turn of the century work. Relevant to this year's field conference 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 of Southwick (1969) (Stop #3) and may be even more broadly applicable (Stop #6). Hopson also interpreted as volcanoclastic 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 #7).

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FIELD TRIP INTRODUCTION - FIRST DAY

METAVOLCANIC ROCKS AND EQIZONAL 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 conference 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 southeastern border into meta-volcanic 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 metabasalt 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.

REFERENCES

- Carlisle, Donald, 1963, Pillow breccias and their aquagene tuffs, Quadra Island, British Columbia: Jour. Geology, v. 71, no. 1, p. 48-71.

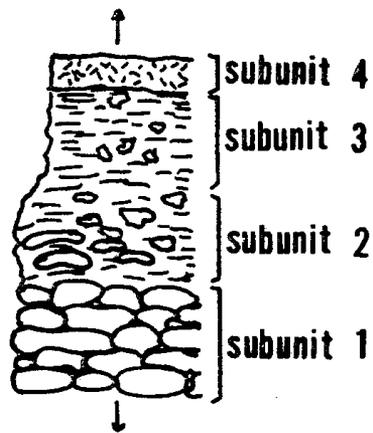


Figure 3. Schematic column to illustrate the four subunits of the metabasalt unit in Cecil County



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

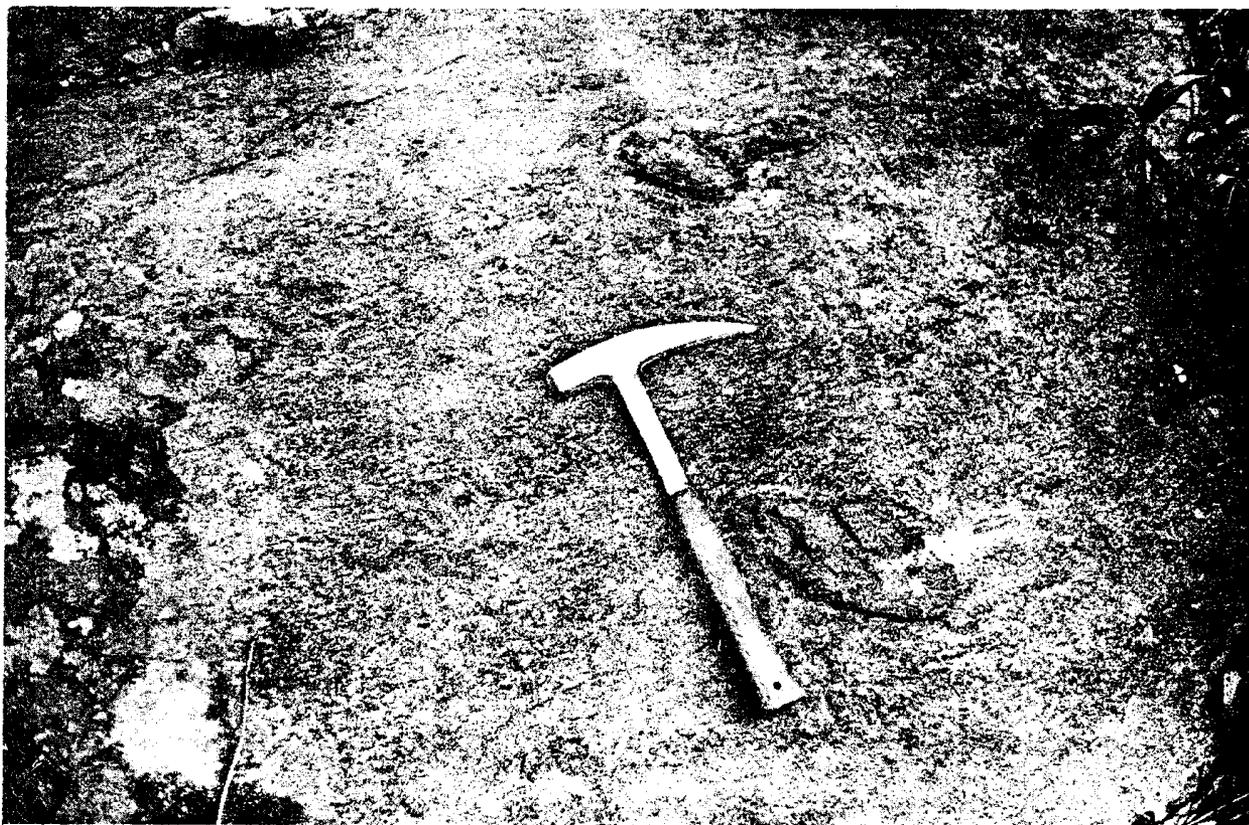


Figure 6. Broken pillow breccia of the metabasalt unit along Northeast Creek, Cecil County

ROAD LOG -- FIRST DAY
Friday, October 2, 1970

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

Mileage

- 0.0 Leave Holiday Inn, turn right onto Reisterstown Road.
- 0.1 Turn right onto entrance ramp of Baltimore Beltway following sign reading BELTWAY TOWSON. For the next several miles we will be driving on Baltimore Gneiss in the Chattolane dome.
- 3.9 Descend hill of Setters Formation and enter broad lowland of Cockeysville Marble. Look back to see the blunt east-plunging nose of the Chattolane dome outlined by the resistant, forested slopes developed on the Setters Formation.
- 5.2 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.
- 8.7 Cockeysville Marble on right.
- 9.7 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.
- 10.2 Conspicuous dip slope exposure of Setters Formation on right.
- 10.3 Ascend hill of Setters. Outcrops on right.
- 10.5 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.
- 15.7 Bear left onto John F. Kennedy Memorial Highway.
- 22.3 Cross Big Gunpowder Falls.
- 24.5 Cross Little Gunpowder Falls. Leave Baltimore County and enter Harford County.
- 27.8 Cross Winters Run.
- 29.0 Coastal Plain sediments on left.
- 31.2 Cross Bynum Run.
- 42.4 Metavolcanics on right.

Mileage

- 42.5 Enter Susquehanna River Bridge. Leave Harford County. Downstream on right is large inactive quarry of the Arundel Corp. Rock is mapped as Port Deposit, but is of probable volcanic origin. Immediately upstream on Cecil Co. side is an abandoned quarry in metavolcanics. Farther upstream can be seen the well known Port Deposit quarry in Port Deposit Gneiss.
- 43.5 Leave Susquehanna River Bridge. Enter Cecil County. Metavolcanics on left.
- 44.8 Toll Booths.
- 45.2 Pass under U.S. 222 (also Md. 222).
- 51.4 Bear right onto exit ramp #8 following sign that reads RISING SUN, NORTHEAST, 272.
- 51.8 Bear left following sign reading RISING SUN.
- 51.9 Bear left onto Md. 272.
- 53.3 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."
- 53.3 Turn right into Boy Scout camp.
- 53.4 Park in dirt lot, disembark, and proceed to outcrop.

STOP #1 (45 minutes)

STOP #1 (Bay View Boy Scout Camp) by 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

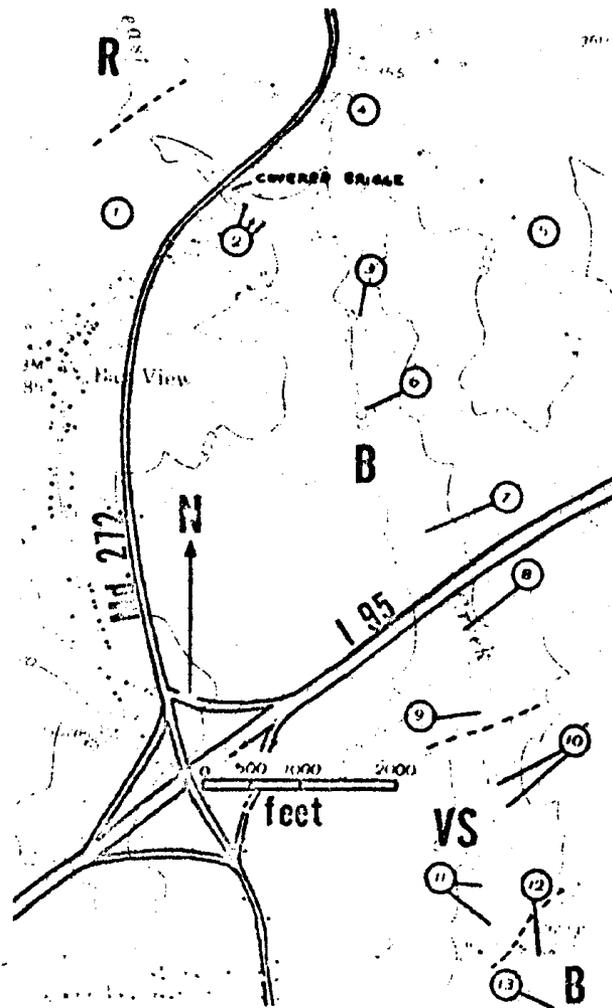


Figure 7. An expanded trip through the pillow basalt section, the rest of the metabasalt unit, and the felsic metavolcanic rocks between the two outcrop belts of the metabasalt unit.

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.

down the creek through the pillow basalt section, the rest of the metabasalt unit, and some of the other metavolcanic rocks.

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- Moore, J. G., 1965, Petrology of deep-sea basalt near Hawaii: Am. Jour. Sci., v. 263, no. 1, p. 40-52.

- 53.4 Board vehicles and return to Md. 272.
- 53.4 Turn right onto Md. 272.
- 53.6 Turn right onto Warburton Road.
- 55.0 Cross North East Creek. Outcrops on right of massive felsic volcanics.
- 56.7 Cross Blue Ball Road (Md. 545).
- 56.8 Cross Middle Road.
- 56.9 Turn left onto Hill Top Road.
- 58.5 Quartz boulders on left
- 58.7 Turn right onto Md. 273.
- 59.1 Old stone houses on left.
- 59.2 Turn left onto Rock Church Road. Pull off on left shoulder of road, park, and disembark.

STOP #2 (45 minutes)

STOP #2 (Rock Church) by 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.

Detailed chemical and mineralogic studies are now being made to determine the nature of the transformation from the nearly undeformed rocks to the amphibolite, and isotopic studies are planned.

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 inter-layered mafic and felsic tuffs.

- 59.2 Return to Md. 273.
- 59.3 Turn right onto Md. 273.
- 61.8 Pass through Blueball.
- 64.5 Pass through Calvert.
- 68.8 Cross Md. 274 in Rising Sun.

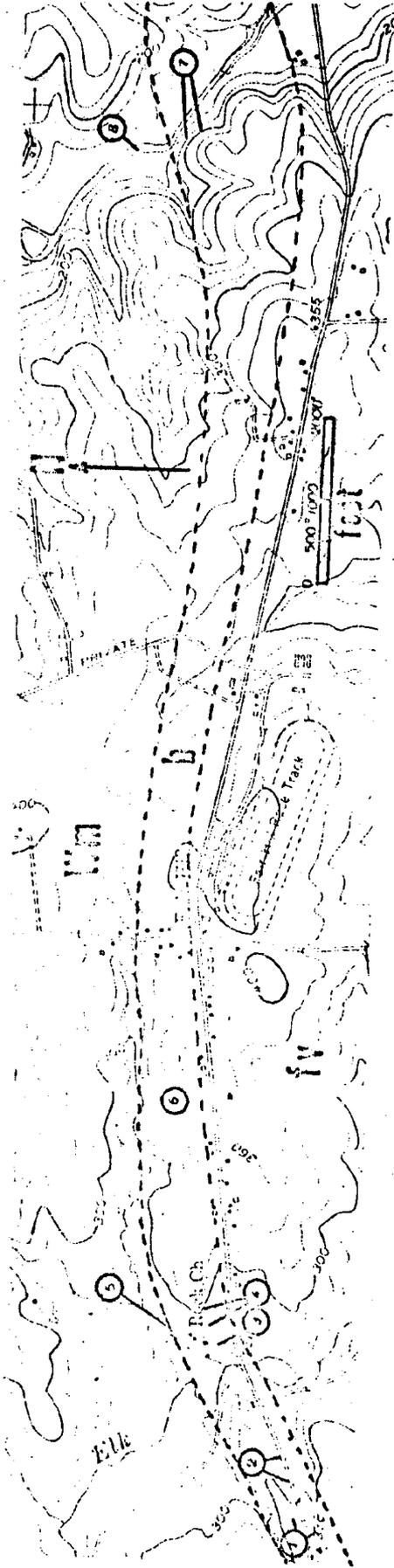


Figure 8. Pillow basalts and layered amphibolites.

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.

- 71.6 Richards Oak on right. This magnificent oak was probably admired by Lafayette who camped here on his way south to Yorktown.
- 75.3 Turn left onto U.S. 222.
- 75.9 Turn right into dirt road along high voltage lines.
- 76.0 Pull off onto left shoulder of road. Park and disembark. Follow path to river and large water-worn outcrop.

STOP #3 (20 minutes)

STOP #3 (Conowingo Dam) by 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, in press). 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.

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- 76.0 Return to U.S. 222.
- 76.1 Turn left onto U.S. 222.
- 76.7 Turn left onto U.S. 1 and cross Susquehanna River via Conowingo Dam.
- 77.6 Turn left onto Shuresville Road.
- 78.3 Turn left onto Shures Landing Road.
- 79.1 Enter property of Philadelphia Gas and Electric Co.
- 79.4 Park in designated area and disembark.

STOP #4 - lunch stop (60 minutes)

STOP #4 (lunch - Fishermen's Park, Conowingo dam) by 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 north-eastern 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 quarried from very localized occurrences in Catoctin and South Mountains of central Maryland and 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 the 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 irreplaceable archeological data which still remain in Maryland. Both site preservation and systematic salvage of non-preservable sites are being attempted.

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- 79.4 Leave Stop #4 (Retrace route back to U.S. 1)
- 80.4 Turn right onto Shuresville Road.
- 81.2 Turn right onto U.S. 1, and recross Susquehanna River via Conowingo dam.
- 82.2 Turn right onto Md. 222.
- 82.4 Outcrop on left - diamictite facies of the Wissahickon Formation.
- 84.2 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."
- 86.4 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.
- 86.5 Disembark and walk to quarry face.

STOP #5 (20 minutes)

STOP #5 (The Port Deposit quarry) by 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

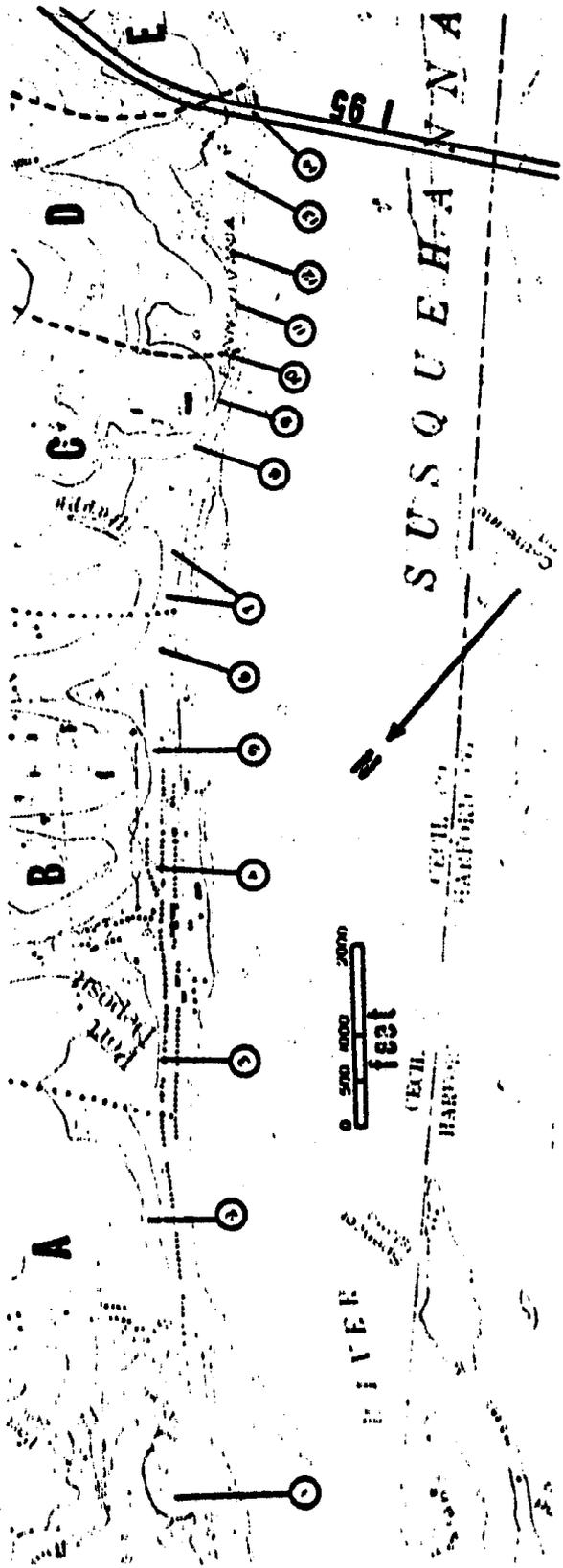


Figure 9. The nature of the Port Deposit Pluton

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 a 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.

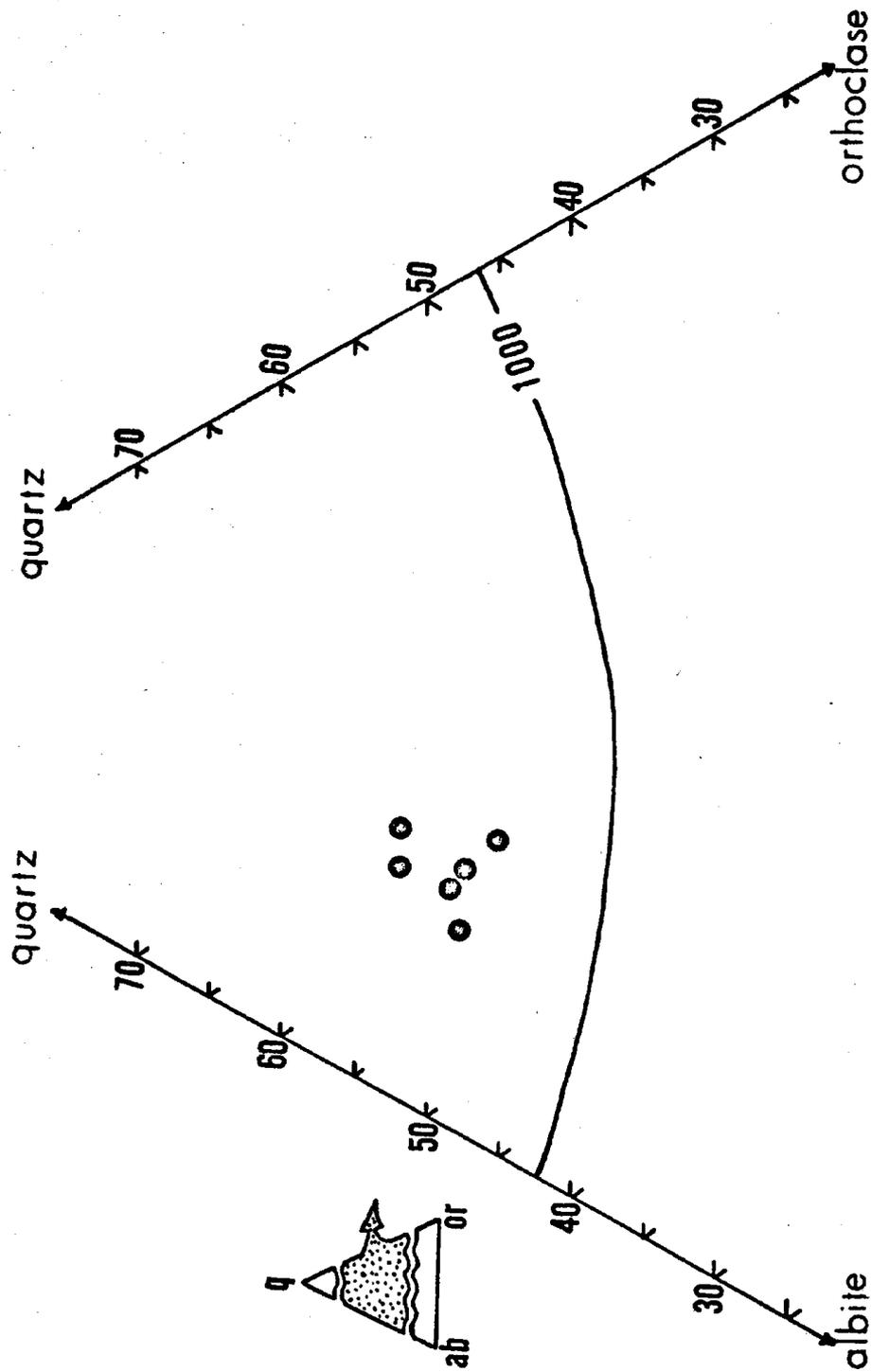


Figure 10. Normative q-or-ab ratios of the Port Deposit Gneiss. Plot after Hopson, 1964. Analyses by U.S. Geological Survey -- Higgins, unpub. data. 1,000-bar projection of synthetic granite minimum shown.

quarry (Stop 5; Fig. 9), 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. A representative hand sample should be collected here for comparison with the rocks of the next stop.

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, in press), and advanced here, is that the Port Deposit was a shallow, surface-breaking pluton that was a source for some of the volcanic rocks.

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- 86.5 Board vehicles and return to Md. 222.
- 86.6 Turn left onto Md. 222.
- 86.9 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."
- 88.3 Outcrops of Port Deposit Gneiss on left. (Private parties should proceed to Stop #5a by turning right into Logan's Wharf, seeking permission to park, and walking downstream along the Susquehanna).
- 88.9 Bainbridge Naval Training Center on left.
- 89.9 Turn right onto unnamed road.
- 90.3 Turn left onto unmarked dirt road (Frenchtown Road) and then an immediate right into the estate of Frank D. Brown, Jr.
- 90.8 Disembark and proceed along path down to Susquehanna River. Buses will proceed to Logan's Wharf in Port Deposit to receive field party at upstream termination of Stop #5a.

STOP #5a (90 minutes)

STOP #5a (Susquehanna River below Port Deposit) by Michael W. Higgins

South of the Port Deposit quarry, the gneiss gradually becomes finer grained. With the decreasing grain size, blocky plagioclase crystals appear and increase to the south. An arbitrary contact between the Port Deposit Gneiss of the quarry (Unit 16, Fig. 2) and a somewhat finer grained gneiss or granofels (Unit 17, Fig. 2) can be drawn near the middle of the town of Port Deposit (Fig. 2). In the cuts of the Penn-Central Railroad south of the town of Port Deposit (Fig. 9), one can see a gradual transition from rocks which might be considered fine-grained Port Deposit into rocks which show relict

TABLE 1

Chemical analyses of gabbros and basalts from Cecil County

Oxides	1	2	3	4
SiO ₂	52.6	48.8	49.7	53.4
TiO ₂	1.1	.31	.73	.73
Al ₂ O ₃	14.9	17.8	15.6	15.6
Fe ₂ O ₃	2.8	.90	2.7	3.1
FeO	10.0	7.0	6.5	7.8
MnO .....	.36	.17	.10	.03
MgO	4.2	10.7	8.9	5.1
CaO	8.7	12.1	10.4	7.8
Na ₂ O	2.6	.60	3.0	4.4
K ₂ O .....	.75	.05	.29	.32
H ₂ O+	1.2	.66	.89	.78
H ₂ O- .....	.11	.07	.31	.02
CO ₂	<.05	<.05	<.05	<.05
P ₂ O ₅ .....	.18	.13	.12	.04
Total.....	100	99	99	99

1. Metamorphosed basaltic dike from Locality no. 8, Figure 9.
2. Metamorphosed gabbro (Baltimore Gabbro of Hopson [1964]) from northwestern Cecil County.
3. Metamorphosed pillow basalt (core of pillow) from along Northeast Creek, Cecil County.
4. Metamorphosed basaltic tuff from along Northeast Creek, Cecil County.

Analyses by P. Elmore, G. Chloe, J. Kelsey, S. Botts, H. Smith, L. Artis, and J. Glenn, U.S. Geological Survey, Washington, D.C.
 Methods of analysis were those described in U.S. Geol. Survey Bulletin 1144-A. Shapiro, Leonard, and Brannock, W. W., 1962, Rapid analysis of silicate, carbonate, and phosphate rocks: U.S. Geol. Survey Bull. 1144-A, 56 p.

volcanic or "subvolcanic" (Cater, 1969) textures and finally into volcanoclastic rocks (Fig. 9). A series of thin sections of these rocks also shows the gradual transition. Here also, along with the felsic rocks, are mafic amphibolites. These amphibolites were called lamprophyre dikes by Hershey (1937), Marshall (1937), and Southwick (1969), because they contain hornblende (Hershey, 1937, p. 119). I regard the hornblende as a metamorphic mineral in these rocks. Chemically, the rocks are basalts, very similar in composition to the pillow basalts and gabbros of the area (Table 1). Moreover, some of these rocks, which Hershey, Marshall, and Southwick thought were all dikes, have amygdules or relict volcanoclastic or pyroclastic textures, which indicate that some of the mafic layers are volcanic beds. Other layers do show relict chilled margins, and probably were dikes or sills.

Overall, the field and petrographic relations suggest that the shallow plutonic rock (Port Deposit Gneiss) of the quarry area (Unit 16, Fig. 2) grades through a transitional, "hypabyssal (?)" zone (Unit 17, Fig. 2) into volcanic and volcanoclastic rocks (Unit 5, Fig. 2), with interlayered amphibolites that represent sills, dikes, flows, and volcanoclastic deposits. This whole sequence of rocks is strongly reminiscent of the Tatoosh pluton and its "hypabyssal" and volcanic phases, described by Fiske and others (1963). The excess modal quartz in the Port Deposit Gneiss, and the fact that chemical analyses of the gneiss plot in the "sedimentary field" of a q-or-ab diagram, may also be consistent with a very shallow plutonic (or hypabyssal) origin. This diagram, as used by Hopson (1964) to indicate a metasedimentary origin for the Sykesville gneiss, is based on water vapor pressures of at least 200 Kg/cm² (Hopson, 1964, p. 110, used the diagram for 1,000-bars P_{H₂O}.) Perhaps, then, it is unfair to compare the Port Deposit with plutonic rocks that crystallized

in a relatively dry environment (Tuttle and Bowen, 1958, p. 70). In the system $\text{NaAlSi}_3\text{O}_8\text{-KAlSi}_3\text{O}_8\text{-SiO}_2\text{-H}_2\text{O}$ from which the "fields" on the q-or-ab diagram are taken (Tuttle and Bowen, 1958), the synthetic granite minimum projection (the line that bounds the "fields") moves steadily up the triangle with decreasing water vapor pressure (Tuttle and Bowen, 1958). To my knowledge, no experimental data exist to show what would happen at extremely low pressure in a wet environment, but presumably the minimum projection would continue to climb on the diagram, at least down to a few bars $P_{\text{H}_2\text{O}}$. Thus, the analyses of Port Deposit Gneiss might plot in the magmatic field, after all. In this case the Port Deposit magma would have "boiled" as it neared the surface, rapidly crossed fields on the experimental diagram, and caused an excess of quartz.

Another alternative lies in late hydrothermal silicification, but it would be somewhat difficult to explain how the Port Deposit could be selectively silicified, whereas the mafic rocks retain their low silica compositions.

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- 93.5 Board vehicles and return to Md. 222.
- 93.7 Turn left onto Md. 222.
- 99.6 Turn left onto U.S. 1, recross Susquehanna River, and continue south into Harford County.
- 100.7 Historical plaque on right - "CONOWINGO. An Indian name meaning 'at the falls'. Captain John Smith ascended the Susquehanna River in 1608, to the head of tidewater. He named the first rapids 'Smith's Falls'."
- 102.1 Pass through intersection of Md. 623.
- 102.3 Pass through junction of Md. 161.
- 103.9 Pass through junction of Md. 440.
- 106.0 Turn left onto Md. 136.
- 108.0 Historical plaque on left - "INDIAN SPRING. Count de Rochambeau's heavy artillery and baggage train camped near this point Sept. 10, 1781. After fording the Susquehanna River at Bald Friar, they proceeded to Bush to join the main troops."
- 108.6 Cross Deer Creek.
- 109.1 Turn right onto Cool Spring Road.
- 109.9 Cross Tobacco Run, continue through right-hand curve and pull off onto grassy shoulder on right.

STOP #6

STOP #6 - (Tobacco Run) by William Crowley

This stop (Fig. 11) is in the "Quartz gabbro and quartz diorite gneiss" of Southwick (1969) who has described it as follows: "Zone of mixed rocks, consisting chiefly of greenish-black uralitized quartz-bearing gabbro on the northwest and dark-gray, weakly gneissic pyroxene-hornblende-biotite-quartz

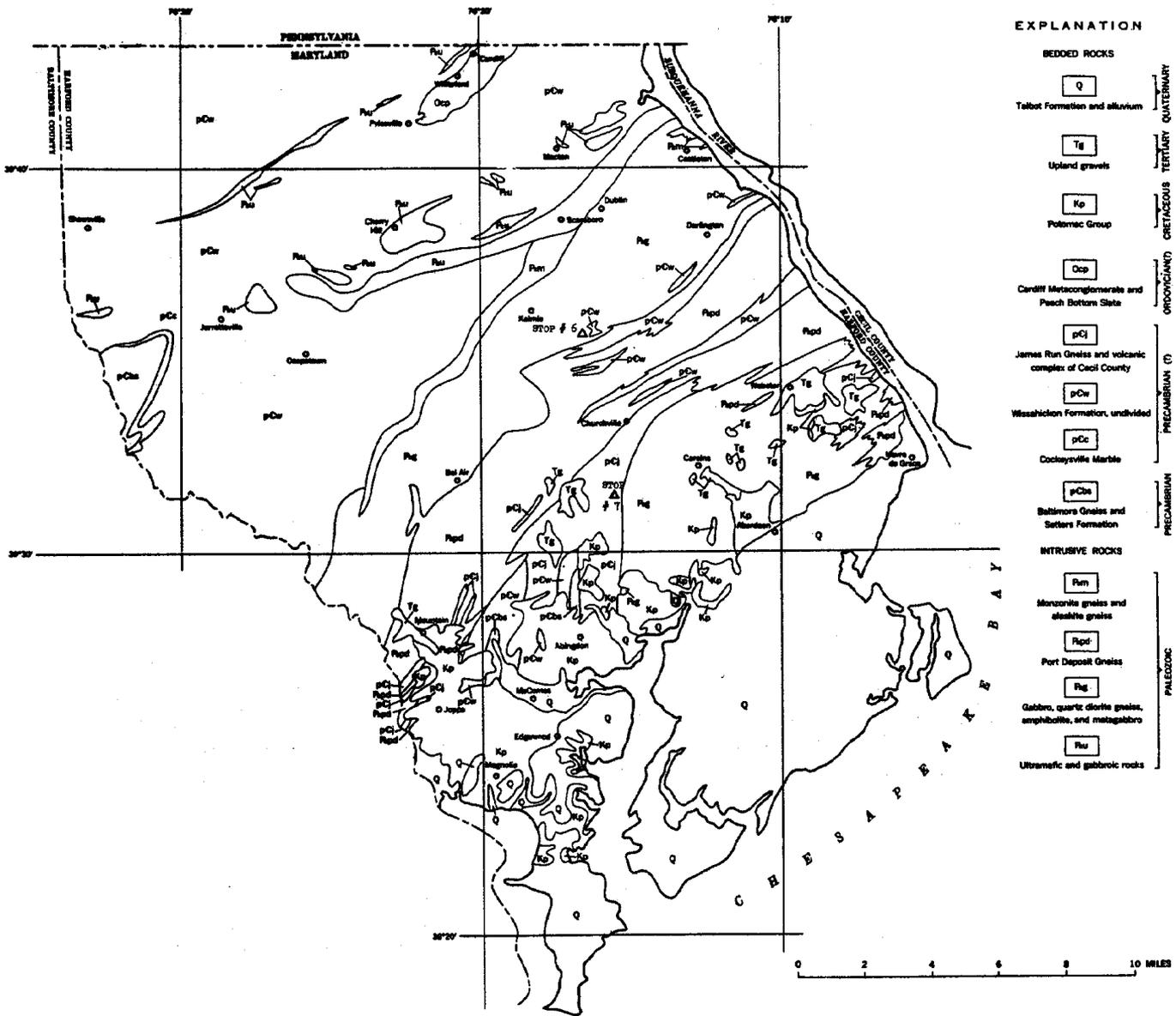


Fig. II. Generalized geologic map of Harford County showing location of Stop # 6 and # 7.

diorite on the southeast. Inclusions of mafic rock in quartz diorite are abundant locally. Very poorly exposed."

The first outcrops downstream from the Cool Spring Road bridge are hornblende gneiss with conspicuous quartz grains and numerous inclusions of finer grained, more hornblendic rock. Higher up on the bank to the left (west) and overlying the hornblende gneiss structurally is quartz diorite gneiss, also with conspicuous quartz grains but lacking inclusions of any sort. The entire unit is assigned a plutonic origin by Southwick, but the remarkable similarity of the quartz diorite gneiss to the matrix of the boulder gneiss seen at Stop #3 raises the possibility that this felsic gneiss might also be interpreted as a sedimentary deposit. The mafic rocks with their numerous inclusions make this an even more inviting hypothesis as they can easily be interpreted as a boulder gneiss-like slide deposit derived from a more mafic source region. To the north in Cecil County, Higgins (personal communication) has observed, in this same zone, a continuous gradation from hypersthene gabbro on the north to felsic gneiss of sedimentary origin on the south, and interprets this as a zone where metasediments have been soaked by gabbro. At this stop, however, there appears to be an interlayering of, rather than a gradation between, felsic and mafic rocks, and a soaking solution is less easily applied.

Several mafic dikes are exposed at this stop. All are less than a foot thick. They strike about N20W and stand nearly vertical.

REFERENCES

- Southwick, D. L., 1969, The crystalline rocks of Harford County: Md. Geol. Survey, Harford Co., p. 1-76.

- 109.9 Board Buses and proceed up the road a short way.
- 110.0 Turn around in driveway on right and return to Md. 136 via Cool Spring Road.
- 110.9 Turn right onto Md. 136.
- 113.6 Cross intersection of Md. 22. Historical plaque on left - "CHURCHVILLE formerly called 'Lower Cross Roads'. Council of Safety met here 5 April, 1775. Considered as site for county seat 1781. George Washington passed 6 May, 1775 on way to be made commander-in-chief of the army. Lafayette and his troops marched past 15 April, 1781 on the way to Virginia. Part of Rochambeau's troops passed through Sept. 1781 toward Yorktown."
- 115.7 Turn left into entrance of Gatch Crushed Stone Company. Park in designated area and proceed into quarry.

STOP #7

STOP #7 - (The Gatch Quarry) by 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. In recent years annual production has been about 400,000 tons, but completion of a new plant now under construction is expected to boost production well beyond this figure.

The Gatch Quarry is the only operating quarry that will be visited during the course of this year's field conference. 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 (see Fig. 11), 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 bulk 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 is a class of altered marine volcanic sediments whose chemical composition does closely match the James Run Gneiss. These are the albitized and zeolitized volcanoclastic 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 (see Fig. 11). If such a correlation is assumed, then the age of the lower Glenarm Series is Cambrian.

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- Tilton, G. R., Doe, B. R., and Hopson, C. A., 1970, Zircon age measurements in the Maryland Piedmont, with special reference to Baltimore Gneiss problems in Studies of Appalachian Geology: Central and Southern, eds. Fisher, G. W., and others: Interscience, New York, p. 429-434.

- 115.7 Reboard buses and leave Gatch quarry.
- 115.8 Turn left onto Md. 136.
- 117.5 Cross intersection of Md. 543.
- 119.5 Cross over Kennedy Memorial Highway. Cretaceous Potomac Group sand and gravel on both sides of road.
- 119.9 Turn right onto Md. 7 (Old Philadelphia Road).
- 120.0 Historical plaque on right - " 'THE BUSH DECLARATION' HARFORD TOWN. County seat of Harford County from its origin March, 1774, until March, 1783. Here the first declaration of independence ever adopted by an organized body of men duly elected by the people was proclaimed on March 22, 1775."
- 120.1 Historical plaque on left - "HARFORD TOWN or Bush. The French troops of Count de Rochambeau in five divisions camped here at the end of August 1782 - the 22nd camp on the return march from the Yorktown victory to the north.
- 121.2 Historical plaque on left - "COKESBURY COLLEGE. The first Methodist college in the world established at Abingdon June 5, 1785 by bishops Thomas Coke and Francis Asbury. Destroyed by fire December 4, 1795. Located 175 yards east of this point."
- 122.6 Historical plaque on left - "GOV. WILLIAM PACA. Signer of the Declaration of Independence. Born October 31, 1740 on Chilberry Hall Farm 1.25 miles south of here. Died October 27, 1799.
- 123.6 Turn right onto Md. 24.
- 123.7 Turn left onto entrance ramp of I-95 following sign reading - SOUTH BALTIMORE, and retrace route to motel.

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 12) will take us through four of the domes, with stops scheduled in two of them. The stratigraphy of the area is shown in Fig. 13.

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. 13), 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 #11) whereas the overlying Cockeysville and Wissahickon are tightly folded (Stop #12) 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 #9) in the Baltimore Gneiss and showed that the map patterns

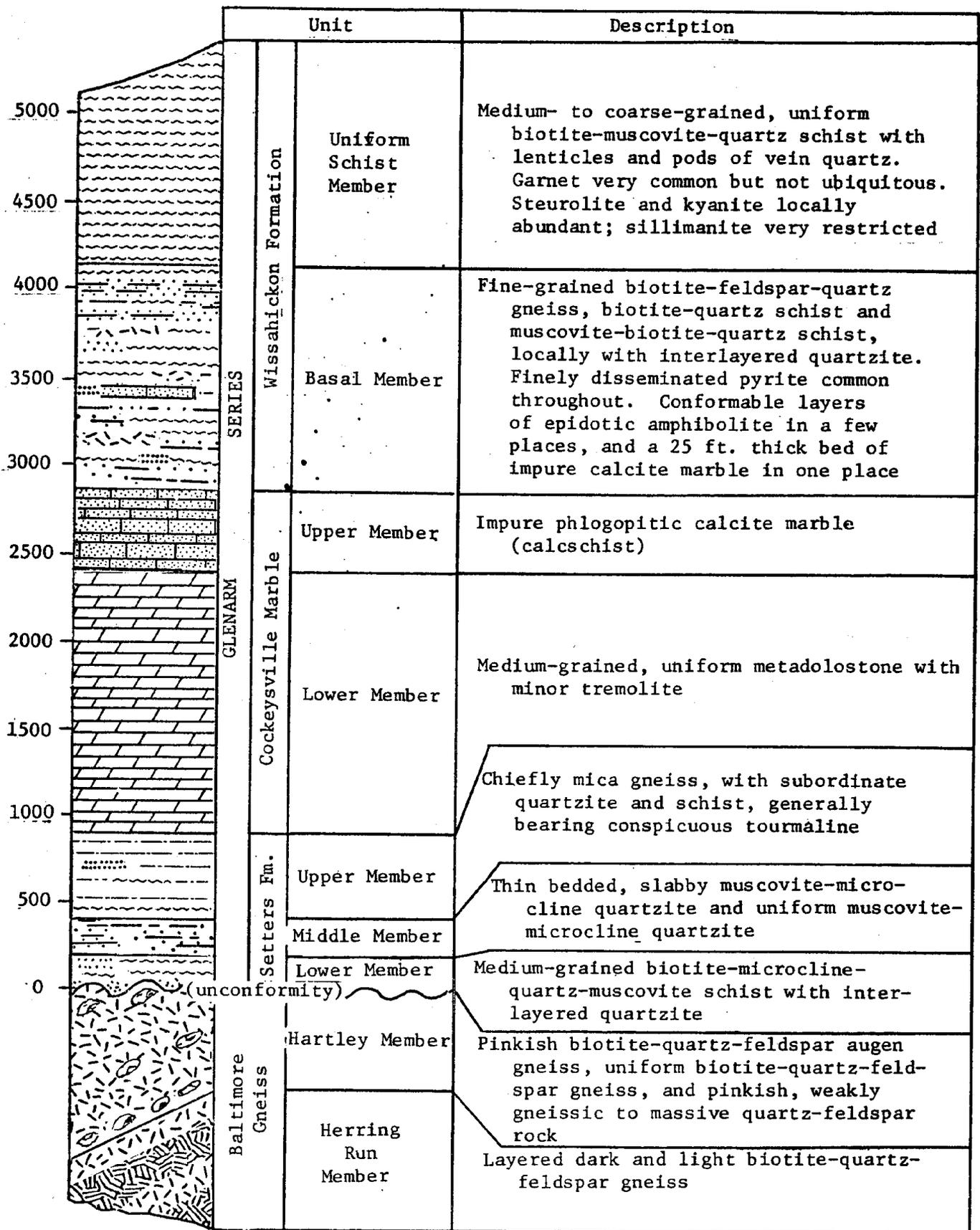


Figure 13. Columnar section showing stratigraphic units exposed on northwest flank of Towson dome.

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 Chattolane 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 allochthonous and was thrust over the Baltimore Gneiss and lower Glenarm Series, his only evidence being the great variations in thickness of the Cockeysville.

Although his evidence is not very persuasive, his conclusion is remarkably like Hall's (1968) hypothesis that in the very similar New York City Series, members B and C of the Manhattan Schist have been thrust over the lower units.

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 Gunpowder Granite is an example of such a rheomorphic offshoot from the Baltimore Gneiss (Stop #10).

The classical interpretation of the domes as simple anticlinal structures is presently under close scrutiny, and in fact similar structures on strike to the northeast have already been shown to be considerably more complex. Indeed, as early as 1937 Bailey and Mackin demonstrated quite convincingly that the gneiss domes of the Doe Run-Avondale area of southeastern Pennsylvania were refolded recumbent folds. And similarly complex configurations have been

established for many of the New England gneiss domes (Thompson and others, 1968; Stanley, 1964). Rodgers (in press) has speculated that the map pattern and associated lineation pattern of some of the domes around Baltimore almost demand a similar interpretation. Minor folds at Stops #8 and #9 suggest the possibility of at least a double deformation at those sites. And my own mapping of the curvilinear Towson dome has shown that minor folds are associated with the doming plunge southwest at the northern hinge of the structure thus indicating a synformal rather than an antiformal geometry at that end of the dome. My current concept of the Towson structure is a dome that is rooted to the south and west but flopped over on its side to the north. As this guidebook goes to press, several test holes are being drilled at the northern hinge of the structure to partially test this concept.

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ROAD LOG --- SECOND DAY
Saturday, October 3, 1970

Departure from the Holiday Inn Northwest, Baltimore at 8:00 a.m.
Field trip will follow route shown on Fig. 12.

Mileage

- 0.0 Leave Holiday Inn. Turn right onto Reisterstown Road.
- 0.2 Turn left onto entrance ramp of Baltimore Beltway following sign that reads "BELTWAY GLEN BURNIE".
- 0.9 Pass under Western Maryland Railroad. This is approximate contact between Setters Formation and Cockeysville Marble on southwest flank of the Chattolane dome. We are driving up section and after passing through the Cockeysville and a thin zone of lower Wissahickon will be in Baltimore Gabbro.
- 1.3 Passing from Cockeysville into Wissahickon.
- 1.7 Pale green weathering serpentinite at base of Baltimore Gabbro on left side of highway.
- 2.7 Bear right onto exit ramp at exit 18 - RANDALLSTOWN WEST.
- 7.6 Turn left onto Marriottsville Road. We are now driving directly down section through Wissahickon Formation towards the Woodstock dome.
- 8.0 Road bears right. Housing development in shallow valley on left is underlain by Cockeysville Marble.
- 8.2 Road bears left, crosses first Cockeysville, then over an inconspicuous ridge of Setters and into Baltimore Gneiss.
- 9.6 Baltimore Gneiss on right.
- 10.3 Quarry in Setters Formation on left. Marriottsville quarry #2 in Cockeysville Marble on forward right.
- 10.8 Turn left onto road leading into #1 quarry (permission to visit quarry must be obtained from quarry superintendent).
- 11.5 Disembark in clearing at bottom of quarry.

STOP #8 (60 minutes)

STOP #8 - (Marriotsville Quarry #1 of Harry T. Campbell & Sons) by William Crowley

The #1 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 #2 quarry. The major product of both quarries is crushed stone for the construction industry.

The quarry is located in Cocksylville Marble on the northwest flank of the Woodstock dome (see Fig. 12). The Cocksylville 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 Cocksylville outcrop belt, and contrasts markedly with the clean metadolomite and calcite marble of the northern part of the belt. Rodgers (in press) 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. 14). 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. 15). 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

SCALE
0 100 200 Feet
(Approximate)

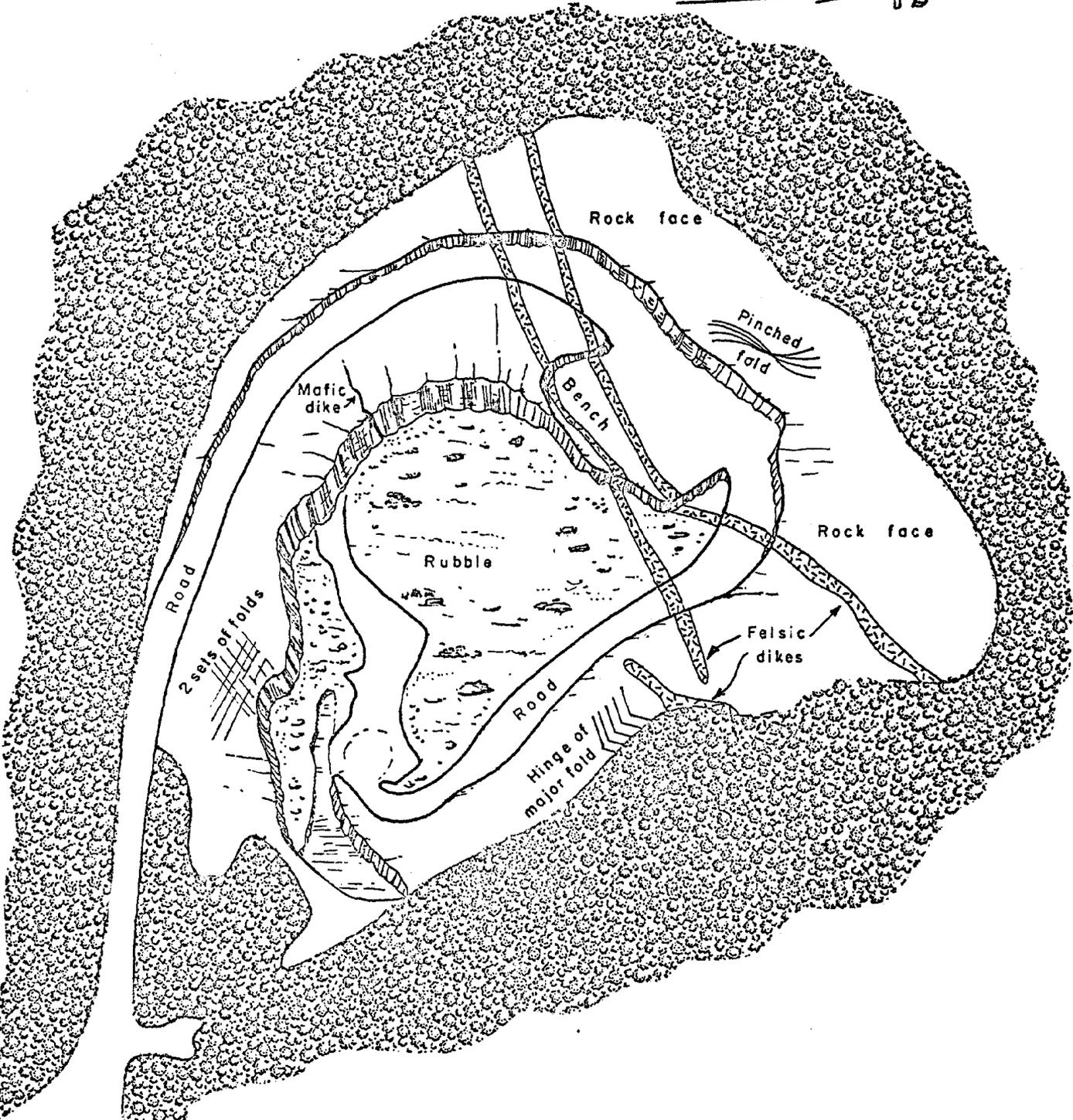
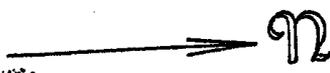


Figure 14. SKETCH OF MARRIOTSVILLE QUARRY NO. 1 FROM AN OBLIQUE AIRPHOTO.

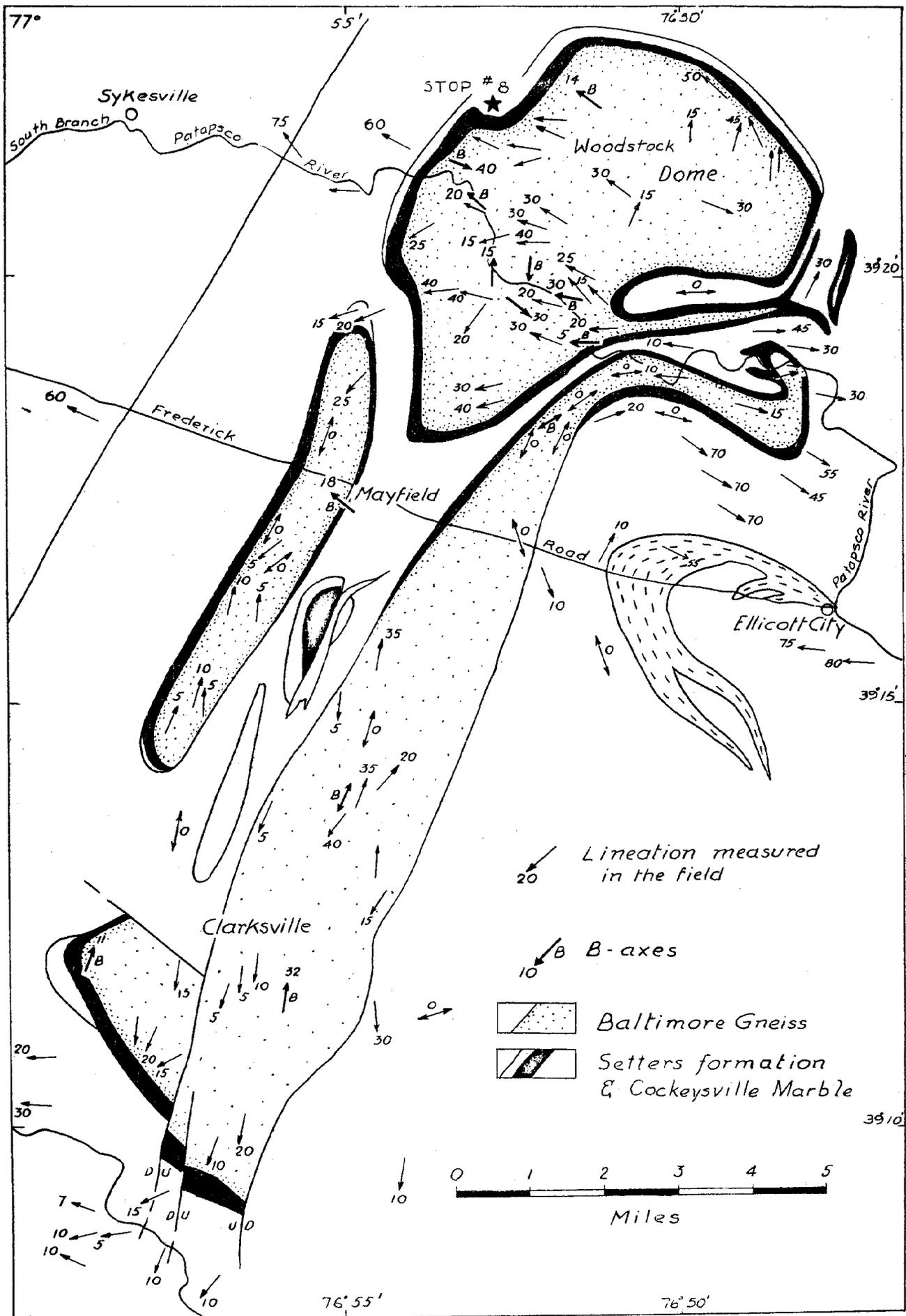


Figure 15. Geologic map of the Woodstock dome and surrounding area.

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. 14). 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 postdates regional metamorphism, but beyond this nothing is known of their age.

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- 11.5 Board vehicles and retrace route to quarry entrance.
- 12.2 Turn right onto Marriottsville Road.
- 15.5 Turn right onto Liberty Road.
- 20.2 Pass under Baltimore Beltway.
- 20.7 Amphibolite of the Baltimore Gabbro on left adjacent to Gino's Hamburgers.
- 21.3 Cross Gwynns Falls.
- 22.4 Turn left onto Northern Parkway.
- 23.8 Cross Reisterstown Road.
- 24.2 Cross Park Heights Avenue.
- 24.9 Pimlico Race Track on right.
- 25.5 Sinai Hospital on right.

- 26.3 Bear right onto entrance ramp of Jones Falls Expressway southbound. Outcrops on left side of expressway are altered ultramafics at the base of the Baltimore Gabbro.
- 26.8 Village of Cross Keys on left. A development of The Rouse Company, the same organization that is developing the New City of Columbia, Md.
- 27.2 Bear right onto exit ramp for Cold Spring Lane.
- 27.4 Turn left onto Cold Spring Lane eastbound.
- 27.5 Outcrops on right. Felsic gneiss succeeded by massive amphibolite on the Baltimore Gabbro.
- 27.9 Cross Falls Road.
- 28.1 Cross Roland Avenue
- 28.8 Cross Charles Street. Loyola College on right.
- 29.5 Cross York Road and descend into valley underlain by Cockeysville Marble. Climb out of valley, cross Setters Formation and pass into Baltimore Gneiss of the Towson dome.
- 30.1 Cross The Alameda.
- 30.5 Cross Loch Raven Blvd.
- 30.9 Turn left onto Hillen Road.
- 31.0 Turn right into Morgan State College.
- 31.2 Disembark and descend 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 #9 (50 minutes)

STOP #9 - (Morgan State College) by 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. 12). 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 Baltimore Gneiss in the Towson dome is amenable to a two-fold subdivision based chiefly on the presence or absence of augen gneiss (Fig. 13). Some augen gneiss crops out here, and mapping of the larger area indicates that this stop lies in a transition zone between the two subdivisions.

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.

- 31.4 Board vehicles and leave parking area. Turn left onto Cold Spring Lane. Baltimore Gneiss on both sides of road.
- 31.7 Turn right onto Hillen Road.
- 31.9 Potomac Group gravels on right.
- 32.5 Hillen Road becomes Perring Parkway.
- 32.7 Cross Herring Run.
- 33.4 Northern High School on right. Mount Pleasant Municipal Golf Course on left. Wildly folded Baltimore Gneiss in stream channel to left of road.
- 34.2 Folded Baltimore Gneiss in stream on right adjacent to Perring Parkway shopping center.
- 34.4 Cross Oakleigh Road.
- 34.9 Cross Taylor Avenue.
- 35.5 Cross Putty Hill Avenue.
- 36.1 Turn into entrance ramp of Baltimore Beltway following sign that reads "BELTWAY TOWSON".
- 37.6 Descend hill from Baltimore Gneiss through Setters Formation into valley of Cockeysville Marble. Setters crops out on left.
- 37.7 Bear right onto ramp of exit 29.
- 37.9 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.

- 38.9 Bare glimpse of a large quarry in Setters Formation on the right.
- 40.5 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.
- 40.8 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.
- 42.2 Conspicuous pegmatite ridge on right.
- 43.5 Village of Glen Arm from which the Glenarm Series takes its name. Bear right past Koppers Plant on left.
- 43.8 Cross Long Green Pike.
- 44.4 Cross hinge of Towson dome.
- 45.0 Turn right onto Harford Road.
- 45.5 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.
- 47.7 Pass junction with 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."
- 48.0 Cockeysville Marble has thinned down to the point where it no longer has any influence on the topography.
- 48.4 Outcrops along road from here to next stop are lowermost Wissahickon Formation with intercalated Gunpowder Granite Gneiss.
- 48.7 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 into contact with Wissahickon Formation and Gunpowder Granite Gneiss.

- 49.1 Cross Gunpowder Falls.
- 49.3 Turn right into gas storage facility of the Baltimore Gas and Electric Company, park, and disembark.

STOP #10 (60 minutes)

STOP #10 - (Gunpowder Falls Liquid Propane-Gas Storage Facility) by 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. Selection of this site 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 probably 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. 12). 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	Calcite	Epidote	Sphene	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 wells 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+ 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.

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- 49.3 Reboard vehicles and leave gas storage facility.
- 49.4 Turn left onto Harford Road and recross Gunpowder Falls.
- 49.5 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.
- 50.4 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 #11 (60 minutes)

STOP #11 - (Notch Cliff Road) by William Crowley

This stop is located approximately one mile directly across strike from Stop #10, 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 (Hartley member of Fig. 13), forms the base of the section. The overlying Setters Formation and Cockeysville Marble are considerable 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. 13). 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.

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- 50.4 Leave Notch Cliff Road stop, retracing route back to Harford Road.
- 51.3 Turn right onto Harford Road.
- 52.5 Turn right onto Cub Hill Road. We are now crossing the Towson dome once again, this time a little south of the last traverse.
- 53.7 Augen gneiss member of the Baltimore Gneiss on the left, succeeded by Setters Formation, well exposed on both sides of the road. Contact between the two (a major unconformity, though actually rather unimpressive) exposed on left.
- 53.9 Turn right onto Cromwell Bridge Road.
- 54.4 Turn right onto Loch Raven Drive and cross the Cockeysville Marble valley.
- 54.6 On left are outcrops of the lower of a two-member subdivision recognized in this valley. The rock is a clean, uniform dolomite marble.
- 54.7 Small abandoned quarry on left still in the lower member.
- 54.8 On the left a large abandoned quarry in the upper member of the Cockeysville, which is a dirty calcite marble or calc schist. The quarry is flanked on upstream side by a large pegmatite marking the contact with the Wissahickon Formation.
- 55.1 Epidote amphibolite on left succeeded by interlayered fine-grained schist, commonly sulfidic, and quartzites, typical of the heterogeneous assemblage of rocks that characterize the basal member of the Wissahickon.
- 55.3 Loch Raven dam on right. Behind it is Loch Raven Reservoir, a major source of Baltimore City's water supply.
- 55.9 Outcrops on left of uniform medium-grained garnet mica schist, typical of the next higher member of the Wissahickon.
- 56.2 We have crossed a synclinal axis and are now back down in the basal Wissahickon, which crops out on both sides of the road.
- 56.6 Gorge on left exposes basal member Wissahickon that includes a 25 foot thick bed of dirty calcite marble.
- 57.1 Cross reservoir.
- 57.2 Basal Wissahickon on right. The road now runs approximately along the lower contact of the Wissahickon. Outcrops of Cockeysville Marble can be seen in places along the shores of the reservoir on the left.

- 58.3 Poor exposure of Cockeysville on right. We are now starting down section as we head for another uplift of Precambrian rocks, the Texas dome.
- 58.9 Bear left at junction and remain on Loch Raven Drive.
- 59.3 Towson Golf and Country Club on right.
- 60.6 Bear left at stop sign onto Dulaney Valley Road.
- 60.7 Cockeysville Marble on right.
- 60.8 Recross Loch Raven Reservoir.
- 61.3 Turn right onto Bosley Road and begin ascent of east flank of Texas dome.
- 61.4 Setters Formation on right.
- 61.6 Baltimore Gneiss on right.
- 62.8 Turn left at junction of Bosley and Old Bosley Roads.
- 63.3 Turn right onto Warren Road. We are now travelling approximately along the base of the Setters Formation on the west flank of the dome.
- 63.9 We are now travelling up section off the northern flank of the dome.
- 64.2 Cross Loch Raven Reservoir.
- 64.6 Cockeysville Marble on right.
- 64.7 Turn left onto Poplar Hill Road (no road sign) and ascend into hilly country underlain by Wissahickon Formation.
- 65.7 Outcrops of Wissahickon on left.
- 65.8 Turn left onto Ashland Ave. The road runs approximately along contact between Wissahickon Formation and Cockeysville Marble. Hills off to the right are Setters Formation flanking the south side of the Phoenix dome, the largest of the Baltimore Gneiss domes.
- 66.2 Pull off on right hand shoulder just before bridge, park, cross road, and follow path leading down to reservoir.

STOP #12 (30 minutes)

STOP #12 - (Ashland Avenue Bridge) by William Crowley

This stop is in Wissahickon Formation flanking the south side of the Phoenix dome (Fig. 12). The rock here is a very uniform medium- to coarse-grained schist with conspicuous garnet and kyanite, and, in places, fine-grained staurolite. This high-grade assemblage is widespread over a large area, and although detailed mapping of the region is far from complete, enough observations have been made to show that its distribution is closely related to the distribution of the gneiss domes. With increasing distance from the domes such high-grade assemblages are replaced by low grade ones.

A few thin quartzites are interlayered with the schist. They tend to bring out more clearly the gently WSW-plunging dextral folds that deform the rocks.

- 66.2 Leave stop 12. Recross Loch Raven Reservoir.
- 66.3 Wissahickon Formation on left.
- 66.9 Cross narrow bridge over Penn. R.R. We have now moved out into a broad lowland of Cockeysville Marble.
- 67.7 Cross bridge over Western Run.
- 68.0 Turn right onto Md. 45 (York Road).
- 68.3 Turn left onto Shawan Road. Hills on right underlain by Setters Formation on south flank of Phoenix dome. Greater Baltimore Industrial Park on right.
- 69.3 Turn left onto entrance ramp of INTERSTATE 83 SOUTH. Hills to both left and right are underlain by Wissahickon Formation on the flank of a Cockeysville-cored anticline.
- 72.2 Harry T. Campbell & Sons Texas quarry in Cockeysville Marble on left. Hilly country beyond the quarry is the west flank of the Texas dome.

74.9

Bear right following sign reading "BELTWAY BALTIMORE WASHINGTON"
and retrace route back to motel. End of second day completes
field conference.