MARYLAND GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS No. 6

Kenneth N. Weaver, *Director*

REVISION OF STRATIGRAPHIC NOMENCLATURE OF THE GLENARM SERIES IN MARYLAND

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Abstract

As originally defined by Knopf and Jonas (1922; 1923), the Glenarm Series (probably Late Precambrian in age) included from the base upwards, the Setters Formation, the Cockeysville Marble, the Wissahickon Formation, the Peters Creek Schist, the Cardiff Conglomerate, and the Peach Bottom Slate. Subsequent work required removal of the Cardiff Conglomerate and the Peach Bottom Slate, and addition of the Laurel and Sykesville Formations. The Setters Formation and the Cockeysville Marble are easily mapped units, and should be retained as defined. The rocks above the Cockeysville are difficult to subdivide into mappable formations because of their uniformity and poor exposure, the lensing, interfingering habit of locally distinct lithologies, the complex structure, and the variable intensity of metamorphism. Subdivisions currently in use are based on a synclinal interpretation of regional structure, and are not easily adaptable to other structural interpretations. In order to keep the system of stratigraphic nomenclature as free of structural interpretation as possible, to avoid creating a stratigraphic column with one formation sandwiched between two parts of another, and to avoid drawing formation contacts where no lithologic boundary exists, we propose that the present Wissahickon, Peters Creek, Laurel, and Sykesville Formations be included in a single formation, the Wissahickon; and that the Wissahickon Formation be subdivided into five informal lithofacies, defined on the basis of original lithology. The lithofacies defined are the lower pelitic schist; the boulder gneiss; the metagraywacke; the metaconglomerate; and the upper pelitic schist. These units have generally consistent geometric relationships to one another throughout the original basin of deposition, but are not time-stratigraphic.

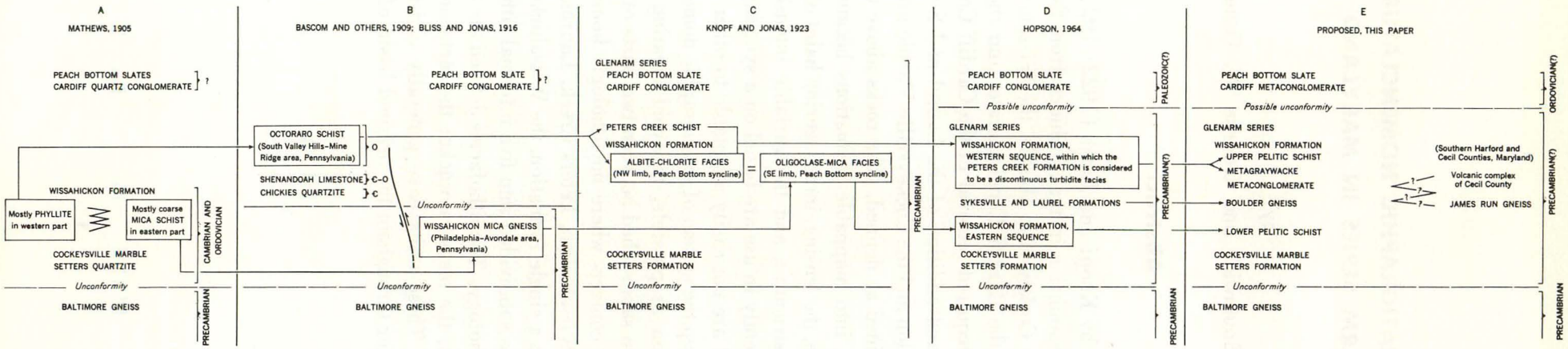

Table I. Chart comparing the proposed nomenclature with earlier nomenclature for the Wissahickon Formation and Glenarm Series.

Introduction

Stratigraphic nomenclature in the Precambrian(?) Glenarm Series is currently in a state of confusion. The series was first named by Knopf and Jonas (1922; 1923) whose definition states (1923; p. 45):

> "Overlying the Baltimore gneiss is a series of pre-Cambrian sediments here named the Glenarm series, from its typical development near Glenarm, 13 miles northeast of Baltimore. The Glenarm Series comprises the Setters formation, the Cockeysville marble, the Wissahickon formation, the Peters Creek schist, the Cardiff conglomerate, and the Peach Bottom slate. The total thickness of the series probably amounts to between 8,000 and 10,000 feet, although no accurate estimates can be made, for the middle formations have been repeated by close folding. So far as now known, deposition of this series was not interrupted by erosion or by orogenic deformation, although the early formations are overlapping shore deposits."

Together, the Wissahickon and Peters Creek form by far the greatest part of the series as so defined and underlie much of the northeastern Piedmont.

Subsequent work has necessitated several changes in the original definition. The Cardiff and Peach Bottom were removed from the Glenarm Series by Stose and Jonas (1939), who concluded that an unconformity existed at the base of the Cardiff even though none could be demonstrated in the field (Stose and Jonas, 1939, p. 103-106). More recently, the Sykesville Formation (Sykesville granite of Keyes, 1895) and Laurel Formation (Laurel gneiss of Chapman, 1942) have been shown by Fisher (1963) and Hopson (1964) to be correlative units of sedimentary origin, interbedded in the Wissahickon Formation. Therefore, these rocks have been added to the Glenarm Series. In addition, recent reinterpretations of Piedmont structure (Fisher, 1963; Hopson, 1964) suggest that previous stratigraphic correlations are in error and that one major part of the Wissahickon Formation overlies the Sykesville and Peters Creek Formations, and another major part underlies them.

The thick sequence of schistose rocks that makes up the Wissahickon Formation and Peters Creek Schist is not a simple layercake of superposed beds. Rocks derived from different kinds of sandy and shaly sediments grade into each other both vertically and horizontally, and when considered together, form a coherent picture of eugeosynclimal sedimentation (Hopson, 1964, p. 118-120, 128-131, fig. 31). Superimposed upon the original sedimentary variation is the stamp of variable and repeated regional metamorphism.

Subdividing these rocks into mappable units is made difficult by their general uniformity and poor exposure over wide areas, the lensing, interfingering habit of locally distinct lithologies, the complex structure, and the variable intensity of regional metamorphism to which they have been subjected.

In this paper we review earlier interpretations of Glenarm stratigraphy and add our own in the hope that clarity and not more confusion will result. We recommend that:

1) The Glenarm Series be retained as a provincial series, composed of the Setters Formation, the Cockeysville Marble, and the Wissahickon Formation.

2) The Wissahickon Formation be subdivided into five lithofacies: the lower pelitic schist lithofacies; the boulder gneiss lithofacies (includes the former Sykesville and Laurel Formations); the metaconglomerate lithofacies; the metagraywacke lithofacies (includes the former Peters Creek Formation); and the upper pelitic schist lithofacies. These lithofacies have generally consistent geometric relations to one another throughout the original basin of deposition but are not time-stratigraphic units.

Radiometric dating of igneous rocks that cut the Glenarm Series has led to the conclusion that the Glenarm Series is no younger than Early Cambrian, and probably is late Precambrian in age (Hopson, 1964, p. 203-207; Wetherill and others, 1966, p. 2145).

Previous stratigraphic nomenclature in the Glenarm Series

Three important stages in the evolution of stratigraphic nomenclature in the Glenarm Series are summarized in Table I, and compared with the nomenclature proposed in this paper.

The lowermost unit in the Glenarm Series is the *Setters Formation*. It was first described by Wil-

liams (1891) and named the Setters Quartz Schist by Williams and Darton (*in* Williams, 1892). Knopf and Jonas (1923) changed the name to Setters Formation, and this usage has been followed by all subsequent authors. Good lithologic descriptions of the formation are given by Knopf and Jonas (1929b) and Hopson (1964). No changes in the nomenclature or definition of this formation are suggested here.

The next higher formation is the *Cockeysville Marble,* named by Williams (1892) and carefully described by Choquette (1960). No changes in the nomenclature of this unit are recommended.

Above the Cockeysville Marble are the *Wissahickon Formation,* originally named by Bascom (1902), and the *Peters Creek Formation,* named by Jonas and Knopf (1921). The evolution of stratigraphic terminology in these formations has been complex and is reviewed in detail in the next section.

The *Sykesville Formation* was originally mistaken for an intrusive granite, and Keyes (1895) first named it the Sykesville granite. This name was retained by Jonas (1928), Cloos and Broedel (1940), and Stose and Stose (1946). Because of its supposedly igneous origin, the rock was not included in the Glenarm Series. While mapping in south-central Maryland, however, Ernst Cloos became convinced that the rock was a metamorphosed sediment and changed its name to the Sykesville Formation. Subsequent authors have continued this usage; Fisher (1963) and Hopson (1964) presented evidence for a sedimentary origin and added the formation to the Glenarm Series.

The Laurel Formation was first mapped as the Laurel migmatite (Cloos and Broedel, 1940) and Laurel gneiss (Chapman, 1942; Cloos and Cooke, 1953). The rock at first was thought to be an intrusive granite (Williams, 1895) or a migmatitic facies of the Wissahickon Formation (Cloos and Broedel, 1940; Chapman, 1942) and therefore was not given formal status in the Glenarm Series. Later, Fisher (1963) and Hopson (1964) showed that the Laurel was a metasedimentary rock, correlative with the Sykesville Formation, and included it in the Glenarm Series. In order to emphasize its sedimentary origin, and because the terms gneiss and migmatite do not adequately describe its lithologic character, Hopson (1964) changed the name to the Laurel Formation.

The *Cardiff Metaconglomerate* (Cardiff quartz conglomerate of Mathews, 1904) and *Peach Bottom Slate* (Peach Bottom roofing slate of Lesley and Frazer, 1880) were originally included in the Glenarm Series by Knopf and Jonas (1923), but were later removed because of a postulated unconformity at the base of the Cardiff (Stose and Jonas, 1939). Though existence of this unconformity has never been proven in the field, evidence discussed in a later section indicates that an unconformity is a strong possibility, and that there may be a considerable age difference between the rocks involved. Therefore, we recommend that the current practice of excluding the Cardiff and Peach Bottom from the Glenarm Series be continued.

The *Marburg Schist, Ijamsville Phyllite, Urbana Phillite, Wakefield Marble,* and *Silver Run Limestone* of Frederick County, Md., were added to the Glenarm Series by Jonas and Stose (1938a). This usage has not been followed by subsequent workers, and we recommend that these units be removed from the Series until better evidence of their stratigraphic position is available.

Two additional units of probable volcanic origin, the *James Run Gneiss* and the volcanic complex of Cecil County, may belong in the Glenarm Series. The James Run Gneiss is here named for James Run in southeastern Harford County (Southwick and Owens 1967, unpub. map), where its typical lithologies crop out. The unit consists of interlayered quartz amphibolite and biotite-quartz-plagioclase gneiss. It conformably overlies garnet schist that closely resembles part of the Wissahickon Formation, which in turn overlies bedded microcline-mica gneiss that is much like part of the Setters (Hopson, 1964, p. 56-63). However, this sequence is separated from the main belt of Glenarm metasedimentary rocks by a broad belt of younger plutons, across which correlation is uncertain at best. Similarly, greenstones and schistose felsites of southern Cecil County (which have been called "Cecil volcanics" or "Cecil County volcanic complex"; *see* Marshall, 1937) are surrounded by younger intrusive rocks, and their stratigraphic relation to known formations of the Glenarm Series is largely a matter of conjecture. Chemically and structurally they are similar to James Run Gneiss, with which they are approximately on strike.

We propose, therefore, that the James Run Gneiss and the volcanic complex of Cecil County

not be included formally in the Glenarm Series until more substantial proof of their stratigraphic position is available.

Development of terminology in the Wissahickon and Peters Creek Formations[1]

Florence Bascom (1902, p. 104) gave the name Wissahickon to the belt of mica schist, gneiss, and granofels that extends from near Philadelphia, Pennsylvania, into Cecil County, Maryland. The type locality is along Wissahickon Creek, a tributary of the Schuylkill River. It is not clear exactly what rocks Bascom originally included in the Wissahickon, because she did not clearly define its limits and because she used the terms Cecil County mica-gneiss and Wissahickon mica-gneiss interchangeably for the same belt of rocks. However, discussion in the same paper suggests that she included a thick section of rocks in the Wissahickon, for she states that the Peach Bottom slates ". . . appear to be a conformable member of the series of which the Wissahickon mica gneiss is an upper member . . ." (Bascom, 1902, p. 104).

Bascom (1905) more clearly delineated the Wissahickon as an extensive formation including both the coarse-grained schists and gneisses near Philadelphia and also the fine-grained schists and phyllites that crop out farther west, between Buck Ridge and Chester Valley, just east of Mine Ridge. She states:

> "The mica-gneiss of the southeastern area extends north and south, from Trenton, where it passes under cover, to and into Cecil County, Maryland. West and east it extends from Buck Ridge to the Delaware, expanding to the southwest, and, where Buck Ridge disappears as a marked topographic feature, it appears to grade across the strike into the mica-schist. The width of exposure thus varies from less than a mile near Trenton, to more than 40 miles at the Maryland boundary." (Bascom, 1905, p. 302).

Also,

> "The mica-schist is chiefly confined to the south Chester Valley hills, expanding to the southwest, where . . . Buck Ridge pitches under the mica-schist and mica-gneiss, which (grade) into each other." (Bascom, 1905, p. 301).

[1] Material in this section duplicates in part the discussion of stratigraphic nomenclature in Hopson (1964). However, because the evolution of nomenclature in these rocks forms an essential background for the discussion which follows, we review it again here.

The Wissahickon schists and gneisses continue southwest into Maryland, with only minor interruptions by intrusive rocks in Cecil and Harford Counties. Mathews (1904; 1905) extended the Wissahickon Formation to include the Maryland rocks. He too considered the Wissahickon a very extensive unit, for he states (1905, p. 335):

> "The Wissahickon formation in Maryland occurs as a broad band wrapping about the older Baltimore gneiss and limestone areas, and occupying practically all the territory between the Blue Ridge and the Coastal Plain deposits except those portions consisting of the sedimentary rocks already described (Setters and Cockeysville), the overlapping Triassic sandstones of Carroll, Frederick and Montgomery Counties, and the igneous rocks."

Though Mathews included in the Wissahickon Formation both the coarsely crystalline schists and gneisses of the eastern Piedmont and the phyllites of the Western Piedmont, he was uncertain of their stratigraphic relations, for he wrote (1905, p. 335):

> "The line of separation between these two divisions (schists and phyllites) is not marked stratigraphically by a pronounced change in lithologic character, and it is not entirely clear that the division is a stratigraphic one, although it seems probable that the phyllites in all instances are of as high or higher horizons than the more crystalline Wissahickon Schists."

Thus, in 1905, virtually all the pelitic rocks overlying the basement in the Maryland and Virginia Piedmont were assigned to the Wissahickon Formation. They were thought to be Ordovician because they appeared to overlie conformably the Cambrian and Ordovician limestone of Chester Valley (Bascom, 1905) and the Cockeysville Marble, which Mathews (1905) correlated with the Cambrian and Ordovician carbonates. This interpretation of the stratigraphy is summarized in Table I, column A.

This interpretation was soon revised, however. In 1909, Bascom (in Bascom and others, 1909) concluded that the coarse-grained schists of the Philadelphia area must be older than the finer grained schists and phyllites west of Buck Ridge. Her main lines of evidence were (1) the more intense recrystallization of the schists near Philadelphia and (2) the restriction of intrusive rocks to the coarse-grained mica schists. Accordingly,

she restricted the name Wissahickon to the eastern belt of coarse-grained rocks and renamed the fine-grained schists and phyllites the Octoraro Schist (Bascom and others, 1909, p. 5). She considered the Octoraro to be Ordovician because of its conformity with the Cambrian and Ordovician limestones of Chester Valley, but she decided that the Wissahickon must be Precambrian because it appeared to underlie the Chickies Quartzite of Early Cambrian age. Because of their supposed age difference, the Wissahickon and Octoraro were inferred to be in fault contact, despite their gradation in the field.

In the Doe Run-Avondale district of Pennsylvania, Bliss and Jonas (1916) followed Bascom's interpretation and mapped the Octoraro Schist and Wissahickon Formation as two different formations, supposedly in fault contact. In addition to the evidence cited by Bascom and others (1909), Bliss and Jonas noted that the gneiss had the chemical composition of an arkose, whereas the Octoraro was more akin to an argillite (see Table I, column B).

Only a few years later, still another interpretation of the stratigraphy was advanced. Jonas and Knopf (1921) noted that the schists underlying the Cardiff Metaconglomerate along the Susquehanna River contained a higher proportion of sandy beds than they did elsewhere. They renamed these more arenaceous rocks the Peters Creek Schist, and described them as (Knopf and Jonas, 1923, p. 46):

> ". . . a series of chloritic and sericitic quartzites, interbedded with chlorite — muscovite schist, and grading toward the top into mildly anamorphosed quartzose and conglomeratic sediments. It comprises part of what was originally mapped as Wissahickon gneiss and Octoraro schist."

Later, these authors modified the name to Peters Creek Formation and more fully described the rocks and their relation to the Wissahickon Formation (Knopf and Jonas, 1929b, p. 176-177).

Because the Cardiff Metaconglomerate is synclinally folded, and appears to grade downward into the Peters Creek Formation, Knopf and Jonas (1923, p. 48) concluded that the syncline in the Cardiff must involve the Peters Creek and the underlying rocks as well. On this basis, they correlated the schists on the northwest side of the Peters Creek Formation with those on the southeast side and named the two sequences the albite-chlorite schist facies and the oligoclase-mica schist facies of the Wissahickon Formation, respectively. The rocks formerly included in the Octoraro Schist were thus placed partly in the Peters Creek Schist and partly in the albite-chlorite schist facies of the Wissahickon; the name Octoraro was dropped (see Table I, column C).

Though details of nomenclature have varied, all who have mapped these rocks since 1923 have followed this general scheme and have shown two belts of Wissahickon rocks separated by the Peters Creek Formation, or, in south-central Maryland, the Sykesville Formation. Originally, this usage was based on the interpretation that the two Wissahickon belts represented stratigraphically equivalent units on opposite limbs of the Peach Bottom syncline. Recently, however, Hopson (1964, p. 54-56, 70-73) has suggested that the structure in the rocks under the Cardiff Metaconglomerate may be homoclinal, rather than synclinal. According to this interpretation, the two belts of Wissahickon rocks (renamed by Hopson the Western and Eastern Sequences of the Wissahickon Formation) are different stratigraphic units, separated by the Peters Creek and Sykesville Formations (see Table I, column D). In the next section we review the evidence bearing on the interpretation of the Peach Bottom syncline.

The Peach Bottom syncline

All workers in the region since Mathews and Johannson (1904) have agreed that a syncline involving the Cardiff Metaconglomerate and the Peach Bottom Slate extends from northern Harford County, Maryland, into Lancaster County, Pennsylvania, but there has been much debate over the extent and stratigraphic significance of this structure in rocks older than the Cardiff. Some authors (e.g., Knopf and Jonas, 1923) have interpreted the syncline as a major structure involving many thousands of feet of underlying metasedimentary rocks, extending from Pennsylvania to central Virginia. Others (e.g., Hopson, 1964) have suggested that the syncline may be a minor fold superimposed on a regional homocline and may not involve a large-scale repetition of Wissahickon strata.

In order to use the small syncline in the Cardiff as evidence for a major syncline in the underlying Peters Creek and Wissahickon Formations, it

must be demonstrated that the Cardiff is conformable with the underlying rocks. Evidence on this point is difficult to evaluate. Knopf and Jonas (1923) originally argued that the contact was conformable because it appears gradational, and because bedding in the Peters Creek Formation nearly parallels that in the overlying Cardiff. Reexamination of the contact confirms their observations. Near Pylesville, Maryland, quartzose chloritoid schist of the Peters Creek grades through pebbly micaceous quartzite to gneissic quartz pebble metaconglomerate of the Cardiff for a stratigraphic interval of about 75 feet. On both sides of the Susquehanna River the Cardiff is adjacent and parallel to metamorphosed graywacke beds in the Peters Creek, but the contact is covered. Lineations and planar structures with similar orientations occur above and below the Cardiff-Peters Creek contact (Agron, 1950); no structural elements in the older rocks appear to be inherited from a pre-Cardiff deformation. Argillaceous rocks on both sides of the contact are at essentially the same metamorphic grade. Fine-grained schists and phyllites in the Peters Creek contain quartz, muscovite, and chlorite with or without albitic plagioclase, chloritoid, and widely scattered small garnets. The Peach Bottom Slate contains graphite in addition to the above assemblage and lacks garnet. Abundant andalusite was reported in the Beach Bottom Slate by Dale (1914). Agron (1950) reported only traces of andalusite, and we have found none.

However, the apparent conformity of the Cardiff-Peters Creek contact may be the result of folding and metamorphism rather than continuous sedimentation. This possibility was recognized by Knopf and Jonas (1929a, p. 38-41) and by Stose and Jonas (1939), who argued that the contact was in fact an angular unconformity. Their interpretation was based on a proposed correlation of the Cardiff-Peach Bottom sequence with the lithologically similar Arvonia Slate of Ordovician age in Virginia; an unconformity occurs beneath the conglomeratic base of the Arvonia, and therefore Stose and Jonas proposed that an unconformity should occur at the base of the Cardiff. Most of the stratigraphic evidence cited by Stose and Jonas in support of this correlation is no longer pertinent, but the lithologic resemblance between the Arvonia and the Peach Bottom is indeed striking, and available evidence on the age of the rocks concerned does support their interpretation. Extensive radiometric data on intrusives cutting the Glenarm Series show that the Wissahickon and Peters Creek Formations cannot be younger than Cambrian and are probably late Precambrian (Steiger and Hopson, 1964; Wetherill and others, 1966, p. 2145). The Cardiff-Peach Bottom sequence is tentatively considered Ordovician (possibly Silurian) on the basis of problematical plant fossils in the Peach Bottom Slate (Agron, 1950; James Schopf, 1963, personal communication). If these ages are correct, then there must be a major hiatus between the Peters Creek and the Peach Bottom.

Such a break has been postulated at the base of the Cardiff, but it could occur at the base of the Peach Bottom. The Cardiff-Peach Bottom contact is not notably gradational; in fact it is less gradational than the Peters Creek-Cardiff contact.

Another important point is the marked lithologic difference between Peters Creek rocks southeast of the Peach Bottom syncline (as outlined by the Cardiff) and those northwest of it. Along the Susquehanna River and southwestward as far as central Harford County, Maryland, most of the southeastern section is rhythmically interbedded metagraywacke and fine-grained pelitic schist. An ill-defined belt of metagraywacke that contains lenses of bouldery slump breccia occurs near the contact with the Baltimore Gabbro of Cloos and Hershey (1936). The northwestern section is chiefly fine-grained schist and laminated metasiltstone with only a few thin metagraywacke beds. This lithologic contrast could be the result of sedimentary facies change under the keel of the syncline, or faulting along the northwest side of the syncline, or unconformity at the base of the Cardiff; in any case, there is no compelling evidence that the two sections are the same unit conformably folded under the syncline, as Knopf and Jonas (1923) concluded.

It is obvious from this discussion that the nature of the contact between the Cardiff Metaconglomerate and the Peters Creek Formation is not well understood. There is a strong possibility that the contact is an unconformity, and therefore the presence of a syncline in the Cardiff is not proof of a major syncline in the underlying rocks.

Further evidence bearing on the problem of the Peach Bottom syncline comes from the structure in the rocks underlying the Cardiff. Though our understanding of the structures in the Wissa-

hickon and Peters Creek Formation is still rudimentary, available evidence does not favor the presence of a major syncline along the projection of the Peach Bottom axis. In south-central Maryland, the major structure appears to be a west-dipping homocline. Relict graded bedding and other features in the schist belts on both sides of the Skyesville Formation suggest that both sequences become younger to the west (Fisher, 1963; Hopson, 1964). If so, the two schist belts cannot be a single stratigraphic unit appearing on two limbs of a syncline with the Sykesville Formation in the trough; they are stratigraphically distinct units, the Sykesville lying between them.

The evidence for homoclinal structures in south-central Maryland led Hopson (1964, p. 54-55, fig. 19B) to postulate a northwest-dipping homocline in rocks beneath the Cardiff as an alternative to the synclinal interpretation of Knopf and Jonas (1923). Mapping in northern Maryland and nearby Pennsylvania has revealed a more complicated situation (Freedman and others, 1964; Southwick and Owens, unpub. map).

Along the Susquehanna River, bedding and bedding schistosity in the Wissahickon and Peters Creek Formations dip predominantly southeast, not northwest. South of the Peach Bottom axis, scattered relict graded beds face southeast, except in a half-mile-wide belt just southeast of the Cardiff, where zones of overturned northwest-facing beds occur (Freedman and others, 1964; Southwick, personal observation). Therefore an anticline in bedding is indicated a short distance southeast of the Peach Bottom syncline.

Northwest of the syncline in the Cardiff, the bedding and bedding schistosity dip less and less steeply southeast as the crest of the Tucquan arch is approached (figs. 1 and 2; *see also* Freedman and others, 1964). Although there is evidence of northwest overturning and recumbent folding in this area, it appears that the major structure southeast of the Tucquan arch is simply the southeast-dipping limb of that fold, modified at Peach Bottom by a second-order syncline and companion anticline (fig. 2b).

There is inconclusive but strongly suggestive evidence for faulting on the northwest side of the Peach Bottom syncline, along the northwest side of the Phoenix gneiss dome in Harford County, Maryland (fig. 1; Agron, 1950; Southwick, unpub. data), and southeast of the Peach Bottom syncline, just southeast of the structure sketched in fig. 2. This faulting may further complicate the structure at Peach Bottom and the relation of the syncline to the Baltimore-Washington anticlinorium, but it probably has little effect on our interpretation of the syncline there as a relatively local fold.

To sum up, available evidence casts considerable doubt on the stratigraphic significance of the Peach Bottom syncline. There is no compelling evidence that the fold involves the rocks beneath the Cardiff to any major degree, and in fact stratigraphic tops inferred from relict graded bedding suggest that it does not. Because the significance of the Peach Bottom syncline is in doubt, we conclude that there is no justification for continuing to use it as the cornerstone of stratigraphic correlation and nomenclature in the Piedmont.

Proposed changes in stratigraphic nomenclature

We think the existing stratigraphic nomenclature is inadequate to properly describe the geology of the Wissahickon Formation and related rocks. In the first place, it is based on a synclinal interpretation of regional structure and is therefore difficult to use in discussing other structural interpretations. For example, in considering the homoclinal interpretation advanced by Hopson (1964), a stratigraphic column must be used in which two units of formational rank (the Sykesville and Peters Creek) are sandwiched between two parts of the Wissahickon Formation. Secondly, the different formations are not neatly stacked on top of each other, and some do not extend laterally for large distances. Instead, the various lithologies of the Wissahickon, Peters Creek, and Sykesville Formations grade laterally and vertically into one another. Coalescing and interfingering lenses and wedges are common, as are isolated lenses of one rock type within another. Similar lithologies recur at different horizons and different positions along strike.

If distinguishable, mappable, lithologic units within this metasedimentary complex are to be termed formations, the name Wissahickon Formation should be restricted to the eastern belt of coarsely crystalline schists, which most closely resemble the rocks in the type section near Philadelphia (Bascom, 1902; Weiss, 1949). The rocks west of the Peach Bottom syncline (or the Sykes-

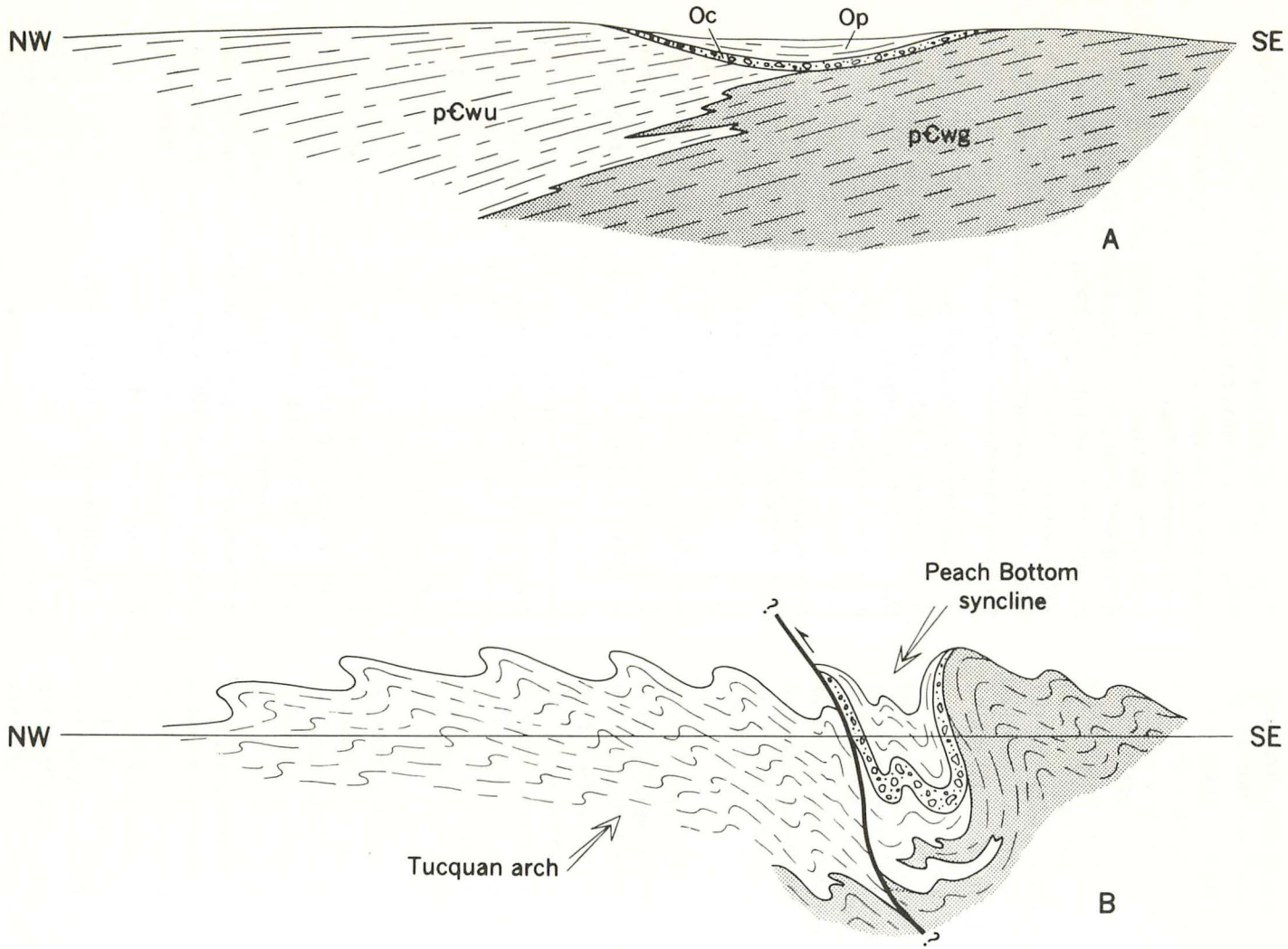

Figure 2. Greatly simplified schematic cross sections of the Peach Bottom syncline near Cardiff, Maryland, showing inferred stratigraphic relationships. In A, the metagraywacke lithofacies of the Wissahickon Formation (p€wg) is shown interfingering to the northwest with the upper pelitic schist lithofacies (p€wu); the Wissahickon rocks are overlain with moderate unconformity by the Cardiff Metaconglomerate (Oc) and Peach Bottom Slate (Op). The other lithofacies of the Wissahickon lie farther to the southeast. B shows the sequence after tight folding. The Peach Bottom syncline and an anticline southeast of it are second-order, nearly upright folds about ½ mile in wavelength on the flank of the Tucquan arch. Near the crest of the arch, minor folds approach recumbency.

The unconformity shown at the base of the Cardiff is possible but has not been proved to exist. Its absence, however, would not alter greatly our interpretation of the syncline as a second-order structure.

ville Formation in south-central Maryland) could then be redefined as a new formation. However, this approach would result in yet another name for rocks that have already been renamed at least three times (see Table I). It would also require that arbitrary formation boundaries be drawn in places where lithologic changes do not occur. Thus, where distinctive intervening units pinch out and give way to a continuous section of pelitic schists (as the Sykesville Formation does south of Rockville, Maryland, for example) a contact between indistinguishable "formations" would have to be drawn. This objection would apply to any other system of nomenclature in which the two belts of rocks now included in the Wissahickon Formation are given separate formational status.

Another problem concerns correlation. Should each local occurrence of a common, recurrent rock type be correlated with a type-section solely on the basis of lithologic similarity, or should it be named a separate formation if direct correlation cannot be proved? The section of interbedded metagraywacke and pelitic schist below Great Falls of the Potomac is a case in point. Although these rocks are very much like the Peters Creek Formation at its type locality on the Susquehanna River, there is no firm evidence for concluding they are at the same stratigraphic level and little justification for calling them Peters Creek. Because they form a mappable unit, they could be named as a separate formation. However, such separate naming would tend to disguise the important fact that similar sequences of metagraywacke recur at different places in the complex and would obscure a fundamental relationship among the original sedimentary facies. In other words, it is important to have a system of nomenclature that emphasizes the lithologic similarity of disconnected, mappable rock units, even though they may not be synchronous deposits.

Isolated lenses of distinctive sedimentary facies, occurring at different places in the section and in different places along strike, are characteristic of this metasedimentary complex. Bouldery sedimentary slump breccias of the "Sykesville" type and flyschlike deposits of the "Peters Creek" type are locally distinctive but grade in all directions into schistose rocks that originally were shales and siltstones. It appears that slumping and turbidity-current activity occurred from time to time at various places along the edge of a deep submarine trough. These episodes caused rapid and more or less local input of course clastic material, whereas slower sedimentation of finer debris took place between and seaward from sites of slumping. There is no certainty, therefore, that lithologically similar rocks are time-equivalent.

Adding to the correlation problems caused by rapid lateral and vertical changes in original sedimentary rock type are the complexities of structure, variable regional metamorphism, and poor exposure. In view of all these problems it seems desirable to have a system of stratigraphic nomenclature that permits applying a single name to lithologically similar rocks within the Wissahickon, while recognizing that they may not represent contemporaneous or even continuous deposits.

Therefore we favor adopting an informal lithofacies nomenclature for these rocks, an approach that tends to de-emphasize the time-stratigraphic connotation that is associated by usage, if not by definition, with formally named formations. We here broaden the definition of Wissahickon Formation to include all the schists, phyllites, metagraywackes, and other metamorphosed clastic rocks that overlie the Cockeysville Marble and are bounded on the northwest by the Ijamsville Phyllite (Jonas and Stose, 1938; Hopson, 1964, p. 121). In Pennsylvania, the northwestern limit of the Wissahickon is tentatively chosen as the contact with the Marburg Schist (Stose and Jonas, 1939). Structural and stratigraphic relations between the Wissahickon and adjacent rocks on the northwest are poorly understood; therefore the top of the Wissahickon is not a well-defined horizon. Rocks formerly termed Peters Creek Formation (Knopf and Jonas, 1929a) and Sykesville Formation (Hopson, 1964) are considered here to be informal lithofacies within the Wissahickon Formation. Similarly, the eastern and western schist sequences of the Wissahickon (as used by Hopson, 1964) are reduced to lithofacies. Other lithofacies are defined below, and more may be defined as needed.

Valid objection might be raised to calling a unit as large as the Sykesville a lithofacies of a formation as immense as the Wissahickon becomes under this usage, but despite the problem of scale, we think the lithofacies concept is the most practical and logical way to deal with these most confusing rocks.

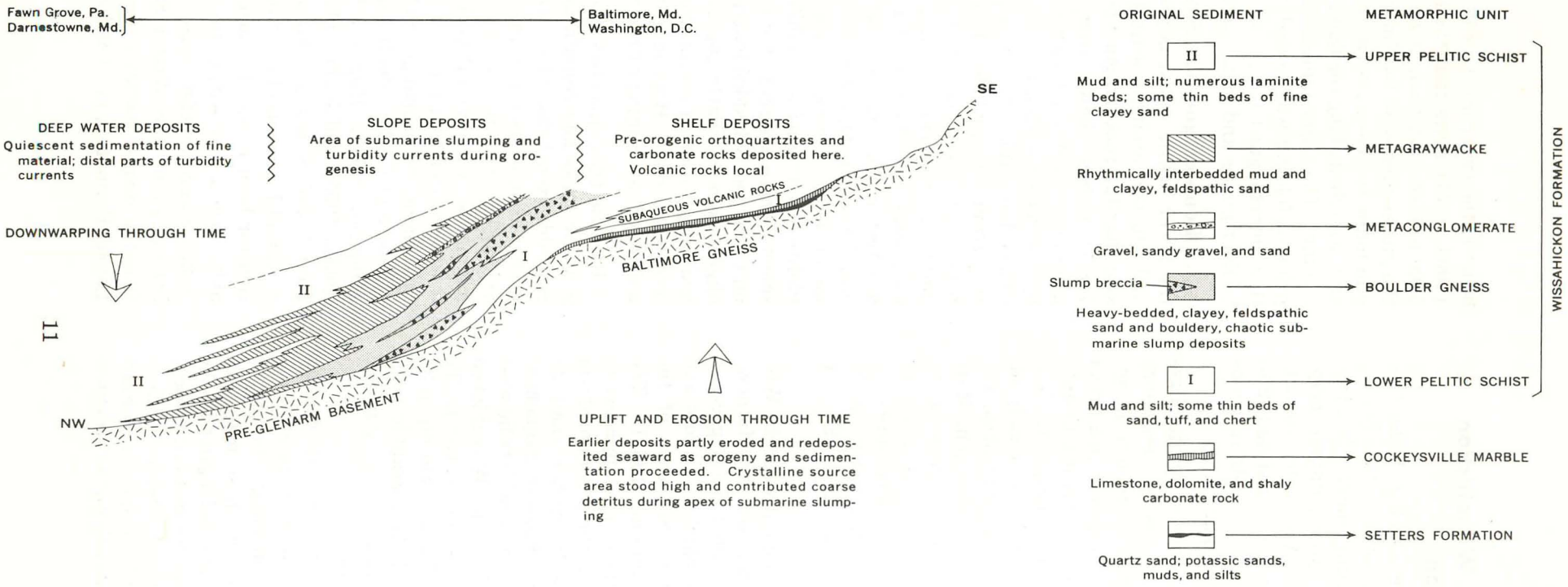

Figure 3. Hypothetical cross section of the Glenarm geosyncline showing the relative position of original sediment types, as inferred from mapping their metamorphosed equivalents. The tongue of subaqueous volcanic rocks represents the inferred position of ancestral James Run Gneiss and the volcanic complex of Cecil County. Not drawn closely to scale.

Lithofacies of the Wissahickon Formation

Five lithofacies of the Wissahickon Formation are here defined on the basis of investigations in Harford, Howard, and Montgomery Counties, Maryland (Southwick and Owens, unpub. map; Hopson, 1964; Fisher, 1963). As a rule, contacts between the lithofacies are gradational and difficult to map precisely. Our view of their relations is shown diagrammatically in Figure 3.

1. Lower pelitic schist. Coarse biotite-oligoclase-muscovite-quartz schist, with accessory garnet, staurolite, kyanite, and sillimanite in appropriate metamorphic zones, crops out in a broad belt that extends from central Harford County south nearly to the Potomac River (Fig. 1). Thin metagraywacke and quartzite beds are locally intercalated with schist throughout this area, but compose less than 10 percent of the section. Rare calc-silicate layers and amphibolites also occur. A detailed description of the rock is given by Hopson (1964, p. 74-87). Typical exposures are along the Patuxent River (fig. 1, localities A, B, C), Little Gunpowder Falls (localities D, E), and Winters Run (locality F).

This belt of schist was correlated with the Wissahickon Formation (then gneiss) by Mathews (1904), and has since been called the oligoclase-mica schist facies of the Wissahickon (Knopf and Jonas, 1923) and the Eastern Sequence of the Wissahickon Formation (Hopson, 1964). The name oligoclase-mica schist facies is inappropriate because it focuses attention on the metamorphism of the rock, which is variable, rather than its original lithology. The term "Eastern Sequence" is also inappropriate, because these schists lie west of other rocks now assigned to the Wissahickon Formation (the former Laurel Formation). To avoid these difficulties and to focus attention on its original lithology and general stratigraphic position, the sequence is here named the lower pelitic schist of the Wissahickon Formation.

The lower boundary of the schist is its contact with the Cockeysville Marble, or with older formations where the marble is missing. Its upper boundary or lateral limit is the first mappable occurrence of arenaceous rocks belonging to the boulder gneiss lithofacies or the metagraywacke lithofacies of the Wissahickon, defined below. Where the lower pelitic schist comes in contact with the upper pelitic schist lithofacies (defined below), the two cannot be distinguished. Hopson (1964, p. 74) notes that the lower pelitic schist is 5500 to 6500 feet thick along the western flank of the gneiss domes at Baltimore. This represents a minimum thickness, because the rock was probably stretched along the flanks of the domes during folding. The three-dimensional form of the unit prior to folding was probably an elongate wedge that intertongued to the west with rocks of the boulder gneiss and metagraywacke lithofacies.

2. Boulder gneiss. Stratigraphically above the lower pelitic schist is a sequence of gneisses and schists containing scattered pebble-to boulder-size detrital rock fragments. Hopson (1964, p. 108-112) has shown that these gneisses are metamorphosed conglomeratic sandstones, formed by the repeated slumping and mixing of still unconsolidated Wissahickon sediments. The detrital rock fragments include: 1) rounded granules and pebbles of quartz and of quartz and feldspar; 2) flattened fragments of mica schist ranging from micaceous blebs 1 centimeter long to slabs as thick as 3 feet and as long as 15 feet; 3) angular cobbles and irregular fragments of a wide variety of metamorphic rocks, chiefly metagraywacke, biotite-quartz gneiss, amphibolite, and calcsilicate schist. These are scattered through a remarkably uniform, poorly bedded matrix of granular garnet-oligoclase-mica-quartz gneiss, which has the chemical composition of a mixture of feldspathic graywacke and shale. Hopson (1964, p. 103-108) gives a detailed description of the rock.

Because these gneisses have the appearance of granitic rocks and contain abundant cobbles that resemble xenoliths, they were originally interpreted as igneous rocks and were first named the Sykesville granite (Keyes, 1895) and Laurel migmatite (Cloos and Broedel, 1940). Later, when it was realized that the rocks were metasediments, their names were changed to Sykesville Formation (Cloos and Cooke, 1953) and Laurel Formation (Hopson, 1964). Mapping by Cloos (Cloos and Cooke, 1953) and Fisher (1963) showed that the Laurel and Sykesville Formations are a single unit, and Fisher used the name Sykesville Formation for both rocks. Because these gneisses probably form a lens within the Wissahickon Formation, we here redefine them as the boulder gneiss lithofacies of the Wissahickon and recommend that the formal names Sykesville Formation and Laurel Formation be abandoned.

In Howard and Montgomery Counties, the boulder gneiss occurs in two major belts that converge in Washington, D. C., and outline the south-plunging nose of the Baltimore-Washington anticlinorium (fig. 1). The western belt appears to be a series of coalescing lenses, the largest of which is 15,000 feet thick (Hopson, 1964, p. 101) and measures 26 miles along strike. These rocks pass gradationally into pelitic schists above and below and grade laterally into rocks of the metagraywacke lithofacies (fig. 1, 3). Within the lenses, fragments and cobbles of different types are locally concentrated in layers that define a gross stratification, but bedding, in the sense of sharp changes in the composition of the matrix, is very rare. These rocks are best exposed along the Patapsco River south of Sykesville (fig. 1, locality G), along the Potomac River at Chain Bridge (locality H), and along Northwest Branch, near Burnt Mills (locality I).

In mapping the geology of Montgomery and Howard Counties, the term Sykesville Formation (equivalent to our boulder gneiss) was applied only to the distinctive boulder gneiss lithology. In Harford County, however, this was found to be impractical. There, the boulder gneiss lithology occurs as discontinuous lenses from a few feet to more than a mile in length, scattered about in heavy-bedded to massive metagraywacke. Numerous thin beds of fissile mica schist also are associated with the gneiss but these are subordinate to metagraywacke. Because many of the boulder gneiss lenses are too small to show individually on regional-scale maps, and because they are impossible to delinate except diagrammatically in areas of poor outcrop, it was decided that the metagraywacke in which these lenses occur had to be included to make a practical map unit. Accordingly, we include in the boulder gneiss lithofacies the distinctive boulder gneiss lithology *per se,* and also metagraywacke in which small lenses and tongues of boulder gneiss are scattered. As so defined the unit outlines the northeast-plunging nose of the Baltimore-Washington anticlinorium in central Harford County (fig. 1).

In detailed mapping of well-exposed areas, it might be advantageous to consider metagraywackes with boulder gneiss lenses as a separate unit, transitional to the metagraywacke lithofacies as defined below. All metagraywackes without boulder gneiss lenses belong to the metagraywacke lithofacies.

Contacts of the boulder gneiss with pelitic schist are gradational over a 200- to 500-foot zone. Approaching the contact from the boulder gneiss side, large rock fragments first disappear. Then the smaller quartz pebbles and micaceous shale chips become rare, and finally disappear also. The matrix becomes finer grained, gradually loses its granular texture, and pases gradationally into mica schist. In mapping the boulder gneiss in south-central Maryland, the disappearance of the quartz granules and micaceous blebs provided an arbitrary but convenient point for placing the contact.

3. Metaconglomerate. An elongate wedge of highly deformed, schistose quartz pebble conglomerate is apparently interbedded with rocks of the metagraywacke lithofacies in central Harford County. It underlies Rock Ridge, a prominent topographic feature of the area and is exposed in large streamcuts along Deer Creek at Rocks State Park (fig. 1, locality J).

The metaconglomerate unit is about 5 miles long and about 1200 feet thick at Deer Creek. It gradually thins to the northeast and pinches out altogether just north of Broad Creek. West of Deer Creek the unit is of nearly constant thickness; its west end is blunt and probably has been faulted. The wedge is conformable with rocks of the metagraywacke lithofacies along its north side and the eastern half of its south side. It is in probable fault contact with rocks of the boulder gneiss and lower pelitic schist along the western part of its south boundary (fig. 1).

The pebbles in some metaconglomerate beds are closely packed; in others they are scattered in a quartzitic to schistose matrix. All of them are flattened tectonically. Most of the pebbles are quartz; black quartzite fragments occur locally but are decidedly rare. Sugary quartzite is interbedded with the metaconglomerate.

Bedding and bedding schistosity are essentially vertical, but have been thrown into steplike shear folds by movement on subhorizontal slip cleavage. Within some thick beds, pebbly and sandy zones are mixed together in a manner suggesting rapid deposition, possibly in a deltaic environment. Relict festooned crossbedding was noted at one locality.

This unit corresponds to the Deer Creek Quartzite of Lesley (*in* Lesley and others, 1892, p. 130-132), who noted its similarity to conglom-

eratic rocks (later named the Cardiff) that underlie the Peach Bottom Slate and who suggested correlation. Such correlation is definitely possible on lithologic grounds (both rocks contain small amounts of kyanite and chloritoid and have other petrographic characteristics in common), but careful search has failed to reveal any structural evidence for it (Southwick, unpub. data). Therefore, the metaconglomerate of Rock Ridge is considered here to be part of the Wissahickon Formation and is referred to as the metaconglomerate lithofacies.

4. Metagraywacke. Metamorphosed psammitic rocks interbedded with mica schist crop out along strike with the boulder gneiss zones, and also west of them (fig. 1). The sandy beds have the chemical composition of graywacke and subgraywacke. They range from 1 inch to 10 feet thick, average about 8 inches, and commonly are graded. In most rocks the grading is marked only by an upward diminution of quartz content, but in some of the thickest, least deformed beds, an upward decrease in original grain size is preserved. Other locally preserved primary structures include ripple cross-laminations, convolute bedding, and slump folds. Hopson (1964, p. 88-89) has described these rocks in detail and has concluded that they were deposited by turbidity currents. The rhythmically interbedded mica schists have the chemical composition of shale; mineralogically, they range from chlorite-quartz-muscovite phyllites to sillimanite-bearing migmatitic schists, depending on the grade of metamorphism. Calc-silicate beds and concretions occur locally. Typical exposures of this metagraywacke-schist sequence are on Bear Island, in the Potomac River near Great Falls (fig. 1, locality K), and along the Susquehanna River near Peters Creek (locality L).

Broad lenticular zones of metagraywacke grade both vertically and laterally into pelitic schist and boulder gneiss (fig. 1 and 3). Along the Potomac River there are at least two such zones, at different stratigraphic levels, and the zone along the Susquehanna River probably represents a third level. Thus rocks of this lithology appear to represent local turbidite facies within the Wissahickon and have little value for regional correlation. (*cf.* Hopson, 1964, p. 120).

In northern Maryland and adjacent Pennsylvania, metagraywacke rhythmically interbedded with schist was mapped as the Peters Creek Formation by Knopf and Jonas (1923; 1929a), who emphasized its gradational relationship to enclosing units of mica schist. In southern Maryland, rocks of similar lithology at a different stratigraphic level have been mapped as an informal metagraywacke member of the Wissahickon Formation (Fisher, 1963, Plates I and II) and as quartzite and schist of the Wissahickon (Reed and Jolly, 1963). Because the rocks formerly mapped as Peters Creek Formation appear to form lenses within the Wissahickon Formation, we here redefine them as a lithofacies of the Wissahickon and recommend that the formal name Peters Creek Formation be dropped. This approach also serves to emphasize the local extent of the metagraywacke lenses and to deemphasize their usefulness in regional correlation.

The essential characteristic of this lithofacies is the presence of metamorphosed graywacke, which makes up 25 percent or more of the section. Mica schists commonly are interlayered with the metagraywacke but locally may be absent altogether. If the schists make up more than about 75 percent of a section, the rocks should be mapped as pelitic schist. Contacts with pelitic schist members are completely intergradational and are placed approximately at the first zone of mappable extent containing more than 75 percent mica schist. Contacts with the boulder gneiss are broadly gradational and difficult to determine accurately. As indicated above, metagraywacke with lenses of boulder gneiss may be placed in the boulder gneiss lithofacies.

5. Upper pelitic schist. The youngest rocks of the Wissahickon Formation in Maryland form a thick sequence of pelitic schists, locally interbedded with rock of the metagraywacke lithofacies. These schists are best exposed along the Susquehanna River in Pennsylvania (fig. 1, localities M and N) and at Bear Island, in the Potomac River at Great Falls (locality O). They range from albite-chlorite-muscovite-quartz schists to sillimanite-bearing migmatitic schists, depending on the grade of metamorphism. Delicately laminated beds, originally composed of impure fine sand and silt, are fairly common. Rare calc-silicate schists and thin mafic layers (metamorphosed tuff beds) occur locally. Large amphibolite bodies (metamorphosed diabase sills), magnesian schists, and serpentinite bodies represent intrusive rocks that were folded and metamorphosed with the enclosing metasediments. The mica

schists are described in detail by Hopson (1964, p. 88-89), along with interbedded psammitic rocks now assigned to the metgraywacke lithofacies.

The mica schists have been called the albite-chlorite schist facies of the Wissahickon (Knopf and Jonas, 1923, 1929a) and (together with interbedded metagrawackes) the Western Sequence of the Wissahickon (Hopson, 1964). The name albite-chlorite schist facies is inappropriate because of the variable metamorphic grade, and the designation "Western Sequence" is inappropriate because rocks of the metagraywacke lithofacies lie west of some parts of the mica schist sequence. To avoid these difficulties, this mica schist sequence is here defined as the upper pelitic schist lithofacies of the Wissahickon Formation.

The essential characteristic of this lithofacies is the predominance of pelitic schists; where different lithologies are present in sufficient amount, the rocks should be assigned to other lithofacies defined above. Criteria for mapping the contacts with metagraywacke and boulder gneiss have already been given. Where upper pelitic schist comes in contact with the lower pelitic schist, the two cannot be distinguished except in unusually favorable cases. The northwestern limit of the upper pelitic schist is tentatively defined as the contact with the Ijamsville Phyllite (in Maryland) and the Marburg Schist (in Pennsylvania).

The form of the unit prior to folding probably was a wedge that locally enclosed rocks of the metagraywacke lithofacies and intertongued with them to the east (fig. 3). The thickness of this original wedge is very difficult to estimate, owing to the extreme effect of repeated folding. Along the Potomac River, roughly 11,000 feet of mica schists belonging to this unit are now exposed, interbedded with 3,000 feet of metagraywacke (Fisher, 1963, p. 21).

Summary

The Glenarm Series, of probable late Precambrian age (Hopson, 1964; Wetherill and others, 1966), consists of the Setters Formation at the base, the Cockeysville Marble, and the Wissahickon Formation. The Wissahickon Formation is redefined to include all rocks called Wissahickon Formation by Knopf and Jonas (1929a; 1929b) as well as rocks formerly termed Peters Creek Formation (Knopf and Jonas, 1929a), Sykesville Formation, and Laurel Formation (Hopson, 1964). It is subdivided into 5 mappable lithofacies which are (1) lower pelitic schist, chiefly a garnet-biotite-muscovite schist, derived from nonsandy argillaceous rocks; (2) boulder gneiss, derived from coarse-grained, chaotic submarine slump deposits and associated metagraywackes; (3) metaconglomerate, derived from gravels and coarse sandstones; (4) metagraywacke, derived chiefly from flysch-like, rhythmically interbedded graywacke and shale; and (5) upper pelitic schist, derived from argillaceous and silty rocks. Reduction of the Peters Creek, Sykesville, and Laurel Formations to lithofacies of the Wissahickon is necessary in order to retain the name Wissahickon Formation for the whole schist-metagraywacke complex of the Glenarm Series, a usage which is desirable in light of both previous usage and geologic relations. Reduction of these units also serves to emphasize their local character and to de-emphasize their use in regional correlation.

The Marburg Schist, Ijamsville Phyllite, Urbana Phyllite, Wakefield Marble, and Silver Run Limestone, added to the Glenarm Series by Jonas and Stose (1938a), should not be included in the Series until better evidence of their stratigraphic position is available.

Acknowledgements

We owe a special debt of gratitude to Clifford A. Hopson for his extensive contribution to the subject discussed in this paper. While the numerous citations of Hopson's 1964 bulletin on the crystalline rocks of Howard and Montgomery Counties are some measure of his contribution, they do not reflect the many discussions and field trips we have had with him during an association of nearly 9 years. Hopson has been instrumental in shaping our thinking on problems of Glenarm stratigraphy, but the lithofacies system of nomenclature that we advocate here is our responsibility, not his. In addition, Hopson has carefully read and criticized an earlier version of this paper.

Other geologists have given us much helpful discussion during the preparation of this paper. Among them are John C. Reed, Jr., Bruce Bryant, Jarvis B. Hadley, and Avery A. Drake, Jr., of the U. S. Geological Survey, Ernst Cloos and F. J. Pettijohn of the Johns Hopkins University, Vinton E. Gwinn of Louisiana State University, and Kenneth N. Weaver of the Maryland Geological Survey. We wish to thank all these men for their interest and assistance.

Appendix

Detailed locations of good exposures of the various Wissahickon lithofacies; see fig. 1 for key.

I. Lower pelitic schist

A. Outcrops along the north bank of the Patuxent River just east of Brighton Dam and on the shores of Triadelphia Reservoir, Howard County, Maryland. Garnet-mica schist and interbedded metasiltstone.

B. Large outcrops along the north bank of the Patuxent River east of Maryland route 108, Howard County. Staurolite-garnet-mica schist and interbedded metasiltstone.

C. Outcrops along the south bank of the Patuxent River east of Ednor Road at Browns Bridge, Montgomery County, Maryland. Kyanite-staurolite-garnet-mica schist and metasiltstone.

D. Large streamcut on Little Gunpowder Falls, 2500 feet southeast of Old York Road, Harford County, Maryland. Coarse garnet-mica schist.

E. Large streamcuts on Little Gunpowder Falls near Pleasantville Road, Harford Count, Maryland. Coarse kyanite-staurolite-garnet-mica schist, locally with sillimanite.

F. Outcrops near Pleasantville Road bridge over Winters Run, Harford County, Maryland. Garnet mica schist in various stages of weathering and disintegration.

II. Boulder gneiss

G. Outcrops along the north and south banks of the South Branch of the Patapsco River, just east of Maryland route 32, at Sykesville. Massive biotite-muscovite-oligoclase-quartz gneiss, containing abundant fragments of micaceous schist and numerous quartz pebbles.

H. Excellent exposures along both sides of the Potomac River between Chain Bridge and the Maryland-District of Columbia boundary line. Massive garnet-mica-oligoclase-quartz gneiss containing abundant fragments of micaceous schist, quartz pebbles, and cobbles of earlier plutonic rocks.

I. Extensive streamcuts along Northwest Branch for about one-half mile southeast of U. S. route 29, at Burnt Mills Hills, Maryland. Coarse-grained garnet-mica-oligoclase-quartz gneiss containing abundant rock fragments.

III. Metaconglomerate

J. Large streamcuts on both sides of Deer Creek about 1000 feet south of Gladden Branch, Rocks State Park, Harford County, Maryland. Heavy-bedded, micaceous, schistose quartz-pebble metaconglomerate; locally contains kyanite and chloritoid.

IV. Metagraywacke

K. Extensive exposures along the Potomac River southeast of Great Falls, Montgomery County, Maryland. Interbedded metagraywacke and retrograded sillimanite--quartz-mica schist.

L. Railroad cuts along the east side of the Susquehanna River at the south end of Peach Bottom Beach, Lancaster County, Pennsylvania. Interbedded metagraywacke and albite-chlorite-muscovite schist. Equally good exposures south along tracks for about 2 miles.

V. Upper pelitic schist

M. Large railroad cuts along the Susquehanna River between Fishing Creek and Midway Station, Lancaster County, Pennsylvania. Chiefly fine-grained albite-chlorite muscovite schist with interbeds of laminated to thin bedded metagraywacke. Metamorphic grain size, especially of albite, increases northward.

N. Large railroad cuts along the Susquehanna River near the mouth of Tucquan Creek, Lancaster County, Pennsylvania. Medium-grained, tough, chlorite-muscovite-albite-quartz schist marked by numerous 1-5mm size albite porphyroblasts.

O. Stream-polished exposures along the Potomac River on the south tip of Bear Island, 1.5 miles southeast of Great Falls, Montgomery County, Maryland. Migmatitic mica schists with interbedded metagraywackes, amphibolites, and calc-silicate granofels.

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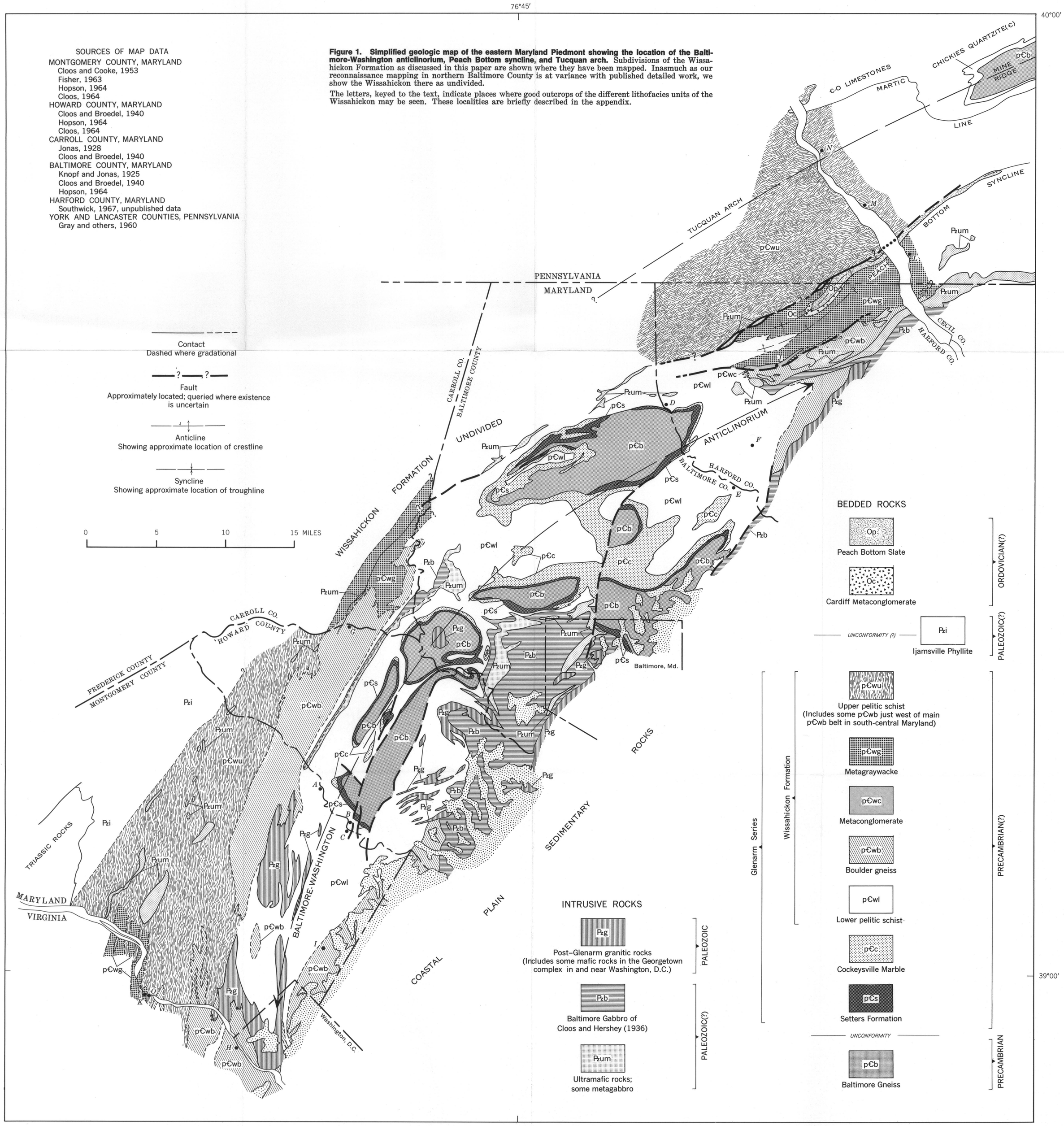

Figure 1. Simplified geologic map of the eastern Maryland Piedmont showing the location of the Baltimore-Washington anticlinorium, Peach Bottom syncline, and Tucquan arch. Subdivisions of the Wissahickon Formation as discussed in this paper are shown where they have been mapped. Inasmuch as our reconnaissance mapping in northern Baltimore County is at variance with published detailed work, we show the Wissahickon there as undivided.

The letters, keyed to the text, indicate places where good outcrops of the different lithofacies units of the Wissahickon may be seen. These localities are briefly described in the appendix.