SOME ENVIRONMENTAL GEOLOGY CONSIDERATIONS IN MONTGOMERY COUNTY, MARYLAND

The Montgomery County folio is intended for use by planners, engineers, hydrologists, and citizens interested in evaluating geologic and hydrologic conditions that may be limiting factors to certain types of land use. The scale of the maps, 1:62,500 (1 inch ≈ approx. 1 mile, contour interval 20 ft), permits only a regional overview, or guide, on a county basis. The maps and accompanying tables and texts provide source and supplementary information to facilitate preliminary area evaluations for some uses, but the data are considered to be reliable only at the published scale. The maps are not intended for enlargement, nor are they, or the engineering data, intended to replace site investigations by qualified technical personnel. Local details at any given site may be quite different from the generalities portrayed on these county maps. These local details must also be considered in planning for a specific land use, although remedial actions and treatments can commonly be engineered at reasonable cost so that otherwise limiting factors can be overcome.

The folio consists of a series of derivative maps that provide a perspective of the surface and shallow subsurface of Montgomery County not readily apparent from published geologic soils, and ground-water studies on which they are primarily based. Engineering properties of rock and overburden are provided in generalized tabular summaries. The maps are designed as multipurpose products to be used independently and in combination with other maps or data published or available elsewhere, such as soils, ground-water, flood-prone areas, slope, vegetation, population, zoning, land use, or geophysical maps. By combining the maps in a variety of ways depending on the relevant limiting factors for any given land use, a series of maps can be derived by the user that focuses on specific problems. For example, the user will be able to evaluate several given areas for a sanitary landfill considering a group of factors using certain map combinations, then be able to assess the limitations or advantages of the same areas for park land or urban development by using other factors and other map combinations. By selecting criteria or guidelines, unique single-purpose derivative maps can be made. Once the essential guidelines to a specific problem are established, other secondary criteria can be modified by trading off or moderating conflicting uses. Current problems, such as evaluating sites for sanitary landfills, sewage-treatment and disposal plants, evaluating areas with limitations for heavy construction, locating transportation or utility corridors, siting septic-tank leaching fields, extracting mineral resources, assessing ground-water resources, determining limitations for surface disposal of treated waste water, selecting areas for park land or rural open space, and many other urban area problems can be more rationally assessed from these maps, at least on a regional basis. Potential uses and possible derivative products from other combinations are discussed in the texts accompanying each map.

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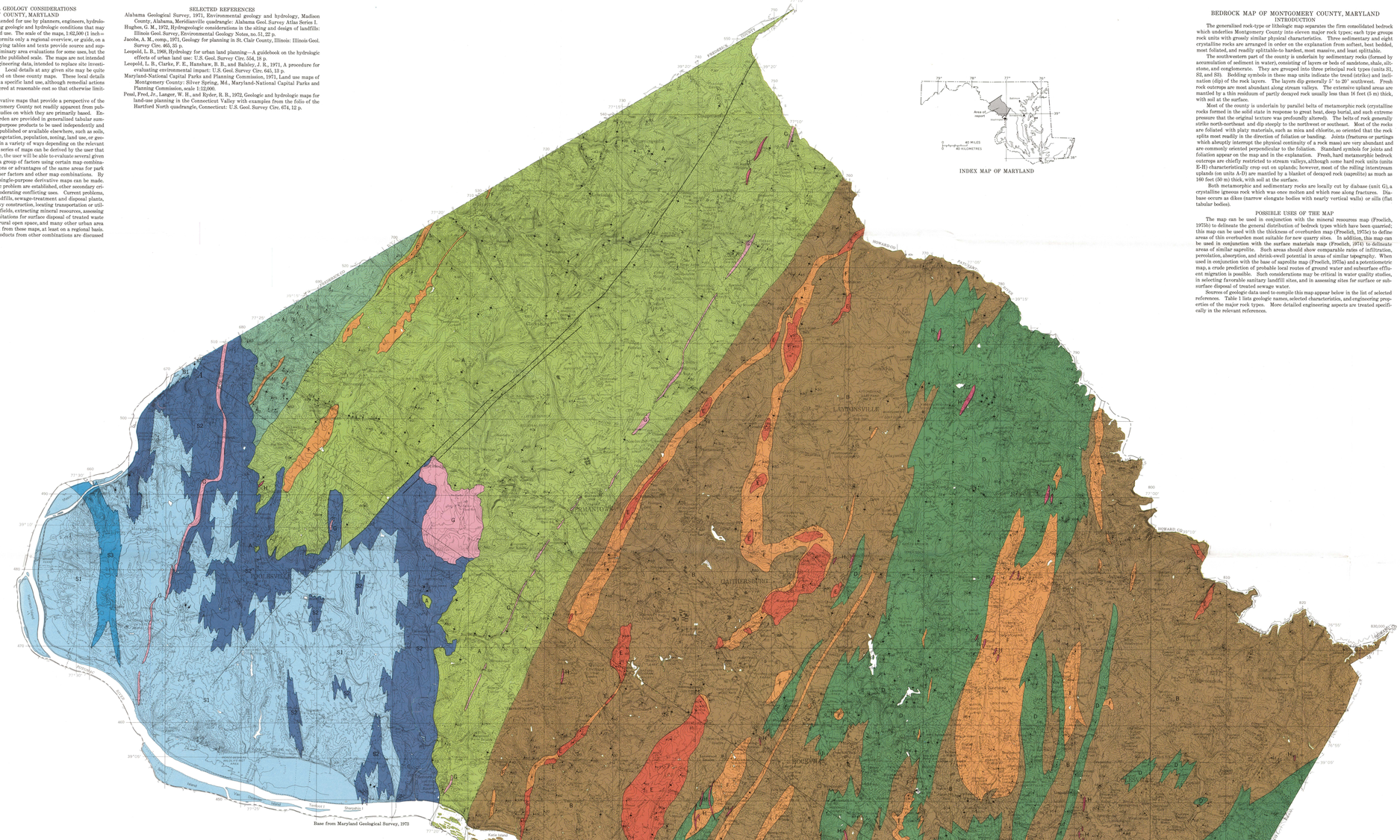


BEDROCK MAP OF MONTGOMERY COUNTY, MARYLAND

INTRODUCTION

The generalized rock-type or lithologic map separates the firm consolidated bedrock which underlies Montgomery County into eleven major rock types; each type groups rock units with grossly similar physical characteristics. Three sedimentary and eight crystalline rocks are arranged in order on the explanation from softest, best bedded, most foliated, and readily splittable-to hardest, most massive, and least splittable.

The southwestern part of the county is underlain by sedimentary rocks formed by accumulation of sediment in water), consisting of layers or beds of sandstone, shale, siltstone, and conglomerate. They are grouped into three principal rock types (units S1, S2, and S3). Bedding symbols in these map units indicate the trend (strike) and inclination (dip) of the rock layers. The layers dip generally 5° to 20° southwest. Fresh rock outcrops are most abundant along stream valleys. The extensive upland areas are mantled by a thin residuum of partly decayed rock usually less than 16 feet (5 m) thick, with soil at the surface.

Most of the county is underlain by parallel belts of metamorphic rock (crystalline rocks formed in the solid state in response to great heat, deep burial, and such extreme pressure that the original texture was profoundly altered). The belts of rock generally strike north-northeast and dip steeply to the northwest or southeast. Most of the rocks are foliated with platy materials, such as mica and chlorite, so oriented that the rock splits most readily in the direction of foliation or banding. Joints (fractures or partings which abruptly interrupt the physical continuity of a rock mass) are very abundant and are commonly oriented perpendicular to the foliation. Standard symbols for joints and foliation appear on the map and in the explanation. Fresh, hard metamorphic bedrock outcrops are chiefly restricted to stream valleys, although some hard rock units (units E-H) characteristically crop out on uplands; however, most of the rolling interstream uplands (on units A-D) are mantled by a blanket of decayed rock (saprolite) as much as 160 feet (50 m) thick, with soil at the surface.

Both metamorphic and sedimentary rocks are locally cut by diabase (unit G), a crystalline igneous rock which was once molten and which rose along fractures. Diabase occurs as dikes (narrow elongate bodies with nearly vertical walls) or sills (flat tabular bodies).

POSSIBLE USES OF THE MAP

The map can be used in conjunction with the mineral resources map (Froelich, 1975b) to delineate the general distribution of bedrock types which have been quarried; this map can be used with the thickness of overburden map (Froelich, 1975c) to define areas of thin overburden most suitable for new quarry sites. In addition, this map can be used in conjunction with the surface materials map (Froelich, 1974) to delineate areas of similar saprolite. Such areas should show comparable rates of infiltration, percolation, absorption, and shrink-swell potential in areas of similar topography. When used in conjunction with the base of saprolite map (Froelich, 1975a) and a potentiometric map, a crude prediction of probable local routes of ground water and subsurface effluent migration is possible. Such considerations may be critical in water quality studies, in selecting favorable sanitary landfill sites, and in assessing sites for surface or subsurface disposal of treated sewage water.

Sources of geologic data used to compile this map appear below in the list of selected references. Table 1 lists geologic names, selected characteristics, and engineering properties of the major rock types. More detailed engineering aspects are treated specifically in the relevant references.

EXPLANATION

Predominant consolidated rock types, in order of decreasing ease of excavation and rippability and, increasing hardness. Main rock name in upper case letters; b, bedded rocks; f, foliated rocks; m, massive rocks

MAP UNITS

SEDIMENTARY ROCKS

- S1 — b — SILTSTONE, shale, and sandstone—Interbedded, red to brown, locally calcareous; siltstone, red to purplish brown shale, and minor beds of light-gray to red-brown sandstone (arkose). Unit is more than 2250 feet (750 m) thick and very extensive. It is readily eroded and forms rolling uplands mantled by a thin red-brown residuum and soil, except where fresh rock is exposed along steep-sided streams. Unit is jointed and commonly broken into blocks an inch to a few feet across
- S2 — b — SANDSTONE (ARKOSE), conglomerate, and siltstone—Interbedded pebble conglomerate having a matrix of gray to red sandstone and gray to pink sandstone and purplish-brown sandy siltstone and silty shale. The unit is resistant to erosion and forms uplands and steep bluffs. The residuum is thin and gravelly and the soil is thin and sandy
- S3 — b — LIMESTONE CONGLOMERATE, and calcareous sandstone, siltstone, and shale—Unit rarely crops out; exposed are chiefly along the canal northwest of Martinsburg. Unit is distinguished mainly because it is limy. The most distinctive rock type is the limestone conglomerate, about 65 feet (20 m) thick, which contains rounded pebbles of gray limestone in a matrix of reddish-brown, clay-rich, calcareous sandstone. Adjacent beds are also limy and readily eroded. The unit occurs in a belt which is generally concealed by upland gravel

CRYSTALLINE ROCKS

- A — f,b — PHYLLITE, chloritic, sericitic, quartzose, partly schistose with slate, quartzite, metagraywacke, and quartz veins—The phyllite is a gray and green foliated rock composed mainly of very fine grained mica and chlorite which impart a surface sheen to the folia. Foliation, the dominant planar element, is usually vertical or dips steeply eastward. Faults (fractures along which rocks have been displaced) and joints commonly parallel foliation, and closely spaced crossjoints are common. The unit also contains beds of gray slate and light-gray quartzitic sandstone. Quartzitic beds, as much as 30 feet (10 m) thick, commonly underlie linear strike ridges. Quartz veinlets are very abundant in some areas. Phyllite weathers to a saprolite upon which is developed a typical thin channery soil containing abundant fresh angular rock chips and fragments. Topography is steep and hilly with narrow ridges, steep parallel valleys and local relief as much as 150 feet (45 m)
- B — f — SCHIST, mica, chlorite, quartz, pelitic; with metagraywacke, gneiss, and quartz veins—The schist is a foliated, silvery gray rock consisting of interlocking plates of mica or chlorite and minor amounts of other common rock-forming minerals. It is commonly interbedded with schistose gneiss (a massive to banded rock containing quartz and feldspar) and impure quartzite in beds ranging from a few inches to tens of feet. Foliation, the dominant planar element, generally dips steeply east or west. Unit B is folded and faulted with fractures commonly parallel to foliation; some fractures are filled and healed, others are brecciated or filled with soft, clayey gouge. Jointing is irregular, but the main breakage is parallel to the foliation; additional sets are commonly perpendicular to foliation and facilitate splitting into polygonal blocks. Schist weathers to a thick micaceous saprolite and soil. Unit B forms rolling uplands and steep-sided strike valleys with local relief rarely more than 100 feet (30 m)
- C — b-m — QUARTZITE, fine- to coarse-grained; interbedded with phyllite, metagraywacke, slate—The quartzite is a light-gray, fine- to coarse-grained partly conglomeratic, thick-bedded (3 to 30 ft (1-10 m) thick), hard, abrasive rock consisting predominantly of cemented quartz grains; it is interbedded with gray, impure sandstone and minor layers of phyllite and slate in units 15 to 45 feet (5–15 m) thick. Bedding and foliation dip generally moderately to steeply eastward. Jointing and secondary veins of quartz are locally prominent, commonly 3 feet (1 m) apart but locally closely spaced; quartzite is locally shattered by faults and fractures. The quartzite forms steep rocky ridges and phyllite beds form saddles. The unit weathers to a thin, sandy rubified residuum and soil, except on phyllite where saprolite as much as 30 feet (10 m) thick is developed and capped by channery soil
- D — m-f — GNEISS, quartz, feldspar, mica, hornblende; includes granite, granofels, granodiorite, pegmatite—The gneiss is a banded massive rock composed mainly of quartz and feldspar with lesser amounts of mica and other accessory minerals. It is commonly interbedded with impure sandstone and mica schist, especially near contacts with unit B. Unit D includes small bodies of massive igneous rocks, such as granite, granodiorite, and coarsely crystalline pegmatite which contains similar minerals. Steeply dipping intersecting joint sets commonly 3 feet (1 m) or more apart are prominent, and locally split the gneiss into large polygonal blocks. Unit D forms rolling uplands and steep-sided valleys. It commonly weathers to silty saprolite as much as 100 feet (30 m) thick with thick soils on uplands; locally, fresh massive gneiss pinnacles jut through the soil cover
- E — m-f — ULTRAMAFIC ROCKS, serpentinite, with chlorite-actinolite-talc schist near contacts; minor gabbro, diorite—Dominantly massive to foliated serpentinite, a dark-green, dense rock usually formed by hydrous alteration of crystalline rocks very rich in magnesium and iron. The serpentinite body at Hunting Hill is locally cut by dikes of gabbro and bodies of diorite. It is massive, hard, and tough except at the margins which are schistose; where unit E is thin, most of the body is foliated. Massive and schistose bodies are commonly sheared and broken by intersecting zones of soft, weak, friable, slippery material and healed with calcite, but quartz veins are rare; intersecting joint systems and fractures are common and break the unit into blocks less than 3 feet (1 m) in diameter. Unit E generally forms rocky uplands with very thin saprolite and shallow clay-rich, poorly drained soils
- F — m-f — MAFIC ROCKS, greenstone and greenschist, amphibolite; metavolcanic meta-igneous rocks (gabbros, etc.)—mafic rocks form a complex which includes banded to schistose and massive rocks rich in magnesium and iron but containing some quartz and feldspar. Greenstone, metavolcanic rocks, amphibolite, and altered igneous rocks are common types. Unit F is cut by many fractures commonly filled by quartz veinlets, and by quartz veins as much as 50 feet (15 m) wide. Joints are closely spaced, intersecting and dip steeply. Unit F generally forms irregular topography with weathered bedrock near the surface, thin to moderately thick saprolite and shallow, clay-rich, poorly drained soils
- G — m — DIABASE, dikes and sills; with baked sedimentary rocks near contacts—Diabase is hard, dense, dark-gray to black crystalline rock occurring in narrow, discontinuous elongate dikes and as a large sill near Boyds. Rocks adjacent to dikes are baked and hardened for about 50 feet (15 m). The massive to blocky unit is commonly jointed parallel to its contacts. A reddish- to yellowish-brown, clay-rich residuum as much as 35 feet (10 m) thick overlies diabase, but residual spheroidal "boulders" commonly crop out through upland surfaces. The dikes form narrow ridges or valleys depending on the type of rock they transect. The sill forms ridges along its periphery and lowlands near the center
- H — m — QUARTZ BODIES, veins and dikes; massive and shattered—Quartz is a white, very hard, brittle mineral which occurs as veins, veinlets, and pods, filling fractures in the much softer schist, gneiss, and sandstones. Some quartz masses are shattered by fractures, whereas others are massive bodies with widely spaced fractures. Quartz does not weather readily, and fresh blocks commonly occur at the surface in the cores of linear hills and ridges

SYMBOLS

- CONTACT BETWEEN ROCK UNITS, APPROXIMATELY LOCATED—Dashed where gradational or inferred
- TREND OF FAULT, FRACTURE, OR LINEAMENT, APPROXIMATELY LOCATED—Dotted where concealed or inferred
- 12 — DIRECTION (STRIKE) AND INCLINATION (DIP) OF BEDDING IN SEDIMENTARY ROCKS
- STRIKE AND DIP OF DOMINANT FOLIATION
  - 75 — Inclined
  - Vertical
- STRIKE AND DIP OF JOINTS (PLANAR CRACKS OR PARTINGS)
  - 82 — Inclined
  - Vertical

TABLE 1.—*Selected properties of rock units in Montgomery County, Maryland*

[Based in part on sheet 6, U.S. Geological Survey, 1967. Selected engineering properties of soils which overlie surface units in Montgomery County are listed on Table 1 of Natural soil assemblages (Froelich, 1974).]

Map symbol and dominant rock type	Principal rock types and equivalent geologic formations (approx. thickness of sedimentary rocks in ft)	Structure and planar elements (splittability)	Residuum (overburden)	Maximum dry density (lbs/ft³)	Relative drillability[1]	Unconfined compressive strength[2]	Young's modulus of elasticity[3]	Overbreak[4]	Surface Excavability[5]	Remarks
SILTSTONE S1	Siltstone, shale, and sandstone. Triassic, Newark Group (New Oxford Formation) (0-2250).	Thin- to medium-bedded (¼ in. to 3 ft), micaceous. Commonly intensely jointed yielding platy fragments.	0-30 ft Avg. 10 ft. Thin silty residual soils.	140–166	4–7	Very low to medium.	Very low to low.	Moderate to excessive.	Easy to moderate.	Shales may slake badly in air and break readily along bedding planes yielding small thin flakes. Gently rolling topography. Locally calcareous at depths exceeding 20 ft.
SANDSTONE S2	Sandstone (arkose), conglomerate (quartz and quartzite pebbles), and siltstone. Triassic, Newark Group (New Oxford Formation) (150-600).	Thin- to thick-bedded (¼ in. to 15 ft); micaceous arkose with interlocking grains interbedded with 1 in. to 1 ft beds of siltstone and shale.	0–20 ft Avg. 8 ft. Very thin sandy residual soil.	156–165	4–6	Moderate to high.	Low.	Moderate to excessive.	Moderate; may require blasting.	Conglomerate may ravel in air. Unit locally porous and may contain considerable water. Forms rolling uplands except in cliff faces flanking major streams. Sandstone is light gray to reddish brown, fine to coarse grained, fairly well sorted; contains 50-75% quartz, 15-40% feldspar, 1-5% muscovite, with silica and ferruginous cement. Conglomerate pebbles: quartz, quartzite, phyllite, average 1 in. diameter, rounded to subangular.
LIMESTONE CONGLOMERATE S3	Limestone conglomerate, sandstone, siltstone, and shale, calcareous. Triassic Newark Group (New Oxford Formation) (0-600).	Thin- to thick-bedded (½ in. to 15 ft); conglomerate crudely bedded, lenticular, with subrounded to rounded limestone pebbles; interbedded with thin calcareous siltstone, shale, and sandstone beds.	0–20 ft Avg. 10 ft. Thin residual soil.	155–168	4–6	Low to high.	Low.	Moderate to excessive. (Locally interbedded with thin limestones).	Moderate to easy; locally requires blasting.	Conglomerate and shale may ravel in air. Unit poorly exposed except along Potomac River valley northwest of Martinsburg. Limestone pebbles in conglomerate have average diameter of ½ in. in coarse sand and calcite matrix.
PHYLLITE A	Phyllite, schistose phyllite, phyllitic slate, quartzite, metagraywacke. Limeville Phyllite, Urbana Phyllite, Harpers Phyllite (Marburg Schist).	Foliated to finely, locally bedded, locally schistose. Steeply dipping foliation and cleavage are dominant planar elements. Fissile, splits along ⅛ in. to ½ in. planes. Faults and joints commonly parallel foliation. Tight folds, cleavage and development commonly closely spaced.	0–100 Avg. 30 ft. Moderately thick gravelly saprolite and thin channery soil.	149–177	3–6	Very low (phyllite) to high (slate).	Low to high.	Slight; excessive where rock faulted, sheared or altered.	Moderate to easy; requires blasting.	Machine boring slowed by quartz veins and quartzite beds. Scaling moderate. Weathering variable. Overbreak and rock load depend on orientation of excavation to foliation. Cleavage and foliation planes commonly intersect at large angles and rock breaks readily into elongate blocks and weathers to abundant chips. Forms ridge and valley topography.
SCHIST B	Pelitic schist, mica schist, metagraywacke, quartz-feldspar-mica schistose gneiss. Wissahickon Formation, pelitic schist facies; Marburg Schist.	Metamorphic foliation is dominant planar element; dips steeply, multiple directions common. Fissile, splits along ⅛ in to ½ in. planes. Many small-scale folds; faults and joints commonly parallel foliation, jointing irregular; transverse sets facilitate breakage into polygonal blocks.	0–160 ft Avg. 60 ft. Thick micaceous saprolite and soil.	163.5–176	3–6	Low to medium.	Low to medium.	Slight to moderate.	Moderate to easy; usually requires blasting.	Machine boring slowed by quartz pods and other hard inclusions. Overbreak and rock load depend on orientation of excavation to foliation. Squeezing ground in wet shear zones probable. Scaling slight to moderate. Rock bursts may be pronounced. Susceptible to shearing at dips of 15° or more toward open cut faces. Commonly forms gently rolling hills and steep linear valleys.
QUARTZITE C	Quartzite, metagraywacke, phyllite, and phyllitic slate. Sugarloaf Mountain Quartzite, Harpers Phyllite (Marburg Schist).	Thick-bedded to massive, interbedded with platy beds of phyllite and phyllitic slate. Dip of bedding and foliation moderate to steep. Prominent joints about 3 ft apart, locally closely spaced. Quartzite locally shattered by faults.	0–10 ft Avg. 3 ft. Thin to no saprolite; locally rubified quartz sand; sandy soil.	161–172	3–5	Medium to high.	High to medium.	Moderate; excessive in crushed zones.	Difficult; requires blasting.	Massive zones may be highly stressed; possibly popping and spalling. Scaling excessive and hazardous in very blocky to crushed zones. Poor stability on cut faces. Commonly forms linear ridges and topographic prominences.
GNEISS D	Schistose, gneiss, granite, granofels, pegmatite, granodiorite, (metagraywacke, schist, etc.). "Sykesville Formation;" Wissahickon Formation, diaschistic facies; Setters' gneiss, includes "Kensington Granite-Gneiss" and "Laurel Gneiss."	Massive, banded, thick-bedded to foliated where interbedded with schist or along shear planes. Splits along ½-in to 3-ft planes. Joints prominent, dip steeply, parallel and perpendicular to banding.	0–100 ft Avg. 40 ft. Moderately thick, micaceous saprolite and soil.	166.6–178.1	3–5	Schistose gneiss: low to medium. Massive gneiss: medium to high.	Medium to high.	Moderate to excessive.	Moderate; requires blasting.	Overbreak and rock loads depend on orientation of excavation to foliation and joint system. Fair to good stability in massive gneiss; schistose gneiss may contain steep cut faces except in thinly layered schistose parts which may shear. Massive jointed units commonly break into blocks rather than slabs or plates. Locally quarried for dimension stone, building stone, flagstone and riprap. Commonly forms gently rolling uplands and steep-walled valleys.
ULTRAMAFIC ROCKS E	Serpentinite (peridotite, pyroxenite, dunite), gabbro (rodingite), diorite, talc schist, etc.	Massive to locally foliated; commonly sheared and broken by intersecting zones of weak, friable slippery material. Joints common, 10-ft blocks at Hunting Hill, ½ in. plates at Quince Orchard.	0–8 ft Avg. 3 ft. Thin to no saprolite or soil.	161–178	2–5	Very low (sheared) to very high (massive).	Very low (sheared) to very high (massive).	Excessive.	Difficult; requires blasting.	Exceedingly difficult to work. Swelling and squeezing ground along wet shear zones; high state of stress likely in massive serpentinite bodies. May act as barrier to ground water and septic effluent migration. Good road metal. Shears easily along contacts and fractures on cut faces when wet. Unweathered to slightly weathered. Commonly forms rolling uplands.
MAFIC ROCKS F	Meta-igneous, metavolcanic, and volcaniclastic rocks; greenstone, greenschist, amphibolite, schist, amphibolites, chlorite-actinolite-talc schist, metagabbro, tonalite, metadiorite(?). Includes Sams Creek Metabasalt of Stose and Stose (1946), Norbeck Quartz Diorite of Hopson (1964), Georgetown Complex of Hopson (1964).	Foliated schistose to banded and massive; locally many fractures. Locally fissile; splits along ⅛ to 3-ft planes. Also blocky. Joints abundant, closely spaced, dip steeply.	0–75 ft Avg. 20 ft. Thin to moderately thick, clayey saprolite and soil.	164–172	1–5	Hornblende gneiss: medium to high.	Low to high.	Slight to moderate.	Moderately difficult; requires blasting.	Machine boring slowed by quartz pods and other hard inclusions. Overbreak and rock loads dependent on frequency and orientation of foliation, rock defects, and alteration. Impeded drainage. Moderately weathered. Commonly forms nearly level uplands or lowlands.
DIABASE G	Triassic dikes and sills with baked wallrock.	Massive to blocky. Joints very common, especially at dike margins; with baked borefish at contact zone. Dikes nearly vertical, sills nearly flat or gently dipping.	0–30 ft Avg. 20 ft. Thin to moderately thick saprolite and soil with spheroidally weathered "boulders."	171–189	1–3	Medium to very high.	High.	Slight to moderate in large bodies; excessive in dikes.	Difficult; requires blasting.	Rock locally in high states of stress. Fresh rock very durable and is excellent for use as crushed aggregate. Sill at Boyds estimated about 80 ft thick near Buckingham. More than 200 ft where drilled, possibly as much as 700 ft maximum. Dikes commonly form linear ridges or valleys.
QUARTZ BODIES H	Veins, dikes, and pods.	Massive and shattered to 2 in. fragments.	0–2 ft. No saprolite, virtually no soil.	165	1–3	Low to high.	Low to high.	Not applicable.	Difficult; requires blasting.	Exceedingly difficult to work where not shattered by fractures. Unweathered. As much as 75 ft thick. Commonly forms bold upland ridges.

[1]Drillability: 1, most difficult; 7, least difficult.

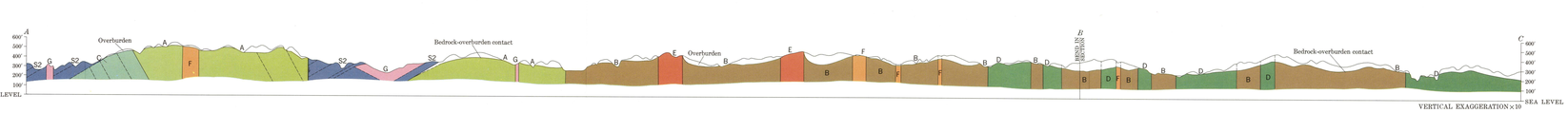
Common equivalents and conversions
1 inch = 25 millimetres (2.54 cm)
1 foot = 0.3 metre
1 sq ft = 0.09 sq metre
1 ton (avdp) = 907 kilograms

[2]Strength class — Range of compressive strength (psi)
Very high — >32,000
High — 16,000-32,000
Medium — 8,000-16,000
Low — 4,000-8,000
Very low — <4,000

[3]Modulus class — Range of static modulus of elasticity (psi)
Very high — $>22 \times 10^6$
High — $11 \times 10^6 - 22 \times 10^6$
Medium — $4 \times 10^6 - 8 \times 10^6$
Low — $1 \times 10^6 - 4 \times 10^6$
Very low — $<10^6$

[4]Overbreak—In tunneling, denotes quantity of rock actually excavated beyond perimeter previously fixed by the engineer as the finished excavated tunnel outline.

[5]Excavability—Relative ease of digging and removal by surface power equipment such as tractors, rippers, scrapers, back hoes, etc.



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BEDROCK MAP OF MONTGOMERY COUNTY, MARYLAND

By
Albert J. Froelich

1975

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1975

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