U.S. DEPARTMENT OF THE INTERIOR

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Geologic map of the Loudoun County portion of the Middleburg quadrangle, Virginia

by

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(Plate 1 accompanies text)

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The Culpeper basin portion of this map is based on the work of K.Y. Lee (1979), supplemented by new field mapping by Froelich in 1990. It incorporates recent new structural interpretations by Froelich and the stratigraphic modifications of Lee and Froelich (1989). A series of U.S. Geological Survey Miscellaneous Investigation Series maps of the Culpeper basin (MI-1313; parts A-J) were published between 1981 and 1989.

DESCRIPTION OF MAP UNITS

af Artificial fill--Various sandy and gravelly materials of local origin; occupies low-lying areas filled and compacted for construction of highways, bridges, dams, overpass approaches and railroad beds; includes disturbed ground, spoil piles, and areas excavated for quarries and borrow pits

SURFICIAL MATERIALS - SEDIMENTS

Qal Alluvium (Holocene)--Sand, silt, gravel, and clay underlying floodplains along streams; sediments are yellowish brown, in some places fairly well bedded, poorly to moderately well sorted, graded deposits with gravel generally at the base of upward-fining sequences. Most gravel is in areas draining the Bull Run Mountains and consists of subrounded quartzite, vein quartz, greenstone and phyllite. Streams draining the Culpeper basin contain pebbles and cobbles of basalt, sandstone and siltstone as well. Streams draining the Catoctin Formation contain abundant pebbles and cobbles of epidosite, vein quartz and lesser amounts of metabasalt and quartzite. Streams draining the Marshall Metagranite and the overlying Fauquier Formation, contain pebbles and cobbles of granite and lesser sandstone. Unit is unconformable on all underlying formations. It is as much as 6 m (20 ft) thick

Qc Colluvium (Holocene and Pleistocene(?))--Gravel, sand, and silt in lensoid aprons flanking the Bull Run Mountains; composed chiefly of unsorted angular to subangular boulders, cobbles and pebbles of quartzite, metaconglomerate, phyllite, epidosite, and lesser metabasalt and vein quartz in a loose matrix of reddish brown to yellowish orange micaceous sand and silt. Thickness ranges from a veneer along the margins of the deposit to greater than 15 m (50 ft) at the foot of the mountains and is thickest in lobes where it overlies sedimentary rocks, as near Buchannon Gap. Much of area underlain by the Catoctin Formation is covered by a veneer of colluvium; however, only the thicker colluvium at the base of Bull Run Mountain has been mapped. Thus, the western contact of the colluvium on Bull Run Mountain is arbitrary because many areas shown as bedrock on the map are overlain by colluvium of unknown thickness. Some areas, such as along ridge crests, mapped as colluvium consist of thin to thick residuum. The basal contact is unconformable. As no direct age determinations have been made, the older parts of the colluvium could be Pliocene or older

Qt Terrace deposits (Holocene and Pleistocene(?))--Gravel, sand, silt and clay in fairly well bedded, gently sloping, graded deposits in lowland benches 3 to 6 m (10 to 20 ft) above present floodplains. Similar deposits form a residual veneer on a partly dissected gently east-sloping upland between altitudes of about 150 to 130 m (500 and 430 ft) where it adjoins colluvium south of the Bull Run Mountain Estates (south of map area in Prince William County. Gravel comprises rounded quartzite, chert, vein quartz and conglomerate and minor subangular clasts of phyllite and chert in a yellowish orange to yellowish brown matrix of silty sand. Thickness ranges from a feather edge to about 7 m (25 ft). As no direct age determinations were made, lower units could be Pliocene or older

BEDROCK

LOWER MESOZOIC SEDIMENTARY AND IGNEOUS ROCKS OF THE CULPEPER BASIN

NEWARK SUPERGROUP CULPEPER GROUP, upper part) AND DIABASE

INTRUSIVE ROCKS

Jd
Jdo Diabase (Lower Jurassic)--Medium to dark-gray, chiefly medium crystalline and equigranular, finely crystalline and aphanitic near chilled margins. Consists of dark-grayish-green to black crystals of pyroxene (augite and pigeonite), subhedral to euhedral laths of plagioclase (chiefly labradorite), and interstitial anhedral olivine with minor magnetite and ilmenite. Occurs in northnortheast- and northwest-trending dikes cutting the metamorphosed pre-Mesozoic rocks west of the Culpeper basin. Diabase is tough, massive, and jointed; commonly thickens and thins and pinches out along strike (it is as much as 150 m (500 ft) wide near Cold Spring Gap). Locally forms ledges, but where thin, the dikes are marked by a linear train of spheroidal boulders. Weathers to orange-brown saprolite, locally as much as 20 ft (6 m) thick. Jdo, olivine-normative tholeiite with Mgo content of 15.5%

as indicated by geochemical analyses. Minor dikes with magma type not determined are shown as Jd. As no direct age determinations were made, the inferred Early Jurassic age is based on 40Ar/39Ar age spectrum dates from similar diabase elsewhere in the Culpeper basin (Sutter, 1985; 1988)

SEDIMENTARY AND EXTRUSIVE ROCKS

SANDER BASALT (Lower Jurassic)

Jsb Basalt--Dark gray to bluish gray, fine- to medium-crystalline, porphyritic, microporphyritic to equigranular, with subhedral to euhedral laths of plagioclase (locally in glomeroporphyritic clusters), and augite and rare pigeonite phenocrysts 1 to 2 mm in diameter in a groundmass of plagioclase, augite, and pigeonite about 0.5 mm in diameter with accessory ilmenite, magnetite, and 5 percent intersertal mesostasis (Tollo, 1988). Locally contains coarse gabbroid segregations in pods and lenses. Vesicular and amygdaloidal at tops of some flows, with vugs filled by calcite, zeolites, and prehnite; pyroxene partly altered to chlorite, actinolite and serpentine, and plagioclase partly altered to sericite and sausserite (Tollo, 1988). In places deeply weathered to red-brown saprolite 1 m to more than 6 m (3-20 ft) thick. Consists of at least six separate flows that underlie a series of subtle ridges separated by subdued valleys underlain by sedimentary rocks. Geochemical analyses from sample sites located on the map show that basalts are predominantly high iron quartz-normative tholeiites (HFQ - Sander types A and B of Tollo, 1988), but the middle flows are low titanium quartz-normative tholeiites (LTQ-Sander types C and D of Tollo, 1988). The upper flows contain some evolved basalts and the gabbroid segregations are high iron, high titanium varieties (Sander types E and S.G. of Tollo, 1988). Section 4E (Lee and Froelich, 1989), a nearly complete section measured along Virginia State Route 701, south of the map area, is 751 m (2465 ft) thick, of which about 545 m (1790 ft) is basalt (units 1,3,5,7). The basalt, well exposed in several abandoned quarries, is characterized by distinctive curved columnar joints about 7.5 cm (3 in) across, locally overprinted by closely spaced brittle fractures

Jss Sandstone and siltstone--Sandstone, dark red to grayish red and greenish gray, fine- to coarse-grained, locally pebbly and crossbedded, feldspathic, micaceous, thin- to thick-bedded; fines upward and grades into climbing ripple-laminated siltstone. Siltstone is red brown, micaceous, and interbedded with dark-red silty shale and in places with green-gray and dark-gray calcareous shale. The sandstone and siltstone units are lenticular and range in thickness from about 3 m (10 ft) to 75 m (246 ft) and extend along strike for several kilometers. The three clastic intervals of the Sander along Virginia State Route 701, south of the map area, are about 205 m (675 ft) thick collectively (Lee and Froelich, 1989, Section 4E, units 2,4,6) with 55 m (181 ft) covered

Jtr TURKEY RUN FORMATION (Lower Jurassic)--Sandstone, siltstone, conglomerate, and shale, in poorly exposed cyclic sequences. Sandstone, reddish-brown, gray, and nearly black, fine- to coarse-grained, micaceous, generally poorly sorted, locally crossbedded, pebbly and locally ripple-laminated; intercalated with siltstone, red-brown, greenish gray and dark-gray, micaceous, ripple-laminated, and shale, dark-red and dark-gray, fissile, and laminated. Dark-gray cyclic sequence near base of formation is fossiliferous, with abundant plant fragments and sparse fish scales, and is probably lacustrine and deltaic in origin. Dinosaur tracks have been found at a quarry in red-brown sandstone and siltstone near the middle of the formation on the north bank of the Little River just north of the northeast corner of the quadrangle. Measured section 4D (Lee and Froelich, 1989) along Virginia State Route 701, south of the map area, is 218 m (715 ft) thick, probably a representative thickness of the Turkey Run in the Middleburg Quadrangle. Unit forms subdued lowlands mantled by thick colluvium near Bull Run Mountain

Jhg HICKORY GROVE BASALT (Lower Jurassic)--Medium- to dark-gray, fine- to medium-crystalline, microporphyritic to equigranular, with subhedral to euhedral plagioclase, augite, and minor pigeonite phenocrysts 1 to 2 mm in diameter in a ground mass of the same minerals about 0.5 mm in diameter, with accessory ilmenite, magnetite and about 5% intersertal mesostasis. Locally vesicular and amygdaloidal at tops of flows, with vugs filled by zeolites, calcite, and prehnite; pyroxene partly altered to chlorite, actinolite, and serpentine, plagioclase partly altered to sericite and sausserite (Tollo, 1988). In uplands, basalt is generally deeply weathered to reddish-brown to gray saprolite 1 m to more than 6 m (3-20 ft) thick that underlies a subtle north-trending ridge. Consists of 2 or 3 separate flows, uniformly of iron-rich, quartz-normative (HFQ) tholeiitic basalt. In measured section 4C (Lee and Froelich, 1989) along Virginia State Route 701, south of the map area, is 212 m (695 ft) thick, which is probably about average in this quadrangle. Basalt is characterized by curved columnar joints about 7.5 cm (3 in) apart, crosscut by through-going tectonic fractures

Jm MIDLAND FORMATION (Lower Jurassic)--Siltstone, sandstone, shale, and conglomerate in poorly exposed cyclic sequences. Siltstone, reddish-brown and light- to dark-gray, micaceous, commonly ripple-laminated, locally bioturbated, calcareous, and locally fossiliferous; intercalated with sandstone, dark-red to reddish-brown and gray, fine- to coarse-grained, feldspathic, locally pebbly, crossbedded, and ripple-laminated; and shale, dark-red, light greenish-gray, and dark-gray to black, silty, burrowed, with dessication cracks, carbonaceous, pyritic, calcareous, microlaminated and locally fossiliferous. In places, lenses of conglomerate and conglomeratic, coarse-grained, arkosic sandstone are present. Formation underlies a subtle north-trending valley or lowland. Measured section 4B (Lee and Froelich, 1989) along Virginia State Route 701, south of the map area, is 381 m (1250 ft) thick, a maximum thickness for this formation

LOWER PALEOZOIC AND PROTEROZOIC ROCKS OF THE BLUE RIDGE

Ꞓh Harpers Formation (Lower Cambrian)--Phyllite, muscovite-magnetite-schist, siltstone, quartzites, and quartz-pebble conglomerate. The lower part of the unit is dominated by silvery gray, bronze-weathering, medium- to coarse-grained muscovite schist studded with magnetite grains up to 1 cm (0.4 in) in diameter. Bedding in the schist is not recognizable due to transposition and quartz veining; schist occurs sporadically in lesser amounts higher in the section. The middle part of the unit is dominated by medium-gray to greenish-gray, yellowish-brown-weathering, fine-grained phyllite interbedded with thin beds of quartzose brownish-gray-weathering, magnetite-bearing siltstone and coarse sandstone and pebble conglomerate. The upper part of the unit contains white to medium-gray, yellowish-weathering, medium-grained, thin- to medium-bedded, flaggy, micaceous quartzite interbedded with lesser phyllite and minor conglomerate with quartz pebbles ranging in size from 1-10 cm (0.4-4 in). Gradational contact with underlying Weverton Quartzite is placed at the base of the first major (greater than 3 m (10 ft) interval of muscovite-magnetite-schist. Due to fault truncation by the Bull Run Mountain fault at the western edge of the Culpeper basin, the upper contact of unit not present in quadrangle. Near north edge of quadrangle the unit is completely cut out by the Bull Run Mountain fault, but south of Aldie it ranges up to 600 m (1970 ft) thickness

Ꞓw Weverton Quartzite (Lower Cambrian)--Quartzite, muscovite schist, and quartz-pebble conglomerate. Quartzite, milky-white to very-light-gray, weathering to medium-gray and locally to brownish-orange where rich in pyrite, medium-grained, thick-bedded (up to 3 m (10 ft)) near the base but generally thinner-bedded higher in the section. Minor feldspar. Near the base bedding is massive, but it is well defined by wispy layers of dark minerals including tourmalene, zircon and magnetite. These heavy minerals highlight crossbeds and in some places, graded beds. These quartzite sequences form distinct ridges or spines. Upward in the section thin beds of muscovite schist are interbedded with the quartzite which also becomes increasingly micaceous. Rare, thin beds of pebble conglomerate (white quartz pebbles ranging from 0.5-3 cm (0.2-1.2 in), interbedded with purplish- and green-weathering platy phyllite, occur at various stratigraphic levels but more commonly near the top of the unit. Near the base of the unit at least two generations of quartz veins make up to 50 percent by volume of the rock. These veins are generally subparallel to a well-developed foliation present in even the most massive quartzite beds. Lower contact is regionally conformable with underlying Catoctin Formation and is placed at the base of the lowest quartzite bed. The thickness ranges from approximately 70 m (230 ft) in the north where it is truncated by the Bull Run Mountain fault to 250 m (820 ft) in the south where a complete stratigraphic section is present

Zd Metadiabase (Late Proterozoic)--Medium-greenish-gray to greenish-black, medium-to dark-yellowish-brown-weathering, fine- to medium-grained metadiabase in dikes and sills with rare, irregular football-shaped masses of epidosite. Actinolite, epidote, albite, sphene, and chlorite occur as pseudomorphs after primary igneous minerals, thus commonly preserving igneous intergranular and ophitic textures. A few outcrops have abundant euhedral plagioclase phenocrysts. A weak metamorphic cleavage, due to aligned chlorite and/or actinolite is common. Joints are very planar but few. Reddish clayey soils commonly form on the metadiabase. Forms dikes in Marshall Metagranite and sills in the Fauquier and the Catoctin Formations. Where exposed contacts with granite are sharp. The dikes and sills are inferred to range from about 1-10 m (3-33 ft) thick, with a few as thick as 20 m (65 ft). The width of many of these have been exaggerated in order to show them on the map. North of Middleburg a long outcrop belt of metadiabase appears to be a single dike about 80 m (260 ft) thick. Isolated outcrops are marked with an X. Chemical analyses of both dikes in Proterozoic basement, and sills in the Fauquier and Catoctin Formations, are nearly identical to one another and plot along trends of published Catoctin metabasalts (Kline and Gottfried, unpublished data)

Catoctin Formation (Late Proterozoic)

Zcb Metabasalt--Dark-grayish-green to medium-bluish-gray, grayish-yellow-green- to yellowish-brown-weathering, fine-grained, variably magnetic, massive to schistose greenstone. Consists primarily of actinolite, chlorite, epidote, albite and sphene replacing the original igneous minerals. Pyrite is a common accessory and chalcopyrite is rare. Epidosite (commonly amygdaloidal) in irregularly shaped resistant masses ranging from tiny blebs to huge "knockers" several meters across. The Paleozoic foliation flows around these masses, which contain highly variable amounts of epidote, quartz and magnetite. In most places it is impossible to distinquish one flow from another, but some breccia zones interpreted as flow-tops can be followed for considerable distances. In the lowermost part of this unit, which occupies a topographic low with the uppermost Fauquier Formation are distinctly different breccias (Zcbb). These are medium-greenish gray, schistose with a wavy foliation, and contain scattered clasts of metabasalt (2-5 cm (1-2 in)) in a fine grained fragmental matrix. These may be hyaloclastites, but no other clear evidence of underwater eruption such as pillow structures has been found in this quadrangle. Limited unpublished chemical analyses suggest that only the high-Ti suite of metavolcanics of Espenshade (1986) occur in this quadrangle. However, the paucity of our data do not preclude some of the metabasalts and breccias (particularly those that are non-magnetic) being part of the low-Ti suite. One piece of float of white to very-light-gray, finely laminated rhyolite was found near Stoke. In the Middleburg quadrangle the metabasalt crops out very poorly and is covered by a thick residuum and/or colluvium. Thickness of unit difficult to determine due to lack of marker beds; the belt of volcanics is roughly 3.3 km (2 mi) wide and, assuming that there is not significant repetition due to faulting, a reasonable maximum thickness might be 2750 m (9000 ft)

Zcs Quartzite, conglomerate, and schist--White to medium-gray, medium-dark-gray-weathering, medium- to coarse-grained, muscovite-rich, quartzite and quartz pebble conglomerate interbedded with medium- to coarse-grained, muscovite schist. Occurs as small discontinuous lenses up to 60 m (200 ft) thick. Phyllite seen as chips in soil. Forms minor resistant ridges

Mafic to ultramafic rocks (Late Proterozoic (?))

Z?pr Metaperidotite--Greenish-black, moderate-to dark-yellowish-brown-weathering, medium-grained, massive serpentinite commonly displaying a very weak cleavage parallel to regional trends. Rock consists of serpentine, amphibole, dark chlorite, and magnetite. In thin section and on some slightly weathered surfaces, this metamorphic mineralogy perfectly pseudomorphs a primary igneous texture. The serpentine replaces subhedral olivine, non-pleochroic amphibole occurs as single crystals, presumably pseudomorphic after subhedral to anhedral pyroxene, and some amphibole occurs as large poikilitic crystals. Chromian(?) chlorite (weak pink to blue pleochroism) in places shows intergranular texture with pseudomorphs after olivine, but more commonly cuts across the relict igneous fabric and may result from the metamorphic breakdown of chromian spinel. Very fine magnetite coats relict fractures and grain boundaries of pseudomorphs after olivine and cleavage traces in amphibole, making the rock strongly magnetic in most places. The amounts of original olivine and pyroxene are highly variable. CIPW norms for two chemical analyses show di/(di + hy) = 0.51 and 0.11, along with abundant olivine and 0.57% normative chromite, suggesting that the original rock was lherzolite. The metaperidotite occurs in two small roundish plutons 400 m (1300 ft) and less than 100 m (330 ft) in diameter) associated with metapyrcxenite (Z(?)py) and/or metagabbro (Z(?)hg). Contacts are not exposed. No contact metamorphic effects are detectable in outcrops of granite near ultramafic rock. A wide dike of metadiabase, traceable for over a kilometer in the granite, cannot be traced through the mafic/ultramafic body north of Middleburg, suggesting a late Proterozoic or younger age, but the relationship is not definitieve. Similar metamorphic effects in the diabase dikes and the mafic/ultramafic bodies indicate that they were together during Paleozoic regional metamorphism. The mafic/ultramafic rocks may have been associated with Catoctin magmatism. Regolith is very thin over the serpentinite

Z?hg Hornblende-bearing metagabbro--Greenish-black, weathering to a speckled white and greenish-black to dark-brown, medium-grained, massive metagabbro with a very weak foliation. Excellent preservation of original igneous gabboric texture. Subhedral plagioclase is replaced by clinozoisite + albite, and anhedral pyroxene is replaced by fibrous tremolite. Brown (magmatic?) hornblende occurs as subhedral single crystals in intergranular relationship with pyroxene and plagioclase pseudomorphs. Two chemical analyses of the metagabbro are olivine-normative. TiO_2 is similar to the Catoctin low-Ti basalt of Espenshade (1986), and MgO is only slightly higher; Al_2O_3 and K_2O in the metagabbro are distinctly higher. Contacts not exposed. Occurs as a small body associated with Z(?)pr

Z?py Metapyroxenite--Dark-greenish-gray to greenish-black, weathering to lighter-greenish-gray to moderate-yellowish-brown, massive, medium-grained, non-magnetic actinolite(?) rock with weak foliation. Composed chiefly of actinolite(?) with lesser amount of chlorite. The amphibole is pseudomorphic after pyroxene. No chemical analyses are available. Occurs in small bodies in plutons associated with Z(?)pr, and alone in a very small (about 15 X 50 m (50 by 160 ft)) lens north of Middleburg, west of Wancopin Creek. No contacts are exposed, and aerial extent is only approximate

Fauquier Formation (Late Proterozoic)

Zfm Metamudstone--Medium-light-gray, light-brown-weathering, thinly laminated (1-10 mm) mudstone and phyllite. Lighter laminae are dominated by quartz and minor feldspar of coarse silt to very fine sand size, and lesser micas. Darker laminae are rich in micas and have finer silt-sized quartz. Graded laminations are common. Fine-grained and, more rarely, medium-grained sandstone beds up to 3 in (8 cm) thick are minor constituents. Micas are very fine white mica with accessory biotite or chlorite. Fine grains of sphene and opaque minerals are common along with traces of zircon. Porphyroblasts of euhedral magnetite (up to 2 mm) and chlorite occur in some samples. Very poorly exposed, but is detectable on slopes and small knolls by phyllite chips in subsoil. Lower contact is gradational with underlying arkosic metasandstone and metasiltstone (Zfas) and is placed at base of abundant fine- to medium-grained sandstone. Thickness ranges from 35-120 m (115-394 ft), except in the vicinity of Barton's Creek, where the unit appears to be absent. Best exposure is in a weathered roadcut just west of the intersection of Rts 627 and 734. The upper part of this unit contains lenses of fine-grained dolomitic marble (Zfmd) that is very light gray, with dark stains on weathered surfaces. Contacts are not exposed, so thickness of lenses is difficult to judge, but ranges from 0-3 m (0-10 ft). Joints subparallel to the strike of bedding may reflect smaller scale bedding (on the order of centimeters). Occurrence of an angular intraformational conglomerate also suggests small-scale bedding. Spherical texture resembling oolites, is preserved in some places. Isolated, anhedral specks of coarse sparry calcite occurs in some horizons. Crops out only in the northernmost part of the quadrangle, where it occurs in at least three horizons within the upper 80 m (260 ft) of the metamudstone unit. There it is interlayered with metadiabase sills (Zfm), one having produced masses of coarse radiating tremolite crystals through contact metasomatism with the dolomite, and possible metabasalt flows. Dolomite and rare black calcitic marble is found in stone walls culled from fields in the metamudstone unit near Rt 50. The area designated as Zfma in the belt of Zfm at the Loudoun-Fauquier County boundary is quartz-pebble conglomeratic metasandstone interlayered with less abundant coarse arkosic metasandstone; this unit resembles Zfa

Zfas Arkosic metasandstone and metasiltstone--Medium-gray, light-brown-weathering, very fine- to fine-grained, moderately well-sorted, arkosic metasandstone with lesser amounts of medium-grained metasandstone, metasiltsone, and metamudstone. A flat, slabby bedding is typical, with beds 1-3 cm thick common, but also as thick as 0.7 m (2.3 ft). Cross bedding is rare. Cleavage subparallel to bedding is common, readily recognizable in finer rocks. Proportion of metasiltstone to mudstone increases upwards. Occassional coarser sandstone occurs locally. Clastic constituents are primarily quartz with a few percent feldspar. Fine Fe-Ti oxides, and minor zircon are common detrital accessories. Metamorphic minerals include white mica, green biotite, and sphene. Jointing parallel to bedding is the dominant fracture set, with other joints rarely to moderatedly developed. Lower contact is gradational with meta-arkose unit (Zfa) and is marked by first appearance of coarse arkoses. Thickness ranges from 60-500 m (197-1640 ft). Best exposures are along Rt 776 and just south of Rt 702

Zfa Meta-arkose--Light- to medium-gray, light-brown-weathering, medium- to thick-bedded, poorly sorted, medium- to coarse-grained meta-arkose with lesser conglomeratic meta-arkose and arkosic metasandstone. Bedding is generally thick (0.3-1 m; 1-3 ft) and poorly defined near the base and becomes thinner (1-10 cm; 0.5-4 in) and more distinct near the top. Tangential crossbedding sets a few centimeters thick and trough crossbedding is common, especially in the upper part, but is thicker and less common near the base. The conglomeratic meta-arkose has granules and pebbles of quartz scattered in coarse arkosic matrix. Medium-grained metasandstone increases in abundance upward and generally constitutes 80 % of the beds of the unit near the top. Finer metasandstone, metasiltstone, and metamudstone are interlayered throughout the sequence, as indicated in excavations, but rarely crop out. Quartz, alkali feldspar and plagioclase are common as detrital constituents in all Zfa lithic types, and Fe-Ti oxides and zircon are accessories. Metamorphic white mica, green biotite, and sphene are almost ubiquitous. Lower contact with the underlying granites (Ym and Ymc) is a nonconformity. At several localities granite and Fauquier lithologies are separated only by a meter or two of cover. While the granitic basement in these areas are intensely deformed, there is no significant deformation in Zfa. In other places a strong deformational fabric is developed in Zfa. Near the base, south of the map area in the vicinity of Halfway, are many lenses of medium- to dark-gray, indistinctly-bedded, matrix-supported cobble metaconglomerate (Zfac), with recognizable locally-derived clasts of the adjacent basement granites. The thickness of Zfac ranges from 0-70 m (230 ft). Thickness of the Zfa unit varies from 25-290 m (82-951 ft) in the central part of the quadrangle, but thickens to 880 m (2886 ft) in the vicinity of Halfway due to pre- to syndepositional faulting. In the vicinity of Dover, this unit is absent or possibly has sparse occurrence

Marshall Metagranite (Middle Proterozoic)

Ym Fine- to medium-grained metagranite--Light-to medium-gray to moderate orange-pink, light-brown-weathering, fine- to medium-grained (1-3 mm), equigranular granite with and without streaks or spots of dark minerals. Modal abundances of quartz (some bluish), alkali feldspar (in places perthitic), and plagioclase range in the granite field of the IUGS classification. Abundance of total mafic phases (primarily biotite) varies from 0 to 15 percent. Some areas are mostly very leucocratic granite (mafics between 0-3 percent, but ranging up to 5 percent) especially north of Middleburg between Rt. 748 and Goose Creek, and in other, less definable, areas south of Middleburg.

Other areas are dominated by granite with more abundant mafics (5-15 percent), occuring in small, south-plunging linear aggregates. These linear aggregates probably formed in Middle Proterozoic time. Dikes of leucocratic granite have been found cutting biotite granite, but not vice versa. Some outcrops, however, seem to show gradual variation in biotite content. No significant mineralogic or primary textural differences exist between these two types, other than abundance of mafics. The felsic minerals are intergrown in a distinctly anhedral-granular texture, with Fe-Ti oxides, red (titaniferous) biotite, rounded zircon, apatite, and metamict allanite(?) as accessory magmatic phases. Low-grade regional metamorphism has altered plagioclase to white mica + clinozoisite-epidote in most places. Alkali feldspar, less altered than plagioclase, has reacted to form white mica + quartz, especially in tectonic fractures in the feldspar. Sphene rims are common on oxides. Rutile(?) needles in a triangular pattern occur on (001) in partially corroded red biotite, but most primary biotite is replaced by green biotite + sphene $\pm$ quartz or by quartz + sphene. In most places there is a penetrative planar fabric in which metamorphic alteration minerals are concentrated and aligned in narrow discontinuous zones generally about a millimeter thick. These narrow zones are separated by domains of more-or-less undeformed granite (microlithons) about 0.3-1.5 cm (0.1-0.6 in) thick, depending on degree of deformation. The linear aggregates of mafic minerals commonly lie in the plane of the penetrative foliation. The foliation normally is weakly exhibited on horizontal surfaces, but strongly expressed on vertical surfaces subparallel to the azimuth of the lineation. The foliation anastomoses around granite microlithons in such a way as to give an augen-like appearance. The foliation is strong enough in places to give the granite a layered appearance. Narrow (2-10 cm; 0.8-4 in), very leucocratic, aplitic and pegmatitic segregations and blue quartz pods or veins occur in the granite, most commonly subparallel to the foliation. White quartz veins are more random in orientation. Some pegmatites occur at high angles to foliation. Most outcrops exhibit varying amounts and orientation of narrow (normally 1-2 mm, in places ranging up to 8 cm), zones of ductile to brittle deformation. Some of the wider zones have a concentration of fine muscovite, producing a shear foliation. In places, this is accompanied by brecciation of the host granite. The deformation zones commonly criss-cross outcrops and strongly influence jointing in the granites

Ymc Coarse-grained metagranite--Medium-to dark-gray, brown-weathering coarse-grained granite. Felsic minerals in the 3-7 mm range are common, but rock texture in many outcrops is dominated by 1-2 cm (0.1-0.3 in) megacrysts of alkali feldspar, which range up to 5 cm (2 in) in places. Dark minerals range from about 3-20 %. Variably developed penetrative foliation anastomoses around megacrysts imparting an augen gneiss texture to the rock in many outcrops. Primary and metamorphic mineralogy, including linear aggregates of mafic minerals, in this unit is similar to the mineralogy of Ym. Areas mapped as Ymc have some outcrops of Ym within them, and some outcrops have mesoscopic lenses of Ym in Ymc with indistinct contacts parallel to the regional structural trend. More commonly in Ym, especially near areas of mapped Ymc, layers or dikes of Ymc 1-5 ft (0.3 to 1.5 m thick) occur with generally indistinct boundaries. Ym mapped in areas associated with Ymc commonly has scattered isolated megacrysts of alkali feldspar. As in Ym, narrow deformation zones are nearly ubiquitous

References

Espenshade, G.H., 1986, Geology of the Marshall quadrangle, Fauquier County, Virginia: U.S. Geological Survey Bulletin 1560, 60 p.

Froelich, A.J., 1985, Map and geotechnical properties of surface materials of the Culpeper basin and vicinity, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-E, scale 1:125,000.

Froelich, A.J., 1989, Maps showing geologic and hydrologic factors affecting land-use planning in the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-J, scale 1:125,000.

Froelich, A.J., and Leavy, B.D., 1981, Mineral resources map of the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-B, scale 1:125,000.

Froelich, A.J., Leavy, B.D., and Lindholm, R.C., 1982, Geologic traverse across the Culpeper basin (Triassic-Jurassic) of Northern Virginia, in Lyttle, P.T., ed., Central Appalachian Geology: Joint Northeastern-Southeastern Geological Society of America Field Trip Guidebooks, Field Trip 3, Stops 5, p. 71-72.

Hentz, T.F., 1981, Sedimentology and structure of Culpeper Group lakebeds (Lower Jurassic) at Thoroughfare Gap, Virginia: M.S. thesis, University of Kansas, Lawrence, 166 p.

Laczniak, R.J., and Zenone, Chester, 1985, Ground-water resources of the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Map I-1313-F, scale 1:125,000.

Leavy, B.D., 1984, Map showing planar and linear features in the Culpeper basin and vicinity, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-G, scale 1:125,000.

Leavy, B.D., Froelich, A.J., and Abram, E.C., 1983, Bedrock map and geotechnical properties of rocks of the Culpeper basin and vicinit, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigation Series Map I-1313-C, scale 1:125,000.

Lee, K.Y., 1979, Geology of the Culpeper basin in Middleburg Quadrangle, Prince William and Loudoun Counties, Virginia, in Triassic-Jurassic geology of the northern part of the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Open-File Report 79-1557, 19 p.

Lee, K.Y., and Froelich, A.J., 1985, Geochemical data for Triassic sedimentary and thermally metamorphosed rocks in the Culpeper basin, Virginia: U.S. Geological Survey Open-File Report 85-217, 19 p.

_____, 1989, Triassic-Jurassic stratigraphy of the Culpeper and Barboursville basins, Virginia and Maryland: U.S. Geological Survey Professional Paper 1472, 52 p.

Lee, K.Y., Leavy, B.D., and Gottfried, David, 1984, Geochemical data for Jurassic diabase and basalt of the northern Culpeper basin, Virginia: U.S. Geological Survey Open-File Report 84-771, 20 p.

Lynch, D.D., Nuckels, E.H., and Zenone, Chester, 1987, Low-flow characteristics and chemical quality of streams in the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-H, scale 1:125,000.

Morsches, S.F., and Zenone, Chester, 1981, Index map of flood studies, Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-A, scale 1:125,000.

Posner, Alex, and Zenone, Chester, 1983, Chemical quality of ground water in the Culpeper basin, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-1313-D, scale 1:125,000.

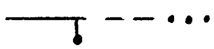
Sutter, J.F., 1985, Progress on geochronology of Mesozoic diabases and basalts, in Robinson, G.R., Jr., and Froelich, A.J., eds., Proceedings of the second USGS workshop on the early Mesozoic basins of the Eastern United States: U.S. Geological Survey Circular 946, p. 79-86.

_____, 1988, Innovative approaches to the dating of igneous events in the early Mesozoic basins of the Eastern United States, in Froelich, A.J., and Robinson, G.R., Jr., Studies of the early Mesozoic basins of the Eastern United States: U.S. Geological Survey Bulletin 776, p. 194-200.

Tollo, R.P., 1988, Petrographic and major element characteristics of Mesozoic basalts, Culpeper basin, Virginia, in Froelich, A.J., and Robinson, G.R., Jr., Studies of the early Mesozoic basins of the Eastern United States: U.S. Geological Survey Bulletin 1776, p. 105-113.

EXPLANATION OF MAP SYMBOLS

 Contact--Dashed where inferred and approximately located; dotted where covered by mapped surficial deposits

 Normal fault--Dashed where inferred; dotted where covered by mapped surficial deposits. Bar and ball on downthrown side

 Zone of phyllonitic granite and other altered and variably sheared granite

 Area within a phyllonite zone that is not phyllonitized

 Shear zone of Paleozoic age

 Tectonic breccia

 Abandonned quarry

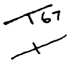
 Spring

PLANAR FEATURES

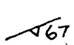
Where several features are noted at one outcrop, the symbols meet at the site of observation. When only one feature is noted, the cross tick marks the site of observation.

Strike and dip of bedding

 Inclined

 Vertical

Strike and dip of penetrative foliation of Paleozoic age

 Inclined

 Vertical

Strike and dip of spaced cleavage of Paleozoic age

 Inclined

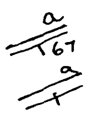
 Vertical

Strike and dip of penetrative foliation in Marshall Metagranite (Ym and Ymc) of probable Late Proterozoic age. Alternating discontinuous narrow mica domains and thicker quartz-feldspar domains. Letter symbol indicates presence of features subparallel to this foliation. All symbols except v are Grenville in age. (a=aplite dike; p=pegmatite dike; bv=blue quartz vein;

l=leucocratic granite dike in biotite granite; m=Ym dike in Ymc; v=quartz vein

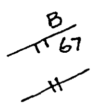
Inclined
Vertical or dip unknown

Strike and dip of Grenville-age features (listed above) in Ym and Ymc that are discordant with foliation



Inclined
Vertical or dip unknown on flat pavement outcrop

Strike and dip of narrow deformation zones (ductile/brittle) in Ym and Ymc. B=brecciation associated with zones of that trend

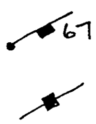


Inclined
Vertical or dip unknown on flat pavement outcrop

Strike and dip of penetrative foliation in phyllonite zones

Inclined

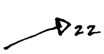
Strike and dip of axial plane of Grenville-age fold



Joint (ball denotes joints filled with quartz veins)
Inclined
Vertical

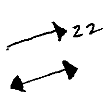
LINEAR FEATURES

Bearing and plunge of slickenlines on bedding

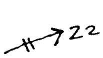


Bearing and plunge of quartz-muscovite mineral lineation in Paleozoic metasediments

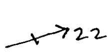
Bearing and plunge of lineation in Ym and Ymc (elongation of aggregates of dark and light mineral aggregates)



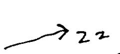
Inclined
Horizontal



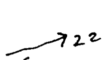
Bearing and plunge of lineation of streaked micas in the plane of a ductile deformation zone



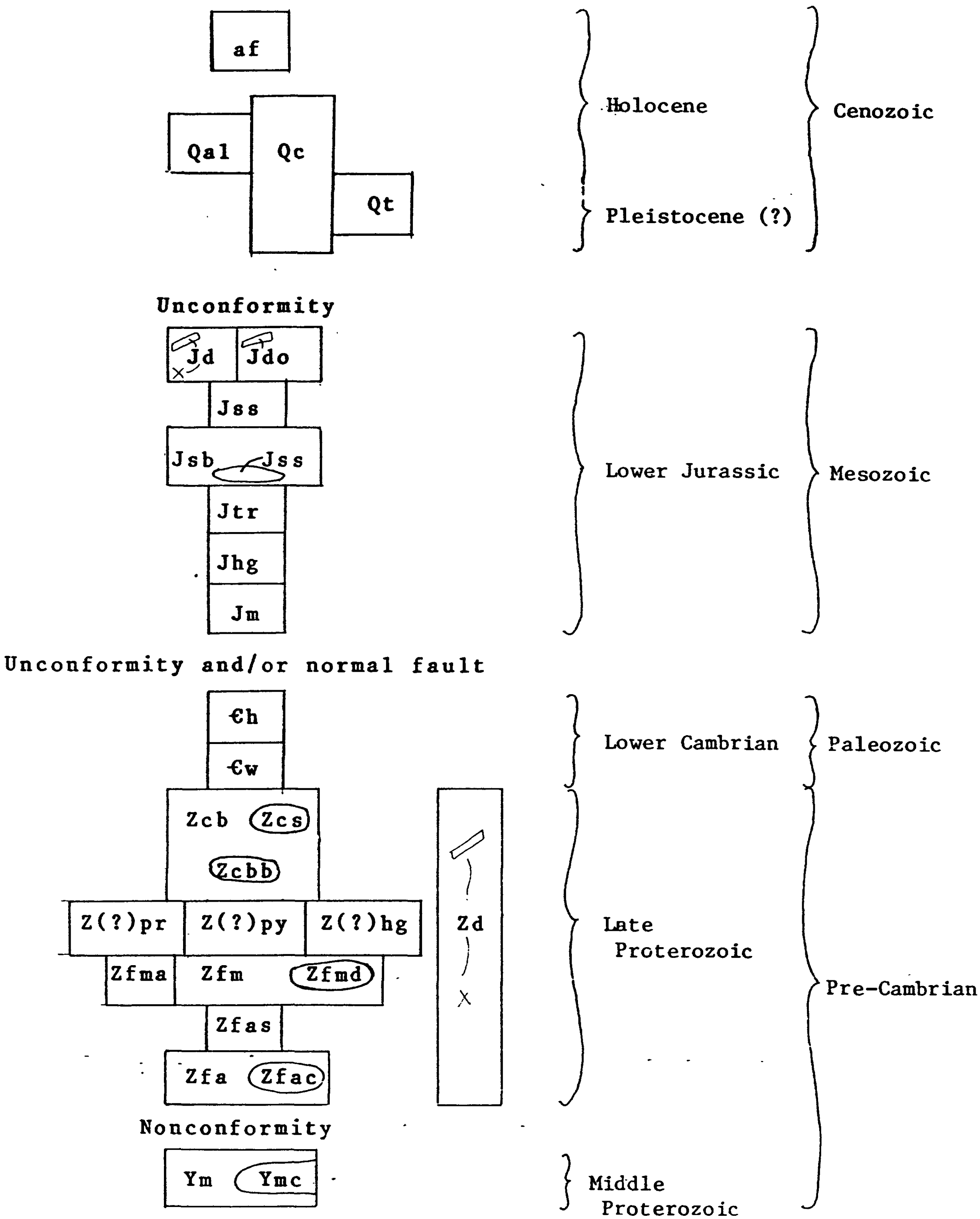
Bearing and plunge of intersection of bedding and penetrative foliation



Bearing and plunge of fold



Bearing and plunge of fold in foliation


af
Qal
Qc
Qt
Holocene
Pleistocene (?)
Cenozoic
Unconformity
Jd
Jdo
Jss
Jsb
Jss
Jtr
Jhg
Jm
Lower Jurassic
Mesozoic
Unconformity and/or normal fault
€h
€w
Lower Cambrian
Paleozoic
Zcb
Zcs
Zcbb
Z(?)pr
Z(?)py
Z(?)hg
Zd
Zfma
Zfm
Zfmd
Zfas
Zfa
Zfac
Late Proterozoic
Pre-Cambrian
Nonconformity
Ym
Ymc
Middle Proterozoic