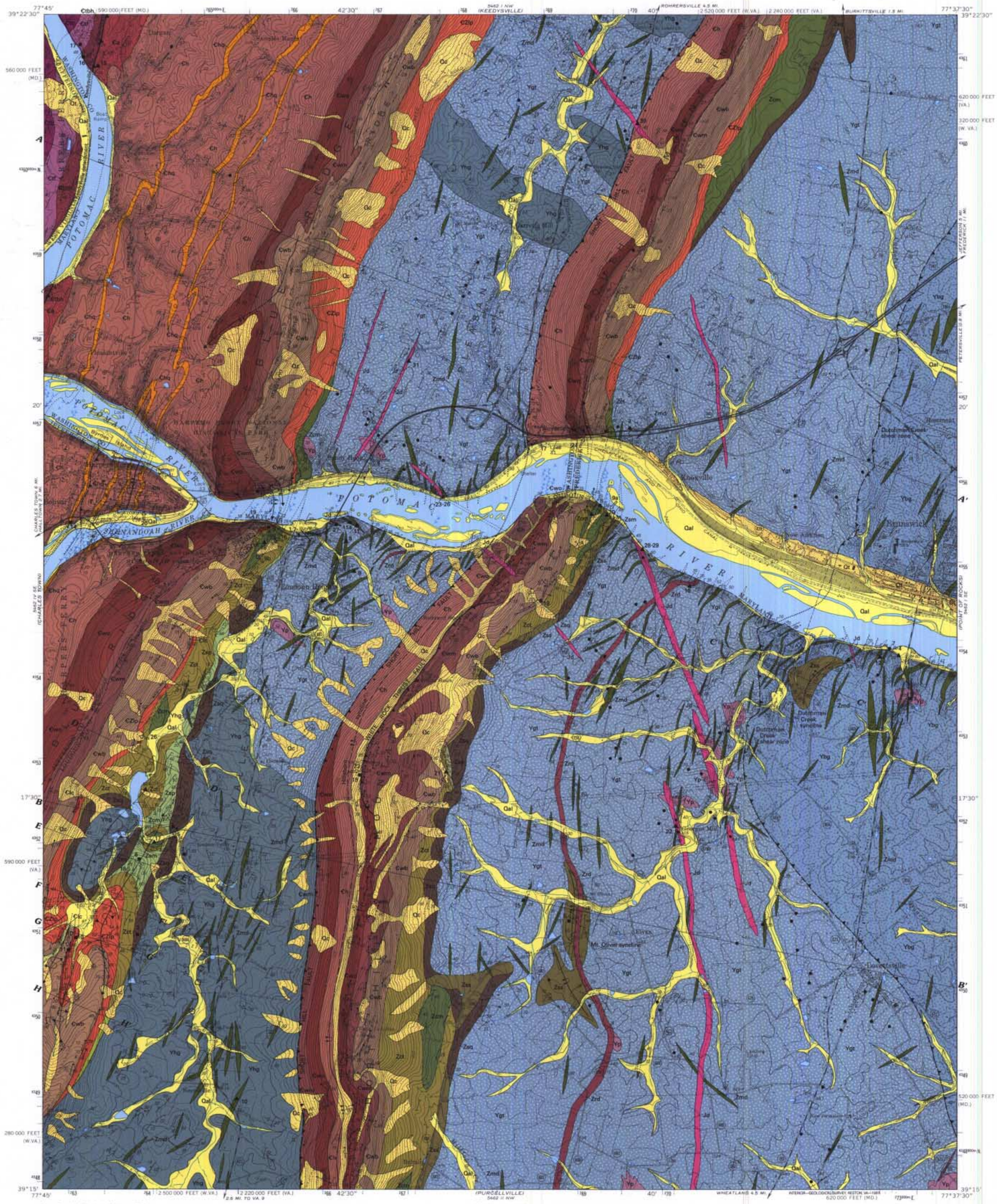


Base from U.S. Geological Survey, 1969

10,000-foot grids based on Virginia coordinate system, north zone, Maryland coordinate system, and West Virginia coordinate system, north zone

1000-meter Universal Transverse Mercator grid ticks, zone 18, shown in blue

APPROXIMATE MEAN DECLINATION, 1996

SCALE 1:24 000

1 MILE
1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped in 1989 and 1990

QUADRANGLE LOCATION

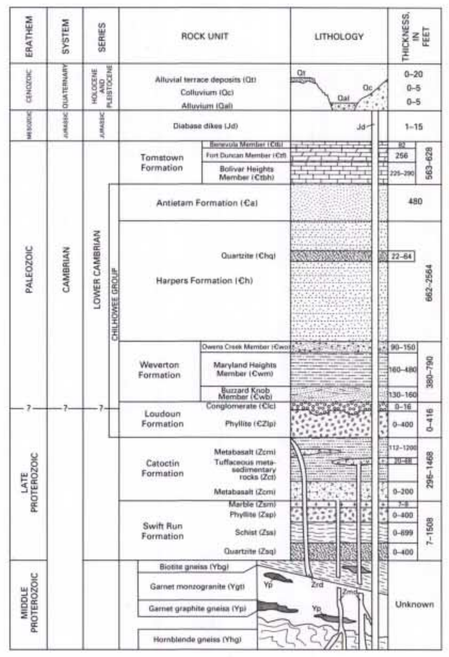
400 feet = 121.9 meters
Surficial deposits not shown

GEOLOGIC MAP OF THE HARPERS FERRY QUADRANGLE, VIRGINIA, MARYLAND, AND WEST VIRGINIA

By

Scott Southworth and David K. Brezinski

1996



CORRELATION OF MAP UNITS

DESCRIPTION OF MAP UNITS

Color designations, in parentheses, are from Goddard and others (1948)

Qal **Alluvium and fine colluvial debris, undifferentiated (Holocene)**—Clay, sand, pebbles, gravel, cobbles, and minor boulders underlying sinuous flood plains along Piney Run, Dutchman Creek, Milltown Creek, Israel Creek, and Little Catoctin Creek and the Potomac and Shenandoah Rivers. Includes alluvial terrace deposits as much as 20 ft above stream channels. Fine colluvial debris from slopes is transitional with alluvium. Sediments are well sorted and are found in fining-upward sequences as much as 20 ft thick

Qc **Colluvium (Holocene and Pleistocene)**—Coarse cobbles, boulders, and large blocks of predominantly quartzite and minor amounts of metabasalt that were transported by gravity, debris flow, and freeze-thaw processes. Abundant on mountain slopes. Includes boulder streams, boulder fields, and talus. Coarse colluvium is concentrated in hillslope depressions and hollows

Qt **Alluvial terrace deposits (Pleistocene)**—Very poorly sorted clay, sand, pebbles, gravel, and boulders from 30 ft to as much as 100 ft above the Potomac River. Clasts are moderately well rounded to well rounded; some quartzite boulders are greater than 5 ft in diameter

Jd **Diabase dikes (Early Jurassic)**—Dark-gray (*N3*), fine-grained to porphyritic diabase composed of quartz, olivine, augite, and plagioclase; weathers to moderate yellowish-brown (10YR 5/4). Includes three geochemical types: high-titanium quartz normative, low-titanium quartz normative, and olivine normative. Subvertical linear bodies as much as 330 ft thick are discontinuous and sometimes en echelon. Residual cobbles and boulders are shown as solid dots where trend of dike is unknown. Dike along the Potomac River has a $^{40}Ar/^{39}Ar$ age of 200 Ma (Kunk and others, 1992) (sample 1, fig. 3). Ten chemical analyses (samples 22–31) are shown in table 1

Tomstown Formation (Lower Cambrian) (Stose, 1906)

Ctb Benevola Member (Brezinski, 1992)—Yellowish-gray (5Y 8/1) to very light gray (*N8*), and white (*N9*), massive, pure, saccharoidal dolomite. Thickness is 82 ft

Ctf Fort Duncan Member (Brezinski, 1992)—Medium-dark-gray (*N4*) to grayish-black (*N2*), medium-bedded, pervasively bioturbated dolomite with very light gray (*N8*) to white (*N9*) sparry dolomite void fillings. Thickness is 256 ft

Ctbh Bolivar Heights Member (Brezinski, 1992)—Medium-dark-gray (*N4*), dark-gray (*N3*) to brownish-black (5YR 2/1) thick- to thin-bedded, locally nodular-bedded limestone, containing olive-gray (5Y 4/1) to olive-black (5Y 2/1), locally anastomosing, burrows. Basal 45 ft is a pinkish-gray (5Y 8/1) to light-gray (*N7*) laminated marble. Thickness ranges from 226 to 289 ft

CHILHOWEE GROUP

Ca **Antietam Formation (Lower Cambrian) (Keith, 1894)**—Very light gray (*N8*) to yellowish-gray (5Y 7/2) quartzite and dark-greenish-gray (5G 4/1) phyllitic metasiltstone that contains *Skolithos* tubes (Nickelsen, 1956). The base is gradational downward into the Harpers Formation. The top is gradational upward into the Bolivar Heights Member of the Tomstown Formation and, locally, is a fault zone. Thickness is estimated at 480 ft

Ch, Chq **Harpers Formation (Lower Cambrian) (Keith, 1894; King, 1950)**—Predominantly dark-greenish-gray (5G 4/1) to brownish-gray (5YR 4/1), laminated to massively bedded, highly cleaved, phyllitic metasiltstone; bedding is obscure. Meta-arkose, sandy metasiltstone, fine pebble conglomerate, magnetite-rich metasiltstone, and calcareous metasiltstone are found locally from the base to middle part of unit. Locally contains fine-grained, thin-bedded, dark-greenish-gray (5G 4/1), 22- to 64-ft-thick metasandstone (Chq) interbedded with metasiltstone. Base is locally sharp but transitional with underlying quartz-pebble conglomeratic quartzite of Owens Creek Member of the Weverton Formation. Top is not exposed in map area. Thickness ranges from about 600 to 900 ft on Short Hill-South Mountain and is 2,500 ft on Blue Ridge and Elk Ridge

Weverton Formation (Lower Cambrian) (Keith, 1894; King, 1950)

Cwo Owens Creek Member (Brezinski, 1992)—Dusky-blue (*5PB 3/2*) to dark-gray (*N3*) quartz-pebble conglomerate and greenish-gray (5G 6/1) quartz-pebble conglomeratic quartzite, metasiltstone, and interbedded quartzite. Poorly sorted, medium to thick bedded, graded, and cross-bedded. Contains local accumulations of magnetite, heavy minerals, red jasper, red quartz, and phyllite clasts. Pebbles commonly are 0.4 in. in diameter. Top of unit is a sharp contact occurring at top of quartz-pebble conglomeratic quartzite; bottom of unit is gradational with the metasiltstone of the Maryland Heights Member. Thickness is 105 ft on Short Hill-South Mountain and 90 to 150 ft on Blue Ridge-Elk Ridge

Cwm Maryland Heights Member (Brezinski, 1992)—Interbedded, dark-greenish-gray (5GY 4/1) metasiltstone and dusky-blue (*5PB 3/2*) to greenish-gray (5G 6/1), very coarse grained to granular quartzite. Quartzite beds vary from 16 to 32 ft in thickness. Total thickness ranges from 160 to 480 ft

Cwb Buzzard Knob Member (Brezinski, 1992)—Light-gray (*N7*) to medium-light-gray (*N6*), medium- to fine-grained, well-sorted, graded, and crossbedded quartzite. Massive to thick bedded at base and top. Middle part is thin bedded and contains light-gray (*N7*) phyllitic metagraywacke and metasiltstone. Lower part is locally arkosic and overlies conglomerate and phyllite of the Loudoun Formation, metabasalt of the Catoctin Formation, or locally, hornblende gneiss. Total thickness ranges from 130 to 160 ft

Loudoun Formation (Late Proterozoic? and Lower Cambrian) (Stose and Stose, 1946)

Clc Conglomerate (Lower Cambrian)—Small cobble to very coarse pebble conglomerate of rounded to subrounded white, blue, and red quartz, gneiss, red jasper, and variegated phyllite in grayish-black (*N2*), hematite-rich siltstone matrix. Pebbles commonly are 0.4 to 0.8 in. in diameter but are as large as 2.4 in. Contains local beds of fine pebble conglomerate and graded, crossbedded quartzite. At most places this unit is in sharp contact with underlying phyllite; at other places, contact is gradational. Unit is podiform and discontinuous and may be local channel fill. Unit has a maximum thickness of 16 ft and is restricted to Blue Ridge

CZlp Phyllite (Late Proterozoic? and Lower Cambrian?)—Consists of gray-black (*N2*), light-olive-gray (5Y 6/1) to light-gray (*N7*), fine-grained phyllite containing tuffaceous clasts and elongated amygdules. Top is a sharp, possibly unconformable, contact with overlying conglomerate of the Loudoun. Base is transitional with tuffaceous metasedimentary rocks of the Catoctin Formation (Zct). Unit contains very fine pebbles of quartz that increase in number upward. Ranges in thickness from 0 to 400 ft, but commonly is less than 200 ft

Catoctin Formation (Late Proterozoic) (Keith, 1894; Bloomer and Bloomer, 1947)

Zcm Metabasalt—Dark-greenish-gray (5G 4/1) to medium-bluish-gray (5B 5/1), fine-grained to aphanitic, massive to schistose metabasalt (greenstone) composed of actinolite, chlorite, epidote, quartz, and albite. Includes amygdaloidal metabasalt and agglomeratic metabasalt breccia that contains epidosite. Epidosite bodies as much as 3 ft in diameter are present locally. Locally interlayered with tuffaceous metasedimentary rocks unit (Zct). Individual flows range in thickness from 20 to 68 ft, but unit ranges from 0 to 164 ft on Short Hill Mountain and 0 to 200 ft on Blue Ridge. Five chemical analyses (samples 17–21) are shown in table 1

Zct Tuffaceous metasedimentary rocks—Pink-gray (5YR 8/1), medium-light-gray (*N6*), light-brownish-gray (5YR 6/1), and medium-black-gray (*N4*) tuffaceous phyllite and schist, mud-lump breccia, and dark-greenish-gray (5G 4/1), thin-bedded metabasalt. Light-greenish-gray (5GY 8/1) metarhyolite tuff is locally present. Unit is locally interlayered with the metabasalt unit (Zcm). Top grades into the overlying phyllite of the Loudoun Formation (CZlp). Unit is generally covered but is well exposed adjacent to massive metabasalt. Outcrop width suggests a maximum thickness of 1,200 ft on Short Hill Mountain and 499 ft on Blue Ridge. More than 112 ft crops out in and along the Potomac River at Short Hill Mountain

Zrd **Metarhyolite dikes (Late Proterozoic)**—Light-gray (*N7*) to medium-light-gray (*N6*), fine-grained to aphanitic metarhyolite that contains grayish-yellow (5Y 8/4) potassium feldspar phenocrysts. A 164-ft-wide dike intrudes basement gneiss and the Swift Run Formation. Medium-gray (*N5*) to medium-dark-gray (*N4*) tuffaceous metarhyolite containing quartz-filled amygdules and light-gray (*N7*) fragments of metarhyolite as much as 2 in long is found as float adjacent to dike along Potomac River. One chemical analysis (sample 16) is shown in table 1

Zmd **Metadiabase dikes (Late Proterozoic)**—Dark-greenish-gray (5G 4/1), medium-grained to aphanitic metadiabase composed of actinolite, chlorite, epidote, and albite. Dikes range in thickness from 0.4 in to 164 ft. In places, metadiabase is coarse grained to porphyritic and commonly has masses of epidosite. Common in basement rocks and less abundant in the Swift Run Formation. Compositionally similar to the metabasalt of the Catoctin Formation (Zcm). Ten chemical analyses (samples 6–15) are shown in table 1

Swift Run Formation (Late Proterozoic) (Jonas and Stose, 1939; King, 1950)

Zsm Marble—Pinkish-gray (5YR 8/1) and yellowish-gray (5Y 8/1) to light-brownish-gray (5YR 6/1), fine-grained, dolomitic marble found as 7- to 9-ft-thick discontinuous pods at or near the top of formation

Zsp Sericitic phyllite—Variegated, sericitic phyllite interbedded with thin, discontinuous beds of dark-gray (*N3*) to light-olive-gray (5Y 6/1) arkose and sandstone. Restricted to Purcell Knob antiformal syncline where intense deformation has tectonically mixed the lithologies with quartz veins and some metabasalt dikes. Base of unit is top of sericitic metasandstone. Top of unit is transitional with overlying tuffaceous metasedimentary rocks (Zct) of the Catoctin Formation. Thickness ranges from 0 to 400 ft

Zss Quartz sericite schist—Light-gray (*N7*), pale-olive (10Y 6/2), and dusky-yellow (5Y 6/4) to moderate-yellowish-brown (10YR 5/4) quartz sericite schist and pale-olive (10Y 6/2) fine pebble conglomerate that contains rounded to subrounded white and blue quartz pebbles, abundant sericite, and sparse chlorite. Quartz sericite schist may be either a fining-upward sequence above metasandstone or a product of deformation; bedding was not recognized. Thickness ranges from 0 to 298 ft on Blue Ridge to more than 699 ft in synclines east of Short Hill Mountain

Zsq Sericitic quartzite and metasandstone—Pinkish-gray (*5YR 8/1*), yellowish-gray (5Y 8/1), light-greenish-gray (5GY 8/1), medium-gray (*N5*), and light-olive-gray (5Y 6/10) to greenish-gray (5GY 6/1), sericite-rich, very coarse to medium-grained quartzite and metasandstone that contains rounded quartz cobbles as much as 4 in. in diameter. Also includes sericite-rich, matrix-supported or clast-supported, rounded, coarse quartz-pebble conglomerate. Graded beds and crossbeds are common as are elongate phyllite clasts as much as 3 in. in length. Unit unconformably overlies Middle Proterozoic basement gneiss and grades laterally into quartz sericite schist (Zss). Paleoregolith of weathered gneiss locally forms the base. Thickness ranges from 0 to 400 ft, but most outcrops are 33 ft wide

Ybg **Biotite gneiss (Middle Proterozoic)**—Medium-light-gray (*N6*) to light-olive-gray (5Y 6/1), equigranular, biotite-bearing gneiss that contains light-brown (5YR 6/4), porphyroblastic to porphyroclastic feldspar augen as much as 2 in long. Unit is mylonitized in the Dutchman Creek shear zone. Unit has compositional phases of granodiorite and granite and contains about 41 to 50 percent plagioclase, 30 percent quartz, 20 to 30 percent potassium feldspar, and as much as 10 percent biotite. Unit has a U/Pb upper intercept age of 1055±5 Ma (Aleinikoff and others, 1993). One chemical analysis (sample 4) is shown in table 1

Ygt **Garnet monzogranite (Middle Proterozoic)**—Very coarse to medium-grained, equigranular to granoblastic, almandine-bearing leucocratic monzogranite. Typically massive, but locally is gneissic and mylonitized. Contains very light gray (*N8*) to light-gray (*N7*) feldspar with medium-gray (*N5*) quartz as much as 0.2 in. in diameter and dusky-red (*5R 3/4*), euhedral to anhedral almandine garnet as much as 0.2 in. in diameter. Garnet can be highly fractured with lineated blebs of chlorite and sericite. Composed of quartz, microperthite, microcline, myrmekite, albite (An_{10}), oligoclase (An_{20-30}), andesine (An_{40-50}), and symplectic biotite and minor amounts of chlorite, ilmenite, zircon, sphene, epidote, leucoxene, and clinozoisite. Modal composition ranges from 35 to 40 percent potassium feldspar, 28 to 32 percent plagioclase feldspar, and 28 to 29 percent quartz; almandine garnet makes up 2 to 5 percent of unit. Unit has a U/Pb upper intercept age of 1070 Ma (Aleinikoff and others, 1993) (sample 5, fig. 3). Three chemical analyses (samples 1–3) are shown in table 1

Yhg **Hornblende gneiss (Middle Proterozoic)**—Medium-light-gray (*N6*) to medium-gray (*N5*), equigranular to granoblastic, hornblende-bearing gneiss with quartz monzonite and granite phases. Usually massive to well foliated, but granite phase is compositionally layered with augen. Composed of 36 to 49 percent perthite and microperthite, 27 to 45 percent saussuritized plagioclase (oligoclase, An_{15-30}), 18 to 27 percent quartz, less than 10 percent orthopyroxene (possibly hypersthene) and biotite, 10 to 20 percent hornblende in crystals 0.2 to 0.4 in long, and minor amounts of epidote, sericite, titanite, and opaque minerals. Unit has a preliminary U/Pb upper intercept age of 1110 Ma (Aleinikoff and others, 1993) (sample 6, fig. 3). One chemical analysis (sample 5) is shown in table 1

Yp **Garnet graphite gneiss (Middle Proterozoic?)**—Light-brown (*5YR 6/4*) to moderate-brown (*5YR 4/4*) garnet graphite gneiss composed of 25 percent quartz, 20 percent chlorite (clots), 20 percent saussuritized plagioclase, 10 to 20 percent graphite (flecks and books), and 10 percent almandine. Produces a distinctive rusty, brick-red soil. Origin of these rocks is uncertain, but they are interpreted to be metasedimentary rocks that were assimilated by the granitoids

EXPLANATION OF MAP SYMBOLS

Contact—Approximately located; dashed where inferred; dotted where concealed

Mylonite and cataclasite zone—Showing strike of mylonitic foliation

FAULT

Thrust fault—Approximately located; dashed where inferred; dotted where concealed. Sawteeth on upper plate

Overturned thrust fault—Dotted where concealed. Sawteeth on upper plate and teeth show direction of dip

Normal fault—Ball and bar on downthrown block

Reactivated fault—Dashed where inferred; dotted where concealed. Ball and bar on downthrown block of early normal fault and sawteeth on upper plate of later thrust fault. In cross section, open arrow shows early motion and solid arrow shows late motion

FOLDS

Overturned anticline—Dashed where approximately located; dotted where concealed. Showing trace of axial surface, direction of dip of limbs, and, where known, direction of plunge

Synformal anticline—Dotted where concealed. Showing trace of axial surface and direction of plunge

Overturned syncline—Dashed where approximately located; dotted where concealed. Showing trace of axial surface, direction of dip of limbs, and, where known, direction of plunge

Antiformal syncline—Dotted where concealed. Showing trace of axial surface and direction of plunge

Minor anticline—Showing bearing and plunge of axis

PLANAR FEATURES

(May be combined with each other or with linear features)

Strike and dip of bed—Ball indicates top of bed known from sedimentary structures

Inclined

Overturned

Rotated more than 180°

Vertical

Horizontal

Horizontal and inverted

Strike and dip of gneissic foliation in Middle Proterozoic rocks

Inclined

Vertical

Strike and dip of cleavage

Inclined

Vertical

Horizontal

Strike and dip of crenulation cleavage

Strike and dip of shear band cleavage

Strike and dip of joint

Inclined

Vertical

Bedrock landslide (Schultz and Southworth, 1989)—Hachures on escarpment; arrow shows direction of downslope movement

Sackungen (gravitational sag)

Rock block slump

LINEAR FEATURE

(May be combined with planar features)

Bearing and plunge of mineral lineation

OTHER FEATURES

Quarry—S, sandstone or quartzite; M, marble; F, hematite; A, gold

Jurassic diabase boulder

Geochemical sample locality—Number refers to table 1

Isotopic (age date) sample locality—Location of samples 1, 5, and 6 are shown; see text figure 3 for location of samples 2, 3, and 4

Reference locality—See text for discussion

Drill core hole

Location of photograph cited in text showing perspective and figure number

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