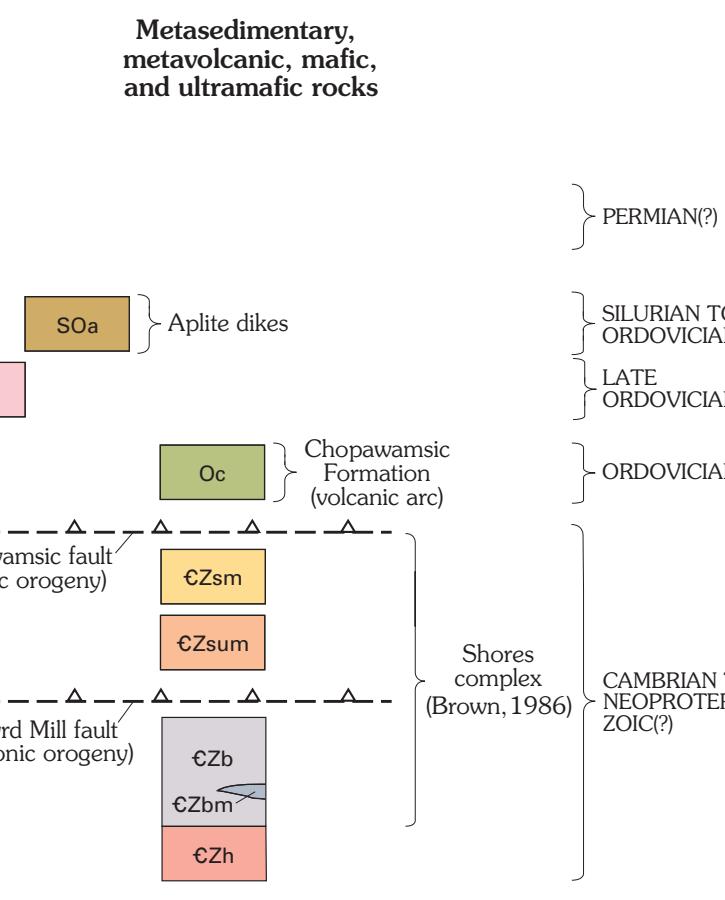


PRELIMINARY BEDROCK GEOLOGIC MAP OF THE LAHORE 7.5-MINUTE QUADRANGLE, ORANGE, SPOTSYLVANIA, AND LOUISA COUNTIES, VIRGINIA

 By
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CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

— Contact—Approximately located; in cross section, dotted where projected above the ground surface

FAULTS

— Fault—Approximately located; dashed where concealed by water; Harris Creek fault of late Paleozoic (Alleghanian orogen) which is perhaps a function of the interaction of the Ellsillie pluton (SOeg) with a dextral-transcurrent stress field (Burton and others, 2019). A foliation in metasedimentary rocks is represented by an equilibrium assemblage of aligned mineral minerals and is early Paleozoic in age, possibly representing an igneous flow foliation that was locally affected by tectonic stresses during synkinematic intrusion.

— Taconic thrust fault—Location is inferred and based on the presence of ultramafic bodies; early Paleozoic age (Taconic orogen) and overturned in the late Paleozoic (Alleghanian orogen). In cross section, dotted where projected above ground surface and dashed below ground surface

PLANAR AND LINEAR FEATURES

Strike and dip of first-generation schistosity (S₁)—Defined by prograde metamorphic minerals, typically biotite, during regional metamorphism of metasedimentary and metavolcanic rocks during the Late Ordovician (Taconic orogen); biotite is parallel to compositional layering, where present. Late Ordovician age is based on ⁴⁰Ar/³⁹Ar mineral age data from Burton and others (2019)

Inclined

Vertical

Strike and dip of foliation in plutonic rocks—Defined by planar-schistose mineral assemblages, typically biotite or amphibole. Probably an igneous flow foliation of early Paleozoic age, but may have tectonically-influenced mineral orientation near contacts due to synkinematic timing of intrusion

Inclined

Vertical

Strike and dip of second-generation schistosity (S₂)—Defined by retrograde metamorphic minerals, typically muscovite, during the late Paleozoic (Alleghanian orogen). Late Paleozoic (Pennsylvanian) age is based on ⁴⁰Ar/³⁹Ar mineral age data from Burton and others (2019)

Inclined

Vertical

Strike and dip of axial plane of second-generation fold (F₂)—Defined as plunging open folds to tight crenulations that are late Paleozoic age (Alleghanian orogen)

Inclined

Vertical

Trend and plunge of F₂ fold axis—Represented by mineral assemblages, mineral orientations, or mineral fabric. Combined with either S₁ or S₂ schistosity or the F₂ axial plane. May indicate tectonic rotation where steeply plunging

Taconic biotite isograd—Represents the first appearance (southeast side of isograd) of biotite in regional metamorphic mineral assemblages

Taconic garnet isograd—Represents the first appearance (southeast side of isograd) of garnet in regional metamorphic mineral assemblages

Outcrop—Rock outcrop location examined in the map area

DESCRIPTION OF MAP UNITS

Minerals were identified in hand sample only and are listed in increasing order of abundance

INTRUSIVE AND VEIN ROCKS

Pvq Vein quartz (Permian?)—White, massive, coarse-grained vein quartz
SOeg Granodiorite of Ellsillie pluton (Silurian to Ordovician)—Pale-yellow to white, massive to locally foliated, fine to medium-grained, biotite-microlite-quartz-plagioclase granodiorite. Uranium-lead (U-Pb) zircon crystallization ages of 444±3 Ma and 437±4 Ma are reported by Hughes and others (2013)

SOa Aplitic dikes (Silurian to Ordovician)—Pink to white, medium-grained to locally coarse-grained, quartz-plagioclase-potassium feldspar dikes of the Lahore pluton, indicating they are possibly contemporaneous with granodiorite of Ellsillie pluton (SOeg). The dikes are usually less than 1 meter wide, but two larger outcrops are mapped in the northwest part of the map area

Olg Biotite diorite and granodiorite of Lahore pluton (late Ordovician)—Light to medium-gray weathering, greenish-gray when fresh, massive to locally well foliated, medium-grained biotite diorite and granodiorite; represents a felsic to intermediate phase of Lahore pluton. A U-Pb zircon crystallization age on monzonite of 446±5 Ma is reported by Sirha and others (2012)

Old Hornblende diorite of Lahore pluton (late Ordovician)—Light to medium-gray weathering, greenish-gray when fresh, massive to locally well foliated, medium-grained hornblende diorite (±pyroxene) and minor gabbro

OC Metasedimentary, metavolcanic, mafic, and ultramafic rocks

Oc Choppawamic Formation (Cambrian to Neoproterozoic)—Medium to dark-gray, fine-grained, muscovite-biotite-quartz-plagioclase metasediments and schist, and lesser pale-yellow, fine-grained, muscovite-potassium feldspar-quartz-plagioclase metafelsite. Garnet was identified in hand sample at locations identified as "G" on map. Shores complex named by Brown (1986) for exposure along the James River in Virginia.

CZsm Metapsuedolite, schist, and metapelitic rocks of Shores complex (Brown, 1986) (Cambrian to Neoproterozoic?)—Medium to dark-gray, fine-grained, muscovite-biotite-quartz-plagioclase metapsuedolite and schist, and minor quartz-laminated metapsuedolite. Garnet was identified in hand sample at locations identified as "G" on map. Shores complex named by Brown (1986) for exposure along the James River in Virginia.

Mafic and ultramafic rocks of Shores complex (Cambrian to Neoproterozoic?)—Dark-green, fine-grained, poorly foliated amphibolite, and well-foliated chlorite-amphibole schist. Contains rare bodies of massive, medium-grained gabbro ("Gb" on map). Includes isolated exposures within unit Czsm of white, fine-grained, well-foliated talc schist ("Ts" on map) and two locations of ultramafic rock ("Uf" on map); and (in float only) massive, dark-green, fine-grained serpentinite (?)

CZsm Byrd Mill formation (informal name) of Shores complex (Cambrian to Neoproterozoic?)—Gray, fine-grained, finely foliated to layered, ±muscovite-chlorite-biotite-plagioclase-quartz metapsuedolite and metagraywacke

CZsm Mafic body in Byrd Mill formation (informal name) of Shores complex (Cambrian to Neoproterozoic?)—Finely layered chlorite-pelitic-amphibole schist. Gabbro is present in nearby float

CZsm Hardware formation (informal name) of N.H. Evans, written commun., 2017 (Cambrian to Neoproterozoic?)—Pale-yellow to white, fine-grained, sericite-quartz phyllite. The unit locally contains fine crystals of magnetite

INTRODUCTION

Bedrock geologic mapping of the Lahore, Va., 7.5-minute quadrangle was completed as part of a broader project, undertaken by the U.S. Geological Survey (USGS) and the U.S. Geological Survey and Mineral Resources, and other Federal and State agencies, to better understand the causative mechanisms of the magnitude-5.8 (M5.8) earthquake that occurred near Mineral, Va., on August 23, 2011. This project involves detailed mapping of at least eight quadrangles in the epicentral region of the Mineral, Va., earthquake in order to improve our understanding of the geologic setting of the Virginia seismic zone, which has a long record of historical and prehistoric earthquakes (Tarr and Wheeler, 2006; Tuttle and others, 2015). Preliminary mapping results are summarized in Burton and others (2014, 2015).

The Lahore 7.5-minute quadrangle contains the contact between Ordovician to Silurian, diorite and granodiorite rocks of the Lahore (Old) and Ellsillie plutons (SOeg) and older metasedimentary and metavolcanic rocks of the Choppawamic Formation and metapsuedolite. The Lahore quadrangle is northeast of the Ferncliff and Louisa, Va., quadrangles and the Shores complex is intruded by the Ellsillie pluton (SOeg) along the pluton's southwestern margin (Burton and others, 2013).

The Lahore 7.5-minute quadrangle contains the contact between Ordovician to Silurian, diorite and granodiorite rocks of the Lahore (Old) and Ellsillie plutons (SOeg) and older metasedimentary and metavolcanic rocks of the Choppawamic Formation (Oc) to the east (of volcanic arc) and informally named units to the west that were previously mapped as parts of mélange zones III and IV of the Mine Run Complex of Pavlides (1989), which include the following map units: (1) the Hardware formation (Czb) of N.H. Evans, written commun., 2017; (2) the Byrd Mill formation (Czsm) of the Shores complex of Brown (1986); and (3) units Czsm and Czum also within the Shores complex of Brown (1986). The Lahore quadrangle is northeast of the Ferncliff and Louisa, Va., quadrangles and the Shores complex is intruded by the Ellsillie pluton (SOeg) along the pluton's southwestern margin (Burton and others, 2013). The new mapping in the Lahore quadrangle shows that the Shores complex contains a large, shallow, pale-colored, planar north-trending mafic and ultramafic-bearing belt with the Shores complex (Czb, Czsm, and Cz) is a fault-bounded accretionary zone (accretionary wedge) between rocks of the Choppawamic Formation (Oc) and Laurentian slope-and-rise deposits (Czsm and Czum) (Burton and others, 2013); this tectonic boundary extends from at least the James River to the south, to the Maryland-Piedmont to the north (Burton and others, 2013). The Shores complex is a large, pale-colored, elongate, somewhat continuous mafic, northeast to southwest-trending magmatic bodies (Czsm and also includes small exposures of gabbro (Gb) and talc schist (Ts), as well as ultramafic float (Uf); just to the northeast of the Lahore quadrangle this belt contains an inactive serpentinite quarry in Virderville, Va. (Mixon and others, 2000).

The Lahore quadrangle contains structures of both early and late Paleozoic age (fig. 1) that correspond to the Taconic and Alleghanian orogenies, respectively. Taconic (late Ordovician) S₁ schistosity in layered rocks is typically fine-grained and parallel to compositional layering, when

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