NEW OBSERVATIONS ON THE CHOPAWAMSIC FAULT,

AN EARLY PALEOZOIC TERRANE BOUNDARY IN THE WESTERN PIEDMONT OF VIRGINIA

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Abstract

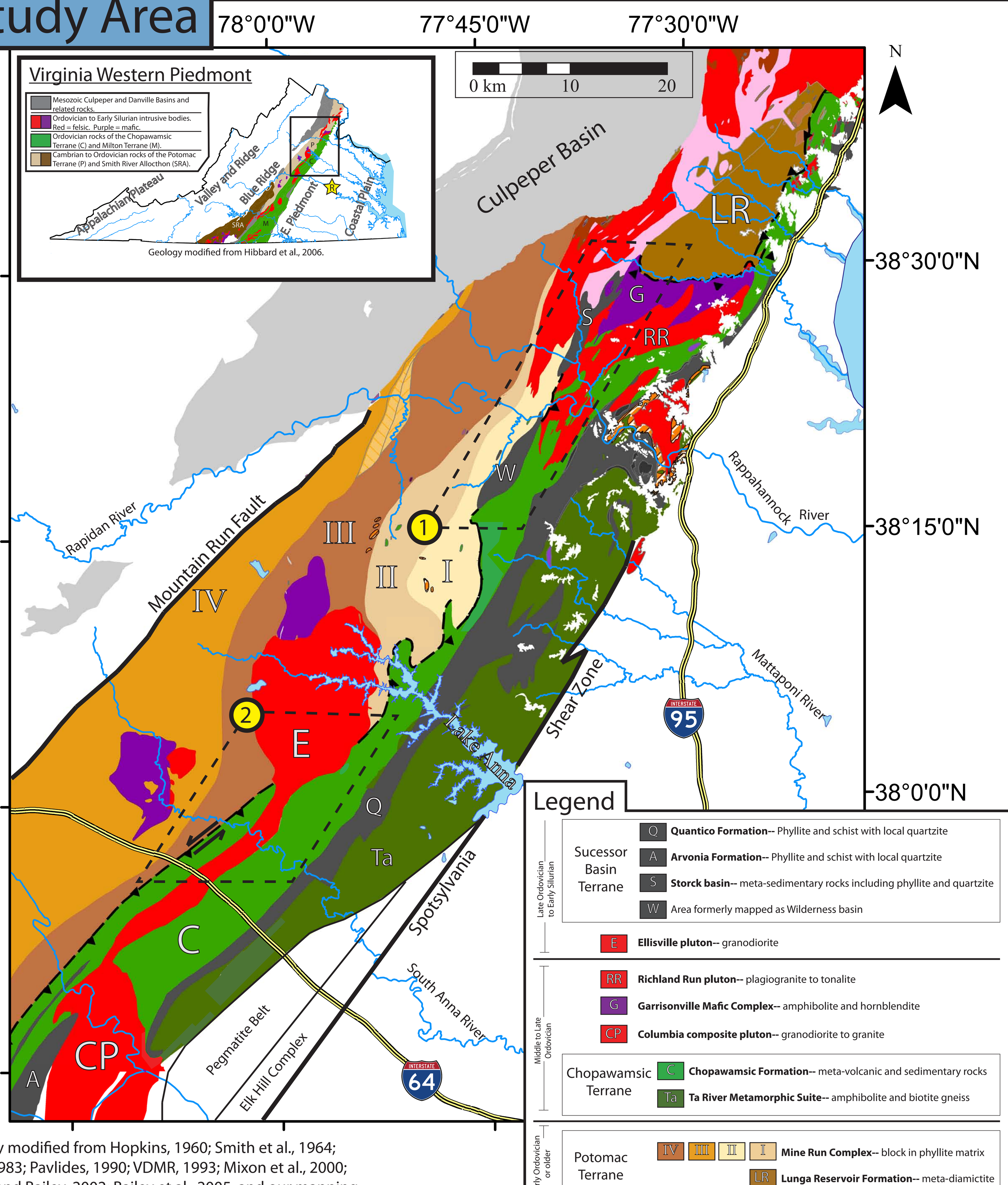
The c. 200 km long Chopawamsic fault is the most significant structure within the western Piedmont of northern Virginia, separating the pre-Early Ordovician Potomac terrane accretionary complex from the Middle-Late Ordovician Chopawamsic terrane volcanic arc. It has been hypothesized that the fault could represent the main Iapetan suture in the southern Appalachians because the Potomac terrane appears to be affiliated with Laurentia, whereas the affinity of the Chopawamsic terrane is unknown, but possibly Gondwanan. Previous field, geophysical, and regional interpretations suggest that the Chopawamsic fault is an east-dipping, west-vergent thrust that is overlain by two small successor basins to the west of Fredericksburg, VA. In order to assess the significance, kinematics and timing of this prominent structure, we have initiated a multidisciplinary investigation of the fault and surrounding rocks.

In the area south of Lake Anna, limited observations of winged sigma feldspar grains indicate a sinistral component of shear along the Chopawamsic fault. Nearby, the Ellisville granodiorite intrudes across the fault, providing a timing constraint on fault motion. New TIMS U-Pb zircon ages indicate that the latest movement on the fault was pre- c. 437 Ma.

Field studies to date confirm the existence of a successor basin atop the fault in the area of Storck, VA; we intend to use detrital zircon analysis of metasediments in the basin in order to further constrain the timing of fault motion. In the Wilderness, VA area, our mapping indicates that the other successor basin previously mapped to overlie the fault, does not exist and that rocks previously mapped as the basin are most likely metasedimentary rocks within the Chopawamsic terrane.

Our 'in progress' investigation will involve additional field and laboratory research along the Chopawamsic fault. We plan to assess the cratonic source of the Chopawamsic terrane with the use of Nd and Pb isotopic analyses as well as detrital zircon populations from each side of the Chopawamsic fault. The detrital zircon study should also provide supplementary constraints on the timing and nature of fault motion. High precision U-Pb TIMS data from previously undated intrusive bodies will also augment our understanding of the early Paleozoic evolution of the western Piedmont.

Study Area



Geology modified from Hopkins, 1960; Smith et al., 1964; Duke, 1983; Pavlides, 1990; VDMR, 1993; Mixon et al., 2000; Spears and Bailey, 2002; Bailey et al., 2005, and our mapping.

Focus Area 1

This area was chosen to investigate two proposed successor basins comprised of undivided metasedimentary rocks which may overlie the Chopawamsic fault. These basins could be related to the larger Quantico and Arvonia formations. We informally refer to the feature in the southern portion of the focus area as the 'Wilderness basin' and the northern feature as the 'Storck basin.'

Storck Area

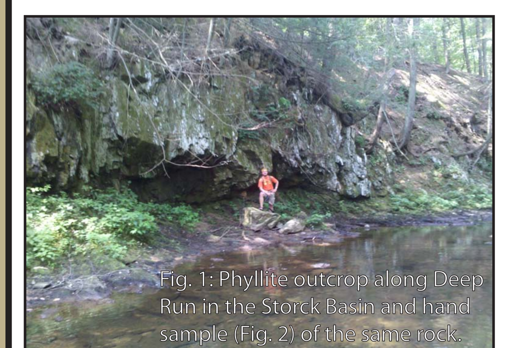


Fig. 1: Phyllite outcrop along Deep Run in the Storck Basin and hand sample (Fig. 2) of the same rock.

Through preliminary mapping in the Storck area, we have identified various metasedimentary rocks, which may be part of a successor basin thought to overlie the Chopawamsic fault. If this feature is a successor basin, it would be an important factor in helping to constrain timing of the fault. A sample of micaceous quartzite from this area (Fig. 3) has been collected and will be dated using detrital zircon analysis.


Fig. 2


Fig. 3


Fig. 4


Fig. 5


Fig. 6

Observations of the heterogeneously deformed Richland Run pluton in the Storck area reveal increasing deformation from E to W approaching the Storck Basin (Figs. 4-6). This deformation array hints at the presence of the Chopawamsic fault beneath the successor basin.

Wilderness Area

The Wilderness area contains rocks that are identical to the known sedimentary lenses within the Chopawamsic Fm. This is evident in outcrop, thin section and XRD (X-ray Diffraction) analysis. The outcrop similarities are displayed in Figures 8 & 9, where Fig. 8 represents the Chopawamsic Fm. and Fig. 9 shows outcrop in the previously mapped Wilderness basin. XRD analysis has aided in distinguishing between phyllosilicates found within these different areas and we conclude that there are only two major different rock types: Mine Run Complex and Chopawamsic Fm.

There is no evidence that a synclinal basin, which was previously mapped as conformably overlying the Chopawamsic fault, exists. While the Storck basin may remain suitable for placing time constraints on the Chopawamsic fault, this area does not present such an opportunity.

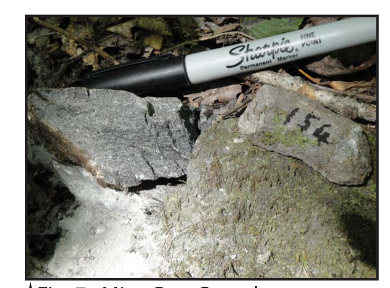


Fig. 7 : Mine Run Complex.


Figure 8: Chopawamsic Fm.

Figure 9 a & b: Rocks previously mapped as the Wilderness basin.

Focus Area 2


Fig. 10

This area was chosen to investigate the possible stitching relationship between the Ellisville pluton and the Chopawamsic fault. While the main body of the pluton has been interpreted to intrude the Mine Run Complex (Pavlides et al., 1994), we have directly observed the Ellisville pluton tail in intrusive contact with the Chopawamsic Formation (Fig. 10). Our detailed mapping, and petrographic and geochemical analyses (Hughes, 2011; Hughes & Hibbard, 2011) lead us to conclude that the Ellisville pluton can be confidently used to constrain the timing of latest motion upon the Chopawamsic fault.

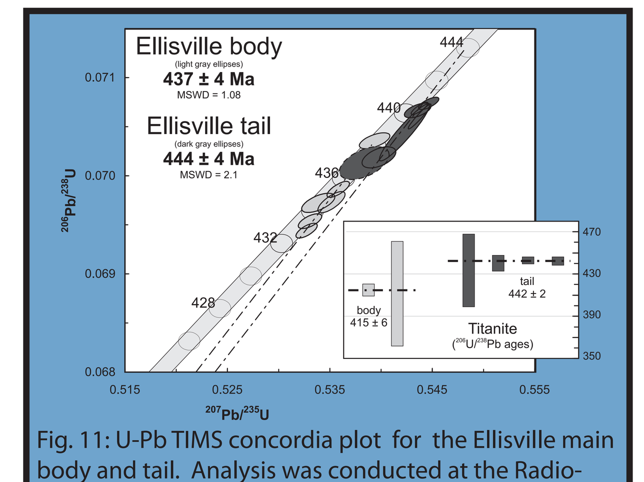


Fig. 11: U-Pb TIMS concordia plot for the Ellisville main body and tail. Analysis was conducted at the Radiogenic Isotope Geosciences Lab at Texas A&M University.

Our new geochronological data affirm an earlier evaluation of the Ellisville pluton as a texturally composite body (Pavlides and Cranford, 1982). While there are no compositional differences within the pluton, we interpret the composite nature to reflect only a main pulse of magmatism throughout the pluton at c. 444 Ma and a later, subsidiary phase at c. 437 Ma. These new data indicate that movement along the fault occurred sometime prior to stitching at c. 444 Ma. Data from the Chopawamsic formation (Coler et al., 2000; Horton et al., 2010) indicate that the fault initiated sometime after 471-453 Ma.

Although generally considered a thrust fault (e.g. Pavlides, 1989; 1990; 1995; Mixon et al., 2000; 2005), there has been no published kinematic information pertaining to the Chopawamsic fault. In Focus Area 2, we have discovered σ-type, winged feldspar clasts which indicate a sinistral component of shear along the Chopawamsic fault (Fig. 12). We interpret these indicators, found just south of the South Anna River, to be indicative of original motion along the fault due to their proximity to the stitching Ellisville pluton -- a feature which records no reactivation along the fault. Steeply dipping clast and mineral lineations have also been observed along the trace of the Chopawamsic fault. Collectively, these kinematic observations suggest the fault formed as a result of transpressional deformation.

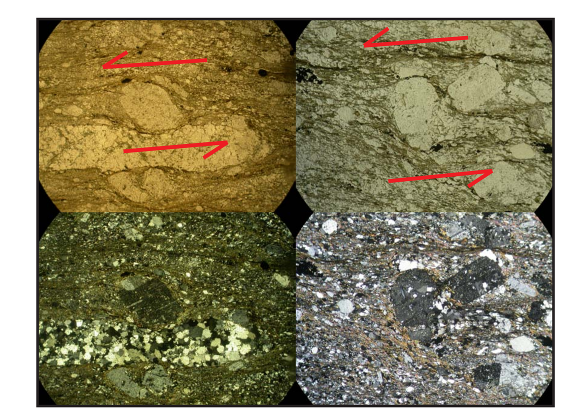
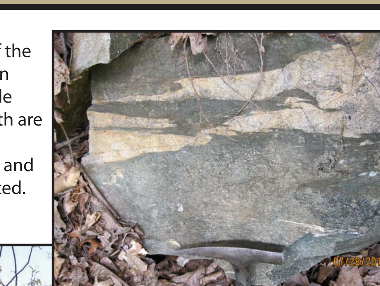


Fig. 12: Photomicrographs taken at 2x. Field of view is 9.5 mm. From left to right is towards Northeast.

Future Work

To test the first order hypothesis that the Chopawamsic fault may represent the main Iapetan suture in the southern Appalachians, we intend to determine the cratonic source for the Chopawamsic terrane. This goal will be accomplished with the use of isotopic fingerprinting and detrital zircon analysis. Comparison with data from the Laurentian Potomac terrane will aid in this endeavor. The dating of volcanics within the Chopawamsic formation and previously undated intrusive bodies will also help to clarify the early Paleozoic evolution of the western Piedmont of Virginia.

Intrusive contact of the Richland Run pluton and the Garrisonville mafic complex. Both are truncated by the Chopawamsic fault and are presently undated.



Collection of a meta-sandstone sample from the Buffards Fm for detrital zircon analysis.

Conclusions

Our investigation along the Chopawamsic fault in the western Piedmont of Virginia remains in progress. Our observations have led us to these preliminary conclusions:

(1) The Storck successor basin remains a valid possible timing constraint over the Chopawamsic fault and further exploration will provide more information

(2) The previously mapped Wilderness successor basin does not exist and cannot aid in providing timing constraints to the fault

(3) The stitching Ellisville pluton represents a petrographically and geochemically coherent pluton that intrudes across the Chopawamsic fault

(4) The Ellisville pluton stitched the Chopawamsic fault and intruded both the Potomac and Chopawamsic terranes at c. 440 Ma

(5) A sinistral component of shear exists along the Chopawamsic fault and we interpret it to be a record of original motion, along with an inferred thrust component

References:

Bailey, C., Koteas, C., Relyea, J., Weikel, E., Dubose, J., and Goodman, M., 2005, Geologic Map of the Columbia 7.5' quadrangle, Virginia. Virginia Dept. of Mines, Minerals, and Energy, Open File Report 05-02.
Coler, D.G., Wortman, G.L., Samson, S.D., Hibbard, J.P., and Stern, R., 2000, U-Pb geochronologic, Nd isotopic, and geochemical evidence for the correlation of the Chopawamsic and Milton terranes, Piedmont Zone, southern Appalachian orogen, Journal of Geology (108), 363-381.
Duke, N.A., 1983, A Metallogenic Study of the central Virginian Gold-Pyrite belt; Unpublished Ph. D. thesis, University of Manitoba.
Hopkins, H. R., 1960, Geology of western Louisa County, Virginia: Unpublished Ph. D. thesis, Cornell University.
Horton, J.W. Jr., Aleinikoff, J.N., Drake, A.A. Jr., Fanning, C.M., 2010, Ordovician volcanic-arc terrane in the Central Appalachian Piedmont of Maryland and Virginia: SHRIMP U-Pb geochronology, field relations, and tectonic significance, *in* Tollo, R.P., Bartholomew, M.J., Hibbard, J.P., and Karabinos, P.M., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir (206), 621-660.
Hughes, S., 2011, Geology of the northern half of the Ferncliff 7.5' quadrangle, USGS EDMAP Open File Rep., scale 1:24,000.
Hughes, S., and Hibbard, J., 2011, The Ellisville granodiorite: A stitching pluton in the western Piedmont of Virginia?, GSA abstracts w/ prog., v. 43, no. 2, p. 31
Mixon, R. B., Pavlides, L., Powars, D. S., Froelich, A. J., Weems, R. E., Schindler, J. S., Newell, W. L., Edwards, L. E., and Ward, L. W., 2000, Geologic map of the Fredericksburg 30' by 60' quadrangle, Virginia and Maryland. USGS Geological Investigations Series Map I-2607, scale 1:100,000, 2 sheets.
Mixon, R.M., Pavlides, L., Horton, J.W., Jr., Powars, D.S., and Schindler, J.S., 2005, Geologic map of the Stafford quadrangle, Stafford County, Virginia: U.S. Geological Survey Scientific Investigations Map 2841, scale 1:24,000.
Pavlides, L., and Cranford, S.L., 1982, Petrology of the "Lahore" complex and Ellisville pluton, composite granitoid bodies in the Piedmont of Virginia: Washington, D.C., U.S. Geological Survey Professional Paper 1275, 60 p.
Pavlides, L., 1989, Early Paleozoic composite mélange terrane, central Appalachian Piedmont, Virginia and Maryland; Its origin and tectonic history, in Horton, W. & Rast, N. (eds.), Mélanges and Olistostromes of the U.S. Appalachians, GSA Special Paper 228, 135-194.
Pavlides, L., 1990, Geology of part of the northern Virginia Piedmont: U.S. Geological Survey Open-File Report 90–548, 1 sheet, scale 1:100,000.
Pavlides, L., Arth, J.G., Sutter, J.F., Stern, T.W., and Cortesini, H., 1994, Early Paleozoic alkalic and cal- alkalic plutonism and associated contact metamorphism, central Virginia piedmont. United States Geological Survey Professional Paper 1529, 147p.
Pavlides, L., 1995, Piedmont geology of the Stafford, Storck, Salem Church, and Fredericksburg quadrangles, Stafford, Fauquier, and Spotsylvania counties, Virginia: U. S. Geological Survey Open File Report 95-577, scale 1:24,000, 2 sheets
Smith, J.W., Milici, R.C., and Greenberg, S.S., 1964, Geology and mineral resources of Fluvanna County, Virginia Division of Mineral Resources Bulletin 79, 62 p.
Spears, D.B. and Bailey, C.M., 2002, Geology of the central Virginia Piedmont between the Arvonia syncline and the Spotsylvania high strain zone, 32nd Annual Virginia Field Conference, Charlottesville, Virginia, 36 p.
Virginia Division of Mineral Resources, 1993, Geologic map of Virginia, Virginia Division of Mineral Resources, scale: 1:500,000.

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