GEOLOGIC MAP OF THE SPRING GARDEN QUADRANGLE, VIRGINIA

BY

WILLIAM S. HENIKA AND PAUL A. THAYER

CENOZOIC QUATERNARY

	UNIT CHARACTERISTICS	GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION
al	Alluvium: Silt, sand, and gravel with clay at base.	Unconsolidated floodplain deposits along streams subject to periodic flooding. Cuts and excavations subject to sliding and sloughing. Ranges from very rapid percolation to slow because of isolated clay deposits. Potential source of sand for aggregate in construction.
td	Terrace depostis: Rounded pebbles and cobbles in a clay or sandy clay matrix. Terraces at lower levels contain gray to yellowish-gray and red fine sandy clay.	Unconsolidated deposits above stream level along slopes and sloughing. Layers with rapid percolation may overlie impermeable clay or residuum resulting in seepage problems in cuts and on steep natural slopes.

MESOZOIC

TRIASSIC

d	Diabase dikes: Fine- to medium-grained, dark-gray to black diabase.	Clay-rich residual soil with rounded boulders overlies vertical sheets of hard bedrock. Contacts may be subject to seepage, slides, and sloughing when exposed in cuts and deep excavations.
Cr	Cataclastic rocks: medium-light-gray to light-orangish-pink protomylonite, mylonite gneiss, schist, and cataclasite.	Sheared and broken rocks. Yellowish-gray to light gray, sandy soils with angular quartz gravel near surface.
Arbitrarily cut off; Pm, TRsm, mr, TRdf, TRcb, Cgl, TRp	Triassic sedimentary rocks: TR df, Dry Fork Formation, Sandstone facies; red to gray, coarse sandstone with subordinate red and gray mudstones. Thickness 5,400 to 10,500 feet (1646 to 3200 m.) Cgl, coarse poorly sorted gray to green conglomerates with coarse-grained sandstones.	Steep slopes covered by colluvial deposits; thin stony residual soil and rock outcrops. Massive bedrock is closely jointed; slides common on steep cuts. Source of crushed stone for construction.

mr, gray to black shales and mudstones with subordinate red and gray mudstones.	Variable permeability, clay-rich residual soil. Cuts subject to sliding and sloughing. Potential source of clays for brick and ceramic ware, and expandable shale for lightweight aggregate.
TRs, Stoneville Formation medium- to coarse-grained gray, green and brownish-red sandstones with subordinate reddish-brown mudstones.	Steep slopes covered by colluvial deposits; thin stony residual soil and rock outcrops. Massive bedrock is closely jointed; slides common on steep cuts. Source of crushed stone for construction.
pm, extremely poorly sorted, reddish-brown sandstones, sandy mudstones and mudstones. Thickness 0-3000 ft. (oto, 914 m.)	Variable permeability, clay-rich residual soil. Cuts subject to sliding and sloughing.
m, reddish brown to maroon mudstones and shales. Thickness 0-3,600 ft. (0-1097 m.)	Variable permeability, clay-rich residual soil. Cuts subject to sliding and sloughing. Potential source of clays for brick and ceramic ware, and expandable shale for lightweight aggregate.

	TR cb, Cowbranch Formation, dark gray to black mudstones with subordinate gray sandstones and maroon mudstones. Thickness 2000 ft. (610 m.)	Variable permeability, clay-rich residual soil. Cuts subject to sliding and sloughing. Potential source of clays for brick and ceramic ware, and expandable shale for lightweight aggregate.
	TR p, Pine Hall Formation, medium- to coarse-grained tan and gray sandstones with minor reddish brown mudstones. Thickness 3,600 to 6,900 feet. (1097-2103 m.)	Steep slopes covered by colluvial depostes; thin stony residual soil and rock outcrops. Massive is closely jointed; slides common on steep cuts. Source of crushed stone for construction.
st	Shelton Formation: Light-organish-pink, coarse-grained, massive lineated gneiss that ranges in	Sandy residual soil with silty clayey or clayey subsoil. Prominent rock outcrops on slopes and streams.

Era	Symbol	Geologic Unit	Soil
		composition from quartz monzonite to granite. (425 m.y., Kish, et al, 1979).	
PALEOZOIC	lw	Leatherwood Granite: Coarse-grained to porphyritic gneissic granite, exhibits rapikivi structure. (450 m.y.).	Sandy redidual soil with silty-clayey and clayey subsoil. Prominent outcrops along slopes and streams.
	na	Rich Acres Formation: Dark-greenish-gray, massive to well-foliated metamorphosed gabbro, diorite, and coarse amphibolite.	Residual soil of variable thickness. Locally highly plastic and compressible clay residuum with high shrink-swell potential and low permeability.
PRECAMBRIAN	fv fg msq mfv gm	Metamorphosed Volcanic-Sedimentary rocks: fv, (felsic gneisses) white to pale-orangish-pink, layered muscovite-quartz feldspar	Relatively deep, loamy residual soil with a clay-rich micaceous layer in the subsoil which may show moderate to slow percolation. Subject to severe erosion on denuded slopes.

gneiss with locally abundant interlayered coarse quartz-feldspar granite and pegmatite sills; shear foliation well developed along the Danville Triassic basin. Relict pumice lapilli, bluish gray quartz and white feldspar phenocrysts are locally preserved volcanic features.	
mfv, (interlayered felsic, intermediate, and mafic gneisses). Muscovite-quartz-microcline-plagioclase gneiss, hornblende quartz-plagioclase gneiss and schist, coarse gray porphyroblastic biotite gneiss, and medium-grained gray to light-pinkish-orange hornblende-biotite gneiss interlayered	Residual soil of variable and rapidly changing thickness; locally, highly plastic and compressible clay residuum with high shrink-swell potential and slow percolation. Subject to severe erosion on denuded slopes.

with mica schist, coarse amphibolite and small metagabbro intrusions common.

msq, coarse silvery gray muscovite schist, chlorite-mica schist and quartzite.

gn: planar-layered medium- to fine-grained biotite gneiss with thin interlayers of silvery gray muscovite schist and massive interlayers of porphyroblastic biotite gneiss.

fg: Fork Mountain Formation, lower part: medium- to coarse-grained, garnetiferous muscovite-biotite gneiss regularly to chaotically interbedded with garnetiferous mica schist and calc-silicate quartzite upper part: Planar-layered medium- to fine-grained biotite gneiss

Deep, residual, sandy loams. Subsoil contains a clay layer that may locally show slow percolation. Denuded slopes subject to severe erosion.

with thin interlayers of
silvery-gray muscovite
schist, garnet-mica schist
and massive interlayers of
porphyroblastic biotite
gneiss, a,
amphibolite and
interlayered hornblende-
biotite gneiss.

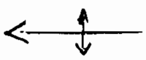
KEY

CONTACTS

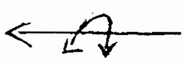
— — — Approximate

- - - - Covered or inferred

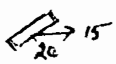
FOLDS

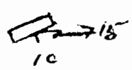
 Antiform: trace of axial surface and direction of plunge

 Synform: trace of axial surface and direction of plunge

 Overturned antiform: trace of axial surface and direction of plunge

 Overturned synform: trace of axial surface and direction of plunge

 Minor Fold: strike and dip of axial surface and direction of plunge

 Minor Fold: strike and dip of axial surface, direction of plunge and symmetry of vergence

 Minor upright antiform: strike of vertical axial surface

 Minor dome showing trend of major and minor axes

F_1 Tight intrafolial isoclines (observed in outcrop)

F_2 Tight refolded isocline

F_3 Open, upright or overturned fold

F_4 Broad, open northwest-trending folds

FRACTURES

	Shear zone

FAULTS

U / D	Approximate (dashed line); covered (dotted line) U, upthrown; D, downthrown block.

ATTITUDE OF ROCKS

45	Strike and dip of beds.

JOINTING

80	Strike and dip of joints
	Strike of vertical joints

FOLIATION

45	Strike and dip of schistosity
	Strike of vertical schistosity
19	Strike and dip of compositional banding

LINEATION

15	Trend and direction of plunge of lineation

QUARRY

	Abandoned crushed stone quarry

SAMPLE LOCATIONS

▲ R-8261	R, repository number of rock sample on file at the Virginia Division of Mineral Resources

STRATIGRAPHY

The Spring Garden quadrangle comprises an area of approximately 60 square miles (97 sq. km.) within the Piedmont province in Pittsylvania County, in south-central Virginia. White Oak Mountain, a prominent northeast-trending hogback ridge composed of well-indurated Triassic feldspathic sandstone, is the most conspicuous topographic feature in the region. Elevations range from 980 (299 m) feet on top of White Oak Mountain, to 7000 feet (2134 m) south-southeast of Motleys Mill to 480 feet (146 m) along Bannister River. The Triassic rocks were deposited in a narrow half-graben, the Danville Triassic basin, which divides the areas of Piedmont metamorphic rocks lying northwest and southeast of the basin. The area has undergone considerable uranium exploration activity in recent years.

Late Precambrian - Paleozoic Rocks

Rocks to the northwest of the Triassic basin: The oldest rocks in the area are gneiss, schist, quartzite and amphibolite (metamorphosed shales, graywacke sandstones and mafic volcanics) which comprise the Fork Mountain Formation here has propor tions of schist and gneiss different from propro tions at the type locality near Martinsville (Conley and Henika 1973). The unit has been traced continuously, however, from the type locality into the Spring Garden quadrangle (Price, 1975, Henika, 1977, Price and Others, 1980).

The lower part of the formation consists of peraluminous schist and gneiss (which contains kyanite), whereas the upper part of the unit is more quartzofeldspathic and contains more mica schist, quartzite and amphibolitic interbeds. This upper part of the formation, exposed along Cherrystone Creek and tributaries to Mill Creek east of Sheva, may be gradational with biotite gneiss (metamorphosed graywacke sandstones, gn) and gneisses formed from volcaniclastic rocks (mfv) in the lower part of the unit to the southeast across the Triassic basin. The Fork Mountain contains pegmatite dikes and sills and a large discordant body of sheared, porphyritic rock belonging to the Leatherwood Granite near Sheva. The Fork Mountain Formation is in upright position on flanks of what appears to be a broad antiformal flexure, whose axial trace is in the adjacent Chatham quadrangle to the west.

Rocks to the southeast of the Triassic basin: This sequence of interbedded felsic, intermediate and mafic gneisses (schists) and an uppermost, extensive felsic gneiss was first mapped as a separate unit unconformably overlying the Shelton granite gneiss of Jonas (1929) by Henika (1977). Detailed mapping has confirmed the idea that this sequence of metamorphosed volcanic-sedimentary rocks laterally grades into the Fork Mountain Formation, and is not part of the Shelton. (See also Henika, 1980).

The metamorphosed volcanic-sedimentary rock sequence is mainly at amphibolite grade; a small pod of it is at chlorite-grade along Sweden Fork primary features of volcanic and sedimentary rock are not well preserved here, but they are to the southwest (Henika, 1977), in which direction hornblende-bearing metavolcanic beds become progressively more abundant at the expense of biotite hornblende and gneiss. In addition, the upper felsic gneiss unit shows a progressive decrease in the amount of biotite and plagioclase in the rock matrix towards the southwest. felsic gneiss unit radioactively distinctive and is conformable with the lower units of the metamorphosed volcanic and sedimentary rock sequence in a synclinal fold in the southeastern part of the Spring Garden quadrangle. To the southwest, beyond the quadrangle, felsic gneiss appear to be in fault contact with the Fork Mountain (Henika, 1977). Reconnaissance indicated that there may be no easy distinction between the lower and upper units beyond the adjacent Java quadrangle although granitoid bodies within the upper unit (Henika, 1980) retain a characteristic aeroradiometric signature beyond that quadrangle.

Rich Acres Formation

Dark-greenish-gray, massive to foliated metagabbro with coarse uralitic hornblende crystals belonging to the Rich Acres Formation is poorly exposed along a tributary to Mill Creek approximately 1000 feet east of State Road 685. Near the contact with the Leatherwood Granite the Rich Acres contains abundant dikes and sills of leucocratic granite and quartz-tourmaline veins with gentle dips. The contact with gneiss and schist of the Fork Mountain Formation is poorly exposed.

Lenticular xenolithic screens or septae of foliated biotite-hornblende gneiss that resembles some parts the older Rich Acres metaggabbro as seen in the Martinsville igneous complex (Conley, 1978, p. 121) is in the central part of the larger area of Leatherwood Granite in the northwestern part of the quadrangle.

Leatherwood Granite

This granite cuts the Fork Mountain and the Rich Acres Formation in the northwestern part of the area. Although the contacts with the Fork Mountain Formation are interdigitated, and although the granite forms lit-par-lit injections along the regional strike of foliation planes in the Fork Mountain gneiss, the granite cuts across the rocks of the Fork Mountain as a whole. The cross-cutting relationship is most apparent along the southern end of the larger pluton along Little Cherrystone

Creek. There foliation of the granite is roughly parallel to that of the Fork Mountain, but the granite contact can be traced across the foliation at the southwestern end of the body.

The gneissic granite exposed in the center of the larger of the two granite plutons is generally coarser contains more biotite the Leatherwood farther west. The granite has a strongly developed cataclastic texture in the Spring Garden quadrangle and has gradational, interdigital contacts with mylonitic rocks along the fault zone at the Triassic basin.

Emplacement of the granite probably postdated isoclinal folds and initial foliation of the Fork Mountain Formation, but predated later, open folding and the development of strong southeastward dipping foliation.

Shelton Formation

Granite gneiss in the core of a small dome in mafic and felsic gneiss is the only exposure of Shelton Formation in the quadrangle. The unit contains coarse, orangish-pink pegmatite along contacts with the metamorphosed volcanic-sedimentary rocks at this locality, and similar pegmatite dikes cut across biotite and amphibole-bearing gneissic layers in large water-worn exposures approximately 1000 feet northwest of the pipeline crossing on Johns Run.

Upper Triassic Sedimentary Rocks

The Upper Triassic sedimentary rocks are red, reddish-gray, or gray continental clastic deposits consisting of interbedded conglomerates, sandstones and mudstones. Individual units are characterized by abrupt lateral and vertical changes in texture, color, composition, and thickness. Coarse-grained clastic rocks dominate the basin margins, whereas fine-grained ones are in the central part of the basin.

Estimates of total thickness of Triassic strata in the mapped area based on outcrop width and average dip range from 3600 feet (1097 m) for the narrowest part of the basin to 13,300 feet (4054 m) for the widest portion.

Triassic sedimentary rocks in the northeastern part of the area are divisible into three formations, which are (from the base upward) Pine Hall, Cow Branch, and Stoneville formations (Thayer, 1970, p. 9). The three formations interfinger, but in most sections across strike, the main bodies of the three units lie one above the other. Southwest of Motleys Mill in the central part of the quadrangle these units intertongue with Dry Fork Formation (Meyertons, 1963, p. 17), which occupies the entire central and south-central part of Danville basin. The Dry Fork is synchronous with Pine Hall, Cow Branch, and Stoneville Formations, and is separated from them by an arbitrary cutoff line drawn southwest of Motleys Mill, beyond which the distinctive beds of the formation do not extend.

Basin History

1. Initial subsidence of the Danville basin took place along a major fault zone on ~~the~~ its northwest side, and was accompanied by downwarping along a non-faulted hinge line on the eastern side.
2. Erosion of metamorphic-igneous borderlands on both sides of the basin provided detritus to the basin. During the early stages of basin-filling, coarse clastics were deposited by braided streams throughout the basin (Pine Hall Formation in the north and the lower portion of Dry Fork in the south). Ponding of the longitudinal drainage of the basin, probably caused by subsidence along the east-west segment of the border fault zone, gave rise to the thick lacustrine sequence (Cow Branch Formation) in the central part of the quadrangle. Subsidence in the basin was not as great to the southwest and coarse fluvial clastics of the middle portion of Dry Fork Formation accumulated at the same time that lake sediments were being deposited to the northeast. During the last stages of basin-filling, fluvial sediments accumulated throughout the basin (Stoneville Formation in the northeast and Dry Fork Formation in the southwest).
3. Faulting along the northwest border during and after sedimentation tilted Triassic strata westward. Unequal

downwarping along the fault produced large-scale gentle folds whose axes are transverse to trend of the fault and basin axis. Post-sedimentation faulting along the northwest border produced extensive zones of silicified mylonite in both Triassic and pre-Triassic metamorphic rocks on both sides of the fault zone.

4. Emplacement of diabase dikes along tensional fractures that transect regional structures.
5. Differential uplift of the entire region with subsequent erosion of an unknown amount of Triassic rocks.

Cataclastic Rocks

These rocks are extensively brecciated and generally have a shear foliation locally along the fault zone forming the northwest border of the Triassic basin. The rock is silicified and cut by multiple fractures, many of which are filled with quartz. Banded or true mylonitic textures are not common. The largest body of cataclastic rocks is more than a mile long and more than 1000 feet (305 m.) across. Rock at the northwestern margin of the cataclastic rock body is gradational ~~into~~ with protomylonitic Leatherwood Granite. To the southeast where the rock is adjacent to Triassic sedimentary rocks, it is derived from Triassic conglomerate. Rock samples from the middle of the body contain elongate needles of bluish amphibole (riebeckite) and aegirine, a mineralogy similar to altered tuffaceous sediments described from Triassic rocks in the southwestern portion of the Danville basin (Allen, 1967, p. 10). Owing to poor exposure, the riebekite-bearing rock was not mapped separately from the remainder of the cataclastic rock unit, but it does seem to have a characteristic radiometric signature and underlies a positive aeroradiometric anomaly (Virginia Division of Mineral Resources, 1980, 1980 Open File Report).

Diabase Dikes

The dikes range from medium- to coarse-grained and have a characteristic subophitic texture. They are composed predominantly of plagioclase and clinopyroxene with lesser amounts of olivine and opaque minerals. Secondary minerals include biotite, hematite, calcite, iddingsite and a turbid clay-like mineral. One dike contains rounded calcite crystal masses up to 10 mm across.

The thickest dike, which occurs south of Spring Garden, has a maximum width of approximately 200 feet (61 m.). Some of the dikes extend for several miles as mapped from rounded exfoliation boulders and dark-reddish-orange clayey soil.

STRUCTURE

Rocks within the area have a long and complex deformational history. There is evidence that the older metasedimentary and metavolcanic rocks have undergone as many as four periods of folding (Henika, 1977 and 1980).

F_1 folds, which occur as elongate isoclinal, intrafolial folds are in the Fork Mountain gneiss along a tributary stream to Mill Creek 1.4 mile (2.2 km.) west of Sheva and along a stream 1.25 mile (2.0 km.) west of Cedar Hill. F_1 folds are more prominent in the thinly layered metamorphosed volcanic and sedimentary rocks lying southeast of the Triassic rocks, such as along Sweden Fork Creek about 1.4 miles southwest of State Road 718.

The larger folds, F_2 and F_3 folds, determine the major outcrop patterns. The F_2 folds are tightly asymmetric to isoclinal and are bent around the noses of the more open northeast-trending folds. The resulting outcrops are hook-shaped. Outcrop-scale interference structures (mesoscopic) involving F_1, F_2 and F_3 folds are along Sweden Fork Creek. The major folds in metamorphic rocks northwest of the Triassic basin are probably F_3 structures (Marr, 1980, oral communication). F_4 folds are the broad, open warps in the Leatherwood Granite and felsic gneiss units.

Danville Triassic Basin

The Triassic sedimentary rocks lie in a portion of the Danville basin. The strata are broad gentle folds (F_4) whose axes are transverse to the longitudinal axis of the basin. Generally, dips along the southeastern margin of the basin are steeper than those on the northwestern side. Strata of Cow Branch Formation and the mudrock facies of Stoneville Formation have the lowest dips of any unit in the basin.

Chatham Border Fault Zone

The Triassic basin fault zone, the Chatham fault zone (Meyertons, 1963, p. 38), forms the contact between Triassic and pre-Trassic metamorphic rocks along the northwestern side of the basin. Meyertons (1963, p. 38) states that the faults are normal and that individual faults have dips of about 65^{o} to the southeast; no fault planes were observed in the Spring Garden quadrangle.

The trace of the fault zone generally trends N 40^{o} E. In the southwestern part of the quadrangle, the fault zone is broken into a series of step-like faults trending northwest and N 20^{o} E.

ECONOMIC GEOLOGY

Crushed Stone

Dry Fork sandstones and mudrocks are currently being quarried from White Oak Mountain in the adjacent Mount Hermon quadrangle. Lithologically identical rocks in the part of White Oak Mountain lying in the mapped area are well-suited as a source for crushed stone. The Commonwealth owns much of this part of the mountain, and has set it aside as a wildlife refuge, but this area could otherwise be used for quarrying operations because of steep local relief (which is an aid to quarrying) and close proximity to U. S. Highway 29 and the railroad at Chatham.

Portions of the Leatherwood Granite, porphyroblastic gneiss layers in the Fork Mountain Formation and in the felsic gneiss units southeast of the Danville Triassic basin may prove to be a potential source of crushed stone. A small quarry, now abandoned, in the granite was operated by the State Highway Department for production of road metal many years ago along Little Cherrystone Creek. The rock at this area is fresh, medium- to coarse-grained gneissic granite with interlayers of Fork Mountain biotite gneiss.

Clay

The results of tests made on weathered shales Stoneville and Cow Branch formations north and northeast of Motleys Mill along the Bannister River (Meyertons, 1963) indicate that these shales may have potential use for the manufacture of building brick and structural wares. Because the water table along the Bannister River and its tributaries is high, only elevated areas on the northwest side of the River should be considered as potential sources.

Lightweight Aggregate

Some 15 miles to the southwest, in the Draper quadrangle, Solite Corporation utilizes black shales and mudrocks of Cow Branch Formation for the manufacture of lightweight aggregate. Similar rocks occur northeast of Motleys Mill, Spring Garden quadrangle, and in the northwestern part of the adjacent

Java quadrangle. Most of the rocks near Motleys Mill are beneath alluvium and terrace deposits along Bannister River, an area subject to flooding. Small areas of Cow Branch strata occur above the floodplain on the north side of the river.

Uranium

The Danville Triassic basin has been targeted for proposed uranium exploration (Dribus, 1978) because of the location of the basin near possible granitic sources of uranium, the probable existence of stratigraphic traps in areas of the basin, and indications of uranium from airborne surveys. The Shelton Formation and granitic rocks interlayered within the upper felsic gneiss unit provide a possible source southeast of the basin and the felsic gneiss unit and the Leatherwood granite provide a northwestern source of uranium. Concentration in the sedimentary rocks of the basin may come from leaching the granitic rocks or by deposition of detritis from these rocks or by both means. Intertonging shale and sandstone near Motley's Mill form a potential stratigraphic trap to concentrate uranium-bearing solutions.

Henika and Johnson (1980, p. CGS-80-B-VI-4) outlined another uranium depositional model, that of groundwater "ponding" adjacent to diabase dikes and at impermeable cataclastic rocks. Anomalous radioactivity associated with cataclastic rocks at the northern quadrangle boundary may be explained by this latter process. Detailed gamma-ray spectrometry indicate that the radioactive elements are concentrated along steeply dipping fractures in the mylonitic rock. An active drilling program was conducted on in the cataclastic rocks in the adjacent Gretna quadrangle by the Marline Oil Company during the summer months of 1980.

REFERENCES

Allen, G. E., 1967, Riebeckite Occurrence in southern Virginia, Virginia Minerals Vol. 13, No. 1, p. 10.

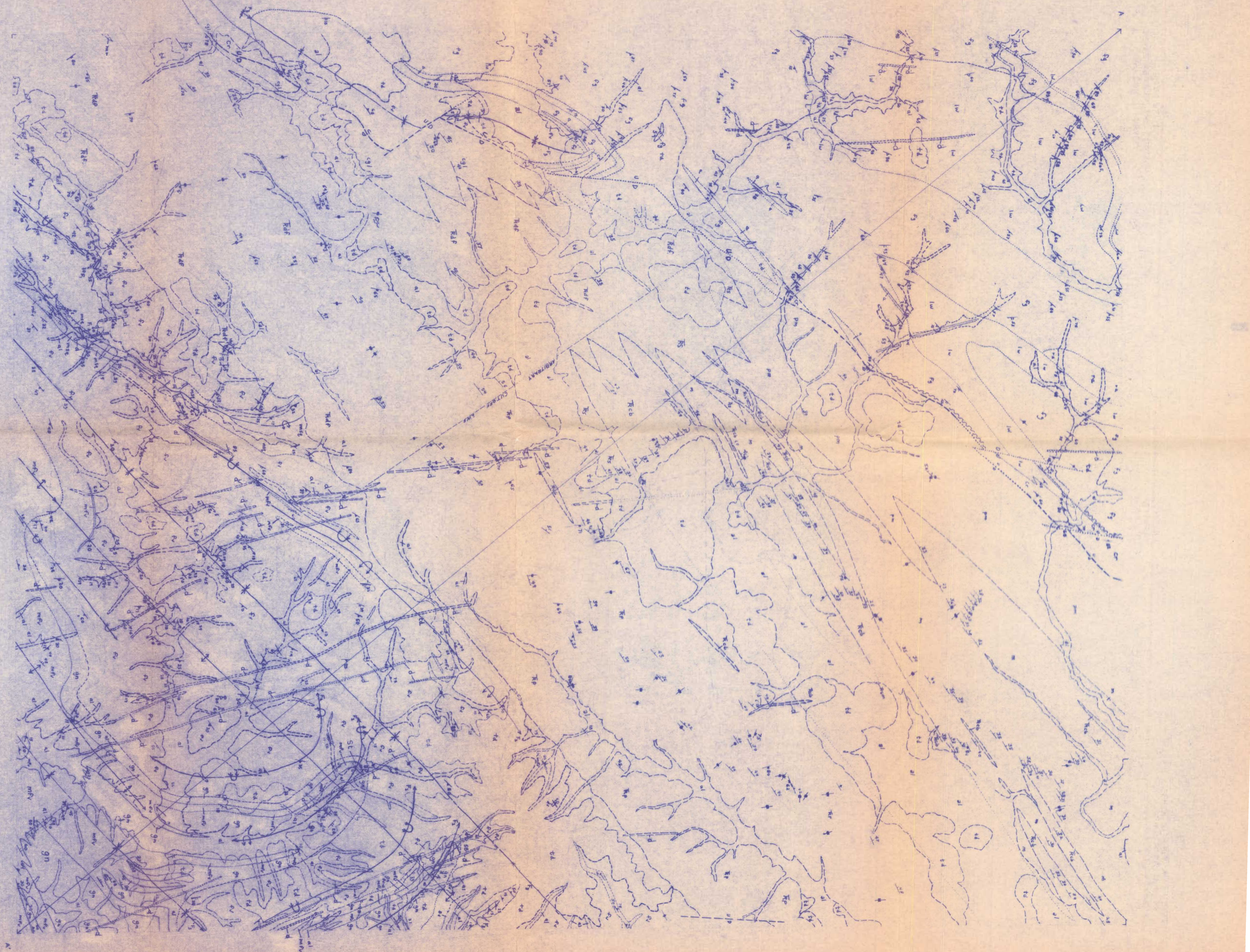
Conley, J. F., 1978, Geology of the Piedmont of Virginia - Interpretations and Problems, in Contributions to Virginia Geology - III: Virginia Division of Mineral Resources, Pulbication 7 p. 115-149.

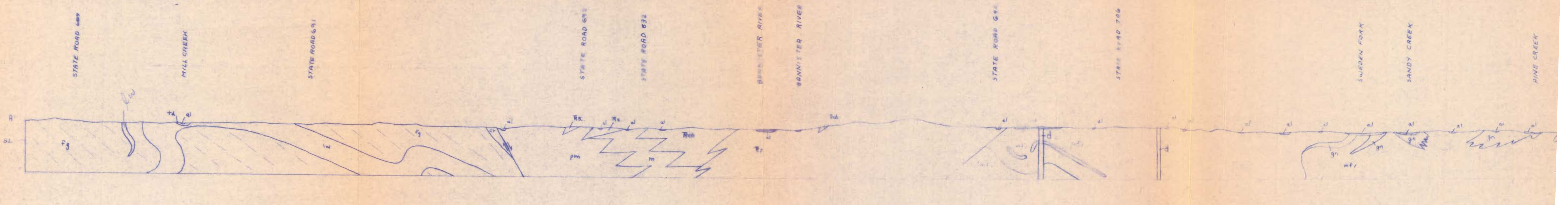
Conley, J. F. and Henika, W. S., 1973, Geology of the Snow Creek, Martinsville East, Price and Spray quadrangles: Virginia Division of Mineral Resources Rept. Inv. 33, 71 p.

Dribus, J. R., 1978, Preliminary study of the uranium potential of the Dan River Triassic basin system, North Carolina and Virginia: U. S. Dept. of Energy GJBX-131(78) open file report.

Henika, W. S., 1977, Geology of the Blairs, Mount Hermon Danville and Ringgold quadrangles, Virginia, with sections on the Triassic System by Thayer, P. A.: Virginia Division of Mineral Resources Publication 2, 45 p.

Henika, W. S., 1980, Metamorphic and Structural Evidence of an Intrusive Origin for the Shelton Formation, in Geol. Inv. of Piedmont and Triassic Rocks Price, V. and others, editors: Carolina Geol. Soc. Field Trip Guide Book p. CGS 80-B-V thru CGS 80-B-V 17.





GEOLOGIC CROSS SECTION
SPRING GARDEN