GEOLOGIC HISTORY AND PROCESSES

PHYSIOGRAPHY

Arlington County is divided into two distinct physiographic provinces by the Fall Zone, which generally follows Interstate 66 from Rosslyn to Four Mile Run, where it tends south to the County line at Route 50. To the north and west of the Fall Zone is the Appalachian Piedmont, a rolling upland surface underlain by igneous and metamorphic rock. To the south and east is the Atlantic Coastal Plain, a wedge of unconsolidated sediments which unconformably overlie the Piedmont rock.

Topography varies moderately over the County. In general, the Coastal Plain province is flat, defined by terraces at several different elevations. All of these terraces have been dissected by erosion, producing occasional steep slopes along stream valleys. The Piedmont is characterized by deeply weathered rock and gently rolling hills which have also been sharply cut by erosion.

The highest point in Arlington County is 451 ft (137 m) at Minor Hill. The lowest is sea level at the surface of the tidal Potomac River below Chain Bridge. Arlington is drained in the west and south by Four Mile Run, in the north by Pimmit Run, and in the east by several small streams which discharge to the Potomac River.

GEOLOGIC HISTORY

Geology of the Piedmont bedrock is complex. It began as Precambrian deposition of sediments which were lithified into rock. Uplifting and compression from the west-northwest created many folds and faults. A series of metamorphic events and igneous intrusions have complicated its geology even further. In Arlington, Piedmont rock consists predominantly of gneiss and schist, with mappable units of metagabbro, metagraywacke, phyllonite, migmatite, metasandstone, and ultramafic rock. Throughout the Piedmont province, intrusions of granite and quartz have occurred. There are few of these within the County boundaries, but they are prominent south and west of Falls Church. The surface of the Piedmont rock is heavily weathered into saprolite, a material which has the appearance of rock but is more similar to soil in its lack of strength.

The Coastal Plain sediments begin as a feather edge on the Piedmont rock and saprolite, and gradually become thicker southeastward, as the underlying rock slopes seaward approximately 100 ft/mile (18 m/km). The lower layers consist of a complex sequence of sand, gravel, clay, and silt fluvial deposits called the Potomac Formation, deposited by the ancestral Potomac River in the Cretaceous. It is unconformably overlain by Tertiary and Quaternary gravel and sand. The Tertiary (Pliocene) deposits are commonly called upland gravels, occurring in a succession of five terraces that descend to the southeast. All five terraces are found on this map; however, the oldest and highest terrace occur only as erosional remnants north and west of the Fall Zone. Two of these in Arlington are at Munson's Hill on the Fairfax County border, and at Hall's Hill near the intersection of Glebe Road and Lee Highway.

Quaternary (Miocene) deposits occur on low-lying terraces near the river. The lowest and youngest consists of silt, clay, and fine-grained sand and gravel, of (possibly) estuarine origin, formed when sea level was about 50 feet higher than present. An example in Arlington is the lower areas of Arlington Cemetery and Crystal City. Others, found in Virginia Highlands and the Marine Corps Memorial, are at higher elevations and older but were formed by the same processes.

CRYSTALLINE ROCKS

The principal sources of information on the Piedmont geology of Arlington are the three published quadrangle maps that cover the County: Washington West (Fleming et al., 1994), Annandale (Drake and Froelich, 1986), and Falls Church (Drake and Froelich, 1997). This information has been supplemented with descriptions from the Manassas and Fairfax quadrangles (Drake et al., 1994, and Drake, 1986) and from a study of the geology of Fairfax County (Drake et al., 1979). Much of the following discussion is reproduced directly from these references.

The metamorphic rocks in Northern Virginia in the vicinity of Arlington are a stack of four lithotectonic units, one of which, the Popes Head Formation, overlies three thrust sheet-precursory melange parts called tectonic motifs. Two of these motifs appear in the mapped area, the Mather Gorge-Sykesville and the Annandale-Indian Run.

Mather Gorge-Sykesville Motif

In the mapped area, rocks of the Mather Gorge Formation occur only as large olistoliths of migmatite (CZmm) and phyllonite (CZmp) within the Sykesville Formation; however, just to the west, the Mather Gorge crops out above the Sykesville on the Plummers Island fault. This formation was earlier interpreted to be Peters Creek Schist and is labeled as such on older maps of the northern Virginia Piedmont, such as the Fairfax and Annandale quadrangles. It is interpreted to be a turbidite deposited under high-energy conditions in a large submarine fan, and in this area has undergone a progressive metamorphic event to migmatite, then a retrogressive metamorphism to phyllonite.

The Sykesville Formation (Cs) is a complicated precursory melange with fragments and olistoliths of exotic rock types. The upper part of the unit (Cso) contains olistoliths of phyllonite that may constitute more than 90 percent of the rock. Rocks of the Sykesville Formation have apparently undergone only one metamorphic event with no evidence of polymetamorphism. The Sykesville Formation overlies the Annandale-Indian Run Motif on the Burke thrust fault.

Annandale-Indian Run Motif

The Annandale-Indian Run Motif consists of the Annandale Group that overlies its precursory melange, the Indian Run Formation, on the Red Fox thrust fault. The Annandale Group consists of the Accotink Schist and overlying Lake Barcroft Metasandstone which constitute a coarsening upward sequence interpreted as an outer submarine-fan association of rocks. These rocks are polymetamorphic, at biotite +/- garnet grade.

The Indian Run Formation is a complicated sedimentary melange like the Sykesville Formation, and was mapped as Sykesville in earlier studies. It differs by mineral composition, and because it contains fragments of the Annandale Group rather than Mather Gorge olistoliths. It has undergone one prograde metamorphism and is at biotite +/- garnet grade.

Transported Intrusive Rocks

Olistoliths of mafic and ultramafic rocks occur in all the crystalline rock formations in these four quadrangles. In the vicinity of Arlington, they occur only in the Sykesville Formation as actinolite schist (CZu) and metagabbro (CZg). Sources and age have not yet been determined.

INTRUSIVE ROCKS

The metamorphic rocks in the vicinity of Arlington have been intruded by rocks of the Falls Church, Georgetown, and Dalecarlia Intrusive Suites, and by the Clarendon granite and quartz bodies. While the intrusive suites are major units elsewhere in the region, only small areas are mapped here and none are found within Arlington County itself.

Falls Church Intrusive Suite

This unit was originally named the Falls Church Tonalite (Oft), and mapped as such on the Annandale quadrangle and Drake et al. (1979); the designation was changed with publication of the Falls Church quadrangle to include other phases, such as the trondhjemite (Oftr) mapped here. It consists primarily of biotite-hornblende tonalite and has an age estimated at 481 +/- 11 Ma (Early Ordovician).

Georgetown Intrusive Suite

Several small bodies of mafic biotite-hornblende tonalite (Ogh) are mapped in Fairfax County to the north of Arlington. They were shown as undifferentiated mafic/ultramafic rock on Drake et al. (1979). Age is 466+/- 3 Ma (Early Ordovician). These tonalites resemble those of the Falls Church Intrusive Suite and may have originated from the same magma stem.

Dalecarlia Intrusive Suite

A body of tonalite (Odt) crops out on the northern edge of the mapped area. It was shown as tonalite on Drake et al. (1979). Age of the Dalecarlia monzogranite (not mapped here) is estimated to be 468 +/- 9 Ma (Early Ordovician).

Clarendon Granite

An intrusion of monzogranite near Clarendon was identified on the Washington West quadrangle and subsequently shown near the CIA compound in McClean on the Falls Church quadrangle. It is not shown on Drake et al. (1979). Age is uncertain but is probably Ordovician.

Quartz Bodies

Several quartz bodies of varied shapes and sizes occur frequently within the crystalline rocks. Most are dikes and veins too small to be mapped and only larger bodies are shown here. They have been mapped similarly on Drake et al. (1979). Age is indeterminate.

AGE OF THE METASEDIMENTARY AND TRANSPORTED IGNEOUS ROCKS

Ages of these rocks cannot be determined directly, but can be inferred from their placement and the age of adjacent rocks. In the Washington West quadrangle, the Sykesville Formation is intruded by Kensington Tonalite (457 +/- 4 Ma) so it is older than this. Mather Gorge predates Sykesville because it occurs within the Sykesville Formation as olistoliths.

Similarly, the Indian Run Formation is older than the Occoquan Granite (479 +/- 9 Ma) which intrudes it to the south. The Annandale Group is older than the Indian Run Formation because the Indian Run contains deformed olistoliths of Annandale rocks.

In summary, the Sykesville and Indian Run Formations are considered to be Cambrian, while the Mather Gorge Formation and Annandale Group are Early Cambrian or Late Proterozoic.

SEDIMENTARY DEPOSITS

The Coastal Plain sediments in the vicinity of Arlington consist of the Cretaceous Potomac Formation, a series of Tertiary and Quaternary terraces, some better defined than others, and recent alluvium and colluvium. While the origin and extent of the Potomac Formation is well understood, geologists have debated the number of terraces (formations), their method of deposition, and their age since they were first mapped in the 1890s.

This has led to somewhat contradictory mapping of the same features, particularly when they are found both east and west of the Potomac River. With the exception of the Washington West quadrangle, recent mapping in the area has been carried out separately by geologists specializing in either Maryland or Virginia formations.

Because at the time of publication there was no geologic map of the Alexandria quadrangle (which would include most of the Coastal Plain geology in Arlington) other sources have been used. Besides the three quadrangle maps and Drake et al. (1979), recent Coastal Plain mapping in Northern Virginia has been done by Force (1975) and Froelich (1985). Other references for Coastal Plain geology in Virginia are Mixon et. al (1989), and Seiders and Mixon (1981). Maryland references included McCartan (1989a and 1989b).

The map units for these terraces on this map generally follow the designations of the Washington West quadrangle, which are aligned with Maryland and DC mapping; however they have been modified to remain similar with those of Northern Virginia mapping, e.g. Froelich (1985). Identification of upland terraces has been straightforward; the three or four shown on each quadrangle are clearly a subset of the five mapped in Drake et al. (1979), and can be readily correlated. This is not the case for the lowland terraces, which have been mapped in somewhat more detail east of the Potomac. For instance, where the most detailed mapping of the Coastal Plain in Fairfax County showed three Quaternary terraces (Qte1, Qte2, Qte3), Washington West indicates that four exist west of the Potomac (Qt2, Q3, Q4, Q5). In particular, the Q4 and Q5 terraces mapped on Washington West east of Fort Myer are shown as one unit of Qte2 on Drake et al. (1979). Several of the these boundaries have been modified during the present mapping and are indicated under the section on Map Construction.

Both the upland and lowland terraces have been correlated in the references with well-defined marine deposited formations in the Coastal Plain east and south of the mapped area. The correlations are inferred based on the assumption that accumulation of large gravel deposits on land must have occurred simultaneously with sediment deposition offshore, so that the fluvial gravels of Northern Virginia are correlated with marine Coastal Plain formations in Maryland.

Potomac Formation

The Potomac Formation consists of a complex, interbedded series of deposits of sand, silt, and clay. The cross-bedding, channeling, shape and size of beds, size grading of deposits, and lack of marine fossils indicate that the formation was deposited by rivers meandering along the edge of the Coastal Plain. During the period of deposition, the base of Piedmont rock gradually subsided and tilted eastward, producing a wedge-shaped deposit, dipping about 100 feet to the mile (18 m/km). By the end of the Cretaceous, uplifting on the west caused the formation to be eroded away, back down to bedrock.

Although in parts of Maryland, the Potomac Group is subdivided into three other formations, these distinctions are not mappable in Northern Virginia. Instead, the formation is subdivided among clay, sand, and undivided units.

Upland Terraces

Deposition for the upland gravels is believed to be fluviatile; they were deposited in deltas, terraces, or meanders of an ancestral Potomac River. Studies of the material show little difference among the terraces other than weathering, a sign of age. East of the Potomac there are marine (sea-bottom) deposits that appear correlated with these by age and elevation, but because of the method of deposition and lithological composition they are not classified identically.

Five such terraces occur on this map; they are essentially identical in description and location to the five upland terrace deposits delineated in Drake et al. (1979), where they correspond to units Ct1 through Ct5. Similar correspondence is found with terrace mapping on the Falls Church and Annandale quadrangles (Tt1 through Tt3) and on the Washington West (T1 through T4).

Based on correlation with similarly aged formations east and south of Arlington, it is probable that Tt1 is the shoreline facies of the marine Choptank formation. It is also probable that Tt2 through Tt4 correlate with the St. Mary's, Eastover, and Yorktown formations in Southern Maryland and Virginia. Tt5, the lowest terrace, appears to correlate to the Park Hall Formation (McCartan, 1989b) in Maryland and the Windsor Formation (Mixon, et al. 1989) in Virginia.

Lowland Terraces

The method of deposition for the lowland terraces is not clear. They are probably estuarine deposits related to sea level changes during the ice ages, although Qt1, at the highest elevation, may have been deposited as a river delta or terrace rather than an estuary bottom.

Two terraces are found on this map, with their designation based on Washington West quadrangle mapping. They are among four such terraces found in this part of the Coastal Plain. The two youngest, equivalent to Q2 and Q3 in the Washington West designation, are not found in the mapped area. These lower terraces would have been located in the areas filled for construction at National Airport and the Pentagon.

Qt1 is equivalent to the highest and oldest terrace, Q5 on the Washington West quadrangle. By description it may correlate with Qte1 of Drake et al. (1979) and Qt1 of Seiders and Mixon (1981), although the correspondence is unclear. According to the Washington West quadrangle description, this terrace correlates with the Chickamuxen Church formation in Maryland (McCartan 1989b) and the Chuckatuck and Charles City formations in Virginia (Mixon et al., 1981). The lower part of the terrace starts at about 50 feet and it slopes gradually upward to about 100 feet.

The lower and younger terrace, Qt2, is equivalent to Q4 of Washington West and Qte2 of Drake et al. (1979). It differs by stratigraphy and degree of weathering from Qt1. Its elevation correlates fairly well with Qte2, with a surface between 35 and 45 feet. Qt2 is correlated with the Omar Formation in Maryland and the Shirley Formation in Virginia.

Recent Deposits

Processes that formed the sedimentary deposits have continued to the present time. Colluvium (Qcl) formed from slumping of sediments down the face of terrace deposit scarps, and from creep, slumping, and sliding of unstable Potomac Formation clays on hillsides. Stream terraces (Qt) have formed along Pimmit and Cubit Channel streams as a result of meandering and channel changes. They are distinguished from recent alluvium (Qal) which makes up the existing floodplain of the same streams.

Throughout much of Arlington, land development has caused significant cut and fill activity. Where it has been extensive enough to alter the surficial geology, these areas are designated as artificial fill (af).

ENGINEERING PROPERTIES OF GEOLOGICAL UNITS

(Condensed from Obermeier and Langer, 1986)

Artificial Fill (af)

Properties of filled areas are highly variable and depend primarily on whether they have been designed as part of engineering works or if they are trash fills such as landfills. Engineered fills are generally well drained, with low to very low permeability. They can be excavated with light power equipment, and are suitable for compaction. If fill material is silty, they may be highly erodible; this is not the case with other unconsolidated materials. Trash fills are commonly poorly drained, with low permeability. They are unsuitable for compaction because of variable content (boulders, stumps, etc.). For the same reason, excavation may be more difficult. Trash fills are highly erodible. Bearing capacity is also variable; they will require excavation and replacement.

Colluvium (Qcl)

Properties of colluvium are variable but somewhat dependent on location. It is typically fairly well drained at upper parts of slopes, with seeps fairly common at the toe. Permeability is very low because of the clay matrix found in underlying Potomac Formation deposits. Ability to compact colluvium varies by location. There are few problems with excavation, but it can be very wet. Colluvium generally does not have suitable bearing capacity for heavy structures; however, in some cases it can be excavated to underlying stronger units. Erodibility varies, based on the composition of the material.

Alluvium (Qal)

Drainage of alluvium is poor: it is usually wet or saturated near the surface in swales and lowlands because of low relief and proximity to the water table. Permeability is highly variable. Buried channel sands are medium to highly permeable, finer grained soils are low. It is commonly too wet for compaction, and its organic and clay-rich deposits also make it unsuitable. Excavation may difficult because of high water table, weak soils, and occasional iron oxide-cemented boulders. Bearing capacity is generally unsuitable for heavy structures; requiring piles to underlying units. Erodibility is low because of low relief, except for active stream erosion.

Stream Terrace Deposits (Qt)

These deposits are generally well drained. The permeability of finer grained materials is low; it is medium for coarser materials. Soils are wet but not saturated. Compaction is commonly suitable and there are few problems with excavation. Bearing capacity is too low for heavy structures. The flat surface topography of these terraces limit erodibility, except for active stream erosion.

Lowland Terrace Deposits (Qt1, Qt2)

Drainage of these terraces is typically poor and water is commonly found at the surface because of low relief and proximity to the water table. Permeability is similar to alluvium; the soils are wet but not saturated. Compaction is commonly suitable. Excavation may be difficult because of the high water table and weak soils. Bearing capacity is generally unsuitable for heavy structures; requiring piles to underlying units. Erodibility is low because of low relief, except for active stream erosion.

Upland Terrace Deposits (Tt1, Tt2, Tt3, Tt4, Tt5)

Drainage depends on the internal structure of the deposit. The hardpan layer can retain water at or near the surface for weeks after rainy season and some local perched water tables may exist. Seeps occur at contact with underlying Potomac Formation; some of these channels are highly permeable. However, typically there is low permeability above the hardpan and much higher below. Upland terrace deposits make excellent fill, readily compacted and they are a good source of sand and gravel for construction materials. There are few excavation problems; except that there may be some iron oxide-cemented layers near the contact with Potomac Formation; removal of this layer must be done with care to prevent water from entering underlying swelling clays. This unit is commonly used for supporting heavy structures on spread footings. It provides good support for H piles, but boulders can inhibit pile driving. Erosion presents a problem only in sandy deposits which have been disturbed.

Potomac Formation Sand (Kps)

Unit is typically dry at the surface within a few days after rain. Seeps can be found on hillsides at many places. Permeability is low, up to medium in sand-filled channels and there are many local perched water tables. The sand-rich facies very easily compacted, makes strong low-compressible fill with enough clay to resist erosion, however, local clay beds must be discarded. The weathered zone generally has few excavation problems; unweathered material may be difficult to excavate with light power equipment if matrix has highly plastic clay. Some iron-cemented layers may be present. Unweathered material normally is very good support for heavy structures; it has high bearing capacity for piles except where cut by faults. Generally this unit has sufficient clay matrix to prevent erosion.

Potomac Formation Clay (Kps, Kpu)

Water remains on the surface of this unit until evaporation. Surface runoff is generally high and seeps are present on slopes. Permeability is very low except in sandy strata; water may fill joints and fractures near the ground surface. This unit is difficult or impossible to compact properly because of highly plastic clay with high shrink-swell potential which tends to crack the foundations of light structures. There are few excavation problems; unweathered material may be difficult to excavate with light power equipment. Excavation is difficult with light power equipment, especially in unweathered zones. Both weathered and unweathered clay may shrink and swell if foundations are not at least 4 ft (1.3 m) below ground surface; corrective drainage is needed and nearby trees must be removed. The unweathered material is good support for heavy structures, with high bearing capacity for piles. When unstripped, the highly plastic clay is extremely erodible.

Granitoid Rock (Oc, Odt, Oft, Oftr)

The weathered profile varies from clay-rich sandy soil to silty sand. Saprolite is typically silty sand, containing some clay, highly micaceous in places, predominantly clay in others. It may be 65 ft (20 m) deep on hilltops. At some places, saprolite is crossed by 3/4 in (2 cm) thick dikes weathered to highly plastic clay which are much weaker than surrounding material.

Water is commonly at the ground surface above a clay-rich layer after rainy periods. Permeability of the clay-rich layer is very low. Permeability of saprolite is higher, but still low because of clay present throughout. Saprolite generally compacts well; ease depends on moisture content for highly micaceous or silty saprolite. It is not highly compressible except where mica content is unusually high. Saprolite can be excavated with light power equipment to 6-10 ft (2-3 m) depth but gradually becomes more difficult with increasing depth. Quartz veins throughout weathered profile may require blasting. Bearing capacity is suitable for heavy structures; allowable load gradually increases with depth below the upper layer. Erosion potential is low to moderate, higher where saprolite is silty or micaceous, or where it has been remolded.

Ultramafic Rock (Czu, CZg)

This unit weathers to thin, highly plastic clay close to ground surface, underlain by weathered or unweathered rock, with very abrupt transition. Depth to unweathered rock averages 3 ft (1 m).

Water is commonly found at the surface after rainy periods because of highly plastic clay and shallow bedrock. Permeability is generally very low. Perched water is common above unweathered rock after rainy period. Saprolite is commonly unsuitable for compaction because of plastic clay. Highly plastic soils and platy weathered rock can be excavated with light power equipment. Unweathered bedrock can support very large loads close to ground surface, but the saprolite may have weak shear zones and swelling soils. Erosion potential is low.

Mafic Rock (Cgh)

The weathered rock is a slightly micaceous clayey silt, very plastic layers can be found on massive rocks in interior of mapped unit. Weathering is much deeper in foliated rock. Depth to unweathered rock averages 15 ft (5 m).

Drainage is variable. The unit is generally well drained above foliated rocks and moderately to poorly drained above massive rocks. Weathered rock and saprolite derived from foliated rocks are highly permeable, and above massive rocks, it is lower. Water is common at shallow depth because of low permeability. Saprolite on foliated rocks is generally moderately to easy to compact, sensitive to moisture content. Saprolite on massive rocks is unsuitable for compaction because of highly plastic clays or thinness of saprolite. Saprolite can be excavated with light power equipment. Weathered rock much be blasted where massive, othewise heavy equipment is required. Bearing capacity is suitable for large structures. Load increases with depth, but dessicated clay-rich soils above saprolite may decrease load. Possible shrink-swell problems may occur down to 6 ft (2 m). Highly plastic materials and saprolite from massive rock has low erodibility. On foliated rocks it is much greater, especially where clay content is low and where remolded.

Quartz (OCq)

Quartz does not weather sufficiently to develop a weathered profile; it is commonly fresh at ground surface. Because of this, drainage, compaction, and structural properties are not applicable.

Gneiss, schist, metagraywacke (Cs, Cso, CZmm, CZmp, CZi, CZa, CZl)

Saprolite is typically a highly micaceous silt containing some sand and clay; parting planes form on foliated bedrock. Commonly 25-35 ft (7-10 m) thick, when far from streams. Depth to unweathered rock averages about 45 ft (14 m), highest on hilltops. Physical properties change erratically vertically and laterally. Shear zones are relatively common, containing material much weaker than surrounding weathered rock or saprolite.

The unit is normally well drained to very well drained, except at toe of slopes or on flat ground. Medium or higher permeability exists throughout the weathered profile. Water collects at contact with unweathered rock. This unit is acceptable as compacted fill; ease of compaction and compressibility depend on moisture content, but the highly micaceous soils are sensitive to compaction control. It can be easily excavated to 6-10 ft (2-3 m) with light power equipment; difficulty increases with depth. Occasional quartzite beds and quartz veins will require blasting. Bearing is suitable for large structures; allowable bearing increases rapidly with depth. Saprolite is highly erodible, especially where micaceous or remolded.

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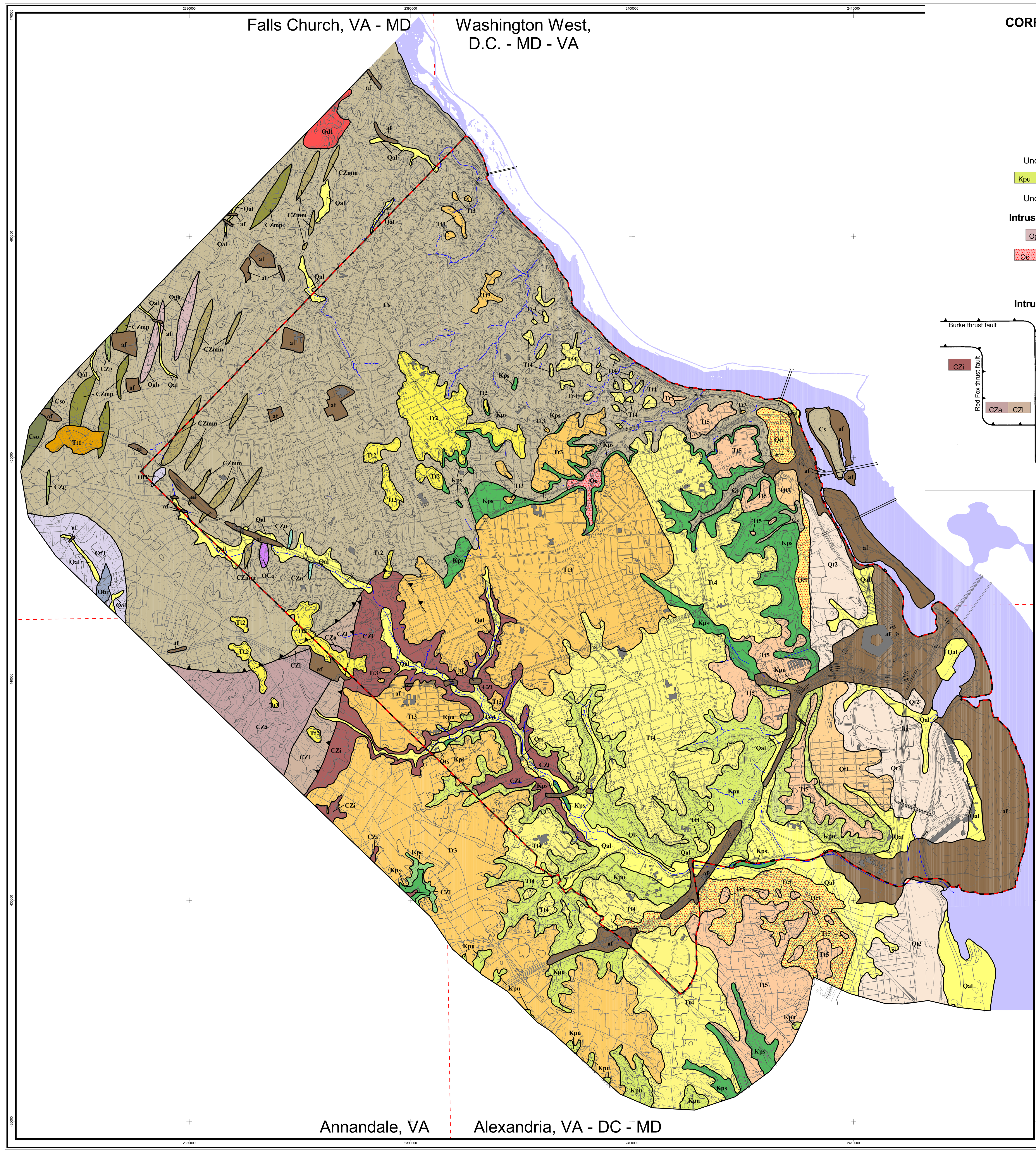

Map prepared by Mapping Center, DPW, Arlington County, VA.
Street Base map digitized from Arlington County 1:600 planimetric series, 1974.
Updated from 1998 Digital Orthophotography.
Streets outside of Arlington County created from USGS DLG files.
10,000 foot grid tics based on Virginia State Plane coordinate system, north zone.
Lambert Conformal Conic Projection
1927 North American Datum
Red dashed line is USGS 7.5 minute quadrangle maps.
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SCALE 1:24,000

Mapping by the U.S. Geological Survey. Crystalline rocks mapped by A.A. Drake, Jr., 1976 and 1991, A.H. Fleming, 1978, and A.E. Nelson, 1976. Surficial deposits mapped by Lucy McCartan, 1975 and 1990, A.J. Froelich, 1975, and A.H. Fleming, 1978.

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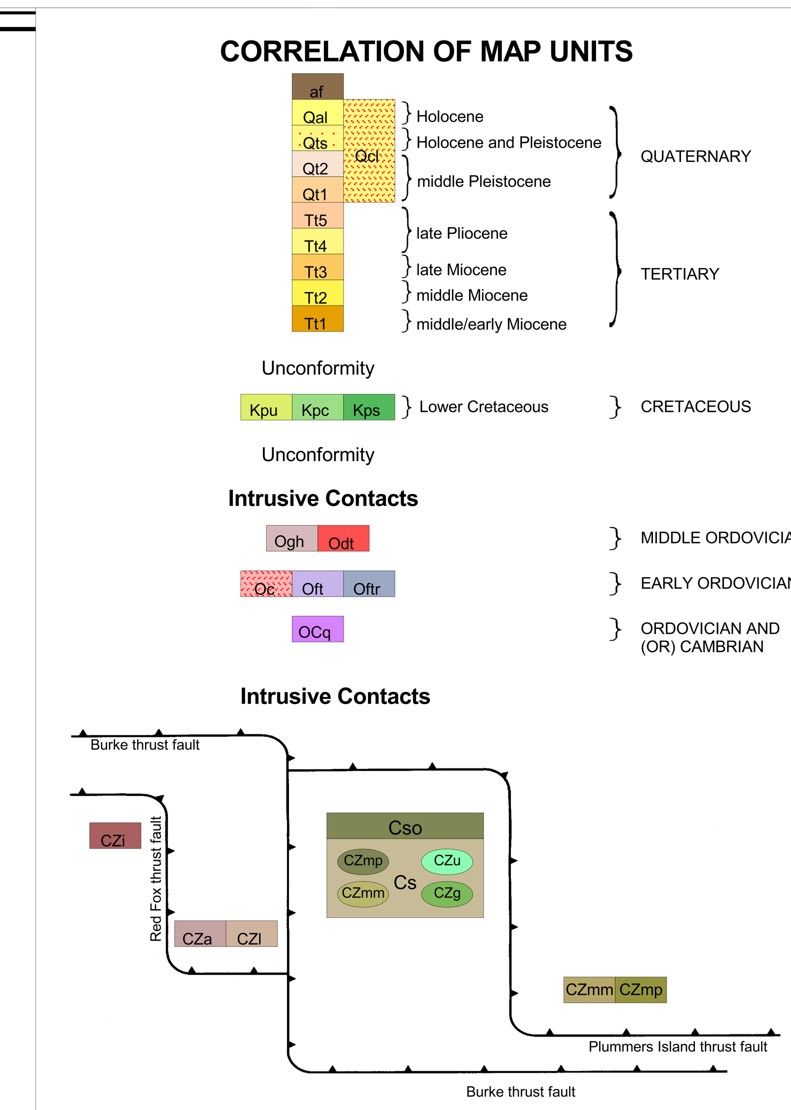
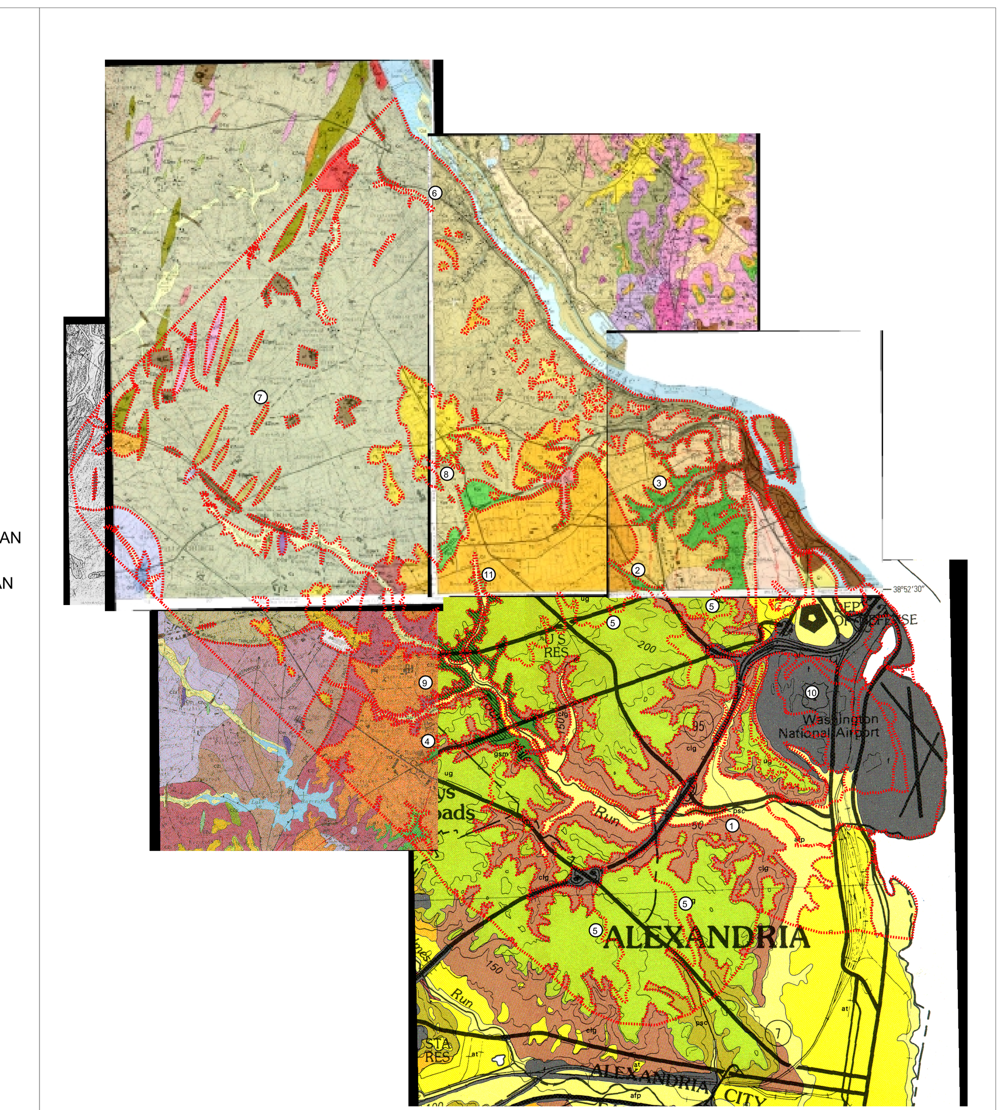
CORRELATION OF MAP UNITS





ARTIFICIALLY CHANGED GROUND

af **Artificial Fill** -- Heterogeneous materials found in large areas regraded, leveled, or filled for construction. Also includes fill of marshes or low-lying areas and those formerly mined for sand, gravel, or clay. Smaller scale fills of variable composition and thickness found throughout the urbanized area have not been mapped.

ALLUVIUM AND COLLUVIUM

Qcl **Colluvium (Quaternary)** -- Unsorted mixture of rock fragments, gravel, sand, silt, and clay formed by slow creep or mass wasting downhill. Generally found on steep slopes underlain by Potomac Formation clays. Thickness varies from a few feet up to 30 feet, with the thickest deposits found at the toe of slopes.

Qal **Alluvium (Holocene)** -- Unconsolidated sand, silt, gravel and clay fluvial deposits underlying modern floodplains and marshes. Sediments are moderately to crudely bedded, well to poorly sorted, of variable thickness. In the Piedmont, Qal consists of micaceous silt and sands, quartz and crystalline rock pebbles, cobbles, and boulders. Where streams drain the Coastal Plain, sediment is derived from weathered saprolite and older alluvial deposits and contains mostly well-rounded pebbles and cobbles, quartz sand and silt, and clays.

LOWLAND TERRACE DEPOSITS

Qts **Stream Terrace Deposits (Holocene and Pleistocene)** -- Gravel, sand, silt, and clay deposited in lowland benches 10 to 25 ft (3 to 8 m) above modern floodplains. Deposits are usually well-sorted, well-bedded material ranging in size from clay to cobbles.

Qt2 **Terrace Deposits (middle Pleistocene)** -- Gravel, sand, silt, and clay , gray brown to medium orange, crudely to well bedded. Found in a terrace below a 50 ft (15 m) elevation west of the Potomac River. Minerology similar to Qal but more deeply weathered. Where unstripped, the upper few feet is yellow to medium orange due to accumulation of iron oxide. Thickness may be up to 35 feet (10 m).

Qt1 **Terrace Deposits (middle Pleistocene)** -- Gravel, sand, silt, and clay, gray to gray-brown, crudely to well bedded. Found in an irregular terrace between 40 and 105 ft (12 m to 22 m) elevation. Similar to Qt2 but more deeply weathered so that relatively fresh minerals have been exposed. Typically 35 to 65 ft (10 to 20 m) thick.

UPLAND TERRACE DEPOSITS

Tt5 **Terrace Deposits (late Pliocene)** -- Gravel, sand, silt, and clay, brownish-gray; medium orange in upper part. Rounded pebbles and cobbles and coarse-grained sands are poorly to well sorted and crudely bedded. Gravel consists of crystalline rocks, quartz, quartzite, and sandstone. Silt and clay are interstitial, probably emplaced post-depositionally by infiltrating water. Clay is mainly kaolinite and soil vermiculite. Tt5 is recognized by firm pebbles and cobbles and by the thin weathered zone in unstripped sections. Found in terraces at elevations from 100 to 140 ft (30 to 40 m).

Tt4 **Terrace Deposits (late Pliocene)** -- Crudely bedded gravel, sand, silt, and clay, pale-brown to medium yellow, reddish-orange in upper part. Gravel and sand are coarse, silt and clay are interstitial and emplaced post-depositionally. Materials are similar to Tt5 but more weathered. Some gravel clasts have desilicified and are friable. Tt4 is recognized by a few such clasts and thick brightly colored weathering profiles. Found in terraces between 170 and 190 ft (50 to 60 m).

Tt3 **Terrace Deposits (late Miocene)** -- Gravel, sand, silt, and clay, reddish-orange to pale-gray in uper part, pale- to medium-yellow below. Unit is crudely bedded. Coarse gravel and sand; silt and clay are mainly post-depositional, although some is derived in place. Materials are similar to Tt5 and Tt4. Most of the crystalline and some quartzite clasts have weathered to clay or a loose aggregate of mineral grains. Tt3 is distinguished by thorough weathering and bright colors in the upper part of unstripped sections. Found as a terrace between 220 and 250 ft (65 to 75 m), overlaps wedge edge of Potomac Formation.

Tt2 **Terrace Deposits (Pliocene(?) and late Miocene(?))** -- Gravel, sand, silt, and clay, bleached white in upper part, to pale orange below; crudely bedded. Materials similar to Tt3. Weathering and leaching have removed much of the iron, accounting for the pale colors. Weathering has also disintegrated many of the gravel clasts. Tt2 is distinguished primarily by its color and position at elevation of about 360 to 410 ft 135 to 160 m).

Tt1 **Terrace Deposits (late Miocene(?))** -- Gravel, sand, silt, and clay, gray- to reddish-brown, found primarily at Tyson's Corner; the oldest and highest of the terrace gravels. Cross-bedded cobble and pebble gravel, consisting of well-rounded crystalline rocks in a matrix of sandy, reddish-brown clay and silt. Gravel clasts are deeply weathered and readily disintegrate. Fluvial gravel unit overlies lenticular sequence of light gray sand and weathered silty clay beds. Thin, unweathered conglomerate lenses occur at the base of the silty clay above unconforming Piedmont saprolite. A silicified log has been excavated from these stream channel deposits. Unit may be as much as 70 ft (21 m) thick and occurs at elevations between 450 and 520 ft (135 to 160 m).

POTOMAC FORMATION

Kpu **Potomac Formation, undivided (Early Cretaceous)** -- Varicolored clay and silt interbedded with pebbly to cobbly sand in fairly well bedded, interfingering fluvial deposits. Unit forms a southeastward-thickening prism of sediment up to 600 ft (180m) thick. Unconformably overlies saprolite on Piedmont crystalline rocks.

Kpc **Potomac Formation, clay and silt (Early Cretaceous)** -- Red-brown, green, and gray silty clay with minor lenticular sands. Clay has high shrink-swell characteristics due to predominance of montmorillonite, and is unstable on steep to moderate slopes. Probably derived from fluvial overbank deposits. Thickness is irregular.

Kps **Potomac Formation, sand and gravel (Early Cretaceous)** -- Buff to gray, find- to coarse-grained feldspathic quartz sand, interbedded with lenticular silt and clay. Thick-bedded units are commonly coarse-grained andcross-bedded. Unit fills erosional channels and grades to fine-grained silty sand probably of point-bar origin, then to overbank silts and clays (Kpc). Thickness is irregular.

MAP CONSTRUCTION

Arlington County lies at the junction of four USGS quadrangles. To construct a single geologic map of this area it was necessary to find source maps for each of the quadrangles, digitize the geologic map units, and reconcile occasional differences between the units.

USGS has published geologic maps for the Washington West, Falls Church, and Annandale quadrangles. These were scanned at resolutions of 300 dpi and 100 dpi. The Falls Church quadrangle was in press at the time this work was begun, so a photocopy was obtained from USGS, then scanned at 100 dpi. Both the Washington West and Falls Church maps had to be scanned in two sections because of the small scan area of the the desktop unit used.

There were no geologic quadrangle maps available for Alexandria, so several other sources were used. Of these, Langer and Overmeier (1979) was published at the largest scale (1:48,000), so it was the basis for most of the digitizing. It was scanned at 100 dpi.

All the scanned maps were saved as TIFF files. These were imported into ARC/INFO and rectified to Virginia State Plane coordinates. Digitizing was carried out in ArcInfo using the registered images as backdrops. Line work was QC'ed and plotted using ArcView.

MAP UNIT DESCRIPTIONS

Descriptions of map units come from the references. They were quoted directly, for the most part. Minor changes were made, particularly with the Sedimentary Deposits, to reconcile the descriptions found in separate maps.

RECONCILIATION OF SOURCES

1) There are several differences in the mapping of Potomac Formation and colluvium sediments among the source documents. Most of the units in Arlington shown on the Washington West and Annandale quadrangles as Kps and Kpu are shown as Qcl on Langer and Overmeier (1979). Although Froelich (1985) generally shows them as Kpu, one area of the south bank of Four Mile Run east of Shirley Highway is described as Kpu with surficial geology of Qcl.

2) Potomac Formation in this area is mapped on Washington West as Kps, on Froelich, (1985) as Kpu, and on Langer and Overmeier (1979) as Qcl. The Washington West description has been used since it is the most recent mapping.

3) Potomac Formation in this area is mapped on Washington West as Kps. In both Langer and Overmeier (1979) and Drake et al. (1979) a small unit of Kpc is mapped just south of the Arlington County Court House. These sources also show Qcl instead of Kps south of Route 50. The Washington West description was used since it is most recent mapping.

4) Potomac Formation in this area is mapped on the Annandale quadrangle as Kps, by Froelich (1985) as Kpu, and by Langer and Overmeier (1979) as Qcl. The description of Froelich (1985) has been used to conform with the large unit of Kpu bordering Four Mile Run.

5) These Upland Terrace and Lowland Terrace boundaries were mapped from Froelich (1985). The Tt5/Tt4 boundary shown on Washington West was deleted in favor of the Froelich (1985) boundary because it was a better match to terraces shown by topographic maps.

6) Qal in Pimmit Run ends at the boundary between the Washington West and Falls Church quadrangles, which is approximately the same boundary as the unit mapped on Langer and Overmeier (1979)

7) Both Langer and Overmeier (1979) and Drake et al. (1979) show a unit of Tt1 at Minor Hill, which was not shown on the Falls Church quadrangle. The Falls Church mapping was used since it is the most recent.

8) The Washington West quadrangle shows Kps underlying the Tt2 unit at Hall's Hill, which is not shown on other maps and does not carry over to the Falls Church quadrangle. The Washington West mapping was used since it is the most recent.

9) The area where Upper Long Branch crosses into Arlington County is shown three different ways. The Annandale quadrangle shows the stream valley as Qal with a unit of Qt on the south bank, apparently overlying crystalline rock CZi. Langer and Overmeier (1979) is similar except that the rock unit is not covered by Qt and there is a small unit of Kps downstream. This map also shows Kpu along both banks just to the Annandale/Alexandria quadrangle border. Froelich (1985) by contrast, shows the streambed as crystalline rock, with banks of Kpu well into the Annandale quadrangle.

A field visit confirmed the mapping in the Annandale quadrangle. West of the map sheet boundary, the Annandale mapping was used and Langer and Overmeier (1979) was used to the east. Unit borders were adjusted slightly to join at the line.

10) The area bounded by the Pentagon site on the north, Four Mile Run on the south and Shirley Highway on the west has been mapped in more detail for this project. Shorelines from 1901, 1917, and 1927 USGS topographic maps were used to delineate areas of artificial fill near Columbia Island and National Airport. The lower Four Mile Run valley was presumed filled where these maps showed ponds and marshes. Pre-development topography was also useful in delineating the Lowland Terrace and recent alluvial deposits throughout this area.

Differentiation between Qt2 and Qt1 in Virginia Highlands was made based on unit descriptions from the Washington West quadrangle and topography, including a scarp and gently sloping terrace surface.

Current street maps were used to identify artificial fill for the Pentagon site and Shirley Highway, based on comparison with earlier mapping. Delineation of Upland Terrace and Potomac Formation on steep slopes was done by recent topography.

11) Washington West quadrangle mapping of Kps in Lubber Run stream valley was in error. Unit is mapped here as Indian Run Formation to correspond with Langer and Overmeier (1979).

INTRUSIVE ROCKS

Oc **Clarendon Granite (Early Ordovician)** -- Leucocratic, moderate- to well-foliated, medium grained, biotite-muscovite monzo-granite.

OCq **Quartz Bodies (Ordovician and Cambrian)** -- Lenticular bodies or irregular masses of quartz. Some are foliated or polyfoliated, whereas other bodies are massive.

Dalecarlia Intrusive Suite (Middle Ordovician)

Odt **Muscovite trondhjemite** -- Fine- to medium-grained, sugary textured, massive to weakly foliated. Forms dikes, sheets, and irregular bodies in monzogranite and adjacent country rocks.

Falls Church Intrusive Suite (Early Ordovician)

Oft Medium- to coarse-grained, medium-dark-gray biotite-hornblende tonalite, and biotite tonalite that typically contains abundant inclusions of mafic and ultramafic rocks. Rock is typically well foliated and in many places has a strong quartz-rod lineation.

Oftr Medium-grained, light-pink to light gray, massive-appearing muscovite trondhjemite. It is strongly deformed and recrystallized.

Georgetown Intrusive Suite (Middle Ordovician)

Ogh Medium- to coarse-grained, mafic biotite-hornblende tonalite that at many places is choked with xenoliths and/or autoliths of ultramafic, mafic, and metasedimentary rocks. Has a metamorphic foliation and quartz rod lineation as well as a relict flow foliation and lineation. Typically contains thin layers of biotite tonalite.

METAMORPHIC ROCKS

Sykesville Formation (Lower Cambrian)

Cs Light- to medium-gray, medium-grained sedimentary melange consisting of a quartzofeldspathic matrix that contains quartz "eyes" and fragments of phyllonite, metagraywacke, migmatite, serpentinite, amphibolite, and actinic schist. Unit also contains mappable olistoliths of metagabbro (CZg), phyllonite (CZmp), migmatite (CZmm), and actinolite schist (CZu)

Cso Upper part of unit, similar to main formation, but containing 50 percent or more phyllonite ostoliths.

CZg **Metagabbro (Cambrian or Late Proterozoic)** -- Dark green, well-foliated medium- to coarse-grained gabbro and much lesser serpentinized peridotite and plagiogranite.

CZu **Actinolite Schist (Cambrian or Late Proterozoic)** -- Medium-grained, light- to dark-green actinolite schist, actinofels, actinolite-chlorite schist, and much lesser talc-bearing rock. At many places the unit contains multiple foliations and a strong stretching lineation.

Mather Gorge Formation (Early Cambrian and/or late Proterozoic)

CZmm Stromatic and lesser phlebitic migmatite consisting of quartz-plagioclase leucosome and quartz-rich schist paleosome.

CZmp Fine-grained, lustrous, greenish-gray, red-brown weathering chlorite-sericite phyllonite that commonly is characterized by pods and knots of quartz that stand out on weathered surfaces. Much of the phyllonite had a migmatite protolith as relict leucosome can be seen in many outcrops.

Indian Run Formation (Cambrian)

CZi Poorly to well-foliated sedimentary melange consisting of a medium-grained quartz-plagioclase-muscovite- biotite-chlorite-garnet matrix that contains fragments of quartz, foliated felsic and mafic metavolcanic rocks, metagabbro (CZg), Accotink Schist (CZa), and Lake Barcroft Metasandstone (CZl). Larger fragments are mapped.

CZa **Accotink Schist of Annandale Group (Early Cambrian and/or Late Proterozoic)** -- Light-gray, fine- to medium-grained quartz-muscovite-biotite-chlorite schist. The unit grades up into Lake Barcroft metasandstone (CZl), the contact being placed where the rock in outcrop contains more than 50 percent metasandstone.

CZl **Lake Barcroft Metasandstone of Annandale Group (Early Cambrian and/or Late Proterozoic)** -- Light- to medium-gray fine- to medium-grained meta-arenite and metagraywacke. The meta-arenite beds are lenticular, are as much as 6 ft thick, and probably result from sedimentary amalgamation. The metagraywacke beds are generally regular, sharp, flat based, graded, and 4 to 6 in (10 to 15 cm) thick.

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SIMPLIFIED GEOLOGIC MAP OF ARLINGTON COUNTY, VIRGINIA, AND VICINITY

Compiled by William Frost and Timothy Ernest, 1999