Plate 5: Map Showing Surficial Geology and Landforms
City of Alexandria and Vicinity

By Tony Fleming, March 2008

The modern Alexandria landscape is the product of fluvial depositional and erosional processes that began in the late Tertiary and have continued essentially uninterrupted to the present time. Constructional landforms consist chiefly of a series of river terraces that descend step-wise from the highest parts of the landscape to the lowest (inset 1). All of the terraces were deposited by the Potomac River (or a precursor stream) and its tributaries. The age of the terraces cannot be determined directly, but the two or three highest ones—the Seminary, Dowden, and probably the Chinquapin Village terraces—are potentially of Pliocene age, while one of the lowest—the massive Old Town terrace—almost certainly was deposited during the Sangamon Interglacial. A variety of intermediate terraces could lie anywhere within this age spectrum. All but the lowest terraces are extensively dissected by erosion, a process that was greatly accelerated by repeated sea-level lowering during multiple Pleistocene glaciations. The erosion has completely stripped off the terrace sediments at many places, exposing the underlying early Cretaceous Potomac Formation in many ravines and hillsides, as well as the early Paleozoic bedrock in Holmes Run gorge. Rapid stream incision, coupled with locally unstable Potomac Formation sediments, has led to many oversteepened slopes characterized by a host of slope processes and deposits, notably landslides and colluvium in a variety of forms.

Plate 5 depicts the principal type of rocks and/or sediments found at the surface in any given area or landform (inset 2). The major terraces are given informal, local names because it is not clear how the terraces mapped here relate to the "T1-T2-T3, etc" scheme shown on published geologic maps of surrounding areas. Many types of slope deposits are also depicted. In general, colluvium and related slope deposits are mapped where they are thick enough to dominate or strongly influence the soil profile or slope morphology; however, these deposits are shown in a somewhat schematic way in order to also depict the distribution of the underlying Cretaceous and bedrock units on hillsides. This is because virtually the entire landscape in excess of 5% slope is nearly completely covered by debris fans of one kind or another, as most ravine bottoms are by alluvium and colluvium. A more complete account of the map units and the landscapes they occur in can be found in "Plate 5 Surficial Geology-Expanded Explanation".

Explanation of Symbols

Boundary between map units, approximately located.

U ? D — Fault, queried where tentatively located, dashed where buried by units presumed to post-date the faulting. U-upthrown side, D-downthrown side. Teeth on top plate of thrust faults

Pre-settlement course of Cameron Run

Course and gradient of tributary stream terrace graded to one of the major upland terraces

Description of Map Units

af dg gp — **Artificial fill and disturbed ground**—Fill and disturbed ground are widespread in the city and range from small cut-and-fills, to old gravel pits and buried ravines, to massive emplacements for infrastructure. The fill material varies widely, commonly including some combination of sand, gravel, clay, topsoil, and construction debris. Only major and obvious areas of artificial fill (af) and disturbed ground (dg) are shown on the map, chiefly large embankments, old gravel pits (gp), and significant buried ravines. Fill and disturbed ground are ubiquitous on the Old Town terrace and in the Cameron Valley, but are mostly not shown on the map in order to depict the pre-settlement geology

PLEISTOCENE - RECENT STREAM DEPOSITS

Qal — **Recent alluvium**—Laterally and vertically variable deposits of boulders, gravel, sand, and mud along the floodways of most streams. The sand- and coarse silt-sized fraction are commonly micaceous. Along lower Cameron Run and the Potomac River, this map unit also includes a few low-lying stream terraces of probable Recent age. Arcuate dashed lines denote point bars; arrows denote high-quality oxbow—natural levee systems

Qs — **Recent swamp deposits**—Chiefly organic silt and clay in low-lying swales and backwater areas that adjoin major streams, and whose mouths are or may have been dammed by coarse alluvial deposits. Closely associated with units Qt and Qto

Qt — **Stream terraces (late Wisconsin through Recent)**—Typically coarse cobble gravel below, grading up into sandy loam and silt, sometimes in repetitive cycles. In most drainages, unit Qt encompasses the lowest set(s) of stream terraces and broadly corresponds to the major portion of the modern floodplain

Qaf — **Alluvial fans (middle Pleistocene through Recent)**—Composed chiefly of gravel, sand, and loam. Localized at the mouths of some of the larger ravines, where they debouch onto the flatter terraces and valley bottoms of major streams. Some fans are steep fronted and truncated by valley incision, whereas others grade smoothly into the lowland surfaces in front of them, indicating that the fans are of different ages

Qto — **Old Town terrace (Sangamon)**—Constitutes a broadly fining-up sequence, gravelly in its lower half, grading up through sand and muddy sand into mud. Above an elevation of about 30-35 feet, the modern surface of the terrace is composed chiefly of silt and clay; below that, it is mostly muddy sand. It has a well-developed, deep ultisol profile. Underlies Old Town and Del Ray, where it approaches 125 feet thick at places. A set of terraces that is clearly graded to the main Old Town terrace was mapped for several miles up Cameron Valley and its tributaries, and in the lowermost reaches of Four Mile Run

Qtu — **High-level terrace remnants (early to middle Pleistocene)**—Gravelly terrace remnants are found at widely divergent elevations and positions along the valley walls of most of the major drainages, especially Cameron and Holmes Runs. Although a few of these still preserve a relatively flat terrace surface, most are small scraps of moderately sloping gravel that have been severely eroded, and some may simply represent a gravel lag or colluvium. They occur at higher landscape positions than the Old Town terrace, and are thus older

TERTIARY – RECENT SLOPE DEPOSITS AND ASSOCIATIONS

These units consist mainly of boulders, cobbles, and gravel embedded in a stiff, oxidized, fine- to medium-grained matrix composed of variable proportions of sand, silt, and clay, plus mica where developed on bedrock saprolite. The composition at any given place tends to reflect that of the underlying and superjacent strata. Although most of the colluvial units appear massive, slope-parallel stratification is evident in good exposures. Most units are relatively well drained and stable, but instability can occur where the unit overlies clayey Potomac Formation strata at shallow depth on steep slopes. Map units are differentiated primarily by their slope positions and relations to adjacent landforms, and to a lesser extent, by composition and intensity of weathering.

Qc — **Colluvium (Pleistocene-Recent)**—Found on almost every slope throughout the map area. Forms fans, sheets, aprons, and chutes. The most robust thicknesses (10-20 feet) are typically found in concave parts of the landscape

Qcl — **Loamy colluvium (Pleistocene)**—Found outboard of the toes of some of the upland escarpments; consists mainly of medium to heavy-textured loam and largely lacks coarse clasts. Probably originated as slope wash, which slowly accumulated in fans

Qft — **Debris fans (Pleistocene-Recent)**—Found along the bases of long, steep slopes that border the major drainages. The fans are similar to colluvium and extend out over the inner portions of adjacent stream terraces. Most of the colluvial material was derived from the Potomac Formation and upland terraces cropping out on the slopes above, but in a few places, the material is derived from, or includes, sediment from the terraces along the modern drainages

Qxsv, Qtsv — **Seminary Valley debris fan complex (middle Pleistocene-early Holocene)**—Localized in the broad embayment between Holmes Run and the massive, dissected "Hospital" escarpment that bounds Seminary terrace. Consists of a mosaic of alluvium, colluvium, slope wash, mudflows and other landslide debris, as well as small alluvial fans produced by high-level ravines coming off the escarpment. Much of the debris has been redistributed and homogenized further downslope by alluvial and slope processes. The larger upper part of the unit (Qxsv) overlies a moderately hilly erosion surface developed mostly on the Cameron Valley sand of the Potomac Formation, a few isolated hills of which poke up through the debris; lower portions of the unit (Qtsv) overlie and have locally been modified by Pleistocene stream terraces

Tc — **High-level colluvium (Tertiary-Recent)**—Sheets, fans, and lag gravel along the edges of the large upland terraces and in the heads of high-level ravines; very common along escarpments separating these terraces, and is deeply weathered. Colluviation of this unit is believed to have occurred mainly in the latest Tertiary and early Pleistocene, though some movement clearly continues today in a few places

TERTIARY – EARLY PLEISTOCENE UPLAND TERRACES

Four major upland terraces deposited by the Potomac River are separated by a series of prominent, but discontinuous river-cut escarpments. Each escarpment was cut when the river occupied the terrace at its base. Large parts of the terraces and escarpments have been completely eroded away, but significant segments still remain in the interior portions of the upland landscape, away from ravines rejuvenated by Pleistocene incision. The terraces consist mostly of coarse gravel, and their surfaces commonly resemble alluvial plains. The escarpments are short, gently to moderately sloping, with relief ranging from 25 to 75+ feet. They are developed chiefly on the Potomac Formation, which is close to the surface and controls the soil profile at most places, but they locally are veneered by respectable accumulations of old, gravelly colluvium, especially in concave places on the hillside. Map units are differentiated by position in the landscape, and escarpments also by the member of the Potomac Formation on which they are developed

QTbs, QTbg — **Beverley Hills terrace**—Series of isolated, strongly dissected erosional remnants. Surface altitude ranges from 145 to 160 feet, while the base of the terrace ranges from 130 to 145 feet. Maximum apparent thickness is less than 25 feet. Mostly coarse cobble gravel in a weathered matrix of yellowish-orange loam (QTbg); locally contains boulders up to 5 feet long. Zones of loamy sand without gravel are reported in boreholes. The flattest parts of the terrace surface are commonly capped by up to 10 feet of clayey silt (QTbs)

QTeja, QTejch — **Jefferson Park escarpment**—Separates Chinquapin Village and Beverley Hills terraces. Developed chiefly on mixed sandy and clayey sediments of the Chinquapin Hollow member (QTejch), and is moderately stable. Far southeastern end (QTeja) overlies Arell clay and is complicated by faulting, intermediate-level river terraces, and colluvial cover

Tcs, Tcl, Tcg — **Chinquapin Village terrace**—Mostly a flat to gently sloping, poorly drained landscape. Typical surface elevation ranges from 185 to 200 feet, with the base being between 170 and 190 feet. Average thickness about 30 feet. Mostly consists of cobbles and pebbles in a matrix of orange loam (Tcg). Has distinct areas capped by heavy, clayey silt (Tcs) and sandy silt and loam (Tcl); the former is marked by relict swamp vegetation within a poorly drained landscape along the inboard edge of the terrace, whereas the latter has a pronounced fragipan. Prominent terrace remnants located on either side of Chinquapin Hollow at an elevation of 165-170 feet, and capped by identical clayey silt, are probably part of the same terrace, having been downthrown across the Fort Williams fault

Tefa, Tefl — **Fort Ward escarpment**—Consists of two distinct sections. The more robust southern section (Tefa) separates Seminary and Chinquapin Village terraces and is developed on the Arell clay. Steeper parts of this escarpment may be prone to slope failures due to the inherently unstable nature of the underlying clay. The northern section (Tefl) separates the Dowden and Chinquapin Village terraces in the Lucky Run drainage north of Shirley Highway. It consists of small, isolated erosional remnants developed on Lincolnia silty clay. Steepest sections are unstable and exhibit landslide scars

Tds, Tdg — **Dowden terrace**—The most extensive of the upland terraces, with an average surface elevation of 240-250 feet, locally approaching 260 feet at a few places. Base varies widely but is most commonly between 225 and 230 feet. Thickness generally 30-35 feet, but exceeds 60 feet near Shirley Highway. Composed chiefly of coarse gravel in a bright orange loamy matrix (Tdg). Large parts of the terrace surface are capped by dense clayey silt (Tds) up to 15 feet thick, with numerous poorly-drained swales and small swamps

Teva — **Varsity Park escarpment**—Separates Seminary and Dowden terraces. Developed on Arell clay, but appears to be fairly stable due to a relatively gentle slope and persistent cover of colluvial gravel

Tss, Tsg — **Seminary terrace**—Broad upland plain centered on the Episcopal Seminary. The summit of the Alexandria highlands, with an average surface elevation of 265-275 feet, locally exceeding 280 feet. Base ranges from 225-250 feet and is mostly at or above 240 feet. Composed chiefly of medium-coarse gravel in strong orange-brown heavy loam (Tsg), but the highest part is capped by heavy sandy silt that locally exceeds 10 feet in thickness and is very poorly drained. The adjacent 230-ft terrace remnant along Quaker Lane south of Seminary Road is likely to be the down-faulted southern extension of the Seminary terrace, based on apparent offset of 30-40 feet of the terrace base and similarity of the sediments

POTOMAC FORMATION (EARLY CRETACEOUS)

The Potomac Formation crops out or is within 30 feet of the surface almost everywhere in the map area west of the Old Town terrace, except where bedrock crops out. It is divided into 6 informal local members and 5 sub-members based on the dominant sedimentary features of each unit. All of these units were deposited in channels, floodplains, oxbows, and point bars associated with a large river system. Clayey units tend to be more resistant to erosion than sandy ones; they typically are fractured and high in expandable clay minerals, producing steep, unstable slopes, in contrast to longer, and commonly gentler slopes on sandy strata

Kpsh — **Shooters Hill gravel**—Medium-coarse, clayey sand, commonly very gravelly, derived from weathered arkosic sand and gravel. Forms a thin (<15 ft) erosional remnant beneath the southern end of the Beverley Hills terrace, and crops out poorly in a thin strip along adjoining hillsides between Ivy Hill Cemetery and the Masonic Temple

Kpa — **Arell clay**—Chiefly massive lacustrine clay, commonly mottled green and red in outcrop, and medium to dark green- or blue-gray below the water table. Typically hard and fractured, forms steep bluffs and hillsides with many prehistoric and modern landslide scars. The core of the unit ranges from 100-150 feet thick and commonly contains little, if any, sand. Small sandy zones are somewhat more common near contacts with other units. The clay unconformably overlies all other units except Shooters Hill gravel, but a lateral facies relationship to parts of the Chinquapin Hollow fine sandy clay cannot be ruled out

Kpch — **Chinquapin Hollow fine sandy clay**—Fine to very fine sandy clay, sandy and clayey silt, organic silt, and clayey fine sand, locally with lignite layers and many cypress fragments. These lithologies are interbedded in predominantly fining-upwards local sequences at a scale of inches, which causes exposures to commonly appear variegated in green and brown hues. Minimum thickness is 120 feet. Appears to unconformably overlie Winkler sand, Lincolnia silty clay, and parts of Cameron Valley sand, but field relations are obscure

Kpw — **Winkler sand**—Medium to coarse, locally pebbly, trough crossbedded, arkosic to quartzose sand. Feldspar is commonly weathered into clay. Cemented by purple hematite at some places. Forms a series of channel-like bodies in the Lincolnia silty clay, concentrated in a southwest-trending belt centered on Shirley Highway. Thickness typically 30-50 feet but locally exceeds 100 feet south of Seminary Road

Kpl, Kpb — **Lincolnia silty clay**—Massive to slabby-looking silty clay and clayey silt, locally somewhat sandy. Light gray-green where fresh, and red-brown where weathered, but locally variegated. Small to medium-sized lenses and channel-like bodies of fine to medium arkosic sand are moderately common. Thickness typically 50-60 feet but may exceed 100 feet in vicinity of Beauregard Street. Base of the unit contains the **Barcroft diamicton**, a thin, discontinuous(?) zone consisting of pebbles, cobbles, and boulders embedded in a dense, red-brown to green-gray, massive, clayey matrix with incipient soil horizonation and organic layers

Kpcv, Kpcc, Kpcg, Kpcs — **Cameron Valley sand**—Complex of channel sands, point bars, and overbank deposits. Lower part of unit (Kpcs) consists chiefly of medium, clayey, arkosic sand and weakly-cemented sandstone with scattered silt layers. At places (Kpcg), the lower portions of the unit contains gravelly sand interbedded with thin to moderately thick, light-colored silty clay beds. Large plugs of silty clay (Kpcc) occur along Four Mile Run near the base of the unit, and at higher horizons in Cameron Valley, some of which may be equivalent to the Lincolnia silty clay. Upper part of unit (Kpcv) consists of large bodies of channel sands interbedded with increasing numbers of silty-clay bodies of various sizes upward in the section. Total thickness ranges up to 125 feet at most places, except over parts of the Cameron and Four Mile Run bedrock valleys, where it exceeds 200 feet

CRYSTALLINE BEDROCK AND SAPROLITE

Fresh, hard bedrock crops out chiefly near the active floodway of the Holmes Run gorge, where stream action routinely strips off soil. The bedrock on the hillsides above the floodway and in the bottoms of tributary ravines is partially to entirely weathered into saprolite, a soft, clayey to loamy residual material that still retains recognizable textures and structures of the original rock, but is only about half as dense

Metamorphosed Intrusive Rocks

Oo — **Occoquon Granite** (early Ordovician). Coarse grained, well foliated, light gray muscovite-biotite monzogranite. In Holmes Run Gorge, the granite exhibits multiple foliations and is folded with the enclosing metasedimentary wallrocks

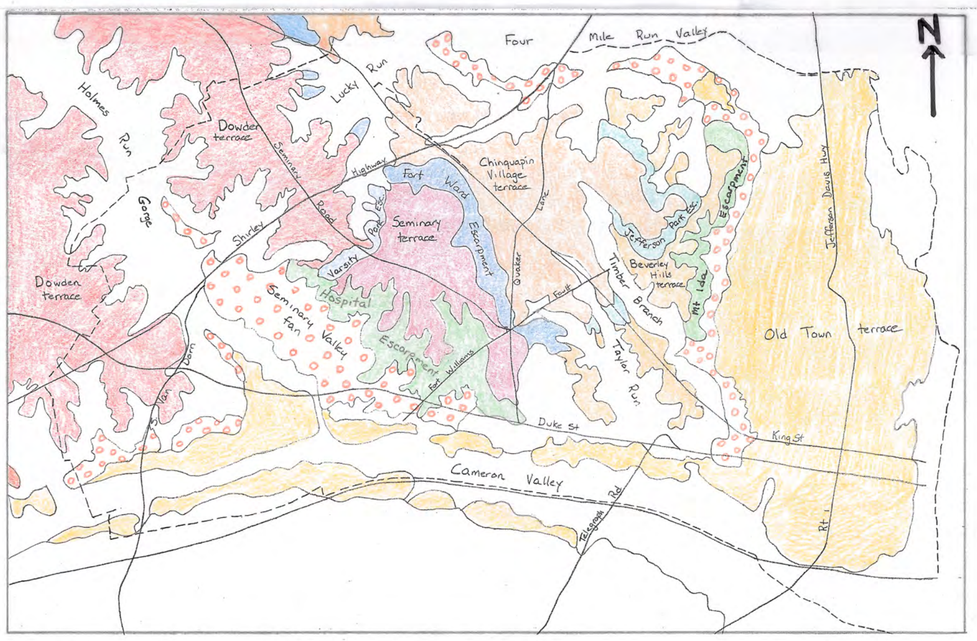
Of — **Falls Church Tonalite** (early Ordovician). Medium to coarse grained, dark gray, hornblende-biotite tonalite. The only exposure in the city is a small, well-foliated body in the mouth of the Rynex ravine on the west bank of Holmes Run, at the city limits

Om — **Muscovite monzogranite** (early Ordovician). Sugary textured to coarse grained, well foliated, white and light gray muscovite monzogranite. Within the city, it occurs only as small dikes in other rocks; a larger body crops out just upstream

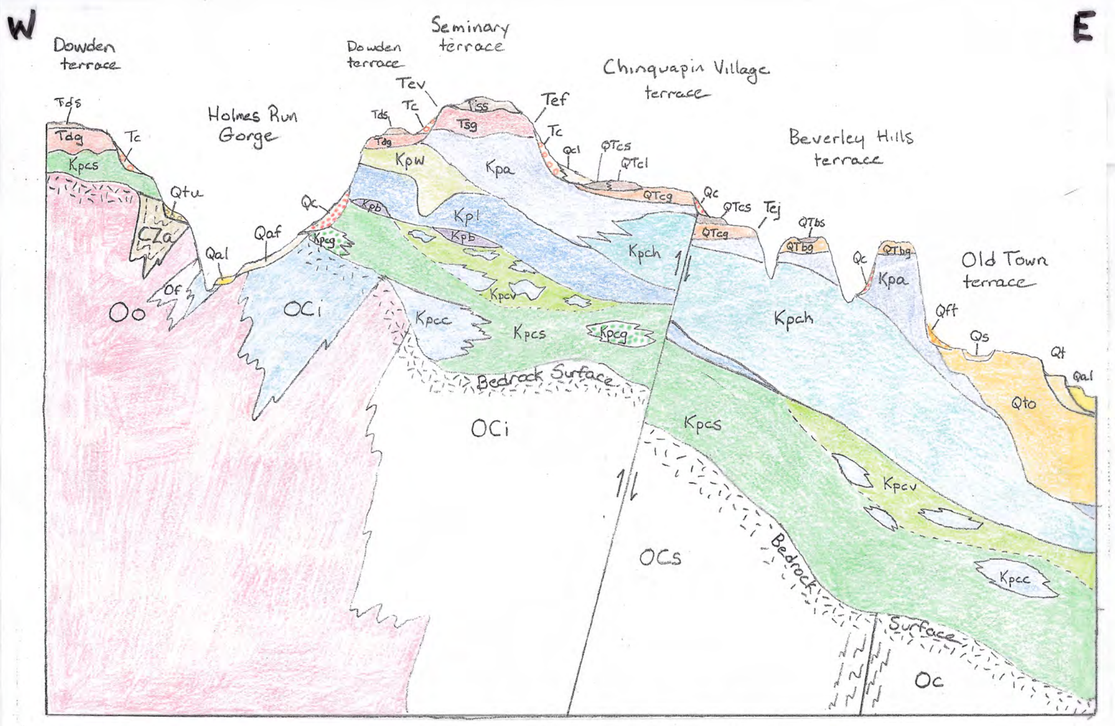
Metasedimentary Rocks

OCi — **Indian Run Formation** (Cambrian and early Ordovician). Sedimentary mélange characterized by scattered quartz pebbles and small mica schist "wafers", along with larger inclusions of Lake Barcroft metasandstone, Accotink Schist, felsic metavolcanic rocks, and rare mafic and ultramafic rocks, set in a medium grained, dark gray brown, massive to foliated quartzofeldspathic matrix with variable amounts of mica and garnet. Most of the rock exposed along Holmes Run upstream of Beauregard Street is inclusion-poor and is intruded by small bodies of Occoquon Granite; downstream of Shirley Highway, however, it contains abundant inclusions

CZl, CZa — **Annandale Group** (Cambrian or late Proterozoic). Crops out only minimally within the map area, and consists of two units. **Accotink Schist** (CZa) forms thin, highly folded bodies of quartz-mica-garnet schist engulfed in Occoquon Granite and Falls Church Tonalite between Holmes Run and the head of Rynex Natural Area. **Lake Barcroft Metasandstone** (CZl) comprises fine grained, light gray quartzitic metaarenite. It occurs as a swarm of xenoliths in Occoquon Granite just upstream of Shirley Highway, and as thin beds within the Accotink Schist



Inset 1. Simplified map identifying the major landforms in the map area



Inset 2. Schematic cross-section showing the relations of map units from west to east across Alexandria