U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Geologic map of the Coastal Plain and Upland Deposits, Washington West quadrangle, Washington, D.C., Maryland, and Virginia

by

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Open-File Report 90-654

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GEOLOGIC MAP OF COASTAL PLAIN AND UPLAND DEPOSITS IN WASHINGTON WEST 7.5-MINUTE QUADRANGLE, WASHINGTON, D.C., MARYLAND, AND VIRGINIA

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Introduction

The Washington West 7.5-minute quadrangle occupies the northeast corner of the Washington West 30x60-minute quadrangle, which is currently being compiled by the U.S. Geological Survey. The focus of 1:24,000-scale mapping within the larger area is new observations and evaluation of previous mapping. References to published maps and reports are given in the following sections. A report by Froelich and others (1980) is a comprehensive bibliography of geologic and hydrologic reports for land-use planning.

Geologic setting

The Washington West 7.5-minute quadrangle covers most of the city of Washington, D.C., and adjacent parts of Maryland and Virginia. The Fall Zone separates the Coastal Plain Physiographic Province to the southeast from the Piedmont Physiographic Province within the quadrangle. The Potomac River has cut a southeast-trending gorge in the southwestern part of the quadrangle, and is flanked by 3-15-m (10-50-ft) terraces south of Theodore Roosevelt Island. Rock Creek, a major tributary to the Potomac River in the north-central part of the map area, flows southward approximately parallel to the Fall Zone. Steep ravines and rounded hilltops characterize the Piedmont; relatively low-lying flat land with broad alluvial floodplains is typical of the Coastal Plain beneath downtown Washington, D.C.

Unconsolidated deposits of the Potomac River and precursor streams and estuaries as old as Early Cretaceous, overlie crystalline bedrock in the southeastern half of the map area. Some of the higher hills are capped by fluvial gravel of Miocene or Pliocene age. A single marine unit, the Calvert Formation of Miocene age, is present near the top of a few hills. Similar weathering characteristics, such as hardness of quartzite clasts, color of matrix, and depth of weathering (progressive alteration of minerals downward in a soil profile), were semiquantitatively estimated to delineate similar gravels. Elevation was used locally for correlation. Regionally, terrace deposits are much higher in Washington, D.C., and adjacent parts of Virginia and Maryland to the northeast than are terrace deposits inferred to be of the same age farther south in Maryland. All the gravel-bearing Tertiary and Quaternary deposits in the Washington West quadrangle were assigned ages by correlating them with units in southern Maryland (McCartan, 1989b, 1989c) on the basis of the same characteristics noted above.

Gravelly deposits presumably of Pleistocene age and fluvial and estuarine origin (units Q3 and Q5) underlie parts of Washington, D.C. Units Q4 and Q5 are present in the first two raised terraces west of the Potomac River at the southern edge of the map, and a narrow, discontinuous, Q4 terrace is present north of the Potomac River and west of Washington, D.C. Unit Q2 is absent from the Washington West 7.5-minute quadrangle but is present to the south. The presence of a broad Pleistocene terrace near the Fall Zone (unit Q5) indicates sea level somewhat higher than present sea level, judging from the limited distribution of Holocene deposits west of the Potomac and beneath artificial fill around and east of the tidal basin.

How the map was made

N.H. Darton (1947, 1950) compiled excellent maps of the sedimentary deposits and configuration of the bedrock surface in the Washington, D.C. area. He examined outcrops and also acquired lithologic logs from foundation borings and water wells. Darton's (1947, 1950) data, supplemented by water well data of Johnston (1964), metro rail system foundation boring logs (Mueser, 1967, 1969, 1970, 1972, and 1975), which were compiled by Froelich (1975) and Froelich and Hack (1975), were used as a basis for this map and for the cross sections. My contributions include subdividing the units of the gravel plains and terraces and assigning ages (Holocene - Miocene) to the units (Q1, Q3-Q5, TU1-TU4) based on stratigraphic position, correlation with units in southern Maryland and Virginia, and an assumption that older units have been uplifted more than younger units. In a few places, my field observations led to other changes in interpretations and in the locations of contacts. For example, I found a sandy yellow schist saprolite on Nebraska Avenue ridge, where Darton (1947) showed Calvert Formation. Medium- to coarse-grained sand with discoidal pebbles shown by Darton (1947) as Cretaceous Potomac Group on the east side of Wisconsin Avenue ridge is more likely to be basal Calvert Formation (Miocene).

Original extent of Coastal Plain deposits

Outcrops of the Potomac Group, Calvert Formation, and several other Coastal Plain units originally extended across the Piedmont far west of their present outcrops. By the end of Early Cretaceous deposition, the older Potomac Group beds had been uplifted and stripped from much of the Piedmont. Evidence for much of the stripping having occurred before the Late Cretaceous is the abundance of unstable minerals from Piedmont rocks in Upper Cretaceous and Cenozoic formations. However, the absence of shoreline facies corresponding to offshore marine facies in the Miocene to uppermost Upper Cretaceous formations indicates that the shoreline facies of these units have been removed. Therefore, these data suggest that the shoreline deposits of these units also extended far west of their present outcrop belt.

Age of the upland gravels

Ages of upland gravels are inferential and speculative in the map area. Theoretically, periods during which gravel accumulated in widespread deposits probably also gave rise to marine units. It is not reasonable to assume that the sediment carried by rivers stopped at the shoreline. Therefore, major gravel deposits are probably associated with marine facies.

In the map area, the oldest (highest, most weathered) gravel (TU4) overlies and is younger than the Calvert Formation. Unit TU4 gravel is more weathered than the best-dated gravel in southern Maryland, which is at the Brandywine site (McCartan and others, 1990). The Brandywine site is considered late Miocene age, either St. Marys or Eastover Formation, on the basis of a diverse flora. Of four Miocene formations, Calvert, Choptank, St. Marys, and Eastover, only the St. Marys and Eastover have significant amounts of gravel associated with the downdip, marine facies (McCartan and others, 1985; McCartan, 1989 c). Updip fluvial gravel deposits would be expected for the St. Marys Formation (upper Miocene) and the slightly younger Eastover Formation (upper Miocene). Comparing the Brandywine floral site gravel with the two highest gravels in Washington, D.C., it seems probable that unit TU4 is the fluvial facies of the St. Marys Formation, and unit TU3 is the fluvial facies of the Eastover Formation. The two lower, younger gravels in the map area are probably late Pliocene age, and they are correlated with the two other widespread gravels of southern Maryland. Unit TU2 is correlated with the Yorktown Formation (TUG3 and TUG4 of McCartan, 1989b, c), and the Bacons Castle Formation (Mixon and others, 1989). TU1 is correlated with the Ravens Crest Formation in southern Maryland (McCartan, 1989a; Park Hall Formation of McCartan, 1989b, c) and the Windsor Formation in Virginia (Mixon and others, 1989).

Effects of faulting and uplift on sedimentary units

The Potomac River is a tidal river as far upstream as Key Bridge. Modern estuarine deposits are present beneath the artificial fill in the vicinity of the Tidal Basin. The large, flat expanses of units Q3 and Q5 are mainly older estuarine deposits. These relatively young formations do not show the effects of faulting and uplift that is apparent in older formations. If older gravelly units with outcrops more than 0.5 (0.8 km) miles wide were deposited in estuaries, which in the case today in this area, and assuming that all such deposits originally have flat upper surfaces, then sloping upper surfaces on old estuary deposits may indicate tilting or differential uplift. Fluvial terrace deposits upstream of presumed estuary deposits could be expected to slope downstream, but the depositional slope would be accentuated by uplift of the western or landward side. The older gravelly units in Washington, D.C., are all at significantly higher elevations than inferred correlative units downstream. The elevation differences increase with age of the unit. For example, Recent deposits (unit Ql) are close to sea level everywhere along the tidal reach of the Potomac, but the upper surface of TU1 is 180 ft (54 m) in Washington, D.C., and 100 ft (30 m) in Charles County, 30 miles (48 km) south (McCartan, 1989b). Bed profiles of the Potomac River and its tributaries are convex upwards and at disequilibrium with respect to present sea level. Several studies have concluded that late Cenozoic uplift has occurred in the region (Higgins and others, 1974; Mixon and Newell, 1977; Reed, 1981; Newell, 1984; and Battiau-Queney, 1989).

Tertiary gravel units TU1, TU2, TU3, and TU4 are more continuous south of the Potomac River than to the north. The distribution of gravels to the north reflects the influence of the Rock Creek drainage, which has no counterpart just south of the Potomac River. Numerous faults and shear zones are exposed in crystalline rocks in Rock Creek gorge, and some of these basement faults offset the youngest Pliocene deposits (TU1) as well. Observed small faults, as well as faults inferred by offset stratigraphy, all have a west-side-up sense of displacement. Attitudes of three small faults just east of the National Zoo (vertical offset of gravel is 2-8 ft (0.7-2.5 m)), quoted from Darton's field notes in Prowell (1983), are N17°W, 68°SW; N28°E, 64°NW; N20°W, steep.

Hypothetical faults shown beneath Rock Creek in cross section B-B' are inferred to parallel the boundary between two thrust sheets emplaced in the Late Precambrian and Cambrian (A.A. Drake, Jr., USGS, oral comm., 1990). The north-northeast orientation of the hypothetical faults is bracketed by the orientations of the small faults that cut Pliocene deposits. The two sets of faults may be related.

A shear zone that coincides with a major lithologic boundary in the crystalline basement rocks is present in Glover-Archbold Valley. The shear zone probably originated in the Early Paleozoic (A.A. Drake, USGS, oral commun., 1990) but was remobilized at least once, during the Miocene. It may be the northern extension of the Stafford fault system (Mixon and Newell, 1977), which is also at the inner edge of the Coastal Plain and has the same, west-side-up, sense of displacement.

A fault that may be associated with the shear zone was exposed in an excavation southwest of the intersection of Van Ness and Wisconsin Avenues in 1989. Sheared crystalline rocks of several lithologies were exposed northwest of the fault. In the southeastern part of the excavation, about 10 ft (3 m) of unweathered, dark-greenish-gray clayey silt of the Calvert Formation yielded diatoms and silicoflagellates that indicate a latest early Miocene age (J.A. Barron and J.D. Bukry, USGS, written commun., 1990). Both the fossils and the lithology suggest a normal marine, shallow shelf environment of deposition with no indication of a nearby beach. The Calvert is absent from the Nebraska Avenue ridge, which is west of the Wisconsin Avenue ridge, although gravel (TU4) caps both ridges. The shoreline facies of the Calvert that was present west of Wisconsin Avenue has been completely removed by erosion. Medium-grained quartz sand with abundant discoidal quartz pebbles is present east of Wisconsin Avenue beneath silty fine-grained sand of the offshore facies of the Calvert. The discoidal pebbles suggest that this was a beach deposit. Its presence beneath the offshore Calvert suggests that it is the basal (transgressive) part of the Calvert, similar to the eroded shoreline deposits to the west.

I infer uplift and erosion of the Nebraska Avenue ridge along the Glover-Archbold fault after deposition of the Calvert Formation and prior to deposition of the TU4 gravel. The age of the Calvert is about 16 Ma (Andrews, 1988); the gravel of unit TU4 is inferred to be an updip equivalent of the St. Marys Formation, which is late Miocene, about 10 Ma (T.A. Gibson, USGS, oral commun., 1990). Therefore, the last documented movement on the Glover-Archbold fault probably occurred between 16 Ma and 10 Ma.

The combined thickness of the Potomac Group and the Calvert Formation on Wisconsin Avenue Ridge is 50 ft (15 m). Absence of the Calvert and Potomac Group from the Nebraska Avenue Ridge indicates that at least 50 ft (15 m) of vertical offset and erosion occurred between 16 Ma and 12 Ma. Faulting probably also accompanied the uplift and erosion of Upper Cretaceous and lower Cenozoic shallow marine and shoreline deposits. Open marine deposits of these ages are present just east and southeast of the map area.

Distinct from unequivocal river and estuary terrace deposits are thin patches of gravel present over much of the eastern two-thirds of the quadrangle; on slopes, sediment eroded from the edges of uplifted terrace deposits moves downhill, entraining weathered material from the underlying units. The resulting colluvium may be massive but commonly exhibits slope-parallel bedding. The distinction between colluvium and alluvium is hard to make in places. In some level areas, the gravel patches represent weathered erosional remnants of a river terrace; other level patches are lag deposits of Potomac Group sediments, vein quartz derived from crystalline saprolite, or colluvium from which finer interstitial grains have been removed. The main components are quartz and quartzite pebbles in a matrix of mixed sand and mud (silt and clay). Two characteristics of colluvium that are seldom shared by alluvium are the slope-parallel bedding and the unsorted combination of cobbles, pebbles, and sandy mud. Pebbly-mud colluvium on the sides of Normanstone Valley in northwest Washington, D.C., has been mistaken for Potomac Group sediment, for example (Darton, 1947). The pebbles in this colluvium were eroded from the Miocene gravel (TU4) on the Wisconsin Avenue ridge. The mud matrix is from the saprolite on the crystalline rock underlying the gravel.

Acknowledgements

I appreciate the help of several USGS colleagues: Anthony Fleming (USGS volunteer and Indiana Geological Survey), for guidance in the field and written field observations, especially in the vicinity of Wisconsin and Nebraska Avenues; A.J. Froelich, for his previous mapping, extensive personal knowledge of the geology of Washington, D.C., and vicinity, and for reviewing this map; A.A. Drake, for his discussion of the crystalline rocks and possible Late Cretaceous and Cenozoic faulting; G.S. Gohn, for his helpful review; and J.A. Barron and J.D. Bukry, for paleontologic analyses of the Calvert Formation sample.

References cited

Andrews, G.W., 1988, A revised marine diatom zonation for Miocene strata of the Southeastern United States: U.S. Geological Professional Paper 1481, 29 p.

Battiau-Queney, Yvonne, 1989, Constraints from deep crustal structure on long-term landform development of the British Isles and Eastern United States: Geomorphology, v. 2, p. 53-70.

Darton, N.H., 1947, Sedimentary formations of Washington, D.C., and vicinity: U.S. Geological Survey map, scale 1:31,680.

Darton, N.H., 1950, Configuration of the bedrock surface of the District of Columbia and vicinity: U.S. Geological Survey Professional Paper 217, 42 p.

Froelich, A.J., Hack, J.T., and Otton, E.G., 1980, Geologic and hydrologic reports for land-use planning in the Washington-Baltimore urban area: U.S. Geological Survey Circular 806, 26p.

Froelich, A.J., and Hack, J.T., 1975, Preliminary geologic map, District of Columbia: U.S. Geological Survey Open-File report 75-537, scale 1:24,000.

Higgins, M.W., Fisher, G.W., and Zietz, Isidore, 1974, Interpretation of aeromagnetic anomalies bearing on the origin of upper Chesapeake Bay and river course changes in the central Atlantic seaboard region: Geology, v. 2, p. 73-76.

Johnston, P.M., 1964, Geology and ground water resources of Washington, D.C., and vicinity: U.S. Geological Survey Water Supply Paper 1776, 97 p.

McCartan, Lucy, Blackwelder, B.W., and Lemon, E.M., Jr., 1985, Stratigraphic section through the St. Marys Formation, Miocene, at Little Cove Point, Maryland: Southeastern Geology, v. 25, p. 123-139.

McCartan, Lucy, 1989a, Atlantic Coastal Plain and basement tectonic southeast of Washington, D.C.: 28th International Geological Congress Fieldtrip Guidebook T214, 22 p.

McCartan, Lucy, 1989b, Geologic map of Charles County, Maryland: Maryland Geological Survey county geologic map series, scale 1:62,500.

McCartan, Lucy, 1989c, Geologic map of St. Marys County, Maryland: Maryland Geological Survey county geologic map series, scale 1:62,500.

McCartan, Lucy, Tiffney, B.H., Wolfe, J.A., Ager, T.A., Wing, S.L., Sirkin, L.A., Ward, L.W., and Brooks, J., 1990, Late Miocene floral assemblage from upland gravel deposits of the southern Maryland Coastal Plain: Geology, v. 18, p. 311-314.

Mixon, R.B., 1985, Stratigraphic and geomorphic framework of uppermost Cenozoic deposits in the southern Delmarva Peninsula, Virginia and Maryland: U.S. Geological Survey Professional Paper 1067-G, 53 p.

Mixon, R.B., Berquist, C.R., Newell, W.L., and Johnson, G.H., 1989, Geologic map and generalized cross sections of the Coastal Plain and adjacent parts of the Piedmont, Virginia: Sheet 1, Geologic Map: U.S. Geological Survey Miscellaneous Investigations map, I-2033, scale 1:250,000.

Mixon, R.B., and Newell, W.L., 1977, Stafford fault system: structures documenting Cretaceous and Tertiary deformation along the Fall Line in northeastern Virginia: Geology, v. 5, p. 437-440.

Mixon, R.B., Szabo, B.J., and Owens, J.P., 1982, Uranium-series dating of mollusks and corals, and age of Pleistocene deposits, Chesapeake Bay area, Virginia, and Maryland: U.S. Geological Survey Professional Paper 1067-E, 18p.

Muesser, Rutledge, Wentworth, and Johnston, General Soil Consultants, 1967, Final report--Subsurface investigation, Pentagon route (C002 to C007), Vol. II, Washington Metropolitan Area Transit Authority: U.S. Department of Commerce, National Technical Information Service, PB 179-654.

_______ 1969, Preliminary subsurface investigation for Washington Metropolitan Area Rapid Transit Adopted Regional System 1968, revised 1969: U.S. Department of Commerce, National Technical Information Service, PB 186-066.

_______ 1970, Final report--Subsurface investigation, L'Enfant -Pentagon route (L001 and L002), Washington Metropolitan Area Transit Authority: U.S. Department of Commerce, National Technical Information Service, PB 216-972.

_______ 1972, Final report--Subsurface investigation, Rockville route (A009 to A013), Washington Metropolitan Area Transit Authority: U.S. Department of Commerce, National Technical Information Service, PB 216-642.

_______ 1975, Final report--Subsurface investigation, Branch route (F004 to F008), Washington Metropolitan Transit Authority: U.S. Department of Commerce, National Technical Information Service, PB 249-773.

Newell, W.L., 1984, Architecture of the Rappahannock Estuary --Neotectonics in Virginia, in Morisawa, M., and Hack, J.T., eds., Tectonic Geomorphology: A proceeding volume of the 15th Annual Geomorphology series, p. 321-342.

Owens, J.P., and Denny, C.S., 1979, Upper Cenozoic deposits of the central Delmarva Peninsula, Maryland and Delaware: U.S. Geological Survey Professional Paper 1067-A.

Prowell, D.C., 1983, Index of faults of Cretaceous and Cenozoic age in the Eastern United States: U.S. Geological Survey Miscellaneous Field Studies map, MF-1269, scale 1:2,500,000.

Reed, J.C., Jr., 1981, Disequilibrium profile of the Potomac River near Washington, D.C.--A result of lowered base level or Quaternary tectonics along the Fall Line? Geology, v., 9, p. 445-450.

Shattuck, G.B., 1907, The geology of St. Marys County, in St. Marys County: Maryland Geological Survey, p. 67-112.

Zietz, Isidore, Gilbert, F.P., Kirby, J.R., Jr., 1978, Aeromagnetic map of Maryland, 1:250,000 scale.

EXPLANATION OF MAP UNITS

af — Artificial fill; heterogeneous composition and texture. Largest areas of low-lying land filled for building purposes, determined from historical topographic maps and Froelich and Hack (1975). Age is Holocene, less than 200 years.

Qcl — Colluvium; generally an unsorted mixture of pebbles in clayey sand or sandy clay; typically on slopes but may also be found on small hilltops. One strip of colluvium is well documented, between units Q3 and Q5 in downtown Washington, D.C. May be several feet (about 2 meters) thick. Age is Quaternary.

Q1 — Alluvium (Qal or Qh of other authors); gravel, sand, silt, and clay, gray to gray-brown. In stream bottoms and in crudely bedded, poorly sorted, unconsolidated deposits of floodplains; only larger deposits shown. Thickness quite variable, up to several feet (meters). Sediment derived from older terraces, colluvium, and saprolite, and from fresh crystalline rock. Predominantly quartz sand and silt, illite, and illite-smectite mixed layer clay; feldspar and immature heavy minerals such as hornblende, epidote, and chlorite are more abundant in Q1 than in older deposits. Age is Holocene.

Q3 — Gravel, sand, silt, and clay, gray brown, yellow, and pale orange; crudely to well bedded. Found mainly beneath Washington, D.C., under surfaces typically 35 ft (11 m) above sea level. Thickness 40-80 ft (13-26 m). The mineralogy is similar to that in unit Q2, but the unit is more deeply weathered. Correlates with Maryland Point Formation in southern Maryland (McCartan, 1989b, c), which in turn is correlated with the fossiliferous upper Pleistocene Nassawadox and Ironshire Formations (east of Chesapeake Bay; Owens and Denny, 1979; Mixon, 1985; Mixon and others, 1989), nad the Sedgefield member of the Tabb Formation in Virginia (Mixon and other, 1989), which are about 70 Ka.

Q4 Gravel, sand, silt, and clay, gray brown to medium orange; crudely to well bedded. Found in a terrace below a 50-ft (15-m) surface west of the Potomac River at Memorial Bridge. Unit Q4 is similar to Q3 except that Q4 has a higher surface elevation and is more deeply weathered. Where unit Q4 is unstripped, upper few feet (a meter or so) is yellow to medium orange due to accumulation of iron oxide derived from weathering of detrital iron-bearing minerals, such as ilmenite, hornblende, chlorite, garnet, and epidote. Thickness is estimated to be as much as 35 ft (110 m). The unit correlates with the Omar Formation (Owens and Denny, 1979; Mixon and others, 1982; and McCartan, 1989b, c) and the Shirley Formation (Mixon and others, 1989). Age is about 180 Ka, on the basis of a uranium-disequilibrium series date on a coral from the Shirley Formation at the Rappahannock River bridge west of Chesapeake Bay, is about 180 Ka.

Q5 Gravel, sand, silt, and clay, gray to gray-brown; crudely to well bedded. Found mainly beneath an irregular surface between 40 and 105 ft (13 and 32 m) in elevation that extends northward from the White House for about 2 miles (3.2 km). The mineralogy is similar to that of units Q3 and Q4 except that unit Q5 is more deeply weathered. Weathered sediment has been stripped from the surface by natural or artificial means in many places, so relatively fresh minerals are exposed. Unit Q5 correlates with the Chicamuxen Church Formation in Charles and St. Marys Counties, Maryland (McCartan, 1989b, c), and with Charles City and Chuckatuck Formations in Virginia (Mixon and others, 1989). Age estimated to be 450 Ka on basis of stratigraphic position and possible correlation with marine units in North Carolina.

Tcl Colluvium, unsorted gravel, sand, silt, and clay. Generally, sparse pebbles scattered in reddish-brown, clayey matrix. Similar to unit Qcl but generated during the Tertiary. Only the largest areas are shown, such as the east slope of Wisconsin Avenue ridge and southwest of the Potomac River.

TU1 Gravel, sand, silt, and clay, brownish-gray; medium-orange in upper part of deposit. Rounded pebbles and cobbles and coarse-grained sand are poorly to well sorted and deposited in crudely-defined parallel beds. Gravel clasts consists of several varieties of crystalline rocks, vein quartz, quartzite, red and brown sandstone, and minor chert. Silt and clay are interstitial and were probably introduced postdepositionally by infiltrating water. Clay minerals are mainly kaolinite and soil (dioctahedral) vermiculite. These clays reflect the long period of weathering of both feldspar at the source and the clay after it is introduced into the interstices. Weathered deposits may be to several feet (meters) depth. Rock fragments compose most of the sand. TU1 is present in areas north and south of the Potomac River beneath surfaces at an elevation of about 180′ (54 m). The unit correlates with the Ravens Crest Formation in Charles and St. Marys Counties (McCartan, 1989a; Park Hall Formation of McCartan, 1989b, c, is hereby abandoned), and the Windsor Formation in Virginia (Mixon and others, 1989). The age, based on projection from a pollen-bearing outcrop along the Potomac River in Charles County, is late Pliocene.

TU2 Gravel, sand, silt, and clay; pale-brown to medium-yellow; crudely bedded. Reddish-orange in upper unit. Gravel and sand are coarse; silt and clay are mainly interstitial, presumably emplaced postdepositionally. Clays are mainly kaolinite and soil vermiculite. Weathering has affected most of the deposit. Gravel includes several varieties of crystalline rocks, vein quartz, quartzite, red and brown sandstone and siltstone, and minor chert. Some clasts have desilicified and are friable. Sand is mainly quartz and some feldspar, and rock fragments. Unit TU2 is present mainly in two large areas north and south of the Potomac River. The age is late Pliocene, on the basis of stratigraphic position and correlation with the Bacons Castle (TUG4) and Yorktown Formation (which includes TUG3) in southern Maryland and Virginia (McCartan, 1989b, c; Mixon and others, 1989).

TU3 Gravel, sand, silt, and clay; crudely bedded. Colors are reddish-orange to pale-gray in upper part of unit, and pale- to medium-yellow below. Gravel and sand are coarse; silt and clay are mainly interstital, presumably emplaced postdepositionally or derived in place by alteration of minerals in detrital clasts. Clay is mostly kaolinite and soil vermiculite. Weathering has affected all of the deposit. Gravel clasts include several varieties of crystalline and sedimentary rocks, vein quartz, quartzite, and minor chert. Sand is mainly quartz. Most of the Piedmont crystalline and some of the quartzite clasts have weathered to the extent that only clay or a loose aggregate of original mineral grains remains. The age is late Miocene, on the basis of stratigraphic position and possible correlation with the Eastover Formation in southern Maryland (McCartan, 1989b, c; McCartan and others, 1990, see text).

TU4 Gravel, sand, silt, and clay, bleached white in upper part of deposit to pale orange below; crudely bedded. Gravel and sand are coarse; silt and clay are mainly interstitial, presumably emplaced postdepositionally or derived in place by alteration of minerals in detrital clasts. Clay is mostly soil vermiculite. Gravel clasts are mainly vein quartz, quartzite, and some red sandstone and mudstone. Other clasts may have disintegrated and now look like interstitial sand and clay. Most sand is quartzose. Weathering and leaching have effectively removed much of the iron from this deposit; this accounts for the pale colors throughout. The age is late Miocene, on the basis of stratigraphic position and possible correlation with St. Marys Formation in southern Maryland (McCartan, 1989b, c; McCartan and others, 1990).

Tc Calvert Formation (early and middle Miocene)--Dark-greenish-gray, clayey silt and fine-grained quartz sand, diatomaceous where fresh. Medium-yellow, silty, very fine-grained sand to tan, medium-grained sand or, in a few places, medium to coarse sand with discoidal quartz pebbles, where weathered. The Calvert is fresh in the map area only where ground-water flow has been impeded by clay and silt. Correlates with lower part of Calvert Formation (Shattuck, 1907, zone 3) exposed along Chesapeake Bay (J.A. Barron and J.D. Bukry, USGS, written communication, 1990). Found in beds a few feet (meters) thick just below gravel caps on a few hills along Wisconsin Avenue ridge, Foxhall Road, and east of Grant Circle.

Kp Potomac Group (Early Cretaceous), undifferentiated- Variegated gravel, sand, silt, and clay; more coarse-grained at base of unit and in sand- and gravel-filled lenses (channel fill) above; mainly fine-grained sand above basal beds. Unit is unconformable on crystalline basement rocks. Beds at or near the base reflect the composition of the underlying or adjacent basement rocks; that is, they contain feldspathic sand, smectitic clay, and clasts of crystalline rocks. Higher in the Potomac Group, the bulk composition tends to be orthoquartzitic (quartz sand and kaolinitic clay). The orthoquartzite beds were probably derived from erosion and reworking of older Potomac Group beds farther west. The three formations composing the Potomac Group in Maryland are not differentiated in the Washington West quadrangle.

CZ Crystalline metamorphic and igneous rocks and saprolite, undifferentiated. Age is Late Proterozoic to Cambrian (A.A. Drake, Jr., U.S.G.S., oral communication, 1990).

MAP SYMBOLS

Contact

+200 Generalized contours at base of Coastal Plain and upland deposits (Darton, 1947, 1950; Froelich and Hack, 1975; and new field observations); elevation in feet, datum is sea level.

D Observed steep reverse fault, map view, D on down-dropped side

U D Inferred steep reverse fault, map view, D on down-dropped side

Steep reverse fault, cross section, arrows showing relative motion

CORRELATION OF MAP UNITS

Stratigraphic Age				Fluvial & Estuarine	Marine	Crystalline	Colluvium	Artificial
Cenozoic	Quaternary	Holocene		Q1			Qcl	af
Cenozoic	Quaternary	Pleist.	late	Q3			Qcl	
Cenozoic	Quaternary	Pleist.	middle	Q4 Q5			Qcl	
Cenozoic	Tertiary	late Pliocene		TU1 TU2			Tcl	
Cenozoic	Tertiary	Miocene	late	TU3			Tcl	
Cenozoic	Tertiary	Miocene	middle	TU4			Tcl	
Cenozoic	Tertiary	Miocene	early		Tc		Tcl	
Mesozoic	Lower Cretaceous			Kp				
Proterozoic-Paleozoic (Cambrian)						ЄZ		