State of Delaware
DELAWARE GEOLOGICAL SURVEY
John H. Talley, State Geologist

REPORT OF INVESTIGATIONS NO. 69

GEOLOGY OF THE OLD COLLEGE FORMATION ALONG THE FALL ZONE OF DELAWARE

By

Kelvin W. Ramsey

University of Delaware
Newark, Delaware
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Front cover: The Old College Building on the University of Delaware campus sits on the crest of the alluvial fan of the Old College Formation. Photo is looking north. Elevation difference between street in the foreground and base of building is about 10 feet. The type section of the Old College Formation was a test boring (Ca45-113) for the building (McDowell Hall) seen at the far left of the photograph. Photo: K.W. Ramsey, Delaware Geological Survey

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GEOLOGY OF THE OLD COLLEGE FORMATION ALONG THE FALL ZONE OF DELAWARE

Kelvin W. Ramsey

ABSTRACT

This publication formally establishes the Old College Formation, a lithostratigraphic unit located along the Fall Zone of Delaware. It is named for sediments encountered in numerous drill holes on, and adjacent to, the Old College campus of the University of Delaware in Newark, Delaware. The Old College Formation consists of micaceous, brown to reddish-brown, fine to coarse sand with scattered gravelly sand overlain by sandy silt beds. The Old College Formation has a distinctive suite of abundant heavy minerals including sillimanite, staurolite, and magnetite. Provenance of the sand is local, derived from erosion of Piedmont rocks along and just to the west of the Fall Zone. The unit is the result of alluvial fan deposition on a pediment-like surface extending from the Fall Zone to the adjacent Coastal Plain. The Old College Formation is a surficial unit that overlies Piedmont saprolite, the Cretaceous Potomac Formation, and the Pleistocene Columbia Formation. No fossil data are available for the unit. Stratigraphic and geomorphic positions indicate that it ranges from 500,000 to 1,000,000 years old; slightly younger than the Columbia Formation.

INTRODUCTION

Geologists working at the University of Delaware in Newark, Delaware have observed over the years a reddish-brown micaceous sand in construction excavations on campus. Recent geologic mapping along the Fall Zone of Delaware showed that this sand was a distinctive stratigraphic unit that consists of micaceous, brown to reddish-brown, fine to coarse sand, and scattered gravelly sand and sandy silt beds. This publication formally names this geologic unit the Old College Formation. The Old College Formation was mapped along the Fall Zone from Newark, where it was first observed, to Wilmington. Detailed analysis of the Old College Formation consisted primarily of examination of samples and drill-hole data from the University of Delaware campus.

Knowledge of stratigraphic units is important for understanding the distribution of sand, silt, and clay bodies. These bodies control the distribution, transmission, and quality of ground water that is used for agricultural, public, and private supply, and industrial purposes. Understanding the nature and distribution of the Old College Formation, which underlies an increasingly urbanized area, will contribute to onsite analysis of engineering properties and infiltration and recharge of ground water where much of the area is covered by impervious surfaces.

Previous Work

Bascom and Miller (1920) completed the earliest detailed geologic map of the area along the Fall Zone of Delaware. For the most part, they mapped the area covered by the Old College and Columbia Formations as the Wicomico Formation. The Wicomico Formation was described as loam, sand, and gravel with boulders that occupied a terrace from 40 to 100 feet above sea level. Spoljaric (1972) recognized a unit along the Fall Zone that was different from the Columbia Formation. He (p. 21) described the deposits as "brown to yellow-brown sands, poorly sorted, cross-bedded … coarse to fine, contain large mica flakes, and on the average have about two percent clay matrix…. The sand grains are angular and of poor sphericity. The heavy mineral suite is dominated by magnetite… which comprises more than 45 percent of the assemblage." Spoljaric (1972) concluded that these deposits were laid down in alluvial fans that were post-Columbia in the area of their deposition but possibly contemporaneous with Columbia deposits farther to the south. He included the sediments with the Columbia Formation on a lithofacies map of Quaternary deposits (Spoljaric, 1972) on which the southern extent of alluvial fans was indicated. Woodruff and Thompson (1972, 1975) included these deposits as generic "Columbia Formation and Holocene sediments." They note that "Holocene deposits also include fresh, poorly sorted, micaceous sands and gravels in and near the Piedmont, derived mainly from underlying or nearby crystalline rocks" (Woodruff and Thompson, 1972, 1975).

Acknowledgements

Partial support of the mapping research was provided by grant 02HQAG0021 from the Statemap Program, a cooperative effort of the Association of American State Geologists and the U.S. Geological Survey, funded by Congress as a part of the National Geologic Mapping Act. C.R. Berquist, Jr., from the Virginia Division of Mineral Resources, and Peter P. McLaughlin, Jr., from the Delaware Geological Survey reviewed the manuscript. Lillian T. Wang and John C. Watson provided assistance with the map graphics.

DEFINITION OF THE OLD COLLEGE FORMATION, (herein named)

Stratotypes

Type Locality. The type locality of the Old College Formation is the Old College Campus of the University of Delaware (Fig. 1), specifically the area of McDowell and Willard Halls (across North College Avenue from Old College Building).

Unit Stratotype. Boring Ca45-113 (Fig. 1) was designated as the unit stratotype for the Old College Formation (Fig. 2; Appendix A). The upper boundary is the land surface. The lower boundary is the unconformity where the unit rests on saprolite of the Christianstead Gneiss.

Reference Section. Borehole Ca55-79 (Fig. 1) was chosen as a reference section for the Old College Formation to illustrate the stratigraphic expression of the unit. Borehole

Ca55-79 represents a section where the lower boundary of the Old College Formation is an unconformity between the Old College Formation and the underlying Potomac Formation (Fig. 3).

Geographic and Geomorphic Distribution

The Old College Formation is the primary surficial geologic unit that occurs in the Coastal Plain along the Fall Zone of Delaware from the Delaware-Maryland state line to the area between Elsmere and Newport west of Wilmington (Fig. 4). Its surface lies at elevations between 100 and 150 feet above sea level and is generally flat and gently sloping from the north to the south and southeast. The southern boundary roughly corresponds to a subtle break in topography between the surface of the Old College Formation at elevations above 100 feet and the surface of the Columbia Formation at elevations of 90 feet or less. Streams such as the Christina River and White Clay Creek flow along the margins of the unit. Other streams such as Little Mill Creek have almost their entire drainage basin on the Old College Formation (Fig. 4).

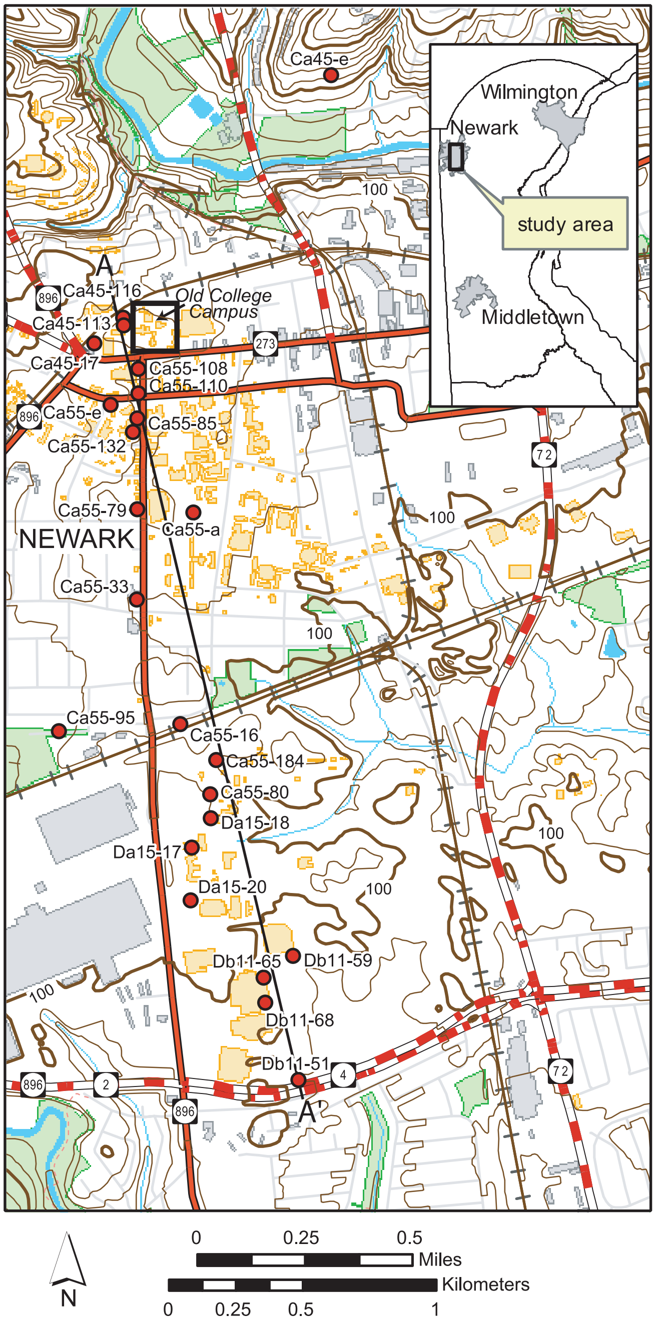

Figure 1. Map showing the type locality of the Old College Formation. The Old College Campus of the University of Delaware is outlined with a black rectangle. Red circles represent location of drill holes and outcrops cited in this report. A-A' is line of cross section shown in Figure 5. Yellow areas are buildings on the University of Delaware Campus. Basemap is U.S. Geological Survey topographic map layers from DataMIL Featureservice. Contour interval is 10 feet.

Stratigraphic Relationships

In the Newark area, the Old College Formation rests unconformably on the saprolite of the Christianstead Gneiss and to the northeast on the saprolite of the Windy Hills Gneiss. To the south, the Old College Formation unconformably overlies the Potomac Formation (Fig. 5). The relationship of the Old College Formation with the Columbia Formation is less clear. It appears to rest unconformably on the Columbia (Spoljaric, 1972) but may also interfinger with it. Gravels within the Old College Formation contain some chert pebbles that are most likely reworked from the Columbia Formation or from an older formation no longer present. There is no chert within the rocks of the source area (the Piedmont). Chert pebbles are a common constituent of the gravel fraction of the Columbia Formation.

Unit Description

The Old College Formation is typically a micaceous, reddish-brown to brown clayey quartz silt overlying a micaceous silty quartz sand to sandy quartz silt and a medium to coarse quartz sand with gravel. In places, a gray to grayish-brown sandy silt is present near the land surface. The sands of the Old College Formation are cross-bedded with laminae of muscovite or heavy minerals defining the cross-bed sets. The upper, silty beds tend to be structureless where bioturbated by roots.

The Old College Formation is a fining-upward unit. At its base, there is a gravelly bed ranging from 1 to 3 feet in thickness. This gravel is composed of pebbles that are generally less than an inch in diameter but may range up to cobble size. The clasts are mostly quartz, with lesser amounts of chert, sandstone, and metamorphic rock fragments. Above the gravel, the unit is a medium to coarse, micaceous, muddy sand that contains laminae of pebbles and thin beds of fine to medium, well-sorted, fluffy (loose) sand (Fig. 6). These sands are distributed in low- to high-angle cross-beds that are arranged in larger-scale cut-and-fill troughs (Fig. 7). The cross-bedding is commonly highlighted by heavy-mineral or micaceous laminae (Figs. 6, 7). The sand ranges from 5 to 25 feet in thickness. The sand fines upward into a sandy silt to silt that has scattered sand laminae. Commonly, the finer beds sharply overlie the sands, especially where the finer beds are gray to grayish brown (Fig. 8). The upper fine beds

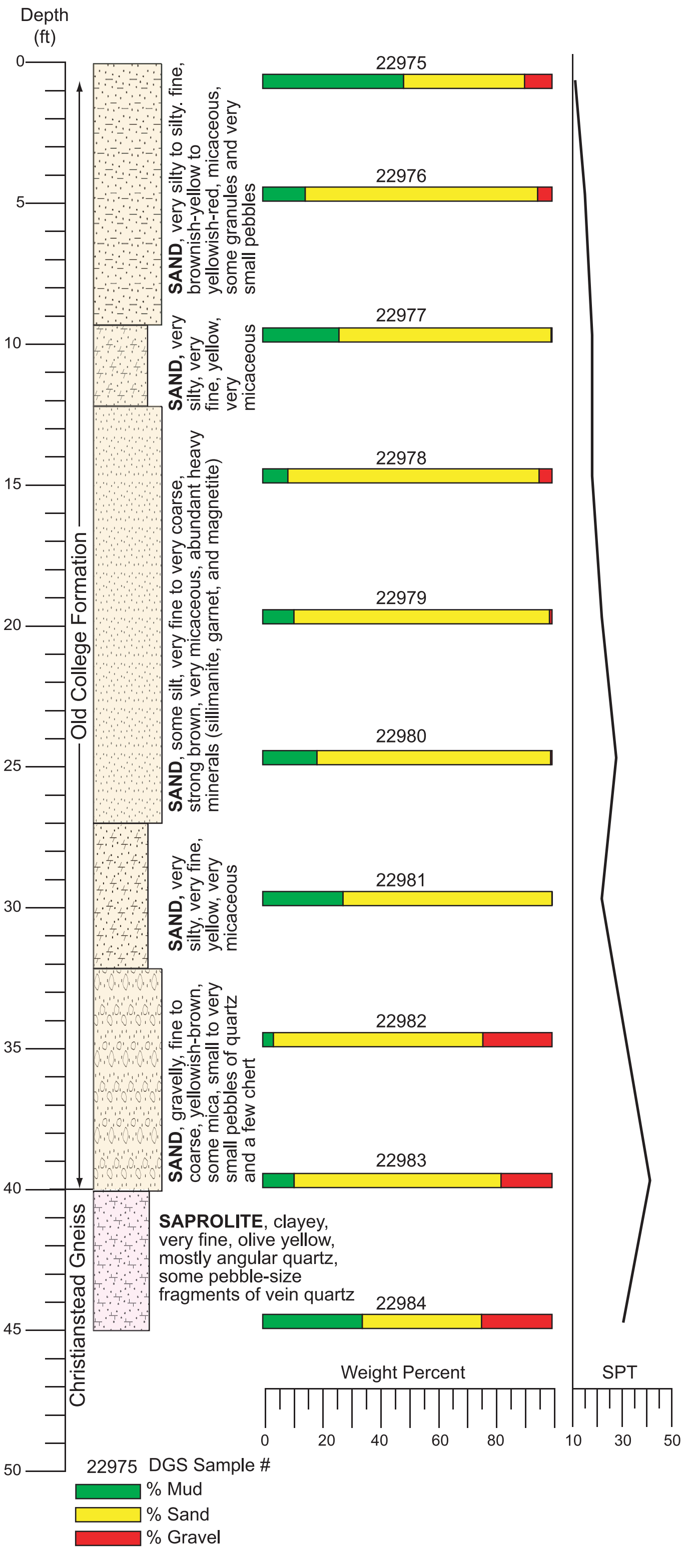

Figure 2. Type section (Ca45-113) for the Old College Formation located at McDowell Hall on the University of Delaware Campus. Refer to Appendix A for photographs of the samples. SPT is an abbreviation for standard penetration test, a test method for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance (blow counts) of the soil to penetration of the sampler.

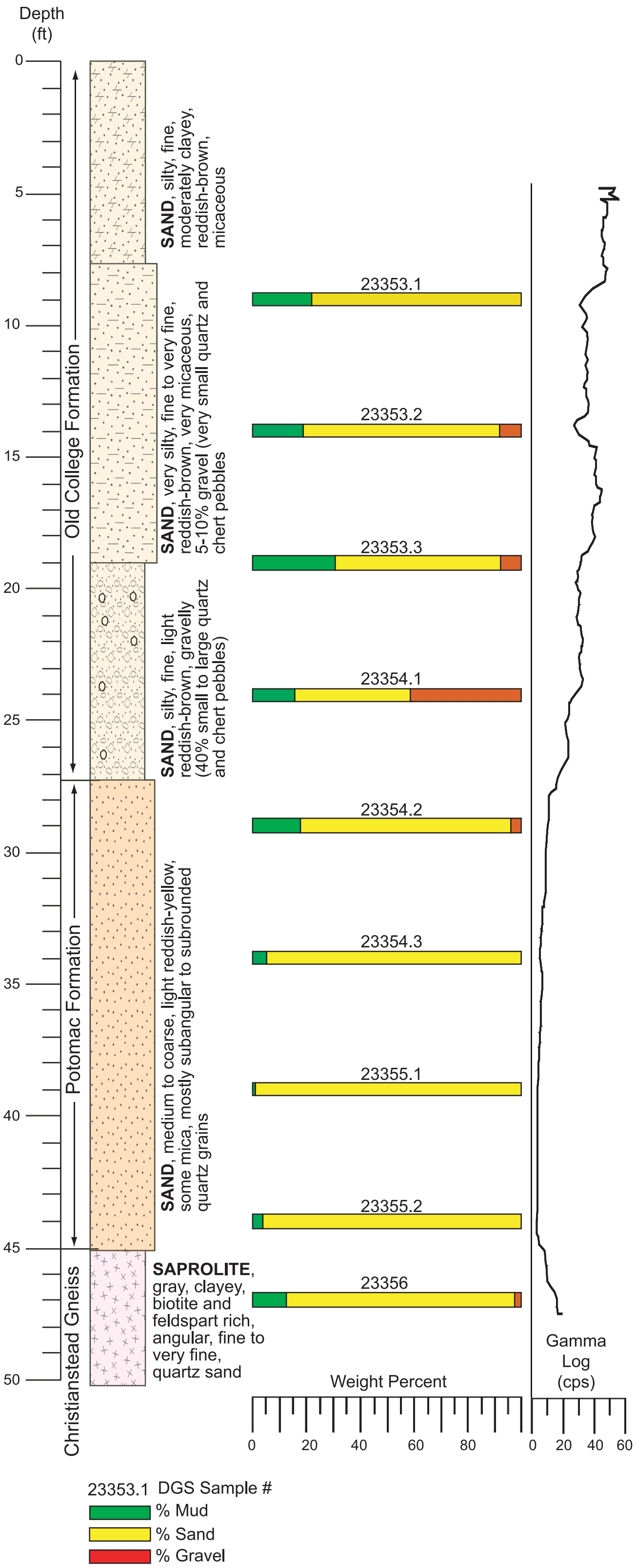

Figure 3. Reference section (Ca55-79) for the Old College Formation. CPS is an abbreviation for counts per second recorded during the collection of the gamma log. The gamma tool measures natural gamma radiation, which can be used as an indicator of the relative content of sand versus clay.

range from 5 to 10 feet in thickness. Variations in thickness of these strata are shown in cross-section (Fig. 5). Overall thickness of the formation ranges from less than 5 feet to 30 or 40 feet.

Grain-size distribution was determined through analysis of 137 samples for percentages of mud, sand, and gravel. A sample weighing approximately 100 grams was split and weighed to the nearest 0.01 gram. The sample was then placed in a ceramic dish with water and approximately a tablespoon of Alconox® was added to disaggregate mud and remove mud coatings from grains. The samples were left in the Alconox® solution for a period of 3 to 20 hours and stirred occasionally. The sample was then placed on a -1 phi (2 mm) sieve resting on a 4 phi (62.5 micron) sieve and washed until the water coming out of the 4 phi sieve was clear. The material on both sieves was then dried under heat lamps and weighed to the nearest 0.01 gram. The gravel and sand fractions were retained by the -1 phi sieve and the 4 phi sieve, respectively. The mud (silt and clay) fraction passed through the 4 phi sieve and was not retained. Weight percentages of mud, sand, and gravel were calculated and tabulated (Appendix B).

The Old College Formation can be characterized as a gravelly-muddy sand to muddy sand (Fig. 9). Those samples that lie in the sandy-mud to mud range come from the upper, fine-grained beds of the Old College Formation. Those samples that are muddy, sandy gravel are from the lower, coarse beds of the unit. For the most part, the mud fraction of the Old College Formation is silt rather than clay. The samples are not sticky when wet and tend to disaggregate rapidly when immersed in water. In general descriptions in this text, the sediments are described as silt or sandy silt rather than mud or sandy mud because the term mud is a less accurate description of the texture. Of the 137 samples, 84 were taken from cores and 53 from disturbed samples (augers and ditch; Appendix B). There appears to be little difference texturally between the two types of samples.

Washed samples from the textural analyses were examined under a binocular microscope and composition was described. The lithology of the unit is related to the local drainage area in the Piedmont from which the sediments were derived. The brown to reddish-brown sands are primarily quartz. Feldspar ranges from less than 1 percent to more than 15 percent, and mica (dominantly muscovite with lesser amounts of biotite) ranges from a trace to over 20 percent of the sand fraction. Rock fragments of metamorphic rocks are common, mostly schist composed of quartz and either sillimanite, muscovite, or biotite. Non-opaque heavy minerals include abundant sillimanite and staurolite (up to 50 percent for each) and lesser amounts of garnet, hornblende, kyanite, tourmaline, and zircon (unpublished DGS data). The opaque heavy minerals, characterized by magnetite, make up to 1 percent of the total sand fraction or 45 percent of the heavy-mineral fraction (DGS unpublished data; Spoljaric, 1972). Silty samples from near the land surface also contain abundant (less than one percent) to 20 percent charcoal fragments. Both light and heavy minerals indicate a source from the Piedmont adjacent to the outcrop area

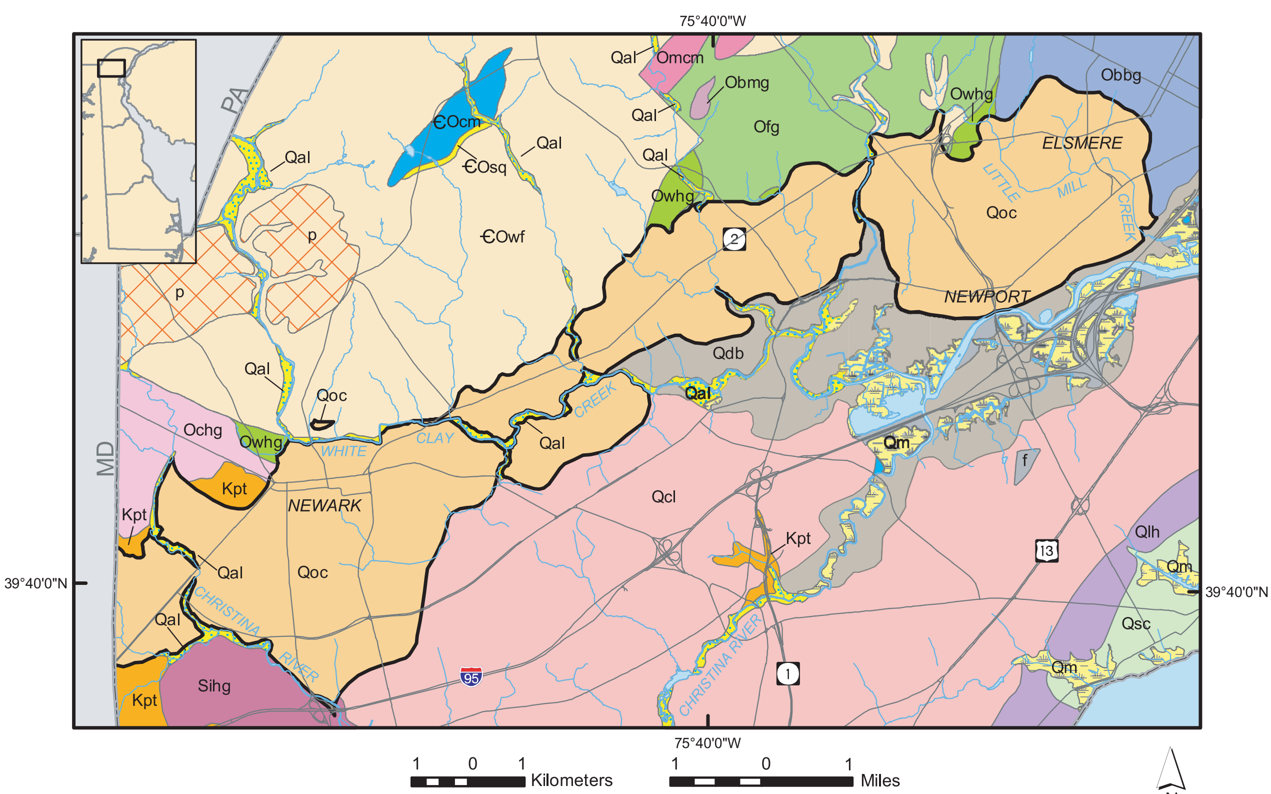

Figure 4. Geologic map showing the distribution of the Old College Formation (Qoc) in Delaware. Qal–alluvium, Qm–marsh, Qdb–Delaware Bay Gp. undifferentiated, Qlh–Lynch Heights Fm., Qsc–Scotts Corners Fm., Qcl–Columbia Fm., Kpt–Potomac Fm., Sihg–Iron Hill Gabbro, Ochg–Christianstead Gneiss, Owhg–Windy Hills Gneiss, Ofg–Faulkland Gneiss, Omcm–Mill Creek Gneiss, Obmg–Mill Creek Metagabbro, Obbg–Brandywine Blue Gneiss, ЄOwf–Wissahickon Fm., ЄOcm–Cockeysville Marble, ЄOsq–Setters Fm., p–pegmatite (from Ramsey, 2005; Schenck and others, 2000).

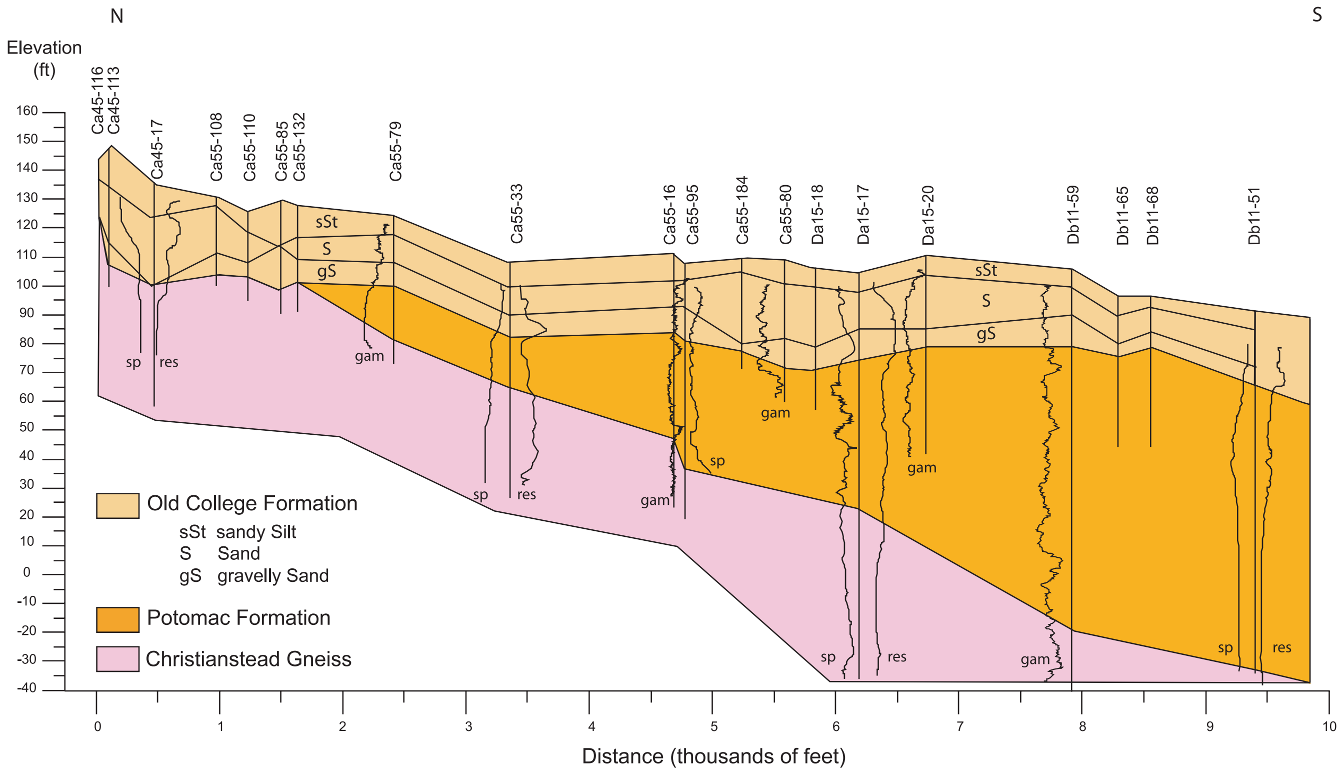

Figure 5. Cross section showing the stratigraphic position of the Old College Formation relative to the Potomac Formation and the Christianstead Gneiss. Borehole locations are shown on Figure 1. gam–natural gamma log, res–resistivity log, and sp–spontaneous potential log. Natural gamma can be used an an indicator of the relative content of sand versus clay. Resistivity reflects the fluid content of a formation, and spontaneous potential traces clay versus sand content.

of the Old College Formation (for Piedmont lithology and mineralogy refer to Schenck and others, 2000). Most of the sand grains are angular to subangular in shape; scattered subrounded grains are also present.

The color of the sediment appears to be the result of iron oxide staining on the grains that imparts a reddish tint. This characteristic also has been observed by the author as a common feature of samples from saprolite in the nearby Piedmont. Coarser grains (granules to very small pebble size) commonly have a black patina on part of their surfaces similar to that observed by the author on grains in modern stream sediments in the area. The abundance of angular and subangular grains indicates a short transport distance. The sediments of the Old College Formation look as if the local Piedmont rocks were crushed and the resulting fragments washed out onto the Coastal Plain.

Depositional Environment

Spoljaric (1972), interpreted the sediments (Old College Formation) as alluvial fan deposits. The fact that the sediments indicate a short transport distance, local provenance derived from the nearby Piedmont, and a gently sloping land surface away from the Piedmont, lend support to this interpretation. The alluvial fans were formed by transport and desposition of sediment derived from saprolite and bedrock along the Fall Zone. The alluvial fans were dominated by bed load rather than debris flow. There are few clasts in the Old College Formation that are above cobble size and sedimentary structures such as small-scale cross bedding are consistent with stream deposition.

The upper muddy part of the unit represents a shift in depositional style. The finer beds may represent overbank deposition or deposition in upland swamps or bogs as sediment supply to the fans waned. Charcoal in the finer beds indicates that vegetation growing on the fan was subject to periodic fires.

Age

No fossils other than pollen have been recovered from the Old College Formation. The pollen samples are from the upper muddy beds of the unit and represent a cool-temperate Quaternary climate. To date, the pollen have not been examined in detail and require further study before more specific conclusions regarding the age of the unit or climate during deposition of the unit can be determined. Stratigraphic relationships show that the Old College Formation is either younger than or contemporaneous with the Columbia Formation. Split spoon samples from some holes indicate that the Old College Formation sharply overlies the Columbia Formation. The Old College Formation contains a significant amount of mica and rock fragments that are minor constituents of the Columbia Formation. The Old College Formation contains chert pebbles that came from 1) reworking of the Columbia Formation, 2) pirating of an older, chert-bearing gravel, or 3) mixing from contemporaneous Columbia deposition.

Figure 6. Photograph of the Old College Formation at outcrop Ca55-a showing planar-bedded cross sets. Dark lines above and to the left and right of the shovel are heavy mineral laminae composed primarily of magnetite. Length of shovel head is approximately 8.5 inches. The outcrop was exposed during excavation for an addition to Alison Hall.

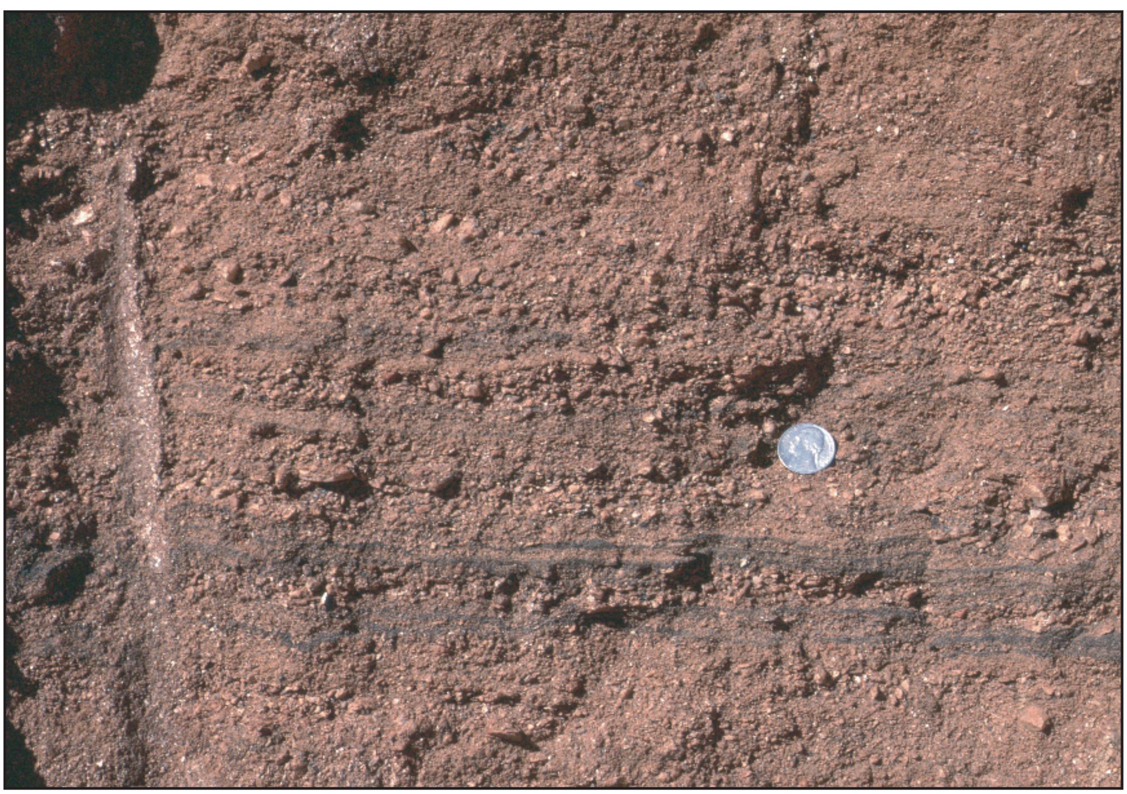

Figure 7. Closeup of coarser beds within the Old College Formation at Ca55-a showing interlaminated gravelly sand and coarse sand. Dark laminae are heavy minerals. Coin is 0.8 inch in diameter.

Figure 8. Outcrop Ca55-e showing the upper, silty sand beds overlying coarser gravelly sand beds. A sharp contact between the two lithologies is common in the Old College Formation. Approximate area covered by the photograph is 4 feet wide by 2 feet high. The outcrop was exposed during excavation for the Trabant University Center.

In the vicinity of Newark, the Old College Formation sits on a bedrock (saprolite) pediment-like platform that slopes gently to the south and southeast (Fig. 1). Ca45-e is an exposure of the Old College Formation on the north side of White Clay Creek (Fig. 1). The base of the Old College Formation, near its northernmost limit, ranges from 100 to 130 feet above present sea level or about 80 feet above the present level of the creek. This indicates that deposition of the unit occurred prior to the incision of the stream through bedrock to its current level.

Recent work on the incision history of the nearby Susquehanna River indicates several rapid downcutting events through bedrock over the last 100,000 years (Reusser and others, 2004). Incision rates of 0.2 to 0.5 meters per thousand years based on beryllium age dating of bedrock terraces have been determined for the Susquehanna. Using the lower rate of 0.2 meters per thousand years (or 1 meter per 5,000 years) for the much smaller White Clay Creek and a depth of approximately 30 meters of downcutting, a minimum age since initiation of downcutting is 150,000 years (approximately 30 meters at a rate of 5,000 years per meter). As Reusser and others (2004) state, it is probable that downcutting along the rivers was not steady but episodic with periods of rapid incision interspersed with periods of little to no incision during which the bedrock terraces were formed; therefore, 150,000 years is a minimum age for the Old College Formation.

The Old College Formation generally overlies, and is at least in part, younger than the Columbia Formation. Unfortunately, the age of the Columbia Formation is not precisely known; it is estimated to be younger than 2.1 million years (the start of the Pleistocene) and older than about 300,000 to 400,000 years old, which is considered to be the age of the Lynch Heights Formation (Ramsey, 1997). Ramsey (1997) considered the Columbia Formation to be between 500,000 and 1,000,000 years old based on the glacial record of the northeastern United States. If the Old College Formation is roughly contemporaneous with the Columbia Formation, then it too is likely older than 500,000 years.

Discussion

The Old College Formation represents a series of alluvial fans that spread out from the Fall Zone between 500,000 and 1,000,000 years ago. Figure 10 is a schematic illustration of the area around Newark before, during, and after deposition of the Old College Formation (Figs. 10A – 10C, respectively). During deposition of the Old College Formation, an ancestral White Clay Creek had its headwaters in the Piedmont and flowed south to southeast. The stream was likely choked with sediment eroded from the saprolite of the adjacent Piedmont located in the White Clay Creek watershed. These sediments were deposited as a series of alluvial fans across a pediment-like surface on the Christianstead Gneiss and on the updip limit of the Potomac Formation. To the south, the stream reworked sediment from the Columbia Formation at its depositional limit and incor-

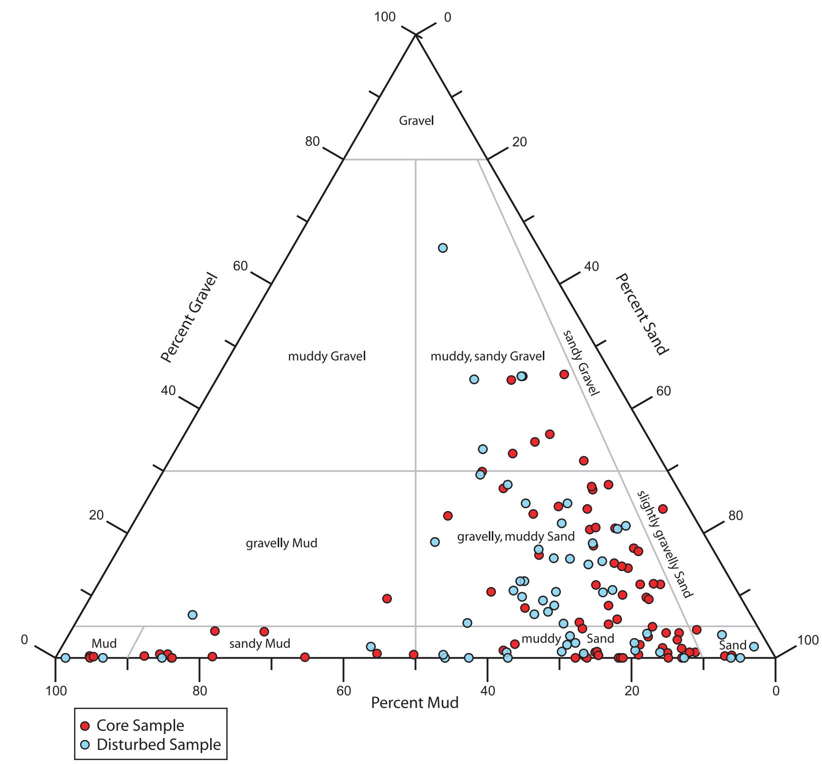

Figure 9. Triangular plow showing mud, sand, and gravel percentages of 84 core samples and 53 disturbed samples (augers and ditch) from the Old College Formation. Data are shown in Appendix B. Lithologic terminology is from Lewis, 1984.

porated it into the Old College Formation. The final stages of deposition were characterized by finer sediment in the form of sandy silts in overbank, swamp, and possibly bog environments. The area was probably forested and subject to periodic fires as indicated by charcoal incorporated into the sediment.

It is unknown what factors led to the generation of these alluvial fans. Most likely, a change to a wetter climate initiated a period of downcutting of the streams into saprolite along the Fall Zone. These sediment-choked streams transported the sediment out onto the edge of the Coastal Plain. At that time, an integrated incised stream valley network in the Coastal Plain did not exist to localize the sediment in stream valleys. As a result, deposition occurred in alluvial fans that blanketed the area.

After deposition of the Old College Formation, a drainage network developed on the Coastal Plain that integrated the drainages coming out of the Piedmont and the surface of the Old College and Columbia Formations. The area was subject to one or more periods of downcutting that were associated with glacial periods and sea-level lowering, which resulted in incision of the streams in the Coastal Plain. Reusser and others (2004) attribute bedrock incision of the Susquehanna and Potomac rivers to a sea-level drop associated with the onset of glaciation and increased runoff associated with increased frequency and magnitude of snowmelt events. The streams tended to follow a path along the topographically lowest areas adjacent to where they came out of the Piedmont. In the Newark area, White Clay Creek took a path to the north and west of the crest (highest area) of the alluvial fan of the Old College Formation along the Piedmont-Coastal Plain boundary (Fig. 10C). An unnamed tributary to White Clay Creek formed along the downslope margin of the Old College Formation to the east of Newark (Figs. 4, 10C). Streams along escarpments are a common feature in the Coastal Plain of Delaware (Ramsey, 1997) where ground-water flow out of the toe of the escarpment provided a source of water for stream formation. In this case, the escarpment is the toe of the alluvial fan, rather than an estuary-margin scarp (Ramsey, 1997). The Christina River followed a path around the southern margin of the alluvial fan of the Old College Formation and then between the downslope margin of the alluvial fan and a topographically high area of the Columbia Formation found to the east of the area of this report. Once the steep stream valleys were incised, erosion and deposition during repeated glacial periods were restricted to these stream valleys.

Modern stream deposits along White Clay Creek at the Fall Zone observed by the author are similar to those of the Old College Formation. One difference is that the modern sediments tend to be white to yellowish-brown rather than the brown to reddish-brown colors of the Old College Formation. The reddish colors may indicate soil forming processes of an extended period of time acting on the Old College Formation.

Conclusions

This publication formally establishes the Old College Formation. More details will be available as future geologic mapping increases knowledge of the extent and general lithologic properties of the Old College Formation. Many other interesting questions remain to be investigated. The location of the unit along the Fall Zone offers the potential for insight into the long-running geologic debate whether the Fall Zone is a structural feature created by a series of faults, or is merely a geomorphic boundary. If the age of the unit can be more precisely determined, a great deal could be learned about the Quaternary geomorphic history of the region and the timing of incision of the major streams in the Piedmont and Coastal Plain.

On the more practical side, studies of water infiltration rates into the Old College Formation may be of benefit, especially considering that it underlies an urbanized area and overlies the updip limit of the Potomac Formation and may be a major contributing pathway of water into the aquifers contained within the Potomac. Hydrogeologic studies may also aid in understanding potential pathways of present and future contaminants and help with design of clean-up or mitigation of pollutants. Likewise, studies of the engineering properties of the sediments of the Old College Formation will aid in designing structures built in this highly urbanized area.

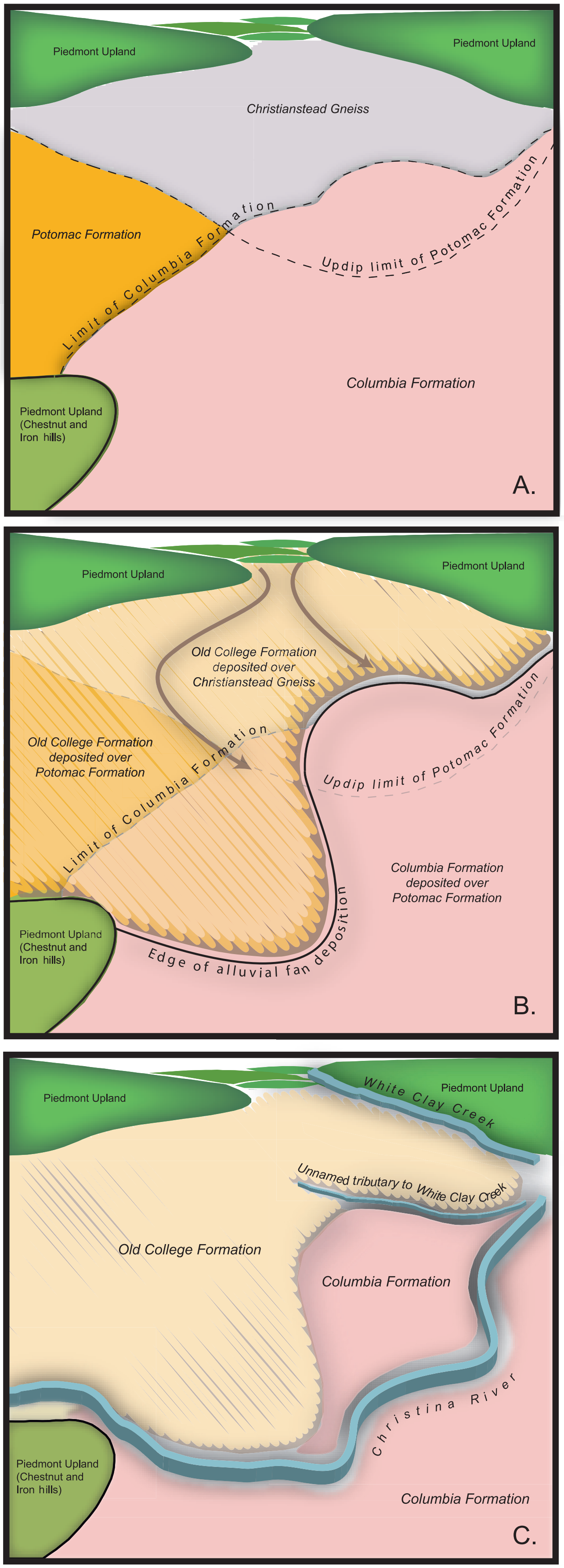

Figure 10. Diagram of the Newark area before (A), during (B), and after (C) deposition of the Old College Formation.

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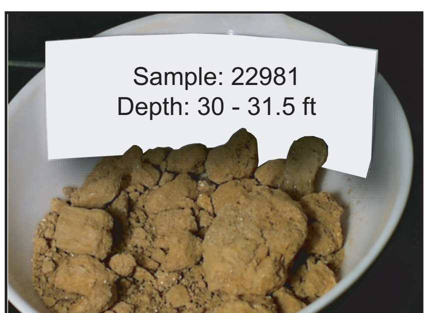
APPENDIXES

APPENDIX A. Photographs of unwashed samples from Ca45-113, type section of the Old College Formation. Samples are from split spoon cores.

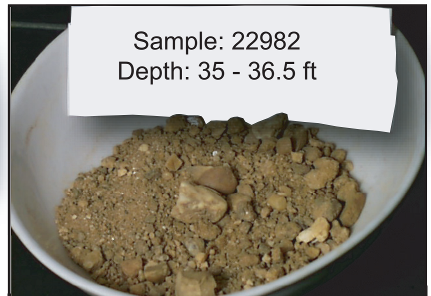
SAND, very silty to silty, fine, brownish-yellow to yellowish-red, micaceous, some granules and very small pebbles

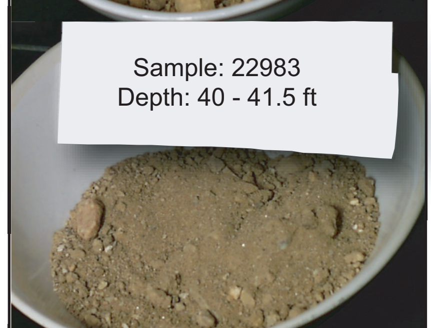
SAND, very silty, very fine, yellow, very micaceous

SAND, some silt, very fine to very coarse, strong brown, very micaceous, abundant heavy minerals (sillimanite, garnet, magnetite)

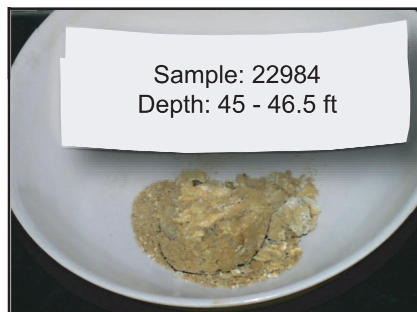


SAND, very silty, very fine, yellow, very micaceous





SAND, gravelly, fine to coarse, yellowish-brown, some mica, small to very small pebbles of quartz and a few chert



SAPROLITE, clayey, very fine, olive yellow, mostly angular quartz, some pebble-size fragments of vein quartz

APPENDIX B. Data for samples collected from the Old College Formation. Percent mud, sand, and gravel are plotted on Figure 9. Location map showing sites from which samples were obtained is shown on page 15. Core samples are shown on pages 12 and 13. Auger and ditch samples are shown on pages 14 and 15.

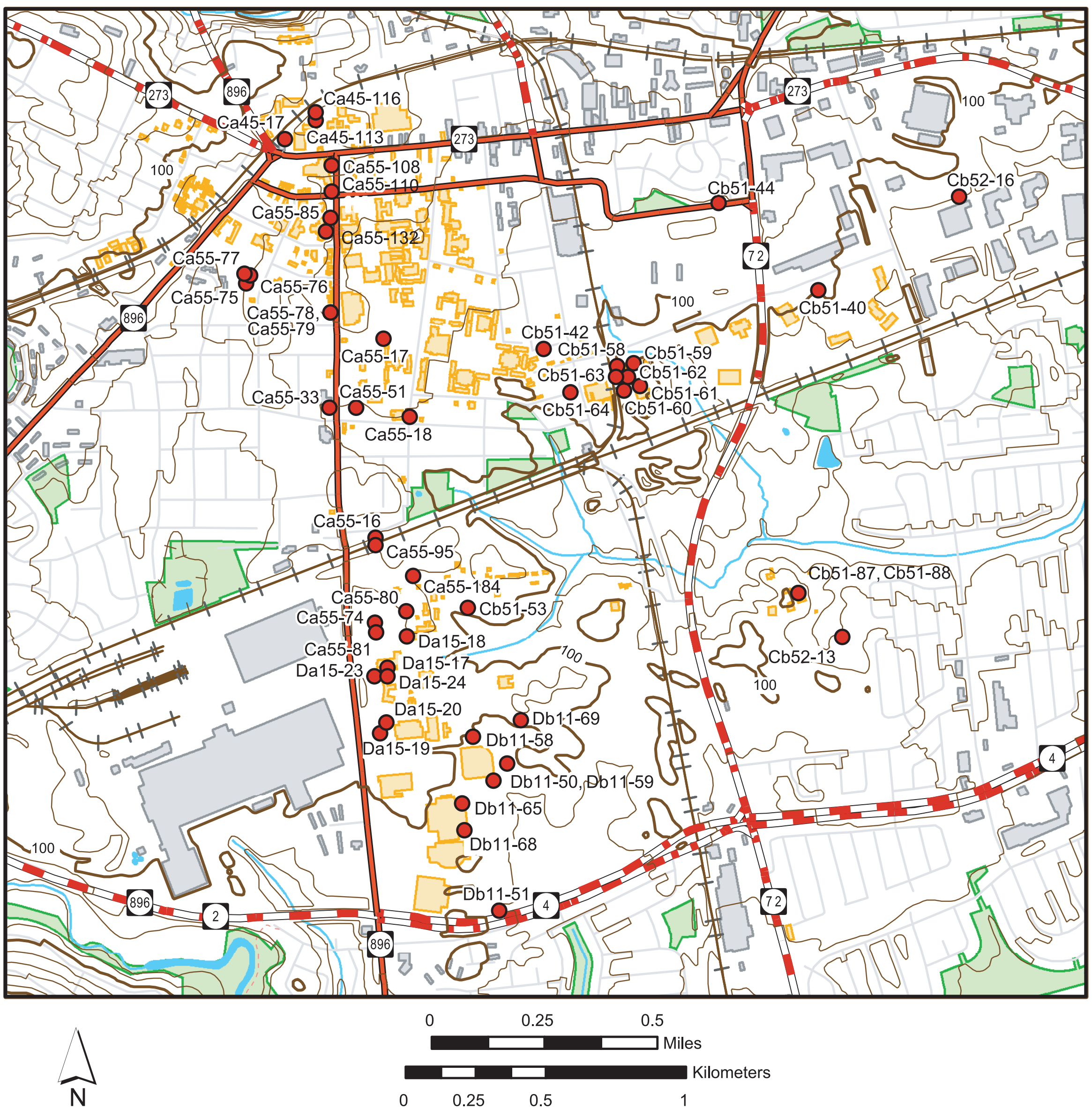
Sample Number	DGSID	Depth to Top of Sample (ft)	Depth to Bottom of Sample (ft)	Percent Mud	Percent Sand	Percent Gravel
22848	Ca55-51	6.0	6.5	24.2	48.6	27.2
22849	Ca55-51	5.0	5.5	75.7	20.0	4.3
22851	Ca55-51	15.0	16.5	6.9	92.8	0.3
22975	Ca45-113	1.0	2.5	49.2	41.3	9.5
22976	Ca45-113	5.0	6.5	14.6	80.4	5.0
22977	Ca45-113	10.0	11.5	26.4	73.3	0.3
22978	Ca45-113	15.0	16.5	8.7	86.8	4.5
22979	Ca45-113	20.0	21.5	10.7	88.4	0.9
22980	Ca45-113	25.0	26.5	18.8	80.7	0.5
22981	Ca45-113	30.0	31.5	27.8	72.2	0.0
22982	Ca45-113	35.0	36.5	3.7	72.4	23.9
22983	Ca45-113	40.0	41.5	10.9	71.5	17.6
23300	Ca55-75	9.5	10.5	83.9	16.1	0.0
23301	Ca55-75	19.5	20.0	13.4	50.7	35.9
23304	Ca55-77	14.5	16.0	35.1	62.7	2.2
23306	Ca55-76	9.5	10.5	24.4	69.9	5.7
23307	Ca55-76	14.5	15.5	34.1	43.1	22.8
23309	Ca55-78	9.5	11.0	18.9	74.9	6.2
23310	Ca55-78	14.0	15.5	14.2	61.9	23.9
23311	Ca55-78	19.0	20.5	22.1	54.8	23.1
23314	Ca55-80	9.0	10.5	24.6	74.5	0.9
23315	Ca55-80	14.0	15.5	16.2	73.7	10.1
23316	Ca55-80	19.0	20.5	11.4	84.6	4.0
23317	Ca55-80	24.0	25.5	14.9	83.5	1.6
23346.1	Da15-18	14.0	15.5	12.2	84.9	2.9
23346.2	Da15-18	29.0	30.5	11.9	61.1	27.0
23346.3	Da15-18	34.0	35.5	9.3	62.9	27.8
23347	Da15-18	9.0	10.5	16.3	65.7	18.0
23348	Da15-18	19.0	20.5	5.9	93.7	0.4
23349	Da15-18	24.0	25.5	10.1	78.1	11.8
23353.1	Ca55-79	9.0	10.5	21.8	78.2	0.0
23353.2	Ca55-79	14.0	15.5	19.0	72.6	8.4
23353.3	Ca55-79	19.0	20.5	30.8	61.2	8.0
23357.1	Cb51-53	9.0	10.0	17.8	80.1	2.1
23357.2	Cb51-53	14.0	15.0	21.5	78.5	0.0
23357.3	Cb51-53	19.0	20.5	87.3	86.4	0.9
23358.1	Cb51-53	24.0	25.5	13.1	77.2	9.7
23359.1	Ca55-74	0.0	5.0	85.2	14.2	0.6
23359.2	Ca55-74	14.0	15.5	15.5	63.9	20.6
23359.3	Ca55-74	25.5	26.5	11.8	60.7	27.5
23359.4	Ca55-74	29.5	30.5	6.6	47.9	45.5
23360.2	Ca55-81	19.5	20.5	24.3	74.7	1.0
23364	Cb51-58	0.0	1.5	95.1	4.6	0.3
23365	Cb51-58	4.0	5.5	24.5	70.9	4.7
23368	Cb51-58	19.0	20.5	12.5	42.3	45.2
23373	Cb51-59	0.0	1.5	87.5	12.2	0.3

APPENDIX B (cont).

Sample Number	DGSID	Depth to Top of Sample (ft)	Depth to Bottom of Sample (ft)	Percent Mud	Percent Sand	Percent Gravel
23374	Cb51-59	4.0	5.5	18.0	57.7	24.3
23375	Cb51-59	9.0	10.5	14.5	64.5	20.9
23376	Cb51-59	14.0	15.5	20.1	47.1	32.8
23377	Cb51-59	19.0	20.5	14.4	41.0	44.6
23382	Cb51-60	0.0	1.5	95.2	4.8	0.0
23383	Cb51-60	4.0	5.5	24.6	58.9	16.5
23384	Cb51-60	9.0	10.5	11.9	63.3	34.8
23391	Cb51-61	0.0	1.5	84.1	15.3	0.6
23392	Cb51-61	4.0	5.5	19.1	69.2	11.7
23400	Cb51-62	0.0	1.5	94.7	5.2	0.2
23401	Cb51-62	4.0	5.5	55.0	44.3	0.7
23402	Cb51-62	9.0	10.5	16.1	49.3	34.7
23403	Cb51-62	14.0	15.5	14.8	70.0	15.2
23404	Cb51-62	19.0	20.5	25.8	44.3	29.9
23508	Da15-19	10.0	11.0	83.8	16.2	0.0
23509	Da15-19	20.0	21.1	68.9	26.9	4.2
23510	Da15-19	21.1	21.5	24.4	75.2	0.4
23511	Da15-19	30.0	31.0	37.2	61.6	1.2
23513	Da15-20	10.0	11.5	78.1	21.7	0.2
23514	Da15-20	20.0	21.0	14.6	84.6	0.8
24660	Cb51-64	20.0	21.0	11.9	67.3	20.8
24661	Db11-58	9.0	10.5	34.2	55.2	10.6
24662	Db11-58	14.0	15.5	20.5	74.1	5.4
27676.1	Cb51-87	1.2	1.6	26.2	73.8	0.0
27676.2	Cb51-87	2.0	2.4	12.9	77.7	9.4
27677.1	Cb51-87	4.2	4.4	12.9	75.3	11.8
27677.2	Cb51-87	5.1	5.5	16.0	80.6	3.4
27679	Cb51-88	5.3	5.7	13.2	82.8	4.0
27680	Cb51-88	10.0	10.8	13.3	72.3	14.4
27681	Cb51-88	16.6	17.0	14.9	85.1	0.0
27682	Cb51-88	22.6	22.8	13.0	87.0	0.0
27683	Cb51-88	26.0	26.5	12.3	86.2	1.5
27684	Cb51-88	30.6	30.9	11.5	87.6	0.9
27685	Cb51-88	35.1	35.3	10.5	72.4	17.1
27690	Db11-69	4.0	4.3	65.3	34.6	0.1
27691	Db11-69	7.8	8.1	21.2	78.8	0.0
27692	Db11-69	11.4	11.8	14.0	71.3	14.7
27693	Db11-69	15.1	15.5	11.0	77.1	11.9

Sample Number	DGSID	Depth to Top of Sample (ft)	Depth to Bottom of Sample (ft)	Percent Mud	Percent Sand	Percent Gravel
30044	Ca55-17	15.0	19.0	16.5	58.7	24.8
30045	Ca55-17	29.0	34.0	17.2	71.9	10.9
30046.1	Cb52-13	32.0	37.0	11.6	67.7	20.7
30050	Ca55-18	19.0	24.0	31.0	58.2	10.8
30051	Ca55-18	29.0	34.0	18.9	79.9	1.2
32011	Cb52-16	0.0	10.0	2.1	96.1	1.8
32012	Cb52-16	10.0	20.0	4.9	95.1	0.0
32013	Cb52-16	20.0	25.0	12.7	87.3	0.0
32014	Cb52-16	25.0	30.0	6.2	93.8	0.0
33743	Ca55-51	5.0	10.0	26.3	44.3	29.4
33744	Ca55-51	20.0	25.0	15.6	83.5	0.9
37136	Db11-50	0.0	5.0	27.9	70.0	2.1
37137	Db11-50	5.0	10.0	26.6	71.0	2.4
37138	Db11-50	10.0	15.0	16.2	65.4	18.4
37139	Db11-50	15.0	20.0	20.6	63.5	15.9
37140	Db11-50	20.0	25.0	26.7	67.8	5.5
37514	Cb51-42	10.0	15.0	28.7	58.9	12.3
37515	Cb51-42	15.0	20.0	22.8	61.2	16.0
37516	Cb51-42	20.0	25.0	27.7	63.1	9.2
37521	Db11-51	5.0	10.0	26.8	69.7	3.5
37522	Db11-51	10.0	15.0	15.9	80.2	3.9
37523	Db11-51	15.0	20.0	18.4	79.2	2.4
37528	Da15-17	5.0	10.0	22.3	52.9	24.8
37529	Da15-17	10.0	13.0	30.0	63.0	7.0
37530	Da15-17	13.0	15.0	29.2	69.8	1.0
37531	Da15-17	15.0	16.0	26.3	73.0	0.7
37532	Da15-17	15.0	20.0	24.2	58.4	17.4
37533	Da15-17	20.0	26.0	12.7	42.1	45.2
37534	Da15-17	26.0	30.0	23.9	42.6	33.5
37535	Da15-17	30.0	33.0	13.3	20.9	65.8
37571	Cb51-44	5.0	10.0	27.9	64.7	7.4
37572	Cb51-44	10.0	15.0	45.9	54.1	0.0
37573	Cb51-44	15.0	20.0	42.6	57.4	0.0
37574	Cb51-44	20.0	25.0	45.9	53.6	0.5
37653	Cb51-40	5.0	7.0	77.5	15.6	6.9
37654	Cb51-40	7.0	10.0	30.3	59.9	9.8
37655	Cb51-40	10.0	15.0	18.9	59.5	21.6
37656	Cb51-40	15.0	20.0	10.2	68.6	21.2
37657	Cb51-40	20.0	25.0	29.3	58.4	12.3
37658	Cb51-40	25.0	30.0	18.7	70.7	10.5
37659	Cb51-40	30.0	35.0	16.3	68.1	15.5
37660	Cb51-40	35.0	40.0	18.5	66.5	15.0
39337.1	Da15-19	0.0	5.0	93.4	6.6	0.0

Sample Number	DGSID	Depth to Top of Sample (ft)	Depth to Bottom of Sample (ft)	Percent Mud	Percent Sand	Percent Gravel
39367	Cb51-63	0.0	5.0	98.6	1.4	0.0
39368	Cb51-63	5.0	10.0	21.6	36.5	0.0
39369	Cb51-63	10.0	15.0	19.5	35.8	44.7
39370	Cb51-63	15.0	20.0	40.0	54.4	5.6
39962	Cb51-64	0.0	5.0	38.0	43.4	18.6
39963	Cb51-64	5.0	10.0	23.3	48.9	27.8
39964	Cb51-64	10.0	15.0	26.5	65.0	8.4
39966	Cb51-64	20.0	25.0	25.2	64.2	10.6
82759	Da15-23	0.0	5.0	55.3	42.9	1.8
82763	Da15-24	0.0	5.0	85.2	14.8	0.0



Location map for sites from which samples were obtained for textural data for the Old College Formation. Yellow areas are buildings on the University of Delaware Campus. Basemap is U.S. Geological Survey topographic map layers from DataMIL Featureservice. Countour interval is 10 feet.

Delaware Geological Survey
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Newark, Delaware 19716

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