Triassic Stratigraphy in the Northern Part of the Culpeper Basin, Virginia and Maryland

GEOLOGICAL SURVEY BULLETIN 1422-C

Triassic Stratigraphy in the Northern Part of the Culpeper Basin, Virginia and Maryland

By K. Y. LEE

CONTRIBUTIONS TO STRATIGRAPHY

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A clarification of the Triassic stratigraphic sequences and depositional environments

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ILLUSTRATION

METRIC-ENGLISH EQUIVALENTS

Metric unit		English equivalent	
Length			
millimetre (mm)	=	0.03937	inch (in)
metre (m)	=	3.28	feet (ft)
kilometre (km)	=	.62	mile (mi)
Area			
square metre (m^2)	=	10.76	square feet (ft^2)
square kilometre (km^2)	=	.386	square mile (mi^2)
hectare (ha)	=	2.47	acres
Volume			
cubic centimetre (cm^3)	=	0.061	cubic inch (in^3)
litre (l)	=	61.03	cubic inches
cubic metre (m^3)	=	35.31	cubic feet (ft^3)
cubic metre	=	.00081	acre-foot (acre-ft)
cubic hectometre (hm^3)	=	810.7	acre-feet
litre	=	2.113	pints (pt)
litre	=	1.06	quarts (qt)
litre	=	.26	gallon (gal)
cubic metre	=	.00026	million gallons (Mgal or 10^6 gal)
cubic metre	=	6.290	barrels (bbl) (1 bbl=42 gal)
Weight			
gram (g)	=	0.035	ounce, avoirdupois (oz avdp)
gram	=	.0022	pound, avoirdupois (lb avdp)
tonne (t)	=	1.1	tons, short (2,000 lb)
tonne	=	.98	ton, long (2,240 lb)
Specific combinations			
kilogram per square centimetre (kg/cm^2)	=	0.96	atmosphere (atm)
kilogram per square centimetre	=	.98	bar (0.9869 atm)
cubic metre per second (m^3/s)	=	35.3	cubic feet per second (ft^3/s)
litre per second (l/s)	=	.0353	cubic foot per second
cubic metre per second per square kilometre [$(m^3/s)/km^2$]	=	91.47	cubic feet per second per square mile [$(ft^3/s)/mi^2$]
metre per day (m/d)	=	3.28	feet per day (hydraulic conductivity) (ft/d)
metre per kilometre (m/km)	=	5.28	feet per mile (ft/mi)
kilometre per hour (km/h)	=	.9113	foot per second (ft/s)
metre per second (m/s)	=	3.28	feet per second
metre squared per day (m^2/d)	=	10.764	feet squared per day (ft^2/d) (transmissivity)
cubic metre per second (m^3/s)	=	22.826	million gallons per day (Mgal/d)
cubic metre per minute (m^3/min)	=	264.2	gallons per minute (gal/min)
litre per second (l/s)	=	15.85	gallons per minute
litre per second per metre [(l/s)/m]	=	4.83	gallons per minute per foot [(gal/min)/ft]
kilometre per hour (km/h)	=	.62	mile per hour (mi/h)
metre per second (m/s)	=	2.237	miles per hour
gram per cubic centimetre (g/cm^3)	=	62.43	pounds per cubic foot (lb/ft^3)
gram per square centimetre (g/cm^2)	=	2.048	pounds per square foot (lb/ft^2)
gram per square centimetre	=	.0142	pound per square inch (lb/in^2)
Temperature			
degree Celsius (°C)	=	1.8	degrees Fahrenheit (°F)
degrees Celsius (temperature)	=	[(1.8×°C)+32]	degrees Fahrenheit

CONTRIBUTIONS TO STRATIGRAPHY

TRIASSIC STRATIGRAPHY IN THE NORTHERN PART OF THE CULPEPER BASIN, VIRGINIA AND MARYLAND

By K. Y. Lee

ABSTRACT

The Newark Group in the northern part of the trough-shaped Culpeper basin is redefined into the Manassas Sandstone, Balls Bluff Siltstone, and the Bull Run Formation. The Manassas Sandstone and the Bull Run Formation are chiefly fluvial coalescence fan-shaped deposits of conglomerate, sandstone, siltstone, and shale. The Balls Bluff Siltstone represents a lacustrine sedimentary sequence and grades into and intertongues with the Manassas Sandstone below and the Bull Run Formation above.

The Manassas Sandstone ranges from 342 m (1,120 ft) to 1,400 m (4,600 ft) in thickness and is divided into the Reston Member and the sandstone member. The Reston is mostly loose to semicompact sand and gravel, which is as much as 19 m (62 ft) thick near Reston, Va., and about 22 m (72 ft) thick, 3 km N. 15° W. of Pender, Va.

The Balls Bluff Siltstone is chiefly calcisiltite and ranges in thickness from 95 m (310 ft) in the southwestern part of the Frederick Valley, Md., to 2,190 m (7,200 ft) in the central part of the northern part of the basin.

The Bull Run Formation ranges from 190 m (630 ft) to 7,930 m (26,200 ft) in thickness and is divided into the Leesburg Limestone Conglomerate Member and the basaltic-flow-bearing clastics member. The Leesburg Limestone Conglomerate Member is 190 m (630 ft) thick in the southwestern part of the Frederick Valley and 1,070 m (3,500 ft) thick south of the Potomac River. It consists chiefly of subangular limestone fragments in dusky-red clayey silt and calcite paste. The basaltic-flow-bearing clastics member consists of greenstone, quartzite, and limestone conglomerates, sandstone, siltstone, shale, and, locally, coal and limestone. These rocks range from 1,950 m (6,400 ft) to 7,930 m (26,200 ft) in thickness in the southwestern part of the northern part of the basin.

The three formations underlying the northern part of the Culpeper basin may be generally correlative with the Stockton, Lockatong, and Brunswick Formations in the Newark basin, New Jersey, on the basis of lithologic similarity and depositional environment. The age of the Newark Group in the Culpeper basin is considered to be Triassic and Jurassic(?).

INTRODUCTION

The Culpeper basin is one of the structural trough depressions bordering the eastern front of the Appalachian Mountain system. It is filled with Triassic sediments that were derived from adjoining highlands. The National Center of the U.S. Geological Survey at Reston, Va., is on the eastern border of the basin.

Roberts (1922, 1923, 1928) systematically studied the Virginia Triassic rocks and divided these rocks into the Manassas Sandstone and the Bull Run Shales. Later, A. P. Bennison and Charles Milton (unpub. data, 1954) carried out detailed geologic mapping in Fairfax County, Va.; Bennison, Milton, and M. N. Bass (unpub. data, 1951), E. C. T. Chao (unpub. data, 1954, 1958), and P. M. Hanshaw (unpub. data, 1969), in Fairfax and Prince William Counties, Va.; and Eggleton (1975), in Fairfax and Loudoun Counties, Va. Dorsey (1918), Palmer (1949), and Fisher (1964) described the Triassic rocks in Montgomery and Frederick Counties, Md.

A detailed stratigraphic study of the Triassic rocks in the Culpeper basin, which began in fall 1973, shows the need to change the nomenclature of these sedimentary rocks in the basin. These rocks, which make up the Newark Group, are redefined into the Manassas Sandstone, the Balls Bluff Siltstone, and the Bull Run Formation (pl. 1) on the basis of stratigraphic relation and depositional environment.

NEWARK GROUP

The present known distribution of the Newark Group in the northern part of the Culpeper basin is shown on plate 1*A*. The Manassas Sandstone and the Bull Run Formation consist chiefly of fluvial coalescence fan-shaped deposits of conglomerate, sandstone, siltstone, and shale. The Balls Bluff Siltstone represents a lacustrine sedimentary sequence and grades into and intertongues with the Manassas Sandstone below and the Bull Run Formation above.

The thickness of the Newark Group varies in the northern part of the basin. It is 630 m (2,100 ft) thick in the southwestern part of the Frederick Valley, Md.; 3,100 m (10,200 ft), south of the Dickerson area, Maryland, and the Lucketts area, Virginia; 4,970 m (16,400 ft) in the area north of Pender and east of Aldie, Va.; and 10,600 m (35,000 ft) in the area north of Centreville to Antioch, Va.

A study of the structural and textural characteristics indicates that the rate of deposition of conglomerate and very coarse to fine clastic materials of the Manassas Sandstone and the Bull Run Formation was much more rapid than the rate of deposition of the Balls Bluff Siltstone. The rate of accumulation of the Balls Bluff Siltstone was generally controlled by the balance between space and supply in relation to the diastrophic movements in the source areas during the processes of sedimentation. For instance, in the lacustrine sequence, the density-current deposits of massive, uneven-bedded, highly calcareous and clayey siltstone indicate the unstable conditions of the depositional environment. Uplift of the highlands in the provenance areas changed the conditions of the depositional environment so that the supply of clastic sediments from the source areas became greater than the space available at the site of deposition. Under these conditions, the stream cur-

rents flowed swiftly down from the highlands and discharged their loads of coarser sediments along the margin of the basin to form the alluvial-fan deposits. The stream currents then carried their highly concentrated finer sediments downward into the basin. The speed of these density currents decreased as they flowed farther into the basin and simultaneously deposited unsorted finer sediments which became massive siltstone. Gradually, when the conditions of the depositional environment changed so that the supply of clastic sediments from the highlands was about equal to the space available at the site of deposition, the sorted lamellar-flow deposits formed even-bedded siltstone in the basin.

On the basis of lithologic similarity and depositional environment, the Manassas Sandstone, Balls Bluff Siltstone, and Bull Run Formation may be generally correlative with the Stockton, Lockatong, and Brunswick Formation, respectively, in the Newark basin of New Jersey (Van Houten, 1969; Sanders, 1974).

Various fossils have been recorded from the Newark Group in the Culpeper basin. N. F. Sohl and R. M. Forester (oral commun., 1976) recognized fresh-water crustacean fauna from a swamp sequence of impure carbonaceous limestone in the uppermost part of the Bull Run Formation in the Middleburg quadrangle, Virginia. The identification of these fauna is in progress. Eggleton (1975) reported phytosaur bones found at Dulles International Airport (pl. 1) and identified by Nicholas Hotton, III, U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C. Russell (1892, p. 54–65) and Roberts (1928, p. 140–149) gave statements on locations of fossil flora and fauna found in the basin. The diagnostic fossils have not yet been definitely established for specific correlation with Triassic strata of Europe. Cornet (unpub. data, 1975) and Olsen (unpub. data, 1975) proposed a Jurassic age for most of the upper part of the Newark Group on the basis of palynologic data and research on fossil vertebrates. Dallmeyer (1975) dated the Palisades sill as 192 m.y. and 186 m.y. by means of $^{40}Ar/^{39}Ar$ incremental release ages. Until further data are available on the age of the Newark Group in the Culpeper basin, the author considers the age as being Triassic and Jurassic(?).

MANASSAS SANDSTONE

The Manassas Sandstone,[1] named for exposures of the sandstone at Manassas, Prince William County, Va., is divided into the Reston Member (new name) and the sandstone member. The Reston grades into and intertongues with the sandstone.

RESTON MEMBER

The lower part of the Manassas Sandstone is herein named and adopted as the Reston Member for the cut exposures of loose to semicompact sand and

[1] Manassas Sandstone of Roberts (1923) is herein adopted for U.S. Geological Survey usage.

gravel east of the entrance junction of the south ramp of the Dulles Airport Access Road with Reston Avenue in the northwestern part of the Vienna quadrangle, Fairfax County, Va.

Distribution.—The Reston is exposed along the eastern border of the Culpeper basin in Fairfax and Prince William Counties, Va. Excellent exposures in the Vienna quadrangle are on Reston Avenue at the bridge over the Dulles Airport Access Road; along the north cut face of Sunrise Valley Drive at the north entrance to the National Center of the U.S. Geological Survey; at the cuts 0.6 km (0.4 mi) due west of the junction of Reston Avenue and the old railroad; and along the roadcuts at the intersection of Reston Avenue and Baron Cameron Avenue. Other exposures are at the roadcuts at the intersection of U.S. Route 50 and West Ox Road, Pender, in the Fairfax quadrangle; and along the north cut about 165 m (540 ft) N. 45° W. from the junction of Braddock Road and Union Mill Road in the Manassas quadrangle.

Lithology.—The Reston is a fluvial wash coalescence-fan deposit, which contains an intermixture of very dark red to very dusky red-purple, moderate-pink to light-red, and very light gray to light-gray, loose to semicompact micaceous feldspar and quartz sand, and angular to subangular rock fragments in an interstitial clayey silt paste that is more abundant in the upper part of this sequence than in the lower part. The rock fragments are chiefly mica schist, light-gray vein quartz, and light-gray to blackish-gray quartzite, as much as 0.5 m (1.6 ft) in diameter near Reston and Pender; and chlorite schist, greenstone, green gneissic rock, and quartzite at a south cut face, more than 1.6 km (1 mile) east of Comptons Corner along Compton Road in the Manassas quadrangle.

At places, the Reston contains channel-shaped, thin to very thick, cross-laminated, and compact lenses of micaceous and feldspathic siltstone and very fine to medium-grained sandstone, conglomeratic sandstone, and quartzite and vein quartz conglomerates.

Generally, the outer limit of the Reston wash-fan consists chiefly of loose, coarse to very coarse sand and granules of feldspar and quartz.

Thickness.—The Reston is estimated to be more than 19 m (62 ft) thick in the area between Sunrise Valley Drive and Baron Cameron Avenue in the Vienna quadrangle and 22 m (72 ft) thick in an area about 3 km (1.8 miles) northwest of Pender in the Herndon quadrangle.

SANDSTONE MEMBER

The sandstone member of the Manassas represents the micaceous and feldspathic sandstone exposed along the sides of Bull Run near the towns of Manassas and Yorkshire, Prince William County, Va., and along the west steep bank of the Potomac River in Loudoun County, Va. It forms the upper part of the Manassas Sandstone and the bulk of the unit.

Distribution.—The sandstone member is extensive in the eastern part of the Culpeper basin. It is well exposed along the sides of Bull Run near the towns of Manassas and Yorkshire and along the west steep bank of the Potomac River, Loudoun County, Va., about S. 40° W. from the powerplant of the Potomac Electric Power Company in Montgomery County, Md., in the Poolesville quadrangle.

Lithology.—The sandstone member contains mostly pinkish-gray feldspar and quartz grains cemented with a very dark red to very dusky red-purple silty clay paste. It is micaceous, very fine to very coarse grained, thick to massive, planar to crosslaminated, and locally is a quartzite conglomerate. It commonly contains lenticular bodies of light-gray to gray, fine to very coarse, granule, quartzite-conglomeratic, micaceous and feldspathic sandstone which contains kaolin paste. Highly calcareous varieties are found in a transitional zone between fluvial and lacustrine facies.

Thickness.—The sandstone is estimated to be 342 m (1,129 ft) thick in the central part of the southwestern part of the Frederick Valley, Md., 720 m (2,400 ft) in the area north of Centreville to Antioch, and 800 m (2,600 ft) in the area north of Pender and east of Aldie; it attains a thickness of 1,400 m (4,600 ft) south of the Dickerson and Lucketts area.

BALLS BLUFF SILTSTONE

The Balls Bluff Siltstone is a sedimentary sequence herein adopted and named after the rocks exposed at the Balls Bluff National Cemetery in the Waterford quadrangle, Loudoun County, Va.

Distribution.—The Balls Bluff is the chief sedimentary constituent in the Culpeper basin and is well exposed along the west steep bank of the Potomac River in the southeastern part of the Waterford quadrangle and the northeastern part of the Leesburg quadrangle. Other excellent exposures are along the sides of the Bull Run in Fairfax, Loudoun, and Prince William Counties, Va.

Lithology.—This unit is mostly calcisiltite that commonly contains thin streaks and layers of gray to blackish-gray limestone, which is locally oolitic, gray dolomite and light-gray and very dark red, highly calcareous, feldspathic, micaceous, very fine to medium-grained sandstone.

The calcisiltite is composed of alternating beds of fine planar-laminated, very thick bedded, feldspathic, and micaceous material, grading into massive, clayey, feldspathic, and micaceous siltstone, which commonly contains layers of silty shale and shale.

Thickness.—The Balls Bluff Siltstone is 95 m (310 ft) thick in the central part of the southwestern part of Frederick Valley, Md.; 615 m (2,020 ft), south of the Dickerson and Lucketts area; 1,940 m (6,400 ft), in the area north of Centreville to Antioch; and 2,190 (7,200 ft), in the area north of Pender and east of Aldie.

BULL RUN FORMATION

The Bull Run Formation[2] was originally called the Bull Run Shales (Roberts, 1922, 1923, 1928) and was named after the rocks exposed at the Bull Run Battlefield (Manassas National Battlefield Park), Prince William County, Va. It is a very heterogeneous assemblage of conglomerate, sandstone, siltstone, shale, basaltic flows, and locally coal and impure limestone. These rocks are extensively distributed in the drainage area of the upper reaches of Bull Run in the southwestern part of the northern part of the basin, Loudoun and Prince William Counties, Va. The Bull Run Formation is divided into the Leesburg Limestone Conglomerate Member and the basaltic-flow-bearing clastics member. The Leesburg Limestone Conglomerate Member grades into and intertongues with the basaltic-flow-bearing clastics member.

LEESBURG LIMESTONE CONGLOMERATE MEMBER

Limestone conglomerate exposed near Leesburg, Loudoun County, Va., is herein named and adopted as the Leesburg Limestone Conglomerate Member. It forms the lower member of the Bull Run Formation. The type section is on the southeastern cuts at the junction of U.S. Route 15 bypass and the entrance road to the Balls Bluff National Cemetery in the Waterford quadrangle, Loudoun County, Va.

Distribution.—The Leesburg Limestone Conglomerate Member underlies the northwestern part of the Culpeper basin in Virginia and Maryland. It is well exposed north of Leesburg and along the steep west bank of the Potomac River in the northeastern part of Loudoun County, Va.

Lithology.—The Leesburg Limestone Conglomerate Member contains angular to subangular fragments of lower Paleozoic gray to blackish-gray, dark-gray, and pinkish-red limestone. This limestone conglomerate is metamorphosed into a light-gray marble, called Potomac Marble, where it is in contact with diabase in the southeastern part of Leesburg. Dolomitic limestone and dolomite fragments commonly appear in the conglomerate in the northwestern part of the basin. Greenstone, slate, schist, vein quartz, and chert fragments form a minor amount of the clayey calcisiltite matrix that is firmly cemented by calcite. The size of these rock fragments increases northwestward. The calcisiltite lenses of the Balls Bluff Siltstone are commonly intercalated with the Leesburg Limestone Conglomerate Member near the outer limit of the fluvial fans.

Thickness.—The Leesburg Limestone Conglomerate Member ranges in thickness from 190 m (630 ft) in the west-central part of the southwestern part of Frederick Valley to 1,070 m (3,500 ft) south of the Dickerson and Lucketts area.

[2] Bull Run Shales of Roberts (1923) is herein adopted as Bull Run Formation for U.S. Geological Survey usage.

BASALTIC-FLOW-BEARING CLASTICS MEMBER

The basaltic-flow-bearing clastics member is represented by the roadcut exposures of very fine to very coarse grained and conglomeratic clastic rocks containing three sequences of basaltic flows along U.S. Route 50 in an area between the junction of U.S. Route 50 and Virginia State Road 616 in the Arcola quadrangle on the east and Aldie on the west in the Middleburg quadrangle, Loudoun County, Va. This member forms the upper part of the Bull Run Formation and is the bulk of the formation. A type exposure of very fine to very coarse-grained clastic rocks containing dinosaur tracks is at the quarry site on the north side of the Little River, about 1,150 m (3,800 ft) due north of Oak Hill in the Arcola quadrangle.

Distribution.—The basaltic-flow-bearing clastics member underlies an extensive area in the west-central part of the Culpeper basin in Loudoun and Prince William Counties, Va. This member is well exposed along U.S. Routes 29 and 211 in the southwestern part of the Gainesville and the southeastern part of the Thoroughfare Gap quadrangles and along the cuts of U.S. Route 50 east of Aldie and west of Lenah. Other excellent roadcut exposures are along Virginia State roads: 601 in the northeastern part of the Thoroughfare Gap and the northwestern part of the Gainesville quadrangles, 700 and 600 in the Middleburg and Arcola quadrangles, and 771 and 651 in the southwestern part of the Leesburg quadrangle. Good exposures are also present along the upper reaches of Bull Run.

Lithology.—The lower part of this member consists of very dark red to dusky-red, micaceous, feldspathic, and very fine to coarse-grained sandstone and clayey siltstone, locally containing limestone, vein quartz, and quartzite conglomerate lenses. These rocks grade upward into a sequence of micaceous, feldspathic, and medium-grained sandstone, fine- to coarse-grained and clayey siltstone, and silty shale. These rocks contain lenses of conglomerate which consist chiefly of rounded to angular fragments of pinkish-red deeply weathered siltstone and blackish-gray and light-gray quartzite in the lower part. This sequence is exposed at the Loudoun County landfill in the Leesburg quadrangle, Loudoun County, Va.

The lowest basaltic flow in the upper part of the sequence is exposed at the Mt. Olive Church in the Leesburg quadrangle and at the Mt. Zion Church in the Arcola quadrangle. This first basaltic flow is dark gray, aphanitic to fine, and in part porphyritic; it contains vesicles in the upper part.

The second basaltic flow overlies the sandstone, siltstone, and shale sequence and is well exposed on the east side of Gilberts Corner in the northwestern part of the Arcola quadrangle. It is dark gray, aphanitic to equigranular, coarse to very coarse, and contains vesicles chiefly in the upper part.

Both flows are hydrothermally altered and mineralized chiefly with copper sulfides, but the degree of alteration and mineralization varies within

each flow sheet. Generally speaking, the second flow is the least intensely altered and mineralized.

The third basaltic flow is separated from the second basaltic flow by a sequence of dark-red, micaceous, feldspathic, laminated, ripple-bedded, and very thin to massive sandstone, siltstone, and silty shale exposed along the northwestern cut of U.S. Route 15 near Gilberts Corner. These sedimentary rocks extend northwest through the dinosaur-track quarry site toward the southeastern border of the Lincoln quadrangle. They intertongue with a limestone conglomerate lens, which contains the second basaltic flow sheet exposed in an abandoned quarry near the south bank of Goose Creek. The dinosaur-track-bearing clastic rocks were quarried for flagstone to be used at the Oak Hill Mansion in the northwestern part of the Arcola quadrangle, Loudoun County, Va.

The third basaltic flow is extensively distributed in the western part of the basin and is well exposed about a fifth of a mile west of Gilberts Corner along U.S. Route 50 in the Middleburg quadrangle. This flow is dark gray to blackish gray, aphanitic to medium, in part porphyritic, contains vesicles in the upper part, and it is generally intensely hydrothermally altered and mineralized with copper sulfides. It branches out to the south and the southwest into several sheets in the southeastern part of the Middleburg quadrangle and the central part of the Thoroughfare Gap quadrangle. These flow sheets contain dark-red to dusky-red very fine to very coarse conglomeratic clastic rocks; they are overlain by a heterogeneous assemblage of very dark red, moderate-brown, dark-yellowish-orange, and light-olive, micaceous, feldspathic, thin to massive, and crosslaminated or planar-laminated sandstone, siltstone, silty shale and, locally, swamp deposits of coal and limestone. Greenstone and quartzite conglomerate lenses are intercalated with these clastic rocks, which are exposed along the sides of the creek in the vicinity of Waterfall in the Throughfare Gap quadrangle. A limestone conglomerate in the uppermost part of this heterogeneous sequence contains the upper part of the third flow sheet, which is exposed at the abandoned Millbrook quarry in the west-central part of the Thoroughfare Gap quadrangle.

Thickness.—The basaltic-flow-bearing clastics member ranges in thickness from 1,950 m (6,400 ft) east of Aldie in the Middleburg quadrangle to 7,930 m (26,200 ft) east and in the vicinity of Antioch in the Thoroughfare Gap quadrangle.

MEASURED SECTIONS

SECTION 1.—*Reston, Va.*

[Type section of the Reston Member of the Manassas Sandstone. Measured by tape, 1974, at the east end of cut, 82.5 m (270 ft) from the entrance junction of the south ramp of the Dulles Airport Access Road with Reston Avenue in the northwestern part of the Vienna quadrangle]

	Thickness in meters (ft)	
Upper Tertiary–Quaternary:		
5. Sand and gravel, light-brown (5*YR* 5/6),[3] pale-reddish-brown (10*R* 5/4), and moderate-red (5*R* 4/6); rounded to subrounded quartz grains and quartzite fragments in abundant interstitial silty clay and clay; poorly sorted	0.5	(1.6)
4. Clay, moderate-yellowish-brown (10*YR* 5/4), dusky-yellow (5*Y* 6/5), and light-brown (5*YR* 5/6), containing a small amount of quartz granule and small quartzite pebbles	0.2	(0.6)
Upper Triassic and Lower Jurassic(?):		
Newark Group (in part):		
Upper Triassic:		
Manassas Sandstone (in part):		
Reston Member:		
3. Clayey and silty sand, dusky-red (5*R* 3/4) and very dark red (5*R* 2/6), fine to medium, containing thin layers of light-brown (5*YR* 6/4) micaceous feldspar and quartz sand and scattered subrounded quartzite fragments as much as 0.2 m (0.7 ft) in diameter, grading downward into very dark red (5*R* 2/6) to very dusky red-purple (5*RP* 2/2), medium to coarse, micaceous, and feldspathic quartz sand, in part containing a subordinate amount of silty clay	0.4	(1.3)
2. Quartz sand, very dark red (5 *R* 2/6), to very dusky red-purple (5 *RP* 2/2), coarse to very coarse, micaceous, feldspathic; generally loose but in part clayey; contains abundant angular to subangular mica schist fragments as much as 0.6 m (2 ft) in diameter and some vein quartz and quartzite	1	(3.3)
1. Quartz sand, very dark red (5*R* 2/6) to very dusky red-purple (5*RP* 2/2), and moderate-brown (5*YR* 3/4), coarse to very coarse, feldspathic, and micaceous; loose; contains abundant mica schist and quartzite fragments	4.1	(14)
Total Reston Member	5.5	(18)
———angular unconformity———		
pre-Triassic mica schist		

[3] Color designations are based on the "Rock-Color Chart" of the National Research Council (Goddard and others, 1948).

SECTION 2.—*Pender, Va.*

[Section of the Reston Member of the Manassas Sandstone. Measured by tape, 1974, along the northeast cut face, 82.5 m (270 ft) east of the intersection of West Ox Road and U.S. 50 in the northwestern corner of the Fairfax quadrangle]

	Thickness in meters (ft)	
Upper Tertiary–Quaternary:		
4. Sand and gravel, moderate-red (5*R* 5/4) and reddish-brown (10*R* 4/6), rounded to subrounded quartz granules and quartzite pebbles in abundant interstitial silt and silty clay	2	(7)
3. Clay and silty clay, moderate-yellowish-brown (10*YR* 5/4) and pale-reddish-brown (10*R* 5/4)	0.1	(0.3)
Upper Triassic and Lower Jurassic(?):		
Newark Group (in part):		
Manassas Sandstone (in part):		
Reston Member:		
2. Quartz sand, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), medium to very coarse and granule, feldspathic, and micaceous; loose but in part semicompact because of higher clay content; contains abundant angular to subangular pebbles and cobbles of mica schist and minor quartzite	1	(3.3)
1. Quartz sand, very dark red (5*R* 2/6) to very dusky red-purple (5*RP* 2/2), coarse to very coarse and granule, feldspathic, and micaceous; generally loose but in part contains interstitial silty clay. Contains abundant cobbles and large pebbles of mica schist and some quartzite and vein quartz	3.1	(10)
Total Reston Member	4.1	(14)
——angular unconformity——		
pre-Triassic mica schist		

SECTION 3.—*Braddock, Va.*

[Section of the Reston Member of the Manassas Sandstone. Measured by tape, 1974, along the cut face north side of Braddock Road; 165 m (540 ft), N 45° W. from the junction of Braddock Road and Union Mill Road; northeastern part of the Manassas quadrangle]

	Thickness in meters (ft)	
Upper Triassic and Lower Jurassic(?):		
Newark Group (in part):		
Upper Triassic:		
Manassas Sandstone (in part):		
Reston Member (incomplete):		
5. Quartz sand, pale-reddish-brown (10*R* 5/4) to moderate-reddish-brown (10*R* 4/6) and dark-reddish-brown (10*R* 3/4), fine to very coarse, subrounded, feldspathic, and micaceous; contains abundant quartz and quartzite granules and pebbles and abundant interstitial clay and silty clay	0.6	(2)
4. Quartz sand, dusky-red (5*R* 3/4) to very dark red (5*R* 2/6), fine to very coarse, subrounded, feldspathic, and micaceous; contains abundant quartz and quartzite granules and pebbles;		

SECTION 3.—*Braddock, Va.*—Continued

Upper Triassic and Lower Jurassic(?)—Continued
Newark Group (in part)—Continued
Upper Triassic—Continued
Manassas Sandstone (in part)—Continued
Reston Member (incomplete)—Continued

	Thickness in meters (ft)	
grades downward into very dark red clayey and fine quartz sand	1	(3.3)
3. Quartz sand, dusky-red (5*R* 3/4), loose, coarse, feldspathic, and micaceous; contains some quartzite pebbles	0.1	(0.3)
2. Feldspar, and quartz sand and granules, moderate-pink (5*R* 7/4) to light-red (5*R* 6/6), loose, medium to coarse, subrounded, and micaceous	0.3	(1)
1. Feldspar sand, very light gray (*N*8) to light-gray (*N*7), loose, medium to very coarse, subrounded, and micaceous, contains minor coarse quartz grains and granules and scattered pebbles of subangular quartzite, angular, dusky-red (5*R* 3/4) to dusky-green (5*G* 3/2) chlorite-mica schist, and moderate pink gneiss	1.5	(5)
Total Reston Member	3.5	(12)

SECTION 4.—*Junction of Little Rocky Run and Bull Run, Va.*

[Section of the lower part of the sandstone member of the Manassas Sandstone. Measured by hand level and tape, 1974, along the northeastern steep bank of Bull Run, opposite the northern end of Lake Street, Yorkshire; 247 m (810 ft) about N. 25° E. from the northern end of Lake Street]

Upper Triassic and Lower Jurassic(?):
Newark Group (in part):
Upper Triassic:
Manassas Sandstone (in part):
Sandstone member (incomplete):

————covered————		
4. Sandstone, grayish-red (5*R* 4/2), fine to medium-grained micaceous, feldspathic, gently cross laminated, thick to very thick; contains layers of very dark red (5*R* 2/6), fine, micaceous and feldspathic siltstone	5	(17)
3. Sandstone, very dark red (5*R* 2/6) to dusky-red (5*R* 3/4), very fine to fine-grained, micaceous, feldspathic, clayey, silty, and massive	6.25	(21)
2. Sandstone, grayish-red (5*R* 4/2) to very dark red (5*R* 2/6), fine to medium-grained, micaceous, feldspathic, planar and gently cross laminated, very thick	4.28	(14)
1. Sandstone, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), medium to very coarse grained, micaceous, feldspathic, conglomeratic, gently crosslaminated, and very thick; contains scattered rounded to subrounded granules and pebbles of vein quartz, quartzite, and hard silty shale	4.37	(14)
Total sandstone member	19.90	(66)

SECTION 5.—*Potomac River*

[Section of the upper part of the sandstone member of the Manassas Sandstone. A N. 65° W.-section measured by hand level, 1974, along the west steep bank of the Potomac River in Virginia. Section started at the foot of the bluff, about 31.25 m (103 ft) S. 10° E. of a cottage overlooking the river, about 2 km S. 32° W. from the powerplant of the Potomac Electric Company in Montgomery County, Md. Virginia State Road 656 ends west of the cottage]

	Thickness in meters (ft)	
Upper Triassic and Lower Jurassic(?):		
Newark Group (in part):		
Upper Triassic:		
Manassas Sandstone (in part):		
Sandstone member (incomplete):		
6. Sandstone, light-gray (*N*7) and light-red (5*R* 6/6), medium to coarse-grained, planar and gently crosslaminated, very thick, micaceous, and feldspathic; contains grains of rounded to subrounded, light-gray and some light-red feldspar, and quartz, chiefly in kaolin-clay paste	4.68	(15)
5. Sandstone, grayish-red (5*R* 4/2) to very dark red (5*R* 2/6), very fine to fine-grained, massive, silty, micaceous, and feldspathic; contains chiefly light-red feldspar and quartz grains in abundant interstitial silty clay	7.81	(26)
4. Sandstone, light-gray (*N*7) and light-red (5*R* 6/6), fine to medium-grained, gently crosslaminated, thick, micaceous, and feldspathic; contains grains chiefly of rounded to subrounded light-gray feldspar and some quartz in kaolin-clay paste	3	(10)
3. Sandstone, grayish-red (5*R* 4/2) to very dark red (5*R* 2/6), fine to coarse-grained, massive, silty, micaceous, and feldspathic; contains grains chiefly of light-red feldspar and quartz and scattered granules and pebbles of vein quartz and grayish-red lithographic limestone, in abundant interstitial grayish-red clayey silt	10.93	(36)
2. Sandstone, medium-light-gray (*N*6) to medium-gray (*N*5), medium- to very coarse grained, very thick, gently crosslaminated, micaceous, and feldspathic; contains grains of light-gray feldspar and some quartz in abundant interstitial kaolin-clay. Conglomeratic in part	4.68	(15)
1. Sandstone, very dark red (5*R* 2/6) to dusky-red (5*R* 3/4) fine- to coarse-grained, very thick, planar to gently crosslaminated, micaceous, and feldspathic; intercalated with fine, silty, clayey, micaceous, and feldspathic sandstone, containing clayey siltstone in part	5.93	(20)
Total sandstone member	37.03	(122)

SECTION 6.—*Balls Bluff National Cemetery, Va.*

[Type section of the Balls Bluff Siltstone. Section measured by hand level and tape, 1974, along the exposures in a gully, 412 m (1,350 ft) N. 4° E. from the flag pole of the Balls Bluff National Cemetery, southeastern part of the Waterford quadrangle, Loudoun County]

	Thickness in meters (ft)
Upper Triassic and Lower Jurassic(?):	
Newark Group (in part):	
Upper Triassic:	
Balls Bluff Siltstone (incomplete):	
19. Siltstone, dusky-red (5*R* 3/4) to very dark red (5*R* 2/6), very fine to fine and medium-grained, highly calcareous, micaceous, and feldspathic	5 (16)
18. Siltstone, moderate-red (5*R* 4/6), very fine to fine-grained, highly calcareous, clayey, micaceous, and feldspathic	6.87 (23)
17. Siltstone, dusky-red (5*R* 3/4) to very dark red (5*R* 2/6), fine, highly calcareous, micaceous, and feldspathic; thick-bedded to very thick bedded and planar-laminated; conchoidally fractured	4.68 (15)
16. Limestone, pale-red (5*R* 6/2) to grayish-red (5*R* 4/2), lithographic, clayey, and silty in part; conchoidally fractured	0.62 (2)
15. Siltstone, dusky-red (5*R* 3/4) to very dark red (5*R* 2/6), very fine to fine-grained, highly calcareous, clayey, micaceous, and feldspathic; contains abundant minute calcium carbonate concretions	2.18 (7)
14. Siltstone, very dark red (5*R* 2/6), fine to coarse-grained, highly calcareous, clayey, micaceous, and feldspathic; massive, contains clay partings in part	3.12 (10)
13. Siltstone, grayish-red (5*R* 4/2), fine to coarse-grained, highly calcareous, clayey, and feldspathic; contains abundant granules of light-gray to gray limestone. Faint crosslamination shown	0.75 (2)
12. Siltstone, very dark red (5*R* 2/6), fine-grained, highly calcareous, micaceous, feldspathic, planar-laminated, and very thick	4.25 (14)
11. Lentil of light-gray (*N*7) to medium-gray (*N*5) Leesburg Limestone Conglomerate Member; limestone fragments in limestone granules and silt matrix, cemented by calcite	1.6 (5)
————covered————	1 (3.3)
10. Siltstone, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), very fine to medium-grained, highly calcareous, micaceous, feldspathic, clayey, and massive; contains scattered blackish-red (5*R* 2/2) to brownish-gray (5*YR* 4/1) calcium carbonate concretions	3.75 (12)
9. Lentil of light-gray (*N*7) to medium-gray (*N*5) Leesburg Limestone Conglomerate Member; limestone fragments in limestone granules and clayey silt matrix, cemented by calcite	2 (7)

SECTION 6.—*Balls Bluff National Cemetery, Va.*—Continued

Upper Triassic and Lower Jurassic(?)—Continued
Newark Group (in part)—Continued
Upper Triassic—Continued
Balls Bluff Siltstone (incomplete)—Continued

	Thickness in meters (ft)	
8. Siltstone, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), very fine to medium-grained, highly calcareous, micaceous, feldspathic, clayey, and massive; contains abundant limestone granules	1.87	(6)
7. Lentil of light-gray (*N*7) to medium-gray (*N*5) Leesburg Limestone Conglomerate Member of Bull Run Formation; chiefly rounded to subrounded limestone fragments in limestone granules; clayey silt matrix, cemented by calcite	1.25	(4)
6. Siltstone, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), very fine to fine-grained, highly calcareous, micaceous, feldspathic, clayey, and massive; contains scattered limestone granules	1.09	(4)
5. Siltstone, very dark red (5*R* 2/6), fine- to medium-grained, highly calcareous, micaceous, feldspathic, planar-laminated, and very thick; contains abundant limestone granules and some vein-quartz fragments	0.75	(2)
4. Siltstone, dusky-red (5*R* 3/4) to grayish-red (5*R* 4/2), very fine to fine-grained, highly calcareous, micaceous, feldspathic, and massive; contains abundant limestone granules and vein quartz	1.25	(4)
3. Siltstone, grayish-red (5*R* 4/2), fine- to medium-grained, highly calcareous, micaceous, feldspathic, clayey, planar-laminated, and thick-bedded; contains abundant rounded to subrounded, very coarse to granule fragments of limestone and some vein quartz and feldspar	0.75	(2)
2. Siltstone, very dark red (5*R* 2/6) to grayish-red (5*R* 4/2), very fine to fine-grained, highly calcareous, feldspathic, micaceous, planar-laminated, and very thick; contains scattered limestone granules	1.56	(5)
1. Lentil of light-gray (*N*7) to medium-gray (*N*5) Leesburg Limestone Conglomerate Member of Bull Run Formation; limestone fragments in limestone granules and clayey silt matrix, firmly cemented by calcite	0.03	(0.1)
———covered by alluvium———		
Total Balls Bluff Siltstone (excluding the lentils of Leesburg Limestone Conglomerate Member of Bull Run Formation	39.49	(131)

SECTION 7.—*Junction of U.S. 15 bypass and entrance road to the Balls Bluff National Cemetery, Va.*

[Type section of the Leesburg Limestone Conglomerate Member of the Bull Run Formation. An east-west section southeast of the junction. Measured by tape and hand level, 1974]

	Thickness in meters (ft)
Upper Triassic and Lower Jurassic(?):	
Newark Group (in part):	
Bull Run Formation (in part):	
Upper Triassic:	
Leesburg Limestone Conglomerate Member (incomplete):	
3. Limestone, light-gray (*N*6) to medium-gray (*N*5), grayish-red (5*R* 4/2), subangular to angular pebbles and cobbles, lithographic to medium-grained; scattered vein quartz, gray quartzite, and greenstone fragments chiefly in limestone granules; dusky-red silt matrix, cemented firmly by calcite	6.25 (21)
2. Lentil of the Balls Bluff Siltstone: grayish-red (5*R* 4/2) to very dark red (5*R* 2/6), fine- to coarse-grained, highly calcareous, micaceous, feldspathic, laminated, and very thick siltstone; contains abundant limestone granules and small pebbles	7.28 (24)
——covered——	59.37 (196)
1. Limestone, light-gray (*N*7) to medium-gray (*N*5), in part grayish-red (5*R* 4/2), lithographic to fine-grained subangular to rounded pebbles and cobbles; intercalated with granules of limestone and some vein quartz, quartzite, and greenstone, dusky-red (5*R* 3/4), clayey silt matrix, firmly cemented by calcite	3.12 (10)
Total Leesburg Limestone Conglomerate Member	76.02 (251)

SECTION 8.—*Oak Hill Dinosaurs Track Quarry, Va.*

[Type section of the basaltic-flow-bearing clastics member of finer variety of the Bull Run Formation. Section on north side of the Little River, 1,155 m (3,790 ft) due north of Oak Hill Mansion. Measured by tape, 1974]

	Thickness in meters (ft)
Upper Triassic and Lower Jurassic(?):	
Newark Group (in part):	
Bull Run Formation (in part):	
Basaltic-flow-bearing clastics member (incomplete):	
——covered——	
6. Shale, very dark red (5*R* 2/6) dusky-red (5*R* 3/4), micaceous, feldspathic, silty and very thin to thick; intercalated with very dark red, very fine to fine-grained, micaceous, feldspathic, and thick siltstone	4.68 (15)

SECTION 8.—*Oak Hill Dinosaurs Track Quarry, Va.*—Continued

Upper Triassic and Lower Jurassic(?)—Continued
Newark Group (in part)—Continued
Bull Run Formation (in part)—Continued
Basaltic-flow-bearing clastics member (incomplete)—Continued

	Thickness in meters (ft)	
5. Sandstone, dusky-red (5*R* 3/4) to grayish-red (5*R* 4/2), very fine to fine grained, calcareous, silty, micaceous, feldspathic, very compact, and very thick; intercalated with and clayey siltstone lenses. Contains dinosaur tracks	5.61	(19)
4. Sandstone, dusky-red (5*R* 3/4) and brownish-gray (5*YR* 4/1), fine- to coarse-grained, micaceous, calcareous, feldspathic, ripple-bedded, very thick; contains abundant granules of subrounded limestone and vein quartz; and intercalated with dusky-red micaceous, and clayey siltstone	3.21	(11)
3. Sandstone, dusky-red (5*R* 3/4) to very dark red (5*R* 2/6), very fine to fine-grained, micaceous, feldspathic, planar-laminated, and very thin to very thick; intercalated with very fine to fine-grained, very thin to thin-bedded, micaceous, and feldspathic siltstone. Contains dinosaur tracks	10.93	(36)
2. Sandstone, dusky-red (5*R* 3/4) to grayish-red (5*R* 4/2), very fine to fine-grained, calcareous, micaceous, feldspathic, laminated, very thick; intercalated with dusky-red, micaceous, and feldspathic siltstone and silty shale; contains granules of limestone and vein quartz. Ripple-bedded in siltstone	9.37	(31)
1. Sandstone, dusky-red (5*R* 3/4) to grayish-red (5*R* 4/2), fine- to medium-grained laminated, slightly calcareous, micaceous, feldspathic; intercalated with greenish-gray (5*G* 6/1) and light-bluish-gray (5*B* 7/1) silty shale and micaceous and feldspathic siltstone	3	(10)
Total basaltic-flow-bearing clastics member	36.80	(122)

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