COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
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GEOLOGY OF THE MOUNT SIDNEY QUADRANGLE, VIRGINIA

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PUBLICATION 11
MOUNT SIDNEY
QUADRANGLE

EXPLANATION

UNIT CHARACTERISTICS

QUATERNARY

al — Alluvium: *Flood-plain deposits of stratified, unconsolidated clay, silt, and sand with sandstone gravel at base. Chert gravel at base and localized calcareous tufa (marl) deposits along streams draining carbonate-rock terrane. Thickness: 0-20 feet (0-6 m).*

td — Terrace deposits: *Dissected remnants of unconsolidated, stratified alluvial deposits of clay, silt, and sand with quartzite gravel at base. Chert gravel at base near streams draining carbonate-rock terrane. Thickness: 0-20 feet (0-6 m).*

JURASSIC

ja — *Alkalic dikes:* Including nephaline syenite, teschenite and teschenite-picrite. Thickness 0-50 feet (0-15 m).

Omb — Martinsburg Formation (Long Glade syncline): *Dark-gray slate with interbedded dark-gray, fine-grained, medium- to thin-bedded, locally nobly c- to nodular-bedded limestone that is locally bioclastic and very fossiliferous. Thickness: 1,000-1,200 feet (305-366 m).*

Omb s, Omb a, Omb — Martinsburg Formation (Omb) (Massanutten synclinorium): *s, dark-gray to black, fine- to medium-grained, medium- to thick-bedded lithic sandstone with graded bedding, flute casts, groove casts, load casts, and some chert and black-slate pebbles interbedded with dark-gray, laminated, thin-bedded calcareous argillite and black slate. Thickness: undetermined. a, dark-gray to black, laminated to thin-bedded calcareous argillite with graded bedding and convolute folds interbedded with black calcareous slate. Thickness: 500-1,000 feet (152-305 m). c, black, very fine grained, graptolitic calcareous slate with a few beds of argillite. Thickness: 100-200 feet (30-61 m).*

ORDOVICIAN

Oelm, Oelh — Edinburg Formation: *Oelm (Lantz Mills), dark-gray to black, fine-grained, nodular-bedded limestone with shaly, undulatory bedding partings, locally fossiliferous. Thickness: 230 feet (70 m). Oelh (Liberty Hall), dark gray to black, fine-grained, thin- to thick- and evenly bedded, turbiditic limestone with local convolute bedding and a few thin beds of black slate. Thickness: 350-1,500 feet (107-457 m).* cs, *black, very fine grained, graptolitic calcareous slate at base. Thickness: 0-100 feet (0-30 m).*

Oil — Lincolnshire Formation: *Dark-gray, medium- to coarse-grained, bioclastic, fossiliferous, black chert bearing limestone with pink silty partings and medium-gray, coarse-grained, bioclastic, fossiliferous, high-calcium limestone (Murat). Thickness: 40-60 feet (12-18 m).*

Omn — New Market Limestone: *Dove-gray, thick-bedded, massive, micritic, high-calcium limestone. Thickness: 50-250 feet (15-76 m).*

Oml, Omd — Lincolnshire Formation and New Market Limestone: *Rock units, undivided. Thickness: 100-300 feet (30-91 m).*

Obul, Obud, Obml, Obld, Ob — Beekmantown Group: *Obul (upper limestone and dolomite unit), dove-gray, thin-bedded, ultrafine-grained limestone interbedded with light-gray, fine- to medium-grained, thick beds of laminated dolomite and a few thin beds of gray to tan shale and pink calcareous mudrock. Thickness: 400 feet (122 m). Obud (upper dolomite unit), light- to dark-gray, fine- to medium-grained, thick-bedded, laminated siliceous dolomite interbedded with coarse grained, locally brecciated siliceous dolomite with beds and nodules of black to tan chert. Thickness: 300 feet (91 m). Obml (middle limestone and dolomite unit), dark-gray, medium- to coarse-grained, fossiliferous, bioclastic limestone with algal structures, oolites, cross-bedded and flat-pebble conglomerate; interbedded with limestone and dolomitic limestone with burrow structures, silty calcarenite, and laminated dolomite. Thickness: 450 feet (137 m). Obld (lower dolomite unit), massive, dark-gray, coarse-grained, locally brecciated, siliceous dolomite with thin, dark-gray chert beds, chert nodules, quartz veins and quartz crystal-lined vugs; interbedded with light- to dark-gray fine- to medium grained, massive to laminated siliceous dolomite. Thickness: 775 feet (236 m). Ob (lower limestone unit), dark-gray, fine-grained, thick-bedded limestone interbedded with light-gray, fine-grained, laminated dolomite in upper part; dark-gray, ultrafine-grained, limestone with black chert nodules, undulose laminations, burrow structures and flat-pebble conglomerate in lower part. Thickness: 750 feet (229 m). Ob, (Beekmantown Group) limestone and dolomite units, undivided. Thickness: undetermined.*

CAMBRIAN

Ccou s, Ccou a, Ccou — Conococheague Formation: *Ccou (upper member), dark-gray, fine-grained algal limestone alternating with flat-pebble limestone conglomerate, thin-bedded limestone with siliceous partings, laminated limestone and thin- to thick-bedded, fine-grained, light-gray dolomite. Thickness: 1,200-1,500 feet (366-457 m). Ccol (lower member), light to medium-gray, fine- to medium-grained, massive to laminated dolomite. Thickness: 800-1,000 feet (244-305 m).* s, *thin (0-10 feet or 0-3 m) beds of tan to brown, medium- to coarse-grained, cross-laminated quartz sandstone.*

Ceu — Elbrook Formation: *Ceu (upper member), medium- to dark-gray (orangish-yellow on weathered surface), fine to medium-grained, medium- to thick-bedded, massive or laminated dolomite interbedded with thin, dark-gray, algal limestone, thin flat-pebble limestone conglomerate, and platy dolomitic siltstone. Thickness: 500-1,200 feet (152-366 m).*

GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

Level land adjacent to streams, which may be readily tilled or excavated, is subject to periodic flooding that limits its use to farm or recreational activities. Excavations are subject to sliding and sloughing. In areas where alluvial and gravel deposits overlie cavernous limestone or dolomite, rapid groundwater withdrawals may produce surface subsidence or collapse. Marl deposits have been used locally as a source of agricultural lime.

Level benches or flats near streams are generally above flood levels. Artificial cuts and excavations are subject to sloughing and creep, and land is subject to subsidence or collapse where terrace deposits overlie cavernous limestone or dolomite.

Small linear areas of rocky land; may be difficult to excavate locally.

Gently rolling to hilly upland has steep, V-shaped valleys along larger streams and rivers. Relatively shallow, well-drained sandy or shaly soil with moderate to steep slopes are present. Erosion may be severe on slopes greater than 10 percent because of thin soil and rapid run-off of storm water. Artificial cuts and excavations may be unstable where beds dip in underdip position. Building sites are good on gentle slopes. Construction restrictions are imposed on the type and location of waste-disposal facilities in areas of shallow soil and rapid run-off of storm water. Ground water for domestic or limited farm use is generally available from wells less than 200 feet (61 m) deep. a, c, and Omb—gently rolling open land has shallow soil and moderate slopes. Severe soil erosion is common on steep denuded slopes, particularly where slate is predominant. Construction restrictions are imposed on the type and location of waste-disposal facilities in areas of shallow soil, rapid run-off of storm water, clayey subsoil and seldom channels in calcareous rocks. Shallow excavations may require some blasting to remove resistant ledges. Artificial cuts and excavations may be unstable where bedding or cleavage are undercut. This land is well suited for agriculture, particularly pasture. Water wells generally provide small yields from depths less than 150 feet (46 m). Gorges with a moderately steep land and may be slightly acidic or contain iron.

Gently rolling land surface with a few low, round hills and linear ridges has formed over limestone and dolomite generally covered with deep, well-drained soil. Appreciable soil creep and severe erosion may occur in modified land areas on steep slopes, whereas on gentle slopes, the soil is generally stable. There is a gradual variation in thickness of the soil over short distances; clay subsoil has a moderately high shrink-swell potential. Common sinkhole and cave development, particularly in the limestone units, necessitates restriction of choice in the determination of the type and location of waste-disposal facilities and other construction. Ground-water availability is good to fair, and the water is generally hard. The ground water in these carbonate rocks is susceptible to contamination from surface sources where sinkholes are present or where the soil is thin; contaminants induced into the sinkholes may be transmitted for considerable distances through solution channels and fractures in the rock. Oelm, Oelh, Ol, On, Obul, Obml, Obll, and Ccu – rock ledges are exposed in most areas and rock-land (areas where ledges are less than 10 feet or 3 m apart) occurs locally on thick sequences of alternating limestone and dolomite. Obud and Obld—residual chert debris covers the rounded hills and lowlands underlain by siliceous dolomite. s, in Ccou and Ccol—deep residual sandy soil formed from thin, calcareous sandstone beds that commonly occur on linear ridge crests and slopes.

KEY

CONTACTS
Exposed or approximate

FOLDS
Anticline—trace; direction of plunge
Syncline—trace; direction of plunge
Direction and angle of plunge of minor anticline
Direction and angle of plunge of minor syncline
Direction and angle of plunge of minor fold showing strike and dip of axial plane
Direction and angle of plunge of minor fold showing strike and dip of axial plane and symmetry of fold

FAULTS
Black line where exposed or approximate; gray line where covered or inferred; U, upthrown side, D, downthrown side, T, upper sheet; arrows indicate direction of relative movement.

ATTITUDE OF ROCKS
Strike and dip of beds
Strike and dip of overturned beds
Strike of vertical beds
Horizontal beds

X — Modified land: *Extensive cut and fill due to grading.*

Sinkhole: *Area of known or potential sinkhole development, subsidence, and cave openings.*

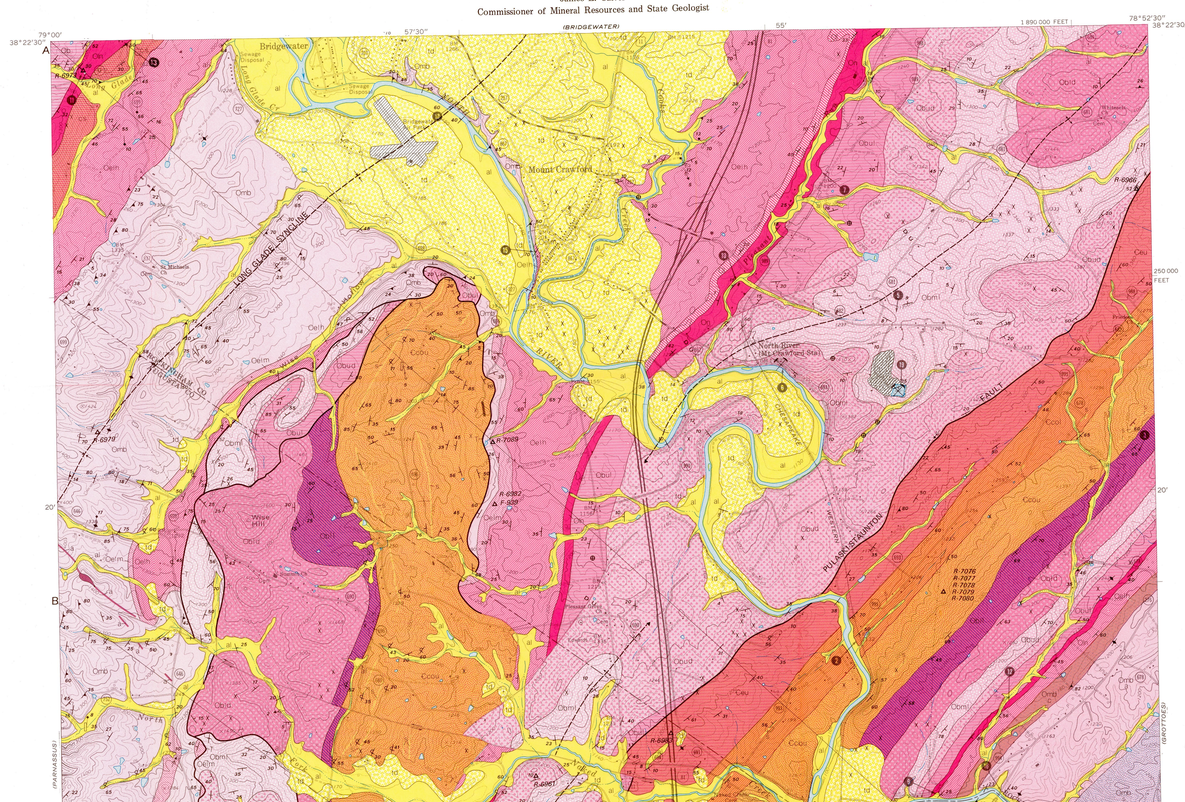
FOLIATION
Strike and dip of schistosity
Strike of vertical schistosity

LINEATION
Direction and angle of plunge of rodding, boudinage, and crinkle folds
Direction, angle of plunge, and symmetry of crenulation

QUARRIES
Abandoned mine or quarry
Crushed stone quarry (limestone and dolomite)

SAMPLE LOCATIONS
R-7082 — R, repository number of rock sample on file at Virginia Division of Mineral Resources.
F-939 — F, repository number of fossil sample on file at Virginia Division of Mineral Resources
1 — Reference locality described in discussion

OTHER LAND-MODIFICATION FACTORS



Base map from U.S. Geological Survey, 1964 (72-PR) Mount Sidney Quadrangle, 7½ Minute Series

Williams & Heintz Map Corporation
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Commonwealth of Virginia

CROSS SECTION DESIGN
1. No vertical exaggeration.
2. Subsurface structure interpreted from surface measurement.
3. Thickness of terrace deposits, and alluvium diagrammatic.

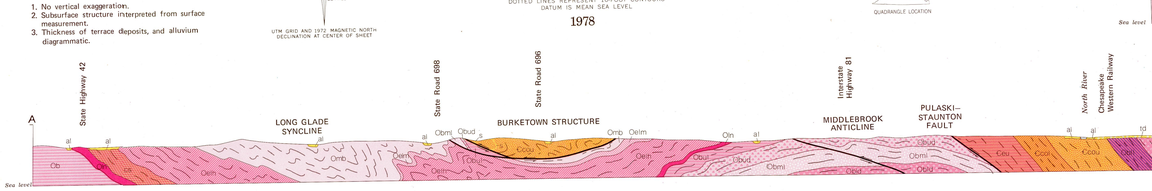
SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER

CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

1978



STRATIGRAPHIC DISCUSSION

Limestone and Dolomite

Alternating dolomite and limestone beds in the Elbrook and Conococheague formations and the Beekmantown Group along the northwestern limb of the Massanutten synclinorium have characteristics similar to cyclic sedimentation described in recent platform carbonate rocks and indicate that such a carbonate depocenter was well established along the Paleozoic continental shelf. Their lithofacies and the inferred depositional environments are generally similar to the subfacies and related subenvironments described in detail by Ginsburg (1971) and Reinhardt and Hardie (1976) in Pennsylvania and Maryland. It is through study of the differences in successive cyclic sediments, and by inference of the differences in depositional environments, that the Cambrian and Ordovician carbonate sequence has been divided for mapping as groups, formations, members, and units. It must be emphasized that these are strictly lithostratigraphic units that may be time transgressive.

Fhyllitic rocks in the *lower member of the Elbrook Formation* have been deleted by the Pulaski-Staunton fault in this part of the Shenandoah Valley. Cyclic deposition of the *upper member of the Elbrook Formation* is delineated by alternating limestone beds and thin, platy dolomite interbeds. The cycles are 10 feet (2.3 m) thick and consist of thin algal limestone (lower intertidal to upper subtidal) that is commonly interlaminated, wavy-bedded limestone and dolomite (high intertidal, algal flat) that are gradational upwards into thin, laminated (supratidal) dolomite beds (Figure 1). Good exposures of the cyclic limestone and dolomites in the Elbrook Formation occur at REFERENCE LOCALITY IV-1, about one mile (1.6 km) west of the town of Mount Sidney.

The Ordovician depositional environments that can be inferred from Elbrook sedimentation shows a strong affinity towards and supratidal conditions and is notably deplete in the lower intertidal to subtidal carbonate sand and intraclast conglomerates that characterize the overlying Conococheague limestones. The contact between the Elbrook and Conococheague formations is placed at the top of the uppermost thin-laminated dolomite that can be related to the last thin carbonate cycle characteristic of the upper Elbrook and below the massive, laminated dolomite beds containing frosted, well-sorted and rounded quartz grains and thin sandstone beds in the lower member of the Conococheague.

The massive, siliceous dolomite of the *lower member of the Conococheague Formation* forms the prominent hills around the nose of the Middle Run anticline (Rader, 1969) northwest of Mount Pisgah, and underlies a continuous ridge that descends in elevation to the northeast along the strike belt from Mount Pisgah to Burkeys Barkwren. Interbedded sandstone, shale and dolomite of the lower member (supratidal to intertidal algal flat), as well as cyclic limestones of the upper member, are exposed along the tracks of the Chesapeake Western Railway in the gap cut by the North River at REFERENCE LOCALITY 2. The lower part of the formation has been described as the Big Spring Station member in Pennsylvania and in Frederick County, Virginia (Wilson, 1952).

Interbedded limestone and dolomite strata in the *upper member of the Conococheague Formation* range from a few inches (centimeters) to several feet (meters) in thickness. Repetition of a distinctive subfacies succession from subtidal to intertidal to supratidal in cycles 12 to 15 feet (4 to 5 meters) thick is a dominant characteristic of the upper unit. The individual cycles, deposited by a regressive sea are bounded by erosional breaks that may represent an intermittently transgressive sea. Erosion between cycles is responsible for elimination of certain subfacies of the prograding cycle, which makes the cycle record incomplete, although not so abbreviated as that underlying Elbrook. A composite succession of subfacies begins with a 6-to 1.5-foot (2-to .5 meter) interval of medium- to coarse-grained cross-bedded, commonly oolitic, calcarenite (subtidal) succeeded by 4 to 3 feet (.3 to 1 meter)of algal stromatolitic limestone (lower intertidal to upper subtidal). The algal limestone has irregular boundaries with coarse carbonate sand and flat-pebble conglomerate layers above that form part of a thick interval (6 to 7 feet, 2 meters) of thin, interbedded "ribbon" limestone and dolomite (lower intertidal). In this, interbedded subfacies commonly becomes more dolomitic towards the top and grades upwards through an interval of wavy, interlaminated ultrafine-grained limestone and dolomite (upper intertidal) into laminated mud-cracked dolomite (supratidal) at the top of the cycle (Figure 1).

More or less continuous zones of sandy dolomite and thin sandstones in the upper part of the Conococheague are exposed near the town of Mount Sidney and form a continuous linear ridge to the northeast. These are similar to the sands in the lower member and contain frosted, highly rounded and well-sorted quartz sand grains. Cross-bedding is common in the sandstones and closely resembles that in aeolian sandstones described by Ragaldi (1972, p. 30). The lack of an obvious source for quartz sand from within a carbonate platform suggests an external source. The character and structure of the Conococheague sandstones may be indicative of aeolian transport and deposition operative during strong wind storms that swept across the Cambrian shelf from dunal areas on the cratonic land mass to the west.

The contact between the Conococheague Formation and the overlying Beekmantown Group is placed at the top of the uppermost thinly laminated, supratidal dolomite that can be related to the last Conococheague cycle. Where the contact is poorly exposed it has generally been placed at the break in slope adjacent to massive limestones in the base of the Beekmantown Group.

Limestones and dolomites of the *Beekmantown Group* have been subdivided into five unnamed formations. The *lower limestone unit* includes limestone and dolomite previously mapped in adjacent quadrangles as the Chepultepec Formation (Brent, 1960, Rader, 1969). Beds in the base of the lower limestone unit (REFERENCE LOCALITY 3) are generally thick-bedded calcarenite or algal limestone and seem to represent a lower intertidal to lower subtidal environment similar to one in the Conococheague cycle. In comparison with the Conococheague beds, the limestones at the base of the Beekmantown Group are much thicker, indicating a longer period of intertidal or subtidal deposition or a more rapid subsidence of the carbonate shelf. Interlaminated limestone and dolomite beds similar to the upper intertidal subfacies of the Conococheague cycle occur sporadically within the lower limestone unit, but there are few complete cycles in the Beekmantown Group. Alternating limestone and dolomite beds in the upper part of the unit are similar to cyclic beds described in younger units of the Beekmantown Group. The contact between the lower limestone and lower dolomite units is placed at the top of the uppermost limestone that occurs stratigraphically below a very thick section composed entirely of siliceous and vuggy dolomite.

The *lower dolomite unit* is resistant to erosion and forms low chert-covered ridges and rounded hills such as the one at Weyers Cave. Rock in this unit is exposed along North River at REFERENCE LOCALITY 4. The unit contains mud cracks, algal lamination and thin dolomite intraclast layers and is considered to be largely supratidal to intertidal in origin, having been deposited on an algal flat similar to environments of the Elbrook Formation. Frosted-quartz sand grains and the relatively high silica content (bedded and nodular chert) suggest recurrent wind transportation of fine silica across the tidal flats from the craton to the west.

The contact between the lower dolomite unit and the *middle limestone and dolomite unit* is placed at the base of the lowest limestone bed that is the beginning of cyclic limestone and dolomite strata which comprise the middle unit. Cyclicly interbedded limestone and dolomite is well exposed at REFERENCE LOCALITY 5. A typical middle Beekmantown limestone cycle contains a calcarenite with thin, flat-pebble conglomerate zones near the base that may be channeled down into the underlying dolomite. Cross-bedded, oolitic carbonate sands (lower intertidal to upper subtidal) have also been observed in the lower part of the cycle. Mottled, partly dolomitized, limestone with burrow structures and thin-bedded to laminated, silty calcarenite beds may alternate in the middle part. At the top of the cycle the partly dolomitized limestone with burrow structures grades upwards into mottled, then laminated dolomite. The calcarenite beds are generally fossiliferous and in addition to algal biostromes, contain cephalopods, gastropods, fragments of crinoids, brachiopods, and trilobites. The sediments were deposited on a relatively high-energy, subtidal, wave-swept platform that graded upwards into a supratidal zone. The frequency of environmental changes may indicate a more tectonically active shelf during Beekmantown time.

The contact between the middle limestone and dolomite unit and the *upper dolomite unit* is placed at the top of the uppermost limestone in the cyclic unit that underlies a thick section composed entirely of siliceous dolomite. The upper dolomite unit is well exposed in an abandoned quarry (REFERENCE LOCALITY 6) along North River, and is generally similar to the lower dolomite unit but not as thick. Such common evidence (mud cracks, algal lamination, thin dolomite intraclast layers) of an algal flat inundated only during major storms. Vuggy, mottled and intensely disrupted beds may indicate crystal growth under evaporative conditions, and the highly siliceous content suggests input by an external (aeolian) depositional system operative during dust storms.

The contact between the upper dolomite unit and the upper limestone and dolomite unit is placed at the base of the lowest limestone above the massive dolomite section. The *upper limestone and dolomite unit* is exposed at REFERENCE LOCALITY 7 along Pleasant Run. The unit contains, incomplete, truncated cycles of massive micritic limestone, micritic limestone with burrow structures, a few layers of shale and calcareous mudrock, overlain by thin, laminated dolomite. Characteristic structures are bird's-eye texture, mud cracks, lamination, intraformational conglomerates and burrows. Environmental conditions seem to have fluctuated between intertidal and supratidal zones, with the culmination being a period of erosion. The contact between the upper limestone and dolomite unit of the Beekmantown Group and the overlying New Market Limestone is placed above the uppermost dolomite in the Beekmantown Group, generally at the base of massive, micritic limestone bed.

Two outcrop belts that contain a sufficient thickness of *New Market Limestone* mapped separately from the overlying Lincolnshire Formation have been delineated northwest of the Pulaski-Staunton fault on the flanks of the Long Glade syncline. Southeast of the fault in the Burketown structure (formerly "Kipps") and on the northwest limb of the Massanutten synclinorium, the New Market has been mapped in combination with the Lincolnshire. The New Market was deposited upon the eroded surface of the upper Beekmantown limestone and dolomite unit. The erosional surface represents a time of greatly reduced subsidence rather than a period of tectonic emergence as there is no evidence of angularity along the contact and no beds have been caused by pre-New Market folding. An example of basal limestone pebble conglomerate and breccia discernible topographic relief developed on the contact can be seen at REFERENCE LOCALITY 8, east of Mount Sidney.

The section along the northwestern limb of the Massanutten synclinorium has several micrite beds up to 14.1 feet (4.3 m) thick (REFERENCE LOCALITY 9) which occur interbedded with coarser-grained, locally bioclastic marine limestones. The micrite beds contain thin dolomite laminations near the base, small algal stromatolites and bird's-eye texture. They are probably very shallow, intertidal lagoon deposits that were subject to intermittent desiccation.

A section more than 200 feet (61 m) thick of pure micritic limestone (the quarry-rock facies of the New Market) occurs along Pleasant Run (REFERENCE LOCALITY 10) on the southeastern limb of the Long Glade syncline. A similar thickness of New Market occurs on the northwestern limb of the same structure near the old lime kiln south of Bridgewater (REFERENCE LOCALITY 11), but contains some impure laminated and cherty beds.

Facies relationships exist between the laminated and bird'sye micrite lithofacies of the New Market and the coarser-grained, cherty, fossiliferous limestones of the *Lincolnshire Formation* (Figure 2). The marine limestones are predominant along the southeastern outcrop belt, whereas shallow, intertidal, micritic limestones are more extensively developed west of the Pulaski-Staunton fault. Very coarse-grained limestone (the Murat unit of the Lincolnshire) occurs interbedded throughout the combined section of Lincolnshire-New Market rocks in the southeastern belt (REFERENCE LOCALITY 12). In the Long Glade syncline a thin, coarse, fossiliferous calcarenite bed occurs at the top of a New Market-Lincolnshire section (REFERENCE LOCALITY 13) and was correlated with the Botetourt Limestone by Fara (1971). The coarse, fossiliferous calcarenites from each side of the Pulaski-Staunton fault are here considered together as one lithofacies within the Lincolnshire Formation because they are so similar in lithology. Such lenticular, coarse, skeletal carbonate sands are deposited in high-energy shoal areas near the seaward edge of carbonate platforms (Figure 1, and Wilson, 1969, Figure 4, page 12). Their distribution across the Mount Sidney quadrangle indicates a transgressive sequence marked by the westward migration of the shelf edge across the platform and over the preexisting strand line (supratidal zone) during the time of New Market and Lincolnshire deposition.

The upper contact of the Lincolnshire Formation is placed at the top of the uppermost cherty, medium- to coarse-grained limestone that is overlain by black slate and black rhythmically-bedded limestone (Liberty Hall unit), or by dark nodular limestone (Lantz Mills unit) of the Edinburg Formation.

Two lithofacies are recognized within the *Liberty Hall unit of the Edinburg Formation*: a discontinuous basal, graptolitic slate* and black, micritic limestone with flysh-like rhythmic bedding, soft-sediment folds and large, slumped limestone blocks (Lowry and Cooper, 1970). The Liberty Hall characteristic of the northwestern limb of the Massanutten synclinorium is best exposed along the tracks of the Chesapeake Western Railway just east of the town of Mount Sidney (REFERENCE LOCALITY 14). At this locality the basal black slate of the Liberty Hall can be readily compared with the overlying basal Martinsburg slate. The thickness of the Liberty Hall declines to the east until, along the southeastern limb of the Massanutten synclinorium in the adjacent Fort Defiance and Waynesboro West quadrangles, the basal Martinsburg slate lies directly upon the Lincolnshire limestone. Figure 2 illustrates that there are intergrading facies relationships between the Liberty Hall and the Martinsburg.

The westward migration of the shelf edge noted in the discussion of the Lincolnshire Formation suggests that from a precipitous subsidence of the eastern edge of the carbonate shelf during middle Ordovician time. This is demonstrated by the direct superposition of graptolitic (deep-water basin) slates (basal Liberty Hall), basal Martinsburg upon coarse, carbonate shoal sands of the Lincolnshire. The limestone facies of the Liberty Hall may also be considered a basinal deposit (Figure 1) because of its characteristic bedding forms and sedimentary structures (Thomson and Thomssen, 1969, p. 67) which indicate deposition by carbonate turbidity currents. Those carbonate turbidites were derived from the carbonate shelf margin, and the increase in thickness of the limestone facies from southeast to northwest across the Fort Defiance and the Mount Sidney quadrangles also indicates that the shelf margin had migrated to the west in middle Ordovician time.

The upper contact of the Liberty Hall is placed at the top of the black, rhythmically-bedded limestone turbidite sequence. Along the northwest limb of the Massanutten synclinorium there is a black graptolitic slate at the base of the overlying Martinsburg; on the southeast limb of the Long Glade syncline there is a lenticular, irregularly bedded, nodular, fossiliferous limestone unit just below the base of the Martinsburg.

The nodular, irregularly bedded, fossiliferous *Lantz Mills limestone* unit of the Edinburg Formation occurs just below the base of the Martinsburg turbidite sequence along North River (REFERENCE LOCALITY 15) at the town of Mount Crawford, and was traced as a separate unit for almost two miles to the southwest where the unit is covered by the Burketown structure. Similar lithofacies that are too thin or discontinuous to map separately occur at the top of the Liberty Hall and are interbedded with the Martinsburg Formation in the trough of the Long Glade syncline.

Sandstone, Argillite, and Slate

Two separate belts of the *Martinsburg Formation* are recognized in the quadrangle, one in the trough of the Massanutten synclinorium, and the other in the Long Glade syncline (Figure 2).

In the Massanutten synclinorium the Martinsburg has been divided into three members, each of which represents a basinal facies of the Ordovician rocks. The basal, black, graptolitic calcareous slate member (REFERENCE LOCALITY 14) was formed from pelagic sediments that were deposited upon the Lincolnshire Formation prior to the initiation of turbidity currents into the basin or at least before the arrival of more proximal portions of flows. Where deep slates intergrade with the Liberty Hall limestone they are included as part of the Edinburg Formation.

The pelagic black slates are transitional upwards into a turbidite facies, the *calcareous argillite* middle member (REFERENCE LOCALITY 16), distinguished by the appearance of a rhythmic succession of silty calcareous argillite, limestone and slate that have the same rhythmic bedding as the Liberty Hall limestone.

The mixture of calcareous and terrigenous sediments in this unit indicates it was derived from two source areas; carbonate mud transported by turbidity flows from the shelf areas adjacent to the basin on the west, and terrigenous mud transported down the basin by turbidity currents from tectonic lands to the southeast (McBride, 1962). The calcareous argillite member in the Massanutten synclinorium is transitional into the *sandstone-bearing* upper member. The contact is placed at the lowest lithic sand bed, a more proximal turbidite unit distinguished by characteristic sole markings at the base of beds. Some of the fine- to coarse-grained lithic sandstones in the upper Martinsburg in the Massanutten synclinorium contain fragments of metamorphic rocks and chert that must have been derived from a distant metamorphosed terrain. The depositional systems noted in the lower units of Martinsburg were still active, as carbonate mud is represented by slate and argillite layers throughout the upper rhythmic succession (REFERENCE LOCALITY 17).

In the Long Glade syncline the Martinsburg Formation is similar to the calcareous argillite unit in the Massanutten synclinorium, containing interlayered slate, rhythmically layered argillite, and deep-water lime beds (REFERENCE LOCALITY 18). The major difference is the existence of some coarse sandstone beds and irregularly bedded, nodular limestone strata, neither of which occur in the Massanutten synclinorium. This indicates that in the slope-facies limestone, indicating that in the Long Glade syncline the Martinsburg original, deep-water basin) slates (basal Liberty Hall, basal Martinsburg) upon coarse, carbonate shoal sands of the Lincolnshire. The limestone facies of the Liberty Hall may also be considered a basinal deposit (Figure 1) because of its characteristic bedding forms and sedimentary structures (Thomson and Thomssen, 1969, p. 67) which indicate deposition by carbonate turbidity currents. Those carbonate turbidites were derived from the carbonate shelf margin, and the increase in thickness of the limestone facies from southeast to northwest across the Fort Defiance and the Mount Sidney quadrangles also indicates that the shelf margin had migrated to the west in middle Ordovician time.

The upper contact of the Liberty Hall is placed at the top of the black, rhythmically-bedded limestone turbidite sequence. Along the northwest limb of the Massanutten synclinorium there is a black graptolitic slate at the base of the overlying Martinsburg; on the southeast limb of the Long Glade syncline there is a lenticular, irregularly bedded, nodular, fossiliferous limestone unit just below the base of the Martinsburg.

The nodular, irregularly bedded, fossiliferous *Lantz Mills limestone* unit of the Edinburg Formation occurs just below the base of the Martinsburg turbidite sequence along North River (REFERENCE LOCALITY 15) at the town of Mount Crawford, and was traced as a separate unit for almost two miles to the southwest where the unit is covered by the Burketown structure. Similar lithofacies that are too thin or discontinuous to map separately occur at the top of the Liberty Hall and are interbedded with the Martinsburg Formation in the trough of the Long Glade syncline.

MINERAL RESOURCES

Crushed stone has been produced from three quarries in rocks of the Beekmantown Group; the Naylor quarry in the upper silicious dolomite unit (REFERENCE LOCALITY 6), the Vulcan Materials quarry in the middle limestone and dolomite unit (REFERENCE LOCALITY 19), and the Salem Stone Corporation quarry in the upper limestone and dolomite unit (REFERENCE LOCALITY 20). Other rock units that are potential sources for crushed stone include the lower limestone and dolomite unit of the Beekmantown, the upper member of the Conococheague Formation where it contains little or no sandstone, and the New Market, Lincolnshire and Edinburg formations in the Long Glade syncline.

High-calcium limestones occur in the upper 200 feet (60 m) of the Beekmantown Group and in the New Market Limestone. Only the New Market Limestone has a potential for development, however, and adequate thickness, and impure limestones are present only in the cases of this unit; one near Bridgewater and Long Glade syncline near Carbonate rock Mount Crawford. All other carbonate rock units are impure limestones, or limestones that may be stones or impure dolomites that may be potential sources for agricultural lime or limestone, or hydraulic lime, but which either contain excessive non-carbonate impurities (silica, clay minerals, iron, etc.) or are so varied in carbonate composition and physical character from bed to bed as to make them impractical for other use. See Edmundson (1945) for additional information.

Slate beds within the sandstone-bearing member of the Martinsburg Formation may have potential for brick, lightweight aggregate or other industrial or ceramic use (Calver, et al., 1964). However, the slates that have great ceramic properties are generally so cleaved, stratified by sandstones, calcareous slate or argillite beds with undesirable characteristics that they may not be usable.

GEOLOGIC FACTORS AFFECTING LAND MODIFICATION

Areas underlain by similar rock types or having similar surficial deposits form land units that have been evaluated on the basis of lithology, slope stability, erodability, and response to excavation and ground-water withdrawals. The locations of major sinkholes and modified-land areas are shown on the geologic map and described in the legend as special units involving land modification. Rock units are guides to land units with similar environmental and physical properties. However, as some of the rock units vary internally in lithology and structure, a detailed evaluation of individual sites is recommended. Data on properties for regional planning, soils and water may be obtained from the following: (1) Virginia Division of Forestry, P. O. Box 3758, Charlottesville, VA 22903; (2) Shenandoah Planning District Commission, P. O. Box 1337, 119 West Frederick Street, Staunton, VA 24401; (3) Soil Conservation Service, U. S. Department of Agriculture, P. O. Box 10026, Richmond, VA 23240; (4) State Water Control Board, P. O. Box 368, Bridgewater, VA 22812.

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REFERENCE NOTE

Portions of this publication may be quoted if credit is given to the Virginia Division of Mineral Resources. It is recommended that reference to the publication be made in the following form:

Gathright, T. M., II, Henika, W. S., and Sullivan, J. L., III, 1978, Geology of the Mount Sidney quadrangle, Virginia: Virginia Division of Mineral Resources Publication 11, text and 1:24,000 scale map.

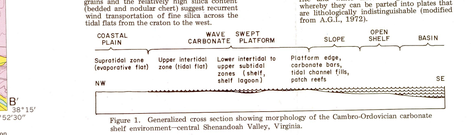
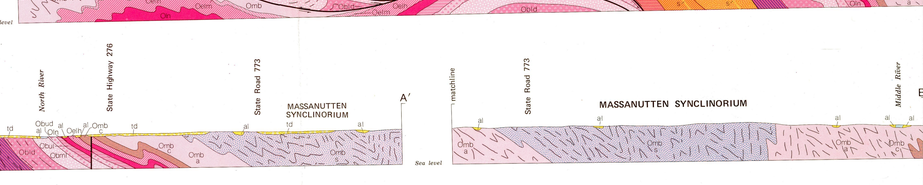


Figure 1. Generalized cross section showing morphology of the Cambro-Ordovician carbonate shelf environment—central Shenandoah Valley, Virginia.

* Slate as used in text is a compact, fine-grained, metamorphic rock formed from such rocks as shale and volcanic ash, which possesses the property of fissility along planes independent of the original bedding (slaty cleavage due to the crystallization of chlorite and white mica along these planes) whereby they can be parted into plates that are lithologically indistinguishable (modified from A.G.I., 1972).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