

Furcron, A. S., and Woodward, Herbert P.

Geology and mineral resources of the
Stony Man quadrangle, Virginia.

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✓ *Ordinary sandstone* →

General features

General features sand and silt residual materials formation fossils

original ms.

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(Extra, not tied in)

Airplane photos available - ?
 { Not PIC owner
 U.S. Forest Service

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Triple space ad; ^{clear} 2 cc = 1 inch
ABSTRACT ^{the within} ^{1 HAW} Long. Prindle

The area described in this report is ~~the territory of the~~
~~Stony Man topographic quadrangle, and~~ lies in northwest-central
Virginia. It includes ~~a region of both lowland and mountainous~~
~~country, extending from~~ ^s Massanutten ^{on} Mountain ^{across Page Valley} ¹ at the northwest into the
Blue Ridge province ^{on} [^] the east. ^{Altitudes} [^] elevations range from
650 to 4,049 feet above sea-level, and ^{area} ^s the country is drained into
the Potomac and Rappahannock rivers. ~~The climate is pleasant,~~
~~and the soils of the valley lowland are fertile. There are many~~
~~scenic points within the quadrangle to which visitors are~~
~~attracted.~~

~~Differences in the effects of erosion upon rocks of unequal~~
~~hardness have produced the uplands and valleys of the quadrangle,~~
~~and a long erosional history may be interpreted from the present~~
~~topographic features. Conspicuous among the physiographic~~
elements of the region are the remnants of two erosion levels,
or peneplanes. ^{ains} These include the Upland ^{ain} peneplane, at elevations
around 3,000 feet, and the Valley-floor ^{ain} peneplane at elevations
around 900 feet. Other ^{Stays} ^{TDD} [^] features of erosional history are pre-
served in ~~the various~~ wind-gaps ~~that occur~~ along the Blue Ridge
crest, and in the records of underground solution, of which
Luray Caverns, ^{are} ~~located within the quadrangle,~~ is a widely known
example.

The rocks of the Stony Man ^{area} ~~region~~ consist of five groups:
~~(1) pre-Cambrian crystalline and metamorphic rocks; conspicuous~~
~~ly represented by the Gettysburg greenstone and a coarse gneiss~~
~~diorite; (2) a Lower Cambrian amygdaloidal lava flow; (3)~~
Paleozoic consolidated sedimentary rocks, ^{is} ⁱⁿ ^{age} ^{from} ^{early} ^{Lower} that range from

Late

Cambrian ~~sandstones~~ to ~~Upper Devonian shales~~; ~~(4)~~ Triassic
 dikes ~~of basalt~~ that ~~cut the Pre-Cambrian terranes~~; and ~~(5)~~
 unconsolidated Quaternary surficial deposits. The ~~Pre-Cambrian~~
~~igneous and metamorphic rocks~~ *underlie* ~~crop out over~~ about two-thirds of
 the quadrangle, *They* ~~and~~ are responsible for the ruggedness of the
 Blue Ridge ~~province~~. ~~Their subdivision into various members~~
~~that include the ancient lava flows now altered into greenstone~~
~~and several types of intrusive igneous rocks, indicates that a~~
~~complicated geologic history has been responsible for the base-~~
~~ment (terrane) of crystalline rocks which forms the Blue Ridge~~
~~The occurrence along the Blue Ridge of unakite~~ *core of* ~~a striking granitic~~
~~rock containing red, blue, and green constituents~~ is of
 special interest, ~~to the mineralogist and student of rocks.~~
 The Paleozoic ~~sedimentary rocks~~, which underlie Page Valley
 and Massanutten Mountain, ~~rest in places upon the Pre-Cambrian~~
~~basement and at other points upon an ancient lava flow of early~~
~~Cambrian age.~~ The ~~sediments~~ may be separated into more than
 twenty recognizable units, ~~whose description adds to the accumu-~~
~~lating knowledge of Virginia stratigraphy.~~ Quaternary materials
 blanket much of the bed-rock, ~~and the presence of wide, coalescing~~
~~alluvial fans of sand and gravel is a striking feature of the~~
~~quadrangle.~~

backbone

typical of

The structure of the region is ~~(typically that of)~~ the central
 Appalachian Highlands, being *Consisting* ~~a complex~~ of folds and thrust faults
 with their attendant minor phenomena. ~~A portion of the large~~ *Eastern part of the*
 Massanutten *Mountains* ~~syncline~~ *Northwestern part of the* crosses the quadrangle, ~~and~~ the overturned
 folds of Page Valley present the curious structure in which
 younger rocks dip beneath the sediments upon which they normally
 rest. ~~The trace of the Blue Ridge overthrust~~ *fault* passes through the
 foothill belt at the western flank of the Blue Ridge, ~~and several~~
 smaller displacements of the overthrust type *are* ~~may be found.~~

Def
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C

The creation of ^{the} Shenandoah National Park has added the eastern two-thirds of the quadrangle to the game reserves ^S and ~~recreation areas~~ ^{recreation areas} ~~pleasure grounds~~ that the Federal Government maintains in ~~areas~~ ^{un} (regions) of ~~more than~~ usually beautiful scenery; ~~and~~ the local portion of the Park is ~~a section that~~ exhibits characteristic Appalachian topography. Deep canyons, rugged mountains, an abundant stand of timber, and clear ^{mountain} streams provide ^{fine} a park area that ~~recreates and preserves the original beauty of the region,~~ ^{An} ~~while an~~ improved system of roads, ^{including} ~~centering around~~ the magnificent Skyline Drive, makes ^{these features readily} ~~them~~ accessible ~~to all~~. The underground ^{Corridors} (caves) and ~~cave~~ ^{an added} formations of Luray Caverns are likewise scenic attraction of the quadrangle.

usually or especially beautiful

corridors
caves
- of caverns
On a scale of interesting

~~In the face of an unusual degree of scenic beauty which adds materially to general interest in the area, the underground mineral resources ^{occupy a} ~~are~~ somewhat ^{in contrast to the surface features} of a minor position. ~~Known~~ quantities of iron and manganese ~~ore~~ ^{do not} have been located and prospected, but the local supplies are ~~not adequate~~ to warrant exploitation, ~~under present conditions of demand and expense of operation.~~ Limestone and other ^{materials} ~~materials~~ for rough construction and road ballast are present in adequate quantities for local use. Copper has been sought but not found in profitable amounts, and small deposits of commercial ~~ocher~~ ^{ocher} were formerly worked. Underground water is ^{available for} ~~present if tapped by~~ deep wells, ~~and~~, in a few large springs, ~~emerges naturally at the surface of the ground.~~~~

Luray, the county-seat of Page County, is the largest ^{town} ~~settlement~~, ^{it} ~~within the region and is served by~~ the Norfolk and Western Railway, the Lee Highway (U. S. ~~Highway No.~~ 211), and several State highways. A few ~~smaller~~ hamlets occur within the quadrangle, ~~but~~ in the deeper and more inaccessible "hollows" of the ridges ~~may be found~~ the picturesque cabins of isolated mountain-folk who still retain some of the customs and phrases of Queen Elizabeth's England.

Abandoned Division of the

time 7

Triple space all = 2 cc
OK

GEOLOGY AND MINERAL RESOURCES
OF THE STONY MAN QUADRANGLE, VIRGINIA

10 Pt. Caps & l.c

BY
A. S. FURCRON
AND
HERBERT P. WOODWARD

lc — INTRODUCTION

Location and Area

The territory covered by this report lies within the northwest-central part of Virginia. It embraces the quadrangle is in Page County; the northeastern part (is in) Rappahannock County; and the southeastern portion (is in) Madison County. The boundary between Page and the eastern counties is the crest of the Blue Ridge, and the local dividing line between Rappahannock and Madison counties is an arbitrary boundary drawn from a summit of the Blue Ridge southeastward to the margin of the area.

The Stony Man quadrangle is bounded on the east and west by meridians of 78°15' and 78°30' West Longitude, respectively, and on the north and south by parallels of 38°45' and 38°30' North Latitude, respectively. It is approximately (13 and three quarters miles) wide in an east-west direction and (17 and one-half miles) long in a north-south direction. It is bounded on the north and east by portions of the Luray topographic quadrangle, on the south

The topographic map of the Stony Man quadrangle can be bought for the U.S.G.S., (Minerals, Va., at 10 cents a copy

4 Pt. Caslon
C+L.C.

Location of the Area

Extent of Fig. 8
Describes area as northwest

9

10
13 3/4
17 1/2

all lower plate and fig. numbers plan

10 Pt Black caps

8 Pt Black caps

square miles

approximately

~~by the Madison quadrangle, and on the west by the south-eastern quadrant of the Woodstock sheet. The scale of the Stony Man and Madison quadrangles is approximately one mile to the inch; that of the Woodstock and Luray quadrangles is approximately two miles to the inch.~~

^{Topographic} A map of the ~~entire area within the proposed~~ Shenandoah National Park, including the eastern ~~part~~ of the Stony Man quadrangle, has recently been completed, and final copies of this map were published in 1934, in two large sections, each on a scale of 1:62,500, or (about) ^{one inch to} ~~one mile~~ ^{link to 2000 feet} on a scale of 1:24,000, or approximately ~~2,000 feet to the inch~~ -- were available to the authors during their ^{Study} survey of the ^{geology of the} Stony Man quadrangle.

study
 Nature and scope of
 Scope of Report
 Purpose of Report
 Character of Report
 a)

✓ This map can be bought from the U.S. G.S. - Washington, D.C.
 - ? - ^{Scope} Nature of ~~the~~ Report → Note - From HSS on; changes in 1930; material to be added in final

In 1932 the Virginia Geological Survey assigned the Stony Man quadrangle to the present authors to be surveyed and studied for a geologic report. A field program was begun in the summer of 1932, and both authors were in the area throughout the latter part of that season. During the summer of 1933, little or no field work was undertaken, and the survey was completed in the summer of 1934.

This report is intended to serve as a guide to the natural resources and geologic features of the Stony Man ^{area} region. ~~In view of the recent creation of Shenandoah National Park,~~ it is hoped that ~~publication of this report~~ will aid visitors ^{to} ~~the~~ ^{Shenandoah National} Park to a better understanding and

have
 and Page Valley

The physical geography and the character & arrangement of the rocks are discussed in considerable detail.

appreciation of the geologic ^{at features} phenomena of the area. The present and future possibilities of the natural resources ^{rock mineral} within this area are also discussed, so that ~~one~~ interested in their development may have at his disposal the results of a careful ~~and~~ recent geologic ^{study} survey. A detailed ^{geologic} ~~out~~ ^{crop} map (Plate ~~2~~) which ~~accompanies~~ ^{accompanies} this report shows the extent of the surface area that is underlain by the various rock formations. Structural ^{sections} are given to show the actual and ^{inferred} relations of these ^{rocks} formations below the surface of the ground, and discussions of the various surface features, rock formations, and other points of geological interest are also given. An attempt has been made not only to present ^{observed} these facts to the scientific readers, but also to ^{interpret} explain them for the local residents ^{and} casual visitors. ^{points} ~~points solely of scientific interest have been condensed and isolated within the report.~~ ^{of interest} ^{treated separately}

The present report is the joint work of both authors. It was mutually agreed that study of the surface geology of the ~~Pre-Cambrian~~ ^{rocks} ~~area~~ should be undertaken by ~~Mr.~~ ^{made} Furcron, and that ^{an investigation} while a survey of the Paleozoic ^{rocks} ~~area~~ should be made by ~~Mr.~~ Woodward. In the report, therefore, ^{the} descriptions of ^{sedimentary} rocks have been made by ~~Mr.~~ Woodward and ^{descriptions} of igneous and metamorphic rocks have been made by ~~Mr.~~ Furcron. The ^{balance} of the report has been jointly written by both authors.

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Pl. Fig. 2

R.C.F. on investigation

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Acknowledgments
ACKNOWLEDGMENTS /ec

The authors are under ~~considerable~~ indebtedness to many sources for material presented herein. ^{They are indebted also} ~~No small portion of this debt is owed~~ to residents of the region, who ~~have~~ courteously cooperated in allowing free access to their property ^{ies}, ~~as well as~~ ^{and} to others who have given local information that otherwise would have been difficult to obtain. ~~The authors are under further indebtedness to earlier workers whose reports and other descriptions have already been published in the geologic literature dealing with this region.~~ For valuable advice and suggestions ~~pertaining to~~ ^{about} ^(regional) the geology of this region, the authors are indebted to Dr. Anna I. Jonas and Dr. Charles Butts ^{of the} ^{Virginia} ~~United States Geological Survey~~ and ~~to~~ Dr. Arthur Bevan, State Geologist of Virginia.

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Mr. Robert A. Laurence ^{was} ~~acted~~ throughout the field season of 1932 ~~as an assistant and junior associate to Mr. Woodward in the securing of data for this report~~ ^{he} ~~Mr. Laurence~~ materially contributed to the field work and ~~has~~ ^a ~~given~~ valuable assistance in the interpretation of the geology ~~of this region~~.

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During the field season of 1934, Mr. Robert L. Bates acted in a similar capacity, and ^{gave} ~~his~~ assistance ~~was of~~ considerable ~~service~~ in the ~~progress of the~~ field work.

Mr. William M. Austin, resident engineer, United States Bureau of Public Roads, in charge of engineering and road construction ~~within~~ ^{the} Shenandoah National Park, kindly gave

^

permission ~~to the authors~~ to enter the Park area at points where road construction was in progress, ^{which facilitated the field work.} and the ~~writers~~ ~~are indebted to Mr. Austin for this permission.~~

MS A

← Mr. L. Ferdinand Zirkel, of Luray, has contributed data regarding springs and other ^{Caverns} ~~unique~~ materials, for which ~~information the authors express their gratitude.~~

Messrs. T. C. Northcott and C. C. Logan, respectively, president and superintendent, of Luray Caverns Corporation, kindly allowed ^{free} access to the ~~Luray~~ Caverns, ^{and} data and photographs furnished ~~by them~~ ^{which} are acknowledged ~~elsewhere~~ ^{used} in the report.

The final editing of this bulletin has been made by the staff of the Virginia Geological Survey, and the authors are especially indebted to Dr. Arthur Bevan, State Geologist of Virginia, and Mr. Linwood H. Warwick, Chief Clerk of the Survey, for full assistance throughout the field work and preparation of the final report.

O = To be done later

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STRATIGRAPHY

General Statement

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This section ~~(of the report)~~ deals with the general character of ^{The} all rocks exposed ~~at the surface (of the ground)~~ within the ~~(area of the) Stony Man quadrangle.~~ ^{and} It is intended to serve as a guide to the identification of ^{the} rock types, ^{as well as to record observed data} ~~at any point within the region,~~ ^{it} and contains a concise description of the character, distribution, and correlation of each of the ^{rock} various units.

The rocks of this quadrangle ^{may be classified according to origin and age} are ~~conveniently grouped~~ into five main ^{groups} divisions; ~~as follows:~~ ~~Pre-Cambrian~~ crystalline rocks; ~~Lower Cambrian~~ volcanic rocks; ~~Paleozoic~~ sedimentary rocks; ~~Triassic~~ dikes ~~of igneous rocks~~; and ~~Quaternary~~ surficial ~~and~~ unconsolidated deposits.

Explored
Tsch
Thom's

The ~~area of outcrop of~~ ~~Pre-Cambrian~~ rock ^{occupies} the eastern two-thirds of the quadrangle. ~~In addition,~~ ^{also} these rocks underlie the remainder of the area and, no doubt, would be reached by wells drilled sufficiently deep through the overlying Paleozoic sediments. The western ^{third} ~~portion~~ of the quadrangle is occupied by ~~the surface outcrop of the various~~ Paleozoic ^{rocks & systems} ~~systems~~ and Quaternary deposits are scattered in an irregular pattern over the entire ^{area} ~~territory~~. The geologic map (Plate ~~2~~) ~~that~~ ^{pre-Cambrian} ~~accompanies this report~~ shows the distribution of these ~~different~~ ~~and Paleozoic~~ systems of rocks, ~~and also~~ ^{It also} shows the ~~least~~ ^{distribution} outcrop of the ~~many~~ smaller ^{formations} ~~divisions~~ into which ^{comprise} the larger groups ~~may be~~ separated.

For ~~purpose of~~ description, the ~~local rocks are~~ grouped into ~~two major divisions,~~ each of which will be discussed in detail. ~~Although both authors have collaborated in the preparation~~

of on map

pl. 1)

of the various rock descriptions, the discussions of igneous and metamorphic rocks are mainly the work of Mr. Furcron, while those of sedimentary rocks are mainly the work of Mr. Woodward.

Igneous and Metamorphic Rocks

General Features
Introduction

Igneous rocks of intrusive and extrusive origin crop out over the greater part of the Blue Ridge region ⁱⁿ of this quadrangle. The mass of the mountain consists of granodiorite and granite ^{which generally crop} ~~cropping~~ out on the flanks of the ridge, but in many places ^{they} ~~extend~~ to the top. The crest ^{of the} ~~north~~ ^{east} of Thornton Gap and south ^{west} of Hughes River Gap is composed of extensive flows of basalt, which have been intruded by granodiorite and granite. ^{the basalt} and ~~which~~ have been generally altered to epidote greenstone. ~~All~~ ^{Fig. A, Plate III} of the rocks mentioned above are of ~~pre-Cambrian~~ ^{pre-Cambrian} age. (See Pl. - -)

~~In addition,~~ amygdaloidal lava flows are ^{found} ~~known~~ at the base of the Cambrian ~~section~~ along the western side of the Blue Ridge, and ~~dikes~~ ^{locally} of Triassic diabase intrude the ^{pre-Cambrian} ~~crystalline~~ rocks ~~of~~ the region.

Discussion of the igneous and metamorphic rocks is mainly by A. S. Furcron, who mapped them in the field.

Fig. 13A?
L.C.I.
K.C.I.
L.C.I.

Blue Ridge

CATOCTIN FLOWS

General Relations

~~Introduction.~~ Ancient basaltic lava flows extensively altered to epidote-chlorite greenstone ^{the Blue Ridge and Western Piedmont Regions} are widespread in Virginia. Two belts of this rock occur in the state. ^{An} The eastern belt enters Virginia from Maryland at Taylorstown, Loudoun County, and extends southwestward through Bull Run Mountain, Warrenton, and Charlottesville to south-central Virginia. The Blue Ridge belt enters Loudoun County at Harpers Ferry and follows the Blue Ridge crest southwestward to Natural Bridge. Keith studied this rock in Northern Virginia ^{and} giving

Keith, Arthur, Geology of the Catoctin belt: U.S. Geol. Surv., 14th ^{also,} Fourteenth Ann. Rept., pt. 2, 1894, pp. 287-386; Harpers Ferry ~~Belts~~, U.S. Geol. Survey Geol. Surv., Folio 19, 1894. Atlas, Harpers Ferry, folio (no. 10), 1894

~~It is the name~~ ^{of the} Catoctin schist. Much of the ^{rock in the} eastern belt is schistose, but ^{along} in the region of the Blue Ridge crest it is ^{usually} massive. ^{Commonly of the basalt is} In the Virginia Blue Ridge this rock is intruded by a batholith of granodiorite which was followed in pre-Cambrian times by the intrusion of granite.

Furcron, A.S., Igneous rocks of the Shenandoah National Park Area: Jour. Geol., ¹⁹³⁴ Vol. 42, No. 4, 1934, pp. 400-410,

Distribution. In the Stony Man Quadrangle, Catoctin flows underlie intrusive rocks at the top of the Blue Ridge. Remnants of the Summit peneplane ^{along the crest of the Blue Ridge in the Stony Man Quadrangle} generally occur upon this rock. The belt is from ~~two~~ 2

Catoctin greenstone generally underlies

to ⁵ five miles wide but is discontinuous in the central ^{part} region of the quadrangle between Hughes River ~~gap~~ and Thornton ⁵ Gap. The widest unbroken belt of greenstone in the Park area occurs just north of Elkwallow ~~Gap~~ ^(US.211). The Lee Highway ^{is} passes through Thornton Gap entirely (up) on greenstone, ~~but~~ ⁽granodiorite crops out on the south side of the road in the gap. Greenstone is ~~entirely~~ confined to the ^{crest of the Blue Ridge} mountain top south of Hughes River Gap except in Tanner's Ridge, where it extends down to the valley floor, nearly to Marksville. North of Thornton Gap, green-stone underlies Lower Cambrian arkose. ~~Jeremiah's~~ Run has cut through the arkose so that a tongue of greenstone extends down this valley to the western base of the mountain. Knob Mountain north of ~~Jeremiah's~~ Run is nearly surrounded by greenstone. A small, isolated area of greenstone about ^{3 1/2} three miles ~~and a half~~ long and less than ^{1/2} half mile wide occurs west of the Blue Ridge in Hoak Hill, between Club Run and Piney Hill.

Jeremys

North of Thornton Gap,

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Thickness.—The preservation of Catoctin flows ⁱⁿ this quadrangle is due to the fact that the level of grade at the time of the formation of the Summit Peneplane happened to be slightly above the base of the flows. Estimates of ^{the} thickness of ^{the Catoctin} ~~this rock~~ may be made on the west side of the Blue Ridge summit, but ~~there is no reason to assume that~~ ^{the} ~~estimate~~ ^s will ~~hold up~~ ^{not apply} farther east. The base of the greenstone is ~~encountered~~ a short distance below the summit of the ^{Blue} Ridge between Stony Man and the southwest ^{er} corner of the quadrangle. ~~In this section the geologist had best approach the contact from the top rather than from the hollow.~~ At Crescent Rock, the greenstone is about 500 feet thick; at Fisher's Gap ^{of} the ~~thickness~~ ^{it} is about 600 feet. From Thornton Gap to Mount Marshall, northeast of the quadrangle, ~~there is a continuous section~~ of greenstone that ~~would indicate~~ ^{suggests} a thickness of 1800 feet. This may not

Fisher's

Thickness, ^{ROCKS}
be the actual ~~case~~ however, for the underlying intrusives ^{are}
younger than the ^{greenstone} flows. It is not possible to determine the original
thickness of the ^{lava} flows ^{because they have undergone much erosion} which ~~was much greater than at present.~~

Megascopic character.--The basalt is generally altered to epidote
greenstone. ~~The~~ ^{The} secondary minerals are coarse enough to be recognized
with the naked eye. ^{the rock} is commonly vesicular and locally scoriaceous.

The vesicles are generally filled with milky ^{white} quartz and epidote.
Sometimes ^{of} the quartz is pink. ~~The~~ Quartz and epidote ~~may~~ ^{occur} ^{separately}
or together. ^{and in many places fill fractures.} In some localities red jasper is a common secondary
mineral, ~~and~~ ^{Small} masses of greenish chalcedony ~~sometimes~~ ^{locally} occur. Small
masses of fibrous quartz and asbestos are common. ~~Quartz and epidote~~

~~Often fill fractures and~~ ^{Some of} epidote ~~is~~ extensively replace the basalt to form
epidosite.

The lower part of the greenstone in many places is massive and
non-amygdaloidal. This fact suggests that it may be possible to divide
the flows into two major divisions. This can not be done in mapping
because the amygdaloidal facies occurs ^{in places} ~~sometimes~~ at the base, next to the
intrusives.

An interesting feature of the greenstone in this part of the Blue
Ridge is ^{the} ~~its~~ tendency to show columnar jointing. ~~This is that of a massive,~~
basal non-amygdaloidal facies. ~~This facies, several hundred feet thick,~~
occurs at the base of the Catactin greenstone ^{It is} ~~but may be~~ locally absent.

~~It~~ resembles a sill rather than a flow. This greenstone ~~is~~ ^{Columnar}
jointing ^{is found} between Skyland and Fisher's Gap along the west side of the mount-
ain, ~~and~~ ^{also} columns may be seen along the trail under Crescent Rock. The ~~de-~~
velopment of the profiles of Hawksbill and Stony Man ^{and} ~~as well as~~ the palisades
at Franklin Cliffs ^{are} ~~is~~ due to rapid erosion in greenstone with a pronounced
vertical jointing, on the steep western slope of the Blue Ridge. Large
columns of greenstone several feet in diameter may be seen in the valley (See Pl. .)
known as Little Devil Stairs in the northeastern part of the quadrangle. (Fig. 66).
~~Fig. 66~~

Pl. 66

^{of}
 Rocks other than greenstone ~~are not found on a large scale in~~
~~this region although~~ local occurrences are not ^{uncommon} ~~infrequent~~. Pyroclastics
 are rare. Near Rattlesnake Knob, just beyond the northern edge of the
 quadrangle and west of Little Devil Stairs, is an agglomerate of green-
 stone bombs in a fine ashy matrix of similar material. At the lower end
 of Little Devil Stairs is a small outcrop of reddish-brown brecciated
 rock which may be a flow breccia. It is largely composed of angular
 fragments of volcanic rock which are ~~(made)~~ ^{made} visible on ~~the~~ weathered surface.

Microscopic character. -- Thin sections show the greenstone to be a
 much altered amygdaloidal basalt. (See Pl. 47) (Fig. 55). Secondary minerals, quartz and
 epidote, produced from original pyroxenes and plagioclase are the dominant
 minerals. Chlorite occurs where the rock is schistose. Magnetite in
 small amounts is ^{almost universal.} ~~practically always present~~. Plagioclase rods in various
 stages of alteration are seen in most thin sections. Olivine and pyroxene
 have been reported, but in thin sections studied in the preparation of this

Phalen, W.C., A new occurrence of unakite, a preliminary paper; Smithsonian
 Miscellaneous Collections, vol. 45, 1903, p. 315,

~~report the original minerals are much altered and these minerals were not~~
~~discovered.~~

A thin section of the red/ fragmental rock at the lower end of Little
 Devil Stairs shows ~~fragments in~~ a reddish glassy matrix ^{with fragments} which contain small
 laths of plagioclase. Some ^{of} calcite and epidote in grains and patches have
 developed.

Geologic Age. -- The Lower Cambrian Loudoun formation extends ^{in places} to the
 top of the Blue Ridge ~~in some localities~~, where it unconformably overlies

67 (93)

Pl. 7

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the Catoclin greenstone. Isolated ~~areas~~ ^{Blue Ridge} of Loudoun arkose ~~occur~~ ^{locally} on the top and east and west sides of the ~~range~~ ^{Blue Ridge}. They are directly ~~underlain~~ ^{lie upon} by greenstone and ~~sometimes by~~ ^{intrusive rocks} (intrusives). The arkose is composed of fragments of greenstone, siltite, and granite, and are clearly unconformable upon the crystalline rocks. Fossils have been found in the ~~sediments~~ ^{not Loudoun formation} but there is good reason to believe that ~~they represent~~ ^{the local areas are probably} the eroded remnants of a former extension of Lower Cambrian deposits ~~over~~ ^{that formerly covered} the Blue Ridge area.

~~Intrusive rocks~~

(? Age in the other pt ?
 Evidence)

INTRUSIVE ROCKS
GENERAL FEATURES

Intrusive granites and granodiorite comprise the mass of the Blue Ridge in this ^{area} district. Two major periods of intrusion are recognized. The first ~~period~~ is represented by the Lovington gneiss which crops out near the eastern base of the range. A batholith of granodiorite, with granite differentiates, intrudes the gneiss and forms the principal part of the range. The gneiss is genetically related to the younger intrusive ^{rocks,} as is shown by similarities in the dominant minerals, quartz and

A.S., Igneous rocks of the Shenandoah National Park Area; Jour. Furcron, ~~op. cit.~~ ^{Geology}, vol. 42, no. 4, pp. 400-410, 1934.

feldspar. The rocks are characterized by a large content of plagioclase which ^{rather commonly} frequently equals in amount the potash feldspars. ~~The large plagioclase content of granites and gneisses in the Blue Ridge, and in the Southern Appalachians in general has been discussed by Watson.~~

Watson, T.L., Granites of the southeastern Atlantic states, U.S. Geol. Surv. ^{by} Bull. ~~no.~~ 426, 1910. 22 pp.

~~The Catactin greenstone is confined to the crest and high flanks of the Blue Ridge and does not come in contact with Lovington gneiss in the~~

district. Beneath it are granodiorite and granites which also intrude it.

F.T. |

No vestige of an older supporting rock, upon which the flows were poured out, has been found so far within the Blue Ridge range of this quadrangle. In the ^{F.T.} Valley and the lowlands of the southeastern part of the quadrangle there are frequent outcrops of an older biotite gneiss and schist which resembles the Lynchburg gneiss. Lynchburg gneiss is closely associated with Catoctin volcanics in central Virginia and is ^a pre-cambrian rock of great age. This gneiss and the Catoctin extrusives appear to be the oldest remaining rocks of this region.

LOVINGSTON GNEISS COMPLEX

General Statement

A belt of ancient granite and quartz monzonite gneiss ^{and} other intrusive and metamorphic rocks, extends along the ^{south} eastern side of the Blue Ridge ~~throughout the central region of Virginia.~~ ^{It includes the} Besides Lovington gneiss, ~~there is~~ ^{the} much biotite gneiss, described below, and Old Rag granite. (~~described in later pages.~~ ^{De} Lovington gneiss was first described from the Lovington ^{area in} region of Amherst and Nelson counties by Watson and Taber as a biotite-quartz monzonite gneiss. ~~Its general distribution~~

Watson, T.L., and Taber, Stephen, Geology of the titanium and apatite deposits of Virginia: (Va. Geol. Surv. ²⁴ Bull. ^{3A5} ~~111~~, 1913, pp. 59-66,

~~in the state is mapped upon the Geologic Map of Virginia, 1928, as Lovington granite gneiss. The belt of gneiss seems to be wider in (this) section of the state than is indicated upon the map.~~ ^{The Stormy Man area}

Biotite Gneiss

The oldest rock of this ^{area} (district) is a biotite gneiss which resembles ^{the} Lynchburg gneiss. It occurs ^{generally} frequently in thin bands which are too

Jonas, Anna I., Geologic reconnaissance in the Piedmont of Virginia, Bull., Geol. Soc. Amer. ¹⁰ Vol. 38, 1927, p. 845,

Furcron, A. S., James River iron and marble belt, Virginia; (Va. Geol. Survey Bull. ~~38~~ 39, 1935, pp. 20-22,

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Submitting General Features?

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show on the geologic
 narrow and discontinuous to map. The average strike of ^{This} the gneiss is
 about N. 40° E. ^{It} ~~This rock~~ has been intruded by ^{The} Lovington gneiss ^{and}
 is ~~thoroughly intruded and injected~~ by Old Rag granite, which, in this
 section usually contains biotite, ~~perhaps derived from the older gneiss.~~

Megascopic Character. -- This older gneiss which ~~occurs so frequently~~
 along the eastern side of the Blue Ridge is generally a fine to medium-
 coarse grained pepper and salt colored rock. It contains a ~~constant~~
 but variable amount of fine biotite which is the principal diagnostic
 mineral in hand specimens. The rock ranges ^{from} between a gray gneiss with
 some biotite to a heavy, black biotite schist. ~~The rock for the most~~ of it
 part is probably of sedimentary origin although, ~~in fact,~~ it is a
 complex of rocks. ^{It contains bands of granitoid rocks and}
 granite-like layers and layers of hornblende gneiss occur.

constant but variable

Microscopic Character. -- Under the microscope ~~The~~ rock is a biotite
 schist or gneiss, composed principally of quartz and untwinned feldspar. It
 is generally fine to medium ~~fine~~ grained and even grained. Biotite
 metacrysts are brown in color, occur with ragged borders, and include
 other minerals of the gneiss. Shreds of muscovite are interwoven with
 quartz and feldspar. Accessory minerals ^{are} magnetite, apatite, garnet,
 and epidote. ~~are present.~~
^{As granitoid bands} ~~granite-like layers~~ are coarser with granitic texture. ^{and} they are
 masked and granulated. ^{commonly} The minerals usually showing wavy extinction.
 Plagioclase, ~~microcline~~, orthoclase, and quartz are the dominant minerals.
 of this variety. Shreds of greenish biotite occur ^{and} in the sections examined.
 Secondary muscovite shreds are common. Epidote is common locally as are
 leucoxene borders around titaniferous magnetite.

N. 40° E.

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Arrows
 Arrows
 Arrows

Lovingston Gneiss

F.T. 1
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Distribution.--This ~~rock~~^{gneiss} occupies the low ~~grounds~~^{land's} in the southeastern part of the quadrangle. The best exposures are in the ~~region~~^{vicinity} of Etlan, Dulaney Mountain, and Peola Mills along ~~the~~^{No. 16} State Highway in the F.T. valley, ~~(which passes through the extreme southeastern corner of the quadrangle)~~^{of the rock}. The gneissic and schistose structure ^{of the rock} has made it relatively less resistant to erosion. Where it extends into the Blue Ridge, it crops out in the lower parts of wide hollows in the ^{east} ~~east side~~^{south} of ~~the mountain~~. The strike of the rock is prevailing northeast-southwest, which trend is followed by valleys in this section.

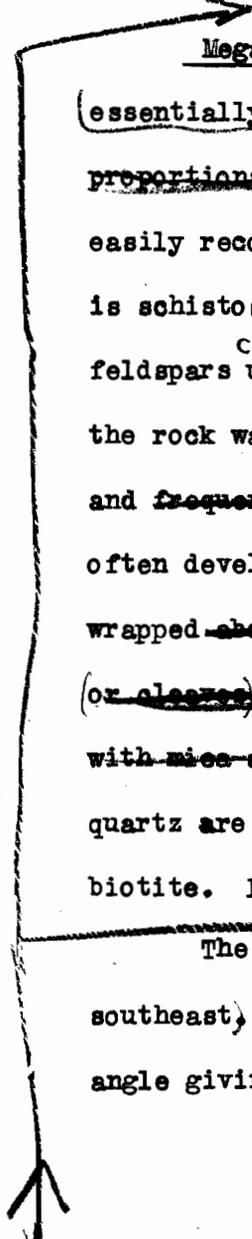
Megascopic character.--The rock is a biotite gneiss and schist essentially composed of ^{variable proportions of} biotite, untwinned feldspar and quartz, ^{which are} the proportions of which vary in different localities. These minerals are easily recognized in hand specimens. ^{etc} when biotite is abundant, the rock is schistose. ~~bands of very biotitic rock occur.~~ Light to dark-gray ^{commonly} feldspars ^{usually} comprise an important part of the rock. ^{Some of} in many places the rock was originally porphyritic, but the feldspars have been granulated and frequently mashed ~~out~~ into bands which include also much quartz. There is often developed typical augen gneiss in which the crushed feldspars are wrapped ~~about~~ⁱⁿ a ground mass of biotite and quartz. The rock ^{commonly} usually breaks ~~(or cleaves)~~ around the feldspars so that freshly broken surfaces are covered with mica and have a silky luster. Small grains of blue or ^{occasionally} ~~sometimes~~ amethyst quartz are abundant, ^{the} in ~~this~~ rock. The ~~amount~~^{of quartz} decreases ^{as} with increase of biotite. Large, partially crushed quartz grains ^{occasionally} sometimes occur.

The gneiss crops out in rounded ledges which dip steeply (to the southeast). A secondary rock cleavage cuts the schistosity at an oblique angle giving to partly weathered outcrops a platy appearance which is character-

6/

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7/7



4 fields forms

istic. The rock is generally deeply weathered to a red soil which ~~often~~ contains fragments of milky vein-quartz. Much of ^{the area} ~~the Lovington gneiss land~~ is cleared, ~~and these excellent farm lands comprise the finest sections in~~ ^{7 fields} ~~Rappahannock county.~~ Except in very fresh ~~hand~~ specimens, the feldspars are stained brown with iron oxide produced by the weathering of biotite. on Hughes River at Sharp Rock, about ^{1.7} ~~(one and seven tenths)~~ miles below ~~Wethers,~~ there are excellent exposures of biotite gneiss at the ford.

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Microscopic Character.--In this section feldspar, quartz and biotite, listed in their ~~usual~~ order of abundance, compose most of the rock. ^(See Pl. 193 194) ~~(Figs. 93, 94)~~. In some sections potash feldspars occur almost exclusively; in others, plagioclase is dominant, while soda-lime feldspars are secondary to potash feldspars in the average section. quartz and potash feldspar decrease with increase in biotite. Microcline is very common. Plagioclase is albite or oligoclase. Micropegmatitic intergrowths of quartz and plagioclase lamellae are frequently twisted and bent.

Pl. 193 194

^{De} Biotite is brown, ^{to} ~~usually~~ greenish-brown and very pleochroic. It occurs typically in long shreds, which are woven through ~~the sections~~ around "eyes" of feldspar and quartz to produce an augen gneiss.

^{Ed} Small rounded garnets often occur. Magnetite is common ~~in all thin sections~~ where it is often surrounded by a rim of leucoxene.

^{De} Biotite ^{of the} ~~sometimes shows~~ alteration to a pale green chlorite; plagioclase is more or less altered to muscovite, epidote and other secondary products, although epidote ^{is} ~~grains are~~ generally scarce. ^{Some of the} titaniferous magnetite ^{is} ~~sometimes altered~~ to brown titanite, but ^{more commonly} ~~usually~~ to leucoxene.

Geologic Age.--This rock is pre-Cambrian, since it is intruded by granodiorite and Old Rag granite. Aplitic dikes of Old Rag granite cut the schistose ~~directions~~ ^{of the} of the rock. These intrusive ^{dykes} separate it from ^{the} catoclin ^{granite} so that ~~the~~ ^{relation} ~~to that rock has~~ not been determined. The

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Schistosity

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prevailing gneissic and schistose character indicate that it is a very
^{old}
~~ancient~~ rock, certainly older than the other pre-cambrian intrusive
rocks of the region. Granite bodies intruded into Lovington gneiss
are prevailingly massive; ~~this indicates that the rock was a gneiss
before middle or later pre-cambrian time.~~

HYPERSTHENE GRANODIORITE

Hypersthene granodiorite

Introduction. ~~This~~ is the most widespread intrusive rock of the region. ~~It~~ ⁱⁿ composes the core of the Blue Ridge ~~upon~~ this quadrangle. It is extensively intruded by ~~less~~ granite so that there are few large areas which can be exclusively mapped as ~~of this type~~ ^{granodiorite}. The rock is well known in the Virginia Blue Ridge ^{gva -} having been studied by several workers in this field.

Distribution. Granodiorite bodies which contain relatively less intrusive granite have been mapped separate ^{by} from granodiorite containing much Old Rag granite. ^(See Pl. 2.) Boundaries between large masses of the two types can be drawn as a rule only in a general manner. ~~The granodiorite mass as it crops out upon the west side of the mountain~~ ^{as} southwest of Thornton Gap, ^{where} granodiorite composes nearly the entire western slope, ^{it} contains less Old Rag granite than it does in most other ^{places} sections. ^{the outcrop extends} It is frequently terminated ^(at the top of the mountain) ^{to} by the cap of Catoctin greenstone and at the base of the slope by the ~~line of the~~ Blue Ridge overthrust.

At Thornton Gap this area becomes continuous with extensive outcrops upon the east side of the Blue Ridge, which occur from the vicinity of Old Rag Mountain to the northeast corner of the quadrangle. The eastern area contains much granite which can be separated from granodiorite.

only locally. Even then as a rule, boundaries between the two types of rock ~~are~~ ^{can be} not sharply drawn. ^(Two small areas) of Granodiorite crop out ⁱⁿ in Graves Mountain and Rosson Hollow in the southeastern ^{part} region of the quadrangle. They are closely related to Old Rag granite. ~~In this section the intrusive rock is generally too acid in character to be classed as granodiorite.~~

~~Handwritten scribble~~

Ref less to other workers?

98
Can not be drawn
are not sharply drawn

Megascopic character. ^{the} ~~Granodiorite~~ is a coarse-grained, dark-

gray, massive rock. There is considerable variation in mineral composition and ^{size} ~~coarseness~~ of grain. Average specimens are coarse grained, with granitic texture. Very coarse ^{grained} or very fine-facies are not common.

Frequently ^{much of the} the weathered surface of granodiorite consists of ^{masses} thin alternating light and dark bands. The lighter bands are etched out in relief. They generally contain more quartz and ^{many} are often distinctly granitic. The darker bands contain more femic minerals, less quartz and a darker feldspar. ~~This banding is generally rather indistinct upon freshly broken surfaces.~~ ^{banding} This is interpreted as ^{having been} a ~~primary banding~~ produced at the time of the consolidation of the rock.

^{the} Feldspar is dark gray ^{commonly}, greenish-gray, ^{but} sometimes light gray, ^{is} ~~in color.~~ ^{much of} It is ~~often~~ untwinned, but polysynthetic laminae are very common. The ~~occurrence of~~ light gray feldspar is usually accompanied by an increase in quartz, producing a rock intermediate between granodiorite and granite.

Pyroxene, hornblende and biotite, ^{are} ~~the usual dark minerals,~~ may be recognized in hand specimens. ~~These minerals are scattered in small amounts through the rock but locally they may be abundant.~~ Sometimes narrow, lighter colored, zone-like pegmatitic bands carry considerable coarse hornblende or hypersthene; ^{for example,} ~~Such occur~~ on top of the ridge between Mary's Rock and the Pinnacle ^{and} near the head of Hawksbill Creek. Biotite ~~is frequently present.~~ ^{has been} It is produced in granodiorite and Old Rag granite at contacts, ~~but also~~ occurs as a primary mineral in the granodiorite in many places ^{where} ~~where~~ no intrusive granite can be seen. Biotite ~~not apparently associated with granite,~~ is abundant in flakes up to one fourth inch in diameter in slightly

(Marys)

6
six months?

~~masked~~ granodiorite on the south side of Hawksbill creek, about six-tenths of a mile above the St. George Mission. Blue or smoky quartz is present in small or moderate amounts in ^{The} granodiorite. Small red garnets are ^{moderately common,} frequently seen.

^{The} granodiorite is massive and has not been disturbed generally by regional metamorphism. It weathers rapidly by mechanical erosion so that ^{exposed} surfaces are quite fresh, ~~and unaltered~~ upon steep slopes, ^{and} ~~exterops~~ In lowlands ^{it} weathers to a red clay soil ~~where especially in such localities,~~ exposed surfaces have a characteristic pitted appearance, as minerals drop out during the course of weathering. ~~Magnetite sands are common in roads and gullies.~~

Microscopic character. -- ^{This is} ~~Thin sections show~~ considerable variation

in the proportions of the dominant types of feldspar and in amounts of quartz. In basic varieties the dominant feldspar is generally andesine, ^{much of} which ~~frequently~~ fails to show polysynthetic twinning. Orthoclase and microcline also occur, frequently intergrown with albite as microperthite. Coarse micropegmatic intergrowths of quartz and feldspar are common. ~~(fig. 10)~~. (See Pl.)

Pl. 170

The dominant pyroxene is hypersthene but augite ^{is rather common} frequently occurs.

^{Some of the biotite is} Brown, strongly pleochroic, ~~biotite occurs in some thin sections.~~ ^{and} Some ~~irregular~~ shaped patches of brown hornblende occur which may show micrographic intergrowth with quartz. The usual accessory minerals are apatite and magnetite. ~~The rock is usually quite fresh and~~ Secondary minerals are unimportant. ^{70, 71} (See pl.)

Pls. 70, 71

With loss of feric minerals and plagioclase, and increase in orthoclase, microcline microperthite and quartz, the rock ^{in places} ~~(sometimes)~~ approaches the composition of the Old Rag granite. This change has been noted in Hughes River Valley east of Thoroughfare Mountain.

99
D.V.C. ?

sp ?

Granodiorite has been described by Watson and Cline from various parts of the Blue Ridge. They preferred to classify it as a hypersthene syenite, although stating ~~at the same time~~ that, "based on the fact that the chief feldspar is andesine, with considerable but less alkali feldspar (orthoclase), the normal facies of the rock should be designated a pyroxene-granodiorite". It was classified as hypersthene granodiorite on the Geologic Map of Virginia (1928).

Check

(?)

Watson, T.L., and Cline, J.H., Hypersthene Syenite and related rocks of the Blue Ridge region, Virginia: Geol. Soc. America Bull., vol. 27, pp. 193-234, 1916.

The following analysis of the rock from Milam Gap (Fishers Gap) was published by Phalen who classified it as an hypersthene akerite.

Phalen, W.C., A new occurrence of unakite--a preliminary paper: Smithsonian Miscellaneous Collections, vol. 45, 1903, pp. 306-316,

The rock near Fishers Gap seems generally to have a higher pyroxene content, than usual for the granodiorite. Watson, using the analysis by Phalen, designates the rock as an hypersthene in the Granitoid System.

TR

Analysis of
hypersthene
syenite

Analysis of hypersthene aegirite from Milan (Fishers) Gap, Va.
(W.C. Phalen, Analyst.)

SiO ₂	-----	60.52
Al ₂ O ₃	----- (including TiO ₂)	16.99
Fe ₂ O ₃	-----	.60
FeO	-----	6.53
MgO	-----	1.59
CaO	-----	4.58
Na ₂ O	-----	2.83
K ₂ O	-----	3.91
H ₂ O	-----	.88
P ₂ O ₅	-----	.74
MnO	-----	.25
Cr ₂ O ₃	-----	Trace
ZrO ₂	-----	Trace
		<u>99.42</u>

~~Hypersthene aegirite from Milan Gap (Fishers Gap), Va. (W.C. Phalen, Analyst.)~~

Other analyses of hypersthene syenite from parts of the Blue Ridge southwest of this district were published by Watson and Cline.

Watson, T.L. and Cline, J.H., op. cit., pp. 202-203.

granodiorite
100a

Relation to Catoctin flows. -- The relation of the intrusive ^{rocks}

of this region to the Catoctin flows is difficult to determine because exact contacts are ^{rarely} ~~(not often)~~ found, ^{and} ~~when they do occur~~ there is often nothing ~~to be observed~~ that can certainly be interpreted as an intrusive effect. Normal granodiorite which is not intruded by later granites, seldom ^{is in} ~~comes to~~ direct contact with greenstone in the Stony Man area. ~~The~~ ^{best} evidence, ^(P. 100) ~~discussed later~~, that Old Rag granite intrudes the flows and the close genetic relationship of this granite to granodiorite, suggests ^{the} that granodiorite is younger.

(102) ?
s/h

Southwest of this quadrangle, ^{exposures of} ~~masses of~~ granodiorite ~~crop out~~ in greenstone suggesting an intrusive relationship. On the Skyline Drive about 1 ~~one and one tenth~~ miles east of Swift Run Gap ^(near Elston), ~~this rock~~ granodiorite is in contact with typical greenstone. ^{St.ingers} ~~Veins of the~~ granodiorite six to ¹² ~~twelve~~ inches wide cut the greenstone, in places forming a network pattern. ~~The granodiorite is partly altered to unskite. The original feldspar of the granodiorite appears to be andesine or basic oligoclase.~~

1.1)
7
Catoctin
1 Swift Run Gap

Relation to Lovington gneiss. -- It may be inferred ~~upon theoretical~~

~~grounds~~ that the granodiorite intrudes the Lovington gneiss, ^{because} ~~since~~ the gneiss is unquestionably intruded by Old Rag granite. ^{of} Granodiorite is intruded ^s ~~into~~ the gneiss of this area ~~as~~ large masses but no dikes ~~of it~~ have been found ~~(in the gneiss.)~~ The massive character of ^{is} granodiorite in contact with gneiss suggests ^{that it is younger.} ~~a more recent age for it.~~ The best evidence ^{in support} ~~of~~ intrusion ^{is} ~~occurs~~ in the ^{south} southeast part of the quadrangle, where the massive granodiorite ~~mass~~ in Graves Mountain is nearly surrounded by the older, highly metamorphosed gneiss.

(102) ?

10
11
17

OLD RAG GRANITE

Introduction.--This rock is ^{here} named from ~~the (district of)~~ ~~immediate area of~~

Old Rag Mountain. Except for the granodiorite, it is the most widespread ^{intrusive rock} intrusive of the Park area, ^{where} It occurs ^{mainly} especially on the ^{south} east side of the ~~range~~. It is a coarse ^{-granite} blue-quartz granite resembling a facies of the Marshall granite which was named and described by Jonas ~~from near~~ ^{near} Marshall, Fauquier County, as "a pink to green granite and quartz mon-

Jonas, Anna I., Geologic Map of Virginia, Virginia Geological Survey, 1928.

zonite; injected by a pegmatite with blue quartz". Marshall granite as defined occurs in a belt east of the Blue Ridge between granodiorite and Lovington gneiss. It was found to intrude Lovington gneiss and Catoclin lava flows.

Idem.

The blue-quartz granite injected into the older facies of ^{The Marshall} ~~this~~ ^{granite} rock can not be separated from it where it has been mapped by the writer, in the Warrenton ^{area} region. Several thin sections were examined from Marshall, the type locality. The greenish, mashed variety contains orthoclase, orthoclase-micropertthite, microcline, some plagioclase, and considerable quartz. Considerable greenish biotite occurs, much of which is secondary. The rock is mashed and more or less granulated, but is not an augen gneiss as is the Lovington gneiss. The feldspars have been considerably altered to muscovite since the period of granulation and fractur-

— Fucini, D.S., Geology and mineral resources of the Warrenton Quadrangle, 1911; manuscript in files of U.S. Geol. Surv.

103
intrusive
intrusive

Proof ?

?

sp-1?

sp

-?|

ing of the rock.

The blue-quartz facies, which in this locality appears to be a pegmatite ^{ic facies} of the older granite, resembles Old Rag granite. ~~in hand~~ ^{from the southeast} specimens and thin sections. As the Blue Ridge is approached, on the Stony Man quadrangle, especially in the region of Old Rag Mountain, this rock becomes coarser and ^{more} widespread ^{as} at the surface, where it may be mapped as a distinct type. In texture it resembles the granodiorite. locally ~~it grades~~ into granodiorite and at other places intrudes it.

Distribution.--The ~~d~~istribution of Old Rag granite so closely follows that of the granodiorite that in many localities these rocks can not be separated ~~from~~ on the map. The most widespread and typical occurrences of this granite are in the region of Old Rag Mountain, Tom's Mountain and Brown's Mountain ⁱⁿ of the southeastern part of the quadrangle. In that ^{area} ~~section~~ the massive granite and granodiorite ~~areas stand out as~~ ^{form} mountains which are partly surrounded by the more easily weathered Lovington gneiss. Smaller areas are mapped in Thoroughfare Mountain, in the upper part of Corbin Hollow, and south of Thoroughfare Gap. A typical exposure of about ² ~~two~~ square miles ^{in extent,} which may be seen along the Hazel Road, occurs east of Beech Spring Hollow near the Lee Highway. Areas of granodiorite ^{southward} ~~east~~ of the top of the mountain contain dikes and stringers of granite which are ^{locally} ~~sometimes~~ so abundant that the rock more closely resembles granite than granodiorite. They are ^{scarcely} ~~of much less fre-~~quent occurrence in the granodiorite exposure ^{upon} the ^{west} ~~west~~ side of the ridge southwest of Thornton Gap ^(See Pl. 42). (See Pl. 42)

Megascopic character.--Light-gray, untwinned feldspar and blue or smoky quartz are the principle ^a ~~principle~~ minerals of ^{the Old Rag granite.} ~~this rock.~~ Where it ~~occurs~~ in large masses, as in Old Rag Mountain, it may be as coarse or coarser than the granodiorite. The feldspar is light gray or nearly white in ^{highly} ~~very~~ quartzose varieties. The quartz may be distributed through

Browns

(Tom's)

to extent

Pl. 42

the rock sparingly or abundantly ~~in well scattered grains~~ ^{it} or may be concentrated in discontinuous planes ^{seemingly in crude layers} to produce the effect of crude layering.

seemingly in layers

Old Rag granite is quite uniform in mineral composition and general appearance. It is usually a coarse rock. It is rarely fine grained, but in dikes and small intrusive bodies the minerals are often about the size of coarsely granulated sugar. Small bodies of this rock which crop out in ^{areas of} ~~(the)~~ Lovington gneiss tend to be equigranular and moderately fine grained. ~~Hand specimens from this district, however, will often show sudden changes in coarseness of grain.~~ ^{locality}

^{The} Granite is ^{some of} ~~sometimes~~ moderately fine grained near contacts with Catocin greenstone, ^{whereas many masses} while thin layers of granite injected into granodiorite are frequently as coarse ^{grained} as the granodiorite.

^{The} Feldspars generally tend to be equidimensional, ~~and~~ ⁱⁿ coarser varieties are half an inch to an inch in diameter. Crystal outlines are not generally developed, ^{and many} ~~often the specimen~~ resembles a mass of cleavable feldspar with smaller quartz grains scattered through ^{it} ~~out~~.

^{The} Feldspar of the granite is usually light gray, ~~rarely nearly white and frequently~~ ^{to} flesh-colored.

Quartz is generally light ^{to} dark blue, ^{but} ~~sometimes~~ ^{is} purple, colorless, ^{or} ~~and often~~ smoky. Quartz and feldspar are frequently equally responsible for the color of the rock, ^{much of} ~~in hand specimens.~~ ^{in places --} ~~Sometimes~~ large amounts of dark smoky quartz suggest, at first glance, a false basic character ^{of} ~~to~~ the rock.

some specimens

Biotite and garnet are common in this granite, ~~but their~~ occurrence is generally confined ⁱⁿ ~~to~~ certain areas, ^{localities} Large plates of mica have been reported from one locality on Hazel Mountain. A blue-

7- (8p)

gray variety of granite occurs locally just east of the quadrangle, ~~the south side of~~ ^{the south side of} ~~south~~ along the road from the Lee Highway near Estes Store toward Piedmont School, as far as Jenkins Hollow. The feldspar (orthoclase-albite perthite), ~~which is almost the color of the quartz,~~ causes the rock to have a present a uniformly blue-gray color.

Microscopic character.--The true granite contains much quartz.

The feldspars are orthoclase and microcline, and orthoclase and microcline-microperthite, with rods of albite. ^(Pl.) ~~The microperthite has a characteristic appearance in thin sections.~~ ^(See Pl. 73) ~~(Fig. 20).~~ Some thin sections consist almost entirely of microperthite and quartz. The ^(Pl.) plagioclase rods are ~~sometimes very abundant and exceptionally~~ ^{in places} constitute ^{about} nearly 50 per cent of the microperthite. Potash feldspar and microperthite are generally accompanied by more or less albite or oligoclase. With increase of plagioclase and decrease in quartz, ^{the} granite may grade into granodiorite. The prevailing absence of ferro-magnesian minerals is noteworthy. Biotite and garnet occur locally, but ~~since~~ they are not generally typical of the rock, ~~they will be discussed under a later heading.~~ The minerals are fresh, unaltered, and rarely show effects of mashing or metamorphism.

A greenish-gray biotite or garnetiferous granite occurs near ^{the tunnel through} Mary's Rock tunnel on the Skyline Drive. ~~A thin section shows this rock to~~ ^{be} a true granite, ^{because} the feldspars are albite-oligoclase, orthoclase, and orthoclase microperthite.

Relation to Lovington gneiss.--The granite has intruded ^{the Lovington} ~~this~~ gneiss rock upon a large scale. Large and small areas of massive Old Rag granite

106
slit
3/7
30 ?

?

P. 173

107
usually

ferromagnesian
some specimens

107
not to be
is not

occur in the Lovington gneiss in the southeast and eastern parts of the ^{Quadrangle} area. The granite ⁱⁿ of Brown's Mountain is practically surrounded by gneiss. East of the ^{areas of} massive granite ~~areas~~, are abundant dikes and stringers of granite in the gneiss, which ^{generally} usually follow the direction of rock cleavage, ~~but sometimes cut across it.~~ Small dikes and stringers of granite ^{in places} (sometimes) show sharp contacts with the gneiss, ^{In other places} or sometimes granite has soaked into gneiss to form a hybrid rock. ^{Most of} The granite is usually fresh, unaltered, ^{In contrast, the} and (unmetamorphosed), although the gneiss has been profoundly altered from its original condition by dynamometamorphism. These small ^{intrusive bodies} intrusive bodies ^{of Old Rag granite} of Old Rag granite are usually ~~medium-fine-grained.~~ They are well exposed in cuts along ^{State Highway No. 16} (the F.T. Valley road) southwest of Sperryville. ^{There is} a good illustration ^{2.2} occurs on this road ~~two and two-tenths~~ miles west of the road to Culpeper.

Relation to Catoclin flows. ~~Greenstone is not often directly bordered by this granite~~ ^{and} ^{and seldom adjacent} ~~upon~~ the Story Man quadrangle; therefore the contact relations ⁱⁿ between these rocks have been determined ~~from~~ other ^{parts} sections of the Park area. Rather fine-grained granite underlies greenstone ^{in places} at Hughes River Gap, but the intrusive relation can not be ~~demonstrated~~ ^{determined} at that locality. The granite intrudes the granodiorite, and is therefore younger than ^{the} Catoclin lava flows.

Clear ^{cut} examples of the intrusion of greenstone by granite are difficult to find. The best locality discovered so far in the Park area is near the Mission Home in the southern part of the Elkton quadrangle. On the ^{road} highway east of the Memorial to Bishop Whittle, coarse-grained, garnetiferous granite cuts Catoclin greenstone. ~~There seems to be a tendency for biotite and garnet to be developed at contacts of this type.~~ A mixed rock is commonly produced, which consists of narrow bands of greenstone, biotite ~~conist~~, and granite. The granite is frequently garnet-

occasional in places
108
dynamic metamorphism?
State Highway No. 16

109
intrusions
intrusive bodies

Not part?

113

~~iferous~~. In the fields east of the Mission, some ^{bands} ~~layers~~ of unaltered greenstone occur in the granite.

Blue quartz

Relation to hypersthene granodiorite.--Blue-quartz granite is constantly associated with granodiorite ^{throughout} ~~throughout~~ the Park are ^a

The mode of association suggests that it is a differentiate of the granodiorite. It is injected into diorite in large masses or as dikes and stringers, ^(See Pl. 74) ~~(Fig. 10)~~. ^{In many places} ~~Frequently~~ narrow sheets of granite

Pl. 74
112
distinctly developed
brought out
more distinctly

alternate with granodiorite so that the resulting rock has a ~~layered or~~ ^{distinctly developed} banded character which is ~~made distinct~~ ^{many of} by weathering. ~~Frequently~~ the granitic layers ~~appear to~~ ^{bands} resemble the granodiorite closely in mineral

composition but contain ~~a larger amount of~~ ^{more} quartz. ~~In such cases~~ [?] It is possible that the two rocks were differentiated at depth and intruded simultaneously.

115

It is difficult to decide in the field ^{whether} ~~if~~ certain areas should

be mapped as granodiorite or granite. In the upper part of Nicholson Hollow the ~~rock~~ ^{exposure} resembles granodiorite in general appearance but is ^{highly} ~~very~~ quartzose and seems to be an intermediate facies between the two

types. At this ^{place?} ~~and in other localities~~ the two rocks ~~intergrade~~ ^{grade into each other.}

117
grade into each other.

← It thus appears that all variations from true granodiorite to true granite occur ~~in this region~~. Intermediate facies are difficult to separate from the granodiorite with which they are closely related.

Large masses of granite occur in ~~the~~ granodiorite near the head of Corbin Hollow ^{and} ~~along~~ ^{Numerous} Hazel Road. Dikes and stringers are found ~~in~~

~~many places~~. Narrow bands of granite inject granodiorite along the Lee Highway east of Thornton Gap. The section along the Skyline Drive west

of Mary's Rock tunnel ^{Shows many} ~~presents many examples~~ of granite dikes and stringers ^{intruding} ~~that intrude~~ the granodiorite. The ^{is} granite ~~in the dikes~~ is moderately fine-grained. Stringers and ^{narrow} ~~thin~~ dikes of coarse ^{-grained} granite of the same type

118
granitic?

119
and
or

intrusive rocks.

cut all the other ~~intrusives~~. ~~Some biotite is developed in the granodiorite near the granite.~~

The development of biotite and garnet seems to accompany frequently the intrusion of granodiorite by granite. This change is especially noticeable in some ^{localities} ~~areas~~ beyond the limits of the quadrangle, north of Sperryville, as well as in the region between the Lee Highway and Old Rag Mountain. (Biotite occurs in small flakes) Flakes of biotite half an inch in diameter occur in granite and granodiorite near the head of Jenkins Hollow. A plate of biotite several inches across was picked up in a granite area on Hazel Road.

Not pertinent?

*v/pel
? :1*

Garnet occurs ^{as a rule} rather sparingly in large, irregular-shaped patches and grains. It is ^{dark-red} ^{and} frequently oxidized in hand specimens. It is distributed in a patchy manner and is fairly abundant in some places, ^{but only slightly so} while ~~nearly absent~~ in others. Small occurrences of especially garnetiferous granite may be seen on the road up Thornton River north of Lee Highway, along Hazel Road, in fields west of Thoroughfare Gap, and along the Lee Highway east of Thornton Gap.

An ^{common} ~~unusual~~ variety of granite occurs in Buck Hollow about three-quarters of a mile south of the Lee Highway. The rock is white, very fine ^{grained}, with milky or transparent quartz and numerous small patches and grains of red garnet.

Geologic Age. -- The intrusion of this granite probably closely followed that of the granodiorite. It intrudes the earlier pre-Cambrian rocks of the Blue Ridge and unconformably underlies Lower Cambrian sediments which are in part composed of its fragments.

UNAKITE AND EPIDOTE-BEARING GRANITE

Pink, epidote-bearing rocks of dioritic or granitic character

are common in this region. They may be considered as facies of the granodiorite and Old Rag granite where they ^{occur} are near the contact with Catoclin greenstone. In some localities these rocks occur in dike-like bodies within the intrusives in such a manner as to suggest a later and possibly a pegmatitic origin. The term "unakite", ~~discussed in later pages,~~ will be used in this report to refer to facies of granodioritic character as contrasted with ~~these facies~~ which distinctly resemble Old Rag granite. It is, however, not always possible to make this distinction.

Distribution. The important bodies of unakite and pink granite

generally occur at or near the contact of granodiorite and granite with Catoclin greenstone. Small stringers, dike-like areas and patches occur in many places ^{to} within granodiorite but are generally ^{not important} ~~(too unimportant)~~ to map. ^{pable.} ~~These areas generally have a northeast trend.~~ Many such areas occur in the granodiorite which crops out ^{on} the west side of Blue Ridge southwest of Thornton Gap. A small mappable area, ^{the} on the west side of the ^{mountain} ridge, occurs near Morning Star. A small dike-like zone of granodiorite and ^{epidote unakite} granite altered to ^{- New Market} this rock crosses the old Gordonsville pike a short distance northwest of Fisher's Gap.

A large belt of pink granite and unakite, which ~~also~~ contains much granodiorite and Old Rag granite, occurs near the summit of the Blue Ridge on the west side, between Tamers Ridge and Sexton Shelter. The belt is broken west of Black Rock where pink granite is ^{almost or} ~~nearly~~, if not completely absent. This belt lies next to the western ^{edge} ~~margin~~ of Catoclin greenstone, and extends under it, for it is exposed in Dark Hollow, east of Fisher's

(Some repetition to be deleted by H.F.)

120

Insert 1
page p 105 - bottom
lc

Episodic
General features

and
of
dike like
dike like
? 2
from p. 105

dike like
from p. 105

dike like
from p. 105

121

106

122

dike like
dike like
100

Gap where erosion has removed the ~~volcanic rocks~~ ^{greenstone}. In the northeastern corner of the ~~map~~ ^{quadrangle} the ~~rock~~ ^{granite} is exposed under greenstone in Little Devil Stairs. A small patch of ~~pink granite~~ ^{it} occurs at the eastern ~~margin~~ ^{edge} of the greenstone area just west of Corbin Hollow.

The granite of Old Rag Mountain and Brown Mountain^s is comparatively free of ~~this facies~~ ^{the unakite}.

Megascopic Character.--^{Some} Granitic varieties are coarse to medium-grained, pink ^{to} red granite. The principal constituents are pink or red potash feldspar ^{and} blue, milky, or smoky quartz. These ~~minerals~~ ^{is} are accompanied by more or less epidote in the ~~form of~~ separate grains, granular masses, or stringers and veins. ^{The unakite} occurs at the margins of greenstone in dike-like veins in granodiorite and granite, where it may replace the minerals of those rocks to form a hybrid rock. The rock has a wide range in composition, ^{from} lying between a pink orthoclase-microcline granite with blue quartz to a pink granite with epidote. ^{increase in epidote} and loss of feldspar produces a quartz-epidote rock. In granodiorite all variations may occur between normal granodiorite showing slight alteration of feldspar to epidote, to a quartzose rock completely altered to epidote and pink feldspar. ^{The} Color ranges from nearly brick-red or purplish-red ^{to} through various shades of red and pink. In granite areas the color is often very light pink or flesh-colored.

The general appearance of the ~~rock~~ ^{flesh} varies markedly from place to place. In this quadrangle it is usually so intimately associated with ~~intrusive bodies~~ ^{intrusive bodies} that no area ^{contains} can be named which is exclusively of this type. ^{unakite} perhaps the best exposures ^{are} at present ~~may be~~ found along an abandoned road down

(123) epidote or unakite

(124) ? Granite

little white unakite

(126) ?

How colored (440) ?

(127) intrusive bodies

C 77

(125) ? (The unakite! Check)

brick red

(128)

Blue Ridge

the west side of the Mountain from Hughes River Gap, where ~~areas of~~ pink granite, cut by veins and stringers of epidote, occurs. ^{h 92.}

Microscopic Character. -- Thin sections of ^{the} granitic facies show

this ~~rock~~ to consist mostly of potash feldspar, plagioclase, quartz and epidote. (See Pl. ~~Fig. 100~~) Epidote, which is secondary, occurs in irregular

~~shaped~~ patches and veinlets. ^{Top} It is ~~often~~ associated with ~~some~~ green chlorite, hematite ^{and} magnetite. ^{IL} Epidote may be a very abundant and important constituent or it may be nearly absent. (See Pl. ~~Fig. 76~~) (See Pl. ~~Fig. 76~~)

~~The composition of the original minerals varies in different thin sections.~~ Orthoclase and microcline are the most abundant feldspars, but they are practically always associated with more or less plagioclase (albite). ~~Orthoclase and plagioclase may occur as micropertite. Plagioclase grains are generally albite which is sometimes a very important constituent.~~

~~(Feldspars often show very distinct granulation.)~~

Garnet may be present; ^{in places} ~~sometimes~~ it is partly altered to chlorite. Green hornblende ~~may~~ occurs locally.

Relation to Catoclin flows. -- The ~~distribution of~~ pink granite upon this quadrangle and in other ^{parts} sections of the Blue Ridge ^{is in many places} frequently follows the contact between greenstone and granodiorite, but ~~there are also~~ many occurrences ~~that are not~~ ~~at all~~ related to greenstone. The belt of granite on the west side of the Blue Ridge extends northward into granodiorite beyond the greenstone outcrops.

^{relative} The age, ~~relation~~ of these ~~two rocks~~ ^{is difficult to determine,} because the greenstone is very ^{slightly} ~~little~~ changed at its contact with granodiorite and granite. In the Blue Ridge of the ^{southwest of} Natural Bridge ~~Special quadrangle~~ similar red granite intrudes greenstone believed to be of the same age. ~~Very little~~

Pl. 75

Pl. 76

No. 11

h 92

?

?

(129)

Why two granitic rocks? Same age? No. 11

Similar? No. 11

? Relation

How? Same age?

How? Same age?

Slight definite information has been obtained so far from a study of available contacts ⁱⁿ upon the Stony Man quadrangle. Granite bodies ~~that~~ ^{that} crop out ~~in~~ in greenstone areas / suggest an intrusive relationship, as in the extreme southwest corner of the quadrangle. A thin band of greenstone was found in the granite just west of Hughes River Gap. In Little Devil Stairs red and pink granite occurs under greenstone. At the contact the greenstone is intruded by stringers of the granite, ~~which contain small amounts of chalcopirite.~~ Granite ^{is} juices appear to have soaked into the ~~flow~~ ^{greenstone} but the observed effects that may be attributed to contact action are confined to

Brady on p. 100-101

~~the lower basal part~~ ^{basal part} ~~several inches~~ of the greenstone. At this contact, as at others, the granite, which is fine grained, ~~frequently assumes~~ ^{is} a brick-red or jasper red color. Sometimes ~~a~~ ^{locally} fine-grained, granular ~~rock of~~ ^{much of it} epidote ~~and~~ quartz occurs ^{at the contact}. The quartz is often red, but may be milky or colorless, ^{and} the greenstone at such contacts ~~may~~ ^s contain red quartz grains.

bright red
brilliant rock
1
higher than
granodiorite
D.S.S.
p. 100 (90)
D.S.S. p. 98 (93)
?

Relation to ~~granodiorite.~~ Replacement of ~~granodiorite~~ by pink feldspar and epidote has produced a rock called "unakite". ~~These minerals replace~~ the feldspars and ferromagnesian minerals of the granodiorite. ^{Ex-} tensive replacements occur locally. In places the ~~greenish grey~~ feldspars of the ~~granodiorite~~ are but partly altered to epidote, ^{elsewhere} or they ~~may be~~ ^{are} completely replaced by epidote and pink feldspar. Such effects are generally local, so that at a ~~short distance,~~ perhaps only a few feet / the intruded rock may be unaffected. [↑] ^X

The ~~variety~~ ^{rock} usually designated as "unakite" contains pink feldspar which comprises 50 to 75 per cent. of ~~the mass.~~ ^{of it} The remaining minerals are epidote and ~~generally blue,~~ ^{though it is} and ~~some~~ smoky or milky quartz, ~~which is~~ ^{which is}

The term "unakite" was first applied by Bradley to ~~similar occur-~~ ^{of} rences in the Unaka Range ~~in~~ the Blue Ridge of North Carolina.

On unakite, an epidote rock from the Unaka Range, on the borders of Tennessee
Bradley, F.H., Amer. Jour. Sci., 3rd. ser., vol. 7, pp. 519-520, 1874.

and North Carolina

to p. 102
D
C
A

3 To p. 102

Occurs at several places in

~~There are several occurrences of Unakite~~ in this quadrangle.

Small patches occur ~~(in)~~ in the granodiorite areas, especially south-west of Thornton Gap. Two occurrences on the old Gordonsville ^{- New Market} pike near Fisher's Gap are large enough to map. Unakite ~~occurrences have~~ ^{was} described at this locality in an excellent paper by Phalen.

Why here?

A new occurrence of unakite -- a preliminary paper: Phalen, W.C., ~~op. cit.~~, pp. 306-316. ^A Smithsonian Misc. Coll., vol. 45, pp. 306-316, 1903.

The largest area of true unakite occurs near the head of Dark Hollow just east of Fisher's Gap. This body is of variable composition.

~~(In many places the granodiorite is but little affected)~~ Generally the feldspars are pink and more or less replaced by or altered to epidote. Epidotization ^{is} may be marked, but, in many ^{in places} cases, original feldspars are partly altered to a greenish mass of epidote and quartz. Small ^{red} quartz grains are scattered through the mass of the unakite or are included in the feldspars. Excellent hand specimens of unakite may be obtained ^{here} in this locality, but ~~the~~ ^{the} unakite is too local and irregular to ~~render the rock~~ ^{be} of commercial value. In some places the original coarse texture of the granodiorite has been preserved in spite of complete replacement of original feldspars by pink feldspar and epidote.

A dike-like zone of unakite in granodiorite is crossed by the highway about ^{1.75 to} ~~a~~ straight line mile, northwest of Fisher's Gap. Several varieties of ~~this rock~~ are present here. ~~Specimens representative of this~~ occurrence ^{Shows} ~~are~~ granodiorite with ~~the addition of~~ red feldspar; true unakite consisting of red feldspar, blue quartz and epidote; masses of pink feldspar with some blue quartz; epidote and blue quartz; veins of epi-

130 ?
red-garnet?

dark blue (1000)

131
sky line or old pike?

(Fisher's Gap)

Needs description by ASP

dote containing large pink feldspars and some blue quartz, and masses of nearly pure epidote, ^{in places} sometimes containing cubes of pyrite.

A narrow band of unakite, ~~which~~ probably an extension of the one described above, occurs on the old road to Skyland on the west side of the ^{Blue Ridge} mountain. ~~Specimens of this rock consist of~~ ^{Tain's} light pink feldspar, blue or smoky quartz, ^{and} patches and stringers of epidote ^{which} contain ^{ing} small reddish quartz grains.

Unakite occurs in Little Devil Stairs. A ~~new~~ grade showing slight replacement of granodiorite is found in ^{Bushy Top} ~~(Bushy Top)~~ at Skyland and at Blackrock ^{Blackrock (Inns)} near Fisher's Gap. ~~Good specimens of several varieties of unakite may~~ ^{are found} ~~be collected~~ near the Skyline Drive just northwest of Franklin cliffs.

Origin of unakite and pink granite. -- The ~~occurrences~~ ^{of} unakite and pink granite ~~within the (area of the) Stony Man quadrangle~~ do not ~~seem to~~ present sufficient evidence to support conclusively a theory of origin ~~for this rock~~. Field studies ^{2/11/34} ~~carried out over the (area of the) Shenandoah National Park~~ however, ~~do~~ show that there is a striking tendency for this rock to occur throughout ~~the area~~ at the contact of granodiorite or granite with Catoctin greenstone. ~~It is true that there are many contacts (localities) where changes of this type do not seem to have taken place) within the intrusive rocks~~ ^{Such} ~~at~~ ^{actual} where ~~actual~~ contacts are ~~to be~~ found there is in many places more or less alteration of the intrusive rock to epidote and red iron oxide. ~~The degree of the change can not be predicted.~~ In some places there is a wide zone of altered granite or granodiorite; in others the alterations ~~of this type~~ are local, ^{in places} and ~~at times~~ ^{alterations} no changes are ~~to be~~ found.

~~Workers in the region~~ ^{It is} generally agreed that epidote is secondary ^{was} in origin, and that it ~~is~~ probably produced by a hydrothermal alteration of

3
light pink
Bushy Top (Inns)

0/3
Blackrock (Inns)

132
unakite?
133
locally

134
clear?
Amby

(contacts)

135

calcium-bearing silicates ⁱⁿ of the intrusive rocks. Red iron oxide seems to produce the jasper-red color which is so common to the granite, especially near the contact with Catoclin greenstone. Thin seams and stringers of ^{iron} oxide replace the granites and granodiorite, and the red color of the feldspars seems to be due to inclusions of this ^{minerals} mineral. granite and granodiorite at Hughes River Gap are traversed by dark red streaks and veins which ^{containing} ~~own their color to this mineral, for the minerals of the rock still retain their original texture and composition, although a thin section shows that they have been replaced along cracks and cleavage directions by iron oxide.~~ (Red iron oxide, where it often accompanies the epidote, seems to be responsible for much of the color in the dark-red and purplish-red varieties of the granite.) The explanation that epidote and red iron oxide have been produced by hydrothermal action of downward circulating meteoric waters does not ~~seem~~ adequately explain why these secondary changes should be so local in the granodiorite, or why they should be ^{connected} related to contact with greenstone.

In some localities it is ^{evident} ~~easy to see~~ that the ~~rock is~~ granodiorite which has been partly altered and replaced by epidote and secondary minerals. In other places ~~the rock is clearly a~~ granite which has ^{clearly} been replaced in a very similar manner. These facts indicate that the rock has been produced by hydrothermal alteration and near the contact ^s with ~~the~~ ^{granite} Catoclin flows. ^{Part} Alteration is extremely irregular ^{and} ~~often~~ ^s extending ~~downward~~ in zones into the intrusive. ^{rock} Zones showing ~~this~~ partial or nearly complete replacement of the original rock ~~often~~ occur far ~~removed~~ from the greenstone border. In such ^{places} ~~places~~ it seems probable that a vigorous interchange of solutions ^{took} ~~has taken~~ place at considerable depths along certain zones. ~~in some places~~ ^{body. it} this type of unakite resembles a cross-cutting intrusive ~~and~~ may have been of pegmatitic character before it was replaced by epidote.

dark-red to dark red

136

6?
137
A15



Should not the argument be concluded and this report?

this type?

137

The fact that the epidote-rich facies of granodiorite and granite so generally occur ^S in proximity to greenstone contacts, strongly suggests that the greenstone was the source of the iron and calcium. It is possible that these elements may have been brought upward by hydrothermal solutions and finally deposited ^{below} ~~under~~ the greenstone although this is considered ^{not} ~~less~~ ^{probable} ~~likely~~. Epidote contains more calcium than anorthite yet the most basic feldspar of the granodiorite is andesine. This latter view will demand processes which could transport and concentrate ^{below} ~~under~~ the Catoclin greenstone large amounts of calcium and ferric oxide from rocks which are markedly deficient in these elements ⁱⁿ ~~by~~ contrast with the epidotic facies.

(138)

? epidote/granit?

The relation of unakite and epidote-bearing granites to the borders of the Catoclin ~~flows~~ does not imply an intrusive contact. It does suggest that hydrothermal solutions have reacted with minerals of the basalt to produce the border zone of epidotic rocks. ^{So far as the unakite is concerned} the flows could be younger than the intrusive ^{rocks}. Evidence that the granites and granodiorite intrude the flows must be collected from other sources.

8?

Watson, in describing the unakite as a type of hypersthene syenite, recognized the vein character of the unakite in Madison County, N.C., and believed that some of it ~~may~~ have arisen as "magnetic segregations or secretions similar to schlieren or possibly pegmatite, some of whose original constituents may have altered to epidote chiefly by hydrometamorphism."

N.C. or Speed run

Watson, T.L., and Gline, J.H., Hypersthene ~~Syenite~~ ^{ica} and related rocks of the Blue Ridge region, Virginia: Geol. Soc. Amer. Bull., vol. 27, pp. 193-234, 1916.

slid

B-G-S-A
G-P-A
Puck

Jonas ~~has~~ regarded pink granite of the Blue Ridge in southwestern Virginia as "in many places, a coarse pegmatite, and the pink feldspars, orthoclase and microcline replace the more basic feldspars of the granodiorite in part or entirely, and with the accompanying epidote form a pink feldspar-epidote-quartz rock called unakite."

Jonas, Anna I., Granodiorite, its intrusion and replacement by the Air point granite in Virginia: Geol. Soc. America, Preliminary list of titles and abstracts, 1933, pp. 29-30,

Later
Ginn

Rocks similar to Air Point granite and removed a considerable distance from greenstone areas occur in the area of the Park. They closely resemble the other occurrences making it difficult to disassociate them. The rock ~~often~~ has the character of granite or pegmatite, as pointed out by Watson and Jonas. Sometimes ^{the} coarse crystallization and cross-cutting character of ^{some} these bodies suggests for ~~them~~ an intrusive origin.

(139)
what other
minerals
are there?

A recent paper upon granodiorite and unakite in southwestern Virginia suggests that the hydrothermal changes in the granodiorite were produced by residual magma extracts, which acted upon the consolidated portions of the granodiorite. In other words, the changes were deuteric, or epi-magmatic.

Jonas, Anna I., Hypersthene granodiorite in Virginia: Bull. Geol. Soc. America Vol. 46, 1935, pp. 47-60,

This writer also discusses the alteration of granodiorite to unakite which was accompanied by albitization in the presence of sodic solutions.

Op. cit., p. 53.

Handwritten scribbles and arrows pointing to the text.

Handwritten scribbles and arrows pointing to the text.

LOWER CAMBRIAN IGNEOUS ROCKS



A purplish-red, slaty, amygdaloidal lava flow occurs In this part of the Blue Ridge ^{Above} ~~over~~ ^(See Pl.) Catoctin greenstone and at the base of the Lower Cambrian arkosic sediments. ~~So far,~~ It is known only ^{on} upon the western side of the range. ~~In the north,~~ the belt begins east of Rileyville, at the extreme northern end of this quadrangle, and ^{it} is generally present at the base of the Lower Cambrian to the southwestern corner of the quadrangle. It is known to extend much farther to the southwest, ~~in the Park area.~~ Good localities for the study of this rock are the east side of Knob Mountain, Jeremy Run Valley, Basin Hollow, and Cabbage Hollow, which is about ¹ a mile west of Basin Hollow.

~~The flow is variable in thickness, and is locally absent.~~ On the east side of Cabbage Hollow, ^{it} ~~varies between~~ ^{ranges from} 100 and 200 feet in thickness. ^{At this locality,} ~~it~~ ^{above} occurs immediately ~~over~~ ^{above} granodiorite. On the west side of the hollow it ~~appears to be~~ ^(entirely) absent. Near Lucas Gap the flow has been reworked at the base of the Loudoun so that it appears to grade into the sediments. Its estimated thickness ^{here} ~~at Lucas Gap~~ is 320 feet. The Catoctin greenstone under the flow ~~at~~ ^{at} this locality is massive, and ^{it} alternates with massive, purplish, amygdaloidal rock containing much epidote.

Several isolated patches of ~~what is believed to be~~ ^{apparently} the same rock occur ^{above} upon the Catoctin greenstone on Tanner's Ridge and ^{at} Big Meadows. In other places, notably west and east of Bailey's Store, the basal Cambrian sediment ~~which is composed largely of this volcanic material,~~ ^{and} superficially resembles red, slaty varieties of the flow rock. This type of sediment ~~is~~ ^{is} well studied ^{shown} in the outlier northeast of Bailey's Store, where ~~hand specimens~~ ^{hand specimens} of the rock contain ~~washed~~ ^{striated} grains of quartz and feldspar. This sediment ^{is} in ^{places} ~~is~~ ^{interlayered} with normal sandstone or shale.

General character and distribution
mountains
Sub-basins

is well studied
in the outlier

1-?

Megascopic character. -- The flow is generally reddish-brown to brown

in color, ^{and but} some zones are chocolate ^{or brown} colored. It is usually non-porphyrific,

but ^{generally} often amygdaloidal, ^{containing} vesicles which are usually filled with white or pink

quartz, ^{and which} are smaller than the ^{those} larger ones of the Catocin greenstone. Alterations

to epidote ^{is} do not characterize this rock. ^{is not epidotized.} In hand specimens the rock is ~~generally~~

Much of it is often slaty, ^{and many of} where the rock is slaty the amygdules are often washed flat.

The rock is less metamorphosed ~~and altered from its original condition~~ than the Catocin greenstone.

Microscopic character. -- Thin sections show a fine, felt-like groundmass

which is probably ^{by} for the most part quartz and feldspar. ^(See Pl. 96) There

is much red oxide of iron which imparts the prevailing red color to

the rock. ^{were not seen} The feldspar phenocrysts ^{thin} are evident in the sections examined,

although ^{quite frequently} there are numerous elongated, rectangular minerals

altered to sericite. In the absence of chemical analyses, ^{can} it is not be

safe to attempt an exact classification of this rock. Hand specimens suggest

that it ^{appears to be} is an altered rock ^{of} rhyolitic character, ^{but} it is probably more

basic than rhyolite and less basic than Catocin greenstone. Although it contains

much iron oxide, it generally carries little epidote. The rock does not remain

uniform in character when traced along the line of strike. Southeast of this

quadrangle it is locally sericitic, resembling in color certain facies of the

~~Lower Cambrian~~

Geologic Age. -- This ^{lava flow} volcanic rock occurs at the ^{base of the lower} base of the ^{most of it} Cambrian series

on the ^{north} west side of the mountain. ^{occurs} between the sediments and

Catocin greenstone ~~for the most part~~, but patches of similar rock are

sometimes found ^{in places} in the greenstone areas. In the former type of occurrence the

fact ^{where} that the flow clearly overlies Catocin greenstone shows it to be the

(140)

Pl. (96)

(141)
Lower Cambrian

Similar vesicles

Felt-like
felt-like

De
See Pl. 96

base of the lower
bottoms of the basal

younger. Small, ~~smaller~~ ~~linear~~ areas and patches of red, slaty volcanic rock in the greenstone areas may overlie the greenstone in the same manner as do small patches of Lower Cambrian sediments.

~~In some cases, smaller~~ isolated patches of ^{Lower Cambrian} ~~this~~ sediment upon the greenstone are ⁱⁿ ~~largely~~ ^{al lava} composed of fragments of the slaty amygdaloid. This indicates that a ^{large} ~~notable~~ amount of ^{This lava} ~~amygdaloid~~ was subject to erosion at the beginning of ^{time} ~~the~~ Cambrian. It is believed that the Lower Cambrian sediments were deposited after a long period of erosion which ^{locally} ~~completely~~ removed the ~~catostin~~ greenstone in ^{an} ~~places~~, exposing ²⁾ the underlying granodiorite. It is not likely that ~~a thin pre-Cambrian flow~~ such as ~~occurs on the western side of the~~ ^{Blue Ridge W} ~~mountain~~, should have been left on the ~~surface of~~ the greenstone after so much erosion.

??
(142)
(Sec 14)
not
proof

~~On the whole,~~ the evidence ~~presented above~~ ^{lava} ~~seems to~~ indicate ^s an early Cambrian age for the ~~amygdaloid~~ in Cabbage Hollow, just west of Basin Hollow, the amygdaloid occurs at the base of the ^{above} lower Cambrian series, and immediately ~~over~~ granodiorite. This shows that the flow must have been poured out after the great erosion period which ~~had~~ laid bare the ~~surface of~~ the granodiorite ~~by the close of pre-Cambrian time~~.

Dist
OK
in

Proof?

(12) →
Missing

TRIASSIC (?) IGNEOUS ROCKS

General features. - The area contains numerous

Microscopic Character.

Diabase dikes, are generally narrow, ranging from a few feet to perhaps 100 feet in width. They are difficult to trace in the field and ^{that have been} usually ~~must be~~ mapped ^{from} the basis of a few outcrops. They have a prevailing ^{by} northwest-southeast trend. ^{Re} One dike is about two miles long, but usually ^{most dikes are} ~~is~~ ^{short out} ~~is~~ ~~extensive~~ for a short distance only. Several narrow ones crop out along the Lee Highway east of Thornton Gap where they intrude granodiorite and granite ^(fig. 79). (See Pl. 1.)

The rock is dense, fine grained, and greenish black. ~~in color.~~

Minerals cannot be recognized with the naked eye. With the hand lens dark ferro-magnesian minerals and gray, lath-shaped feldspars can be identified ^{usually}. The greenish color suggests some alteration of ferro-magnesian minerals, but in dominant aspect the dikes are fresh, unmetamorphosed, and resemble ^{the} those of Triassic ^{dikes} age to the east of the Piedmont province.

Microscopic character. - Several thin sections were examined.

Under the microscope ^{are} the rock in each case is augite gabbro with the ophitic texture of diabase. Listed in the order of their ^{abundance} importance, plagioclase (labradorite?), augite, and some quartz are the dominant minerals. ~~plagioclase has the usual broad twinning lamellae of labradorite, but is too much weathered to assure certain identification.~~ Light colored augite, ^{Much of the augite is} sometimes showing good crystal form, is abundant but considerably altered to chlorite. Magnetite grains occur rather abundantly, as is usual with this rock. Minerals have not been strained or mashed by regional metamorphism. The assemblage is that of the normal Triassic diabase, but ^{eastward} the rock is more weathered than in ~~fresh~~ diabase from the Piedmont region.

144
have been mapped usually must be

Pl. (79)
- 7/
Diorite
para-morphosis
P. 98
(93)
(100)

145
146
147
5b
humming?
6()-?

Continuation

Sedimentary Rocks
General Statement

over = insert

Sub-head
SS p. 76 (73)

(148)
6 []

The northwestern third of the quadrangle is occupied by sedimentary rocks (~~which are entirely~~) of Paleozoic age. Over these and some of the crystalline rocks are distributed unconsolidated deposits of Quaternary and Recent origin. ~~In addition,~~ scattered deposits of more or less altered ^{Cambrian} sediments occur in the ^{Blue R. Dge. (See pl. 1)} eastern portion of the quadrangle where they are associated with the crystalline rocks but correlated with the Paleozoic sediments. All are described in this section of the report.

(149)
6 (-) ?

(150)
following

~~A considerable problem confronts the field geologist in the~~
~~studying the local Paleozoic sediments: (The chief difficulty is~~
~~to overcome) the lack of exposures which characterizes practically~~
~~all of the various Paleozoic units.~~ ^{formations are rather scarce.} Page Valley is a lowland ^{whose} surface is almost completely covered either with deep residual soil or with thick alluvial gravels. ~~As a result, the under-~~
~~lying bedrock crops out in extremely limited areas, and the few meager~~
~~exposures do not furnish adequate opportunity to ascertain the full~~
~~character of the rocks. It is probable that no analogous region~~
~~along the Valley of Virginia contains as few exposures of bedrock~~
~~as does Page Valley.~~ Hence, ~~the~~ descriptions of the local sediments include data ~~which have been~~ ^{As} obtained from adjacent areas where the rocks are better exposed. ~~Since~~ ^{locally actual} it is almost impossible to determine the thicknesses of the ~~different~~ rock units, estimates ^{have} can be made ⁱⁿ only from the widths of ~~their~~ ^{and} outcrops ~~or~~ from distant exposures. Collections of fossils and measurements of stratigraphic sections are likewise rarely obtainable in the ^{quadrangle} ~~Stony Man~~ region, and the ^{discussion of the} ~~stratigraphy of the Paleozoic System~~ is correspondingly less complete in ~~this report~~ than it ^{might} be ~~for an analogous area~~ elsewhere ~~in Virginia.~~

The generalized columnar section ^{given below} ~~which follows~~ shows
~~a grouping of the local Paleozoic rocks in their proper chrono-~~
~~logical order, the oldest formations being shown at the bottom.~~
~~of the table, and younger units at the top.~~ The (columnar) section
indicates ^{Therefore,} the sequence and thicknesses of the sedimentary rocks of
this quadrangle as they might [?] ~~theoretically~~ be ^{penetrated} ~~ascended~~ in a
well ^{drilled through} ~~that would penetrate~~ the entire ^{sections. Plate} ~~series.~~ (See Fig. ✓)

6(-) ✓

(152) 6? /
Fig 62 ✓

Do not copy yet

Table?

Table

Unsure as to origin

Table 1. -

Columnar Section of Paleozoic Rocks for the Stony Man ⁱⁿ ~~Area~~ ^{Square}

(153)

(154)

(155) shale - 10-formation? limestone?

(156) formation?

(157) formation quartzite

(158) Blount Group shale

(159) equivalent dolomite

(160) limestone? calc. shale formation

Permian shale quartzite

System

Formation

Approximate Thickness (feet)

Devonian (1,420' - 1,635')	("Romney" shale	1,200' - 1,400'
	(Onondaga shale	100' ±
	(Helderberg Group	120' - 135'
Silurian (1,140' - 1,200')	(Tonoloway limestone	140' - 155'
	(Bloomsburg shale	550' ±
	(Tuscarora sandstone	550' ±
Ordovician (3,220' - 3,900')	(Martinsburg shale	2,500' - 3,000'
	(Chambersburg limestone	250' ±
	(Athens shale	400' - 500'
	(Lenoir limestone	69' - 105'
	(Mosheim limestone	0' - 32'
Canadian (1,350' - 1,560')	(Beliefonte dolomite	650' - 760'
	(Nittany dolomite	590' - 700'
	(Stonehenge limestone	100' ±
Ozarkian (1,750' -)	Conococheague formation	1,750'
Cambrian (4,300' - 5,900')	(Elbrook limestone	1,300' - 1,800'
	(Waynesboro shale	500' - 1,000'
	(Tomstown dolomite	700' - 900'
	(Antietam sandstone	500' - 600'
	(Harpers shale	400' - 500'
	(Loudoun formation	800' - 1,400'

(PreCambrian crystalline rocks)

Use

Devonian
(1,420 to 1,635)
feet

Approximate
Thickness
(feet)
1,200 - 1,400

Devonian
(1,420 to
1,635 ft.)

1,200 to 1,400
550 ±

46

71

Cambrian System

Features
General Statement

~~(The outcrop of)~~ Cambrian rocks, which ^{are ?} comprise the ^{oldest} most ^{minimally} ancient ^{sediments} ⁱⁿ the Stony Man ^{quadrangle} region, ~~(is)~~ limited to a narrow belt in the west-central portion of the quadrangle and to isolated areas in the Blue Ridge ~~massif~~. ^{Fig. B, Plate XIII (See Pl. Fig. and)}

The Cambrian System is readily divisible into ~~two distinct series~~: an older arenaceous group and a younger calcareous ^{group}. ^{Resistant sandy beds} The older group forms the range of low foothills along the ^{weakest} ~~ridge~~ of the Blue Ridge escarpment, and the younger group underlies the ~~alluvial deposits that have been built out beyond the margin of the Valley lowland~~. The Cambrian System rests unconformably upon the ^{basal beds} ~~underlying crystalline terrance~~ with ^{strong} evidence that a long period of disturbance and erosion preceded ^{the} ~~its~~ formation. The total thickness of Cambrian rocks in this ^{area} region is at least 4,000 feet and ^{it} may possibly ^{be} reach 6,000 feet.

By many authors the Conococheague formation, which is here listed as Ozarkian, is considered to be of Upper Cambrian age. ~~With the overlying Stonehenge, Nittany, and Bellefonte formations, it belongs to a calcareous assemblage, collectively known as "Cambro-Ordovician".~~

Omit here

(161) compare vs compares

(162) quadrangle Fig. (13) massif

(163) west base-to-door

(164) pre-Cambrian deposition

(165) Ref. to which in Plate page 42?

Series ? ? ?

Loudoun Formation

The basal Cambrian sediment in the Stony Man quadrangle consists of an aggregate of sandstone and shale known as the Loudoun formation.

Definition.- This formation takes its name ^{was taken} from Loudoun County, in northern Virginia, where it was first described by Keith, ~~in~~ 1894.

Keith, Arthur; U.S. Geol. Surv. Atlas, Harpers Ferry Folio (No. 10), 1894.

In the Harpers Ferry region of northern Virginia, ^{and adjacent states} ~~eastern West Virginia, and Maryland,~~ the Loudoun formation is overlain by a pure sandstone, known as the Weverton sandstone, from which it can readily be distinguished. In the Stony Man ^{area} ~~region,~~ however, the Weverton sandstone is either absent or so similar in ~~character~~ ^{formation} to the Loudoun that the two can not be separated. (~~Thus it is possible that the Loudoun formation as designated in this report may also include a representative of the Weverton formation of northern Virginia.~~) Both beds give way in central and ^{southwestern} ~~(southern)~~ Virginia to the Unicoi formation, which is the lowest member of the Chilhowie Group.

Woodward, Herbert P., Geology and mineral resources of the Roanoke area, Virginia, Virginia Geol. Surv. Bull. 34, p. 28, 1932.

Although the Loudoun formation of this report is the equivalent of the Unicoi formation, the use of the latter name for horizons in ^{northwestern} northern Virginia does not appear to be appropriate.

As will be subsequently mentioned in the discussion of this formation, the name Loudoun is commonly applied both to the basal Cambrian elastic beds along the west foot of the Blue Ridge and to more or less isolated outcrops of ^{scattered} ~~sediments~~ ^{similar} elsewhere in the Blue

check No 10 19 114
if present?
167
west central
all
168
Stase?
Butts?

are generally considered to be part of the Loudoun formation. - 127 #6.
Ridge province. Although it is probable that the two types of
sedimentary materials are heterotaxial and equivalent, ^{There is a} the possibility, however,
that they may be of ^{different} unlike age, can not be ignored.

Distribution and Character. - - The local outcrops of the Loudoun
formation can be separated geographically into two groups, and, as
in which ^{are somewhat different.}
the lithologic characters of the formation ~~conform somewhat to this~~
~~geographic separation, both distribution and general character can~~
~~well be described under a joint heading.~~

Loudoun sediments of the Foot-hill Belt. - - The largest and most
persistent outcrop of ^{the Loudoun} this formation occurs ^{is} along the west foot of
the Blue Ridge in a belt which extends from Compton southwestward
to Stanley. This belt is ~~continuous~~ ^{is} except for two small
areas immediately south of Marksville and east of Piney Hill where
the formation has been removed by strike faulting ^{ed out}. The belt main-
tains a width of ^{is} about ^{half a} one half mile ^{wide except} for much of its strike across
the quadrangle, but is notably ^y widened in several places where the
formations ^{beds} extends upward ^{along} ridges that rise toward the summit
of the Blue Ridge. ^{on} Specifically, Knob Mountain (Fig. 81), The
Neighbor (Fig. 80), Chapman Mountain, and the main Blue Ridge crest
between Beahms and Elkwallow Gaps, ~~contain outcrops of the Loudoun~~
~~formation that are connected with the foot-hill belt (Fig. 106).~~

^{Equival of} The formation produces ^{Topography that is relatively} rather smooth ^{of} and ^{slightly} medium coarse ^{Texture.}
topography, although its main belt of foot-hills is considerably
lower than the ^{is} true Blue Ridge. ^{is} Its soil is ^{Somewhat} reasonably fertile for
mountainous country, ^{and} supporting a sturdy growth of timber ^{and} ~~berry~~
~~bushes (grow upon its outcrop).~~

Throughout this belt, ^{in this belt} the Loudoun formation is ~~essentially~~
~~an arenaceous unit~~ composed chiefly of ^{is} medium-bedded sandstone,
arkose, and sandy shale. (See Pl. (82)). Its general color is dark and the

(171)
Cops
n.l.c.
169
this is
the Knob
170
Pl. (81)
Pl. (80)
171
Cops
See above
Pl. (82)

3/7
6
17

sandstones are commonly dark reddish-purple. The texture of the sandstone ^{are} ~~members~~ is medium ^{grained} and cross-bedding is common and conspicuous, showing clearly in the lighter colored or streaked members of the unit. The shaly beds have been ^{slightly} ~~mildly~~ metamorphosed, and in places approach phyllites ~~in character~~. They are commonly light and silvery in appearance, or are slightly bluish. The formation as a whole becomes stained ^{on} weathering ^{and} ~~produces only~~ small debris ^{along} ~~upon~~ its ^{surface} ~~(surface)~~ outcrop.

?

Blue Ridge
to
Catawba
to
large flow
discussed

~~Where exposed in this belt,~~ the base ^{at base} of the Loudoun formation ^{are} is slightly pebbly, but no strong basal conglomerate was observed. ~~As described elsewhere in this report,~~ The formation ^{generally} overlies the Catoclin greenstone and hypersthene granodiorite throughout much of the foot-hill belt, but ^{in places} it is occasionally ^{lies upon} separated from these underlying units by a thin bed of amygdaloidal ^{lava} material which is thought to be of lowermost Cambrian age. ~~This volcanic material is commonly reddish-brown to brown in color, (it is) dense and has a slaty structure.~~ In some ^{places} exposures, especially ^{as} in the ^{near} vicinity of Bailey's Store, the lowermost ^{lava} beds of the Loudoun are derived from the underlying volcanic flow; in other exposures, the flow appears to be ^{created} intermingled with the basal sediments.

Rep station of p. 125-26

The best exposures ^{are} in this belt of Loudoun (sediments) occur along the upper reaches of Stony Run in Basin Hollow; near Pumpkin Hill; and near Compton.

Loudoun sediments of the eastern Blue Ridge area. - Geographically distinct from the foothill belt of Loudoun sediments is a series of isolated patches, ~~or outliers~~, of metamorphosed ^{rocks} sediments that ^{are} occur in intimate association with the ^{Pre Cambrian} crystalline rocks of the ^(See Pl. 1) quadrangle. ~~A line of these outcrops occur~~ ^{they} in the southeastern corner of the quadrangle extending from Thorofare Gap ~~south~~ southwestward through Pine Hill Gap nearly to Hughes River, and from Robertson

?

River to Fernham School and Dark Hollow. Another interrupted belt occurs near the crest of the Blue Ridge and contains narrow ~~cuttings~~ inliers near Blackrock, Franklin Cliffs, Crescent Rock and Skyland. An isolated ^{ava} occurrence is crossed by ^{the} Lee Highway near Beech Spring Church.

The ~~Loudoun~~ outcrops in the eastern half of the quadrangle are small and locally overlie most of the igneous rocks of the ^{area} region. ~~The areas, which are narrow and linear in shape, tend to strike in a northeasterly direction, but may depart radically from that trend. There is a distinct tendency for these narrow outcrops to occur along the present borders of Catoclin greenstone. The outcrop at Beech Spring Church, however, occurs within an area of hypersthene granodiorite, and the belt near Therefore and Pine Hill gaps occurs at the contact of granodiorite and Old Rag granite.~~

of what material?

^{se} The ~~small outcrops~~ of sediments have been more highly mashed and metamorphosed than the Loudoun beds of the foot/hill belt, ~~west of the Blue Ridge.~~ The shales have become contorted green phyllites, and arkosic beds have ~~assumed~~ a gneissoid appearance that makes it difficult to separate them from Pre-Cambrian metamorphic rocks. The phyllites contain mashed lumps or pebbles of quartz and feldspar, and ^{locally} occasionally include large, well-rounded pebbles of quartz in a greenish matrix of quartz, feldspar, chlorite, and sericite. Contorted, green phyllites are well exposed in Rose River Valley, south of Buzzard Rocks, and in Pine Hill Gap. The phyllites weather to a poor soil that generally supports a growth of scrub pine. Feldspar and quartz in the massive arkosic beds have been mashed into ~~layers or bands~~; and east of the Community School, the profound mashing has produced a ^{fine-grained} ~~fine~~ white, slaty rock with a silky luster induced by secondary sericite. It is difficult to distinguish such rocks from deformed granites.

(171)
L.C.
m.c.
L.C.

8/2/7

Pl. (84)

(Pl.) 125 717

A thin section of typical green phyllite (Fig. 84), from Pine Hill Gap contained crushed, or partly crushed, lumps of quartz and feldspar. Bands of green pleochroic chlorite that enwrap crushed feldspar and quartz also occur, and ^{some of} the feldspars and quartz are occasionally mashed into narrow bands of interlocking grains ^(one word) that ^{having} show a wavy extinction. A thin section of Loudoun arkose contained leaves of muscovite and biotite that ^{enclose} fine quartz grains. The latter were interwoven between crushed feldspar and quartz lenses, some of which were mashed into nearly straight bands. ^{Most of} ^{are} the feldspars of this section were almost entirely perthite and plagioclase.

The most accessible exposures of the Loudoun in the ~~eastern~~ ^{Blue Ridge} portion of the quadrangle are those in Thorofare and Pine Hill ^{Hill} gaps, and at Beech Spring Church. An interesting but somewhat inaccessible exposure occurs below Franklin Cliffs at the head of Little Hawksbill Creek, where a coarse conglomerate forms the base of the outcrop.

Thickness. - ~~No opportunity to measure a~~ detailed section of the Loudoun was ^{could not be} found within the ~~general area of the~~ quadrangle. Hence the ~~total~~ ^{total} thickness ~~may be~~ estimated only from the width of its ~~formational~~ ^{formational} outcrop and from comparisons with ^{other} nearby sections. ^{is} It is thought that the Loudoun has a local thickness of from 800 to 1,400 feet.

Structural Relations. - In the foot-hill belt, ^{The Loudoun} ~~this~~ formation is commonly tilted or ~~inclined with the overlying deposits at angles that approach 50° to 70 degrees.~~ ^{of} Although the ~~Loudoun~~ ^{formations} is not tightly folded, some of its members show a pseudo-cleavage that has resulted from strong deformation. The formation rests upon the Lower Cambrian ~~amygdaloidal~~ lava flow, ~~or upon the greenstone,~~ or

173

174

granodiorite. Its contact with the overlying Harpers shale is rarely visible. ~~The formation contains little massively bedded material; hence it is not well exposed and ledges are frequent only along stream beds or steep slopes.~~

Not here

The structural relations of the formation ~~east of the~~ ^{in the Blue Ridge} foot-hill belt are not entirely clear, but it is suggested that the Loudoun may occur in extremely tight synclinal ^{is} ~~inliers~~ whose compression has induced a greater amount of metamorphism than elsewhere.

175
Value
Importance
Material

~~occurs~~

Mineral Resources. - Economic Material. - The Loudoun formation contains no ~~material of~~

~~(economic) value, for the Blue Ridge hematite common to its more southerly outcrops is apparently absent in the ^{Stoneman area} ~~away~~ region.~~ Immediately north of the quadrangle on Moody Creek, there are residual deposits of brown iron ^{ore} that occur near the contact of the Loudoun and ^{the Catoclin} ~~greenstone.~~ Probably the source of the iron was the ~~nearby~~ ^{by} crystalline rocks.

Age and Correlation. - ~~The Loudoun formation has no known or reported fossils.~~ ^{Fossils have not been reported from} From its position as the ^{oldest} ~~most ancient~~ Paleozoic sediment of the northern Appalachian region, it is assigned to ~~the~~ ^{roughly} Lower Cambrian ~~age.~~ It is probably equivalent to the Unicoi formation of ^{the} ~~the~~ region south of Roanoke, ^{Virginia} ~~(Virginia).~~

It has already been mentioned that in its local expression the unit exhibits two somewhat varying phases which maintain geographic separation. These two phases include the relatively unmetamorphosed sediments of the foot-hill belt along the west slope of the Blue Ridge, and the more highly altered materials of the isolated outcrops that occur in the eastern part of the Blue Ridge Province.

176
of
(---)?

177
Dep. 122
mer

shown
As represented on the ~~accompanying~~ geologic map and

pl. 1)

(Pl. 1)

in the foothills of the Blue Ridge

structure sections, both phases of these sediments, are designated as Loudoun and are here described as of Lower Paleozoic age. It is not wholly clear, however, that this point of view can ultimately escape challenge, and the authors have considered the possibility that the two ^{facies} phases may represent original sedimentation during different time ^{periods}. The geographic separation of the two ^{facies} phases of sediments and their somewhat ^{different} variant lithologic character are points which suggest that they ~~two~~ may have had somewhat different geologic histories. The affinity of the eastern sediments for the contact of the greenstone is a structural relationship that is not entirely clear. However, as it is customary to refer ^{such} to altered sediments ⁱⁿ of the Blue Ridge ^{To the} Province as Loudoun outliers, the authors are following precedent, in using this name for both phases of the sediments; and so far as the authors are aware, there is no opportunity in the Stony Man region to demonstrate the probability that the two are identical in age, or the possibility that one is older than the other.

Harpers Shale

The ~~Harpers Shale~~^{IT} consists of a series of gray shales and thin sandstones that rests ~~directly~~ upon the Loudoun formation.

Definition.- The Harpers shale is named from its occurrence at Harpers Ferry, West Virginia. In southwestern Virginia, an

Keith, Arthur; U.S. Geol. Surv. Geol. Atlas, Harpers Ferry, Folio, (No. 10), 1894.

equivalent formation is known as the Hampton shales, and both names

Campbell, M.R.; U.S. Geol. Surv. Geol. Atlas Bristol Folio, (No. 59), 1899.

refer to approximately the same stratigraphic horizon. As the local formation occurs near the type region of the Harpers shale, it has been described under this name instead of under the name Hampton shale.

Distribution.- This formation occurs in a narrow belt that extends from a point east of Marksville to the northern margin of the quadrangle.

The belt is interrupted at several points near Varner and Piney Hills, and in Green Hollow where one of the Blue Ridge overthrusts has

broken its continuity. So far as was observed, the formation is almost without surface exposure in the Stony Man region, and no ledges

of bedrock can be definitely ascribed to the Harpers shale. It is possible, however, that a quarry face near the western end of Pumpkin Hill exposes a short section of this formation (Fig. 25). (See Pl.)

As it is soft and easily eroded, and as its outcrops lie between those of resistant sandstones, the Harpers shale is responsible for a narrow lowland between the ridges of the foothills along

P. 1 (53)

the Blue Ridge ^{It} This lowland area is commonly covered with a thick veneer of boulders and gravels washed down from the adjacent mountains. ^{The} ~~of the Harpers shale~~ Its effect on the topography is almost as striking, although in a negative fashion, as that of the resistant beds of the Lower Cambrian sandstones. The formation produces no natural soil, as its outcrop is uniformly covered with float from the adjacent quartzite ridges, as well as with alluvial debris from the Blue Ridge. The lowland ^S northeast of Piney Hill and northwest of Rattleburg School are probably developed on Harpers shale.



Character. - In adjacent regions the Harpers shale ^{comprises} a series of soft, dark ^{colors} sandy shales, interbedded with thin layers of sandstones. Commonly ^{is} the formation fine and distinctly laminated, with thin, dark shale ^{laminae} occurring between sandy lenses that attain considerable thickness. In some sections of the formation, the rock could be adequately described as a thin-bedded sandstone; elsewhere it is a siliceous shale. ~~The Sandstones~~ appear ^S to increase in thickness and abundance ⁱⁿ near the upper ^{part} position of the formation. In fresh exposures ^{fresh} the rock is bluish and hard, but it weathers rapidly to a buff-colored, clay shale and to shaly fragments.

Thickness. - On the basis of the width of its outcrop, the Harpers shale is estimated to be from 400 to 500 feet thick in this area. This estimate appears to ^{be} considerably ^{is much} less than ^{the} normal thickness of the formation, which is commonly given as ~~from~~ 1,000 to 2,000 feet. ^{Possibly} a greater thickness ^{than that estimated} is concealed in the Stony Man ^{area} region, ^{this} the formation has a much thinner representation in the local area than in adjacent regions.

Structural Relations. - The Harpers shale occurs in the stratigraphic section between two ^{resistant} competent Lower Cambrian quartzites. The entire series has been ^{steeply} folded, so that the shale now occurs in ^{steeply}

inclined position, ^{it} ~~and~~ has been more intimately wrinkled than the resistant rocks above and below it. ^{Although} ~~Its contacts~~ with the overlying Antietam sandstone and with the underlying Loudoun formation ~~are not visible in this region,~~ ^{tion} It is thought, however, that ~~these contacts are conformable,~~ ^{to be}

180
Material
vs
value
importance
181
Harper shale
this formation

Mineral Resources. - ^{These are minerals} ~~(Economic Material)~~ - No ~~material~~ of economic importance ~~occurs~~ in the Harpers shale.

182
this formation

Age and Correlation. - ^{the Harpers shale} ~~This formation~~ is not known to contain ~~any~~ fossils. ~~In the exposure~~ ^{At} the western end of Pumpkin Hill, a few obscure markings occur on the ~~surface of~~ some of the shale ^s lenses, but ~~it is not known whether these markings are organic or inorganic.~~

~~It is possible that they are faccidal markings produced by some form of marine plant growth.~~ ^{represent} ~~As previously mentioned, it is not entirely clear that the rock in this exposure belongs to the Harpers shale.~~ On the basis of its stratigraphic position, the Harpers shale is assigned to the Lower Cambrian. It is the northern equivalent of the Hampton shale of southwestern Virginia and Tennessee.

~~The~~ Antietam Sandstone

The Antietam sandstone is a coarse-grained, ~~elastic rock~~ which in places has ^{becomes} been hardened into quartzite. It is ~~the uppermost member of the Lower Cambrian arenaceous group.~~

4/ Definition.- ^{It} This formation extends along the ~~entire length~~ of the Blue Ridge ^{across} in Virginia. ~~In northern Virginia~~ It is known as the Antietam sandstone, ^{was} named from Antietam Creek, Washington County, Maryland. In the ~~region~~ ^{known} South of James River, it is described as the Erwin quartzite of the ~~Chilhowie group.~~

2 Williams, G.H., and Clark, W.E.; Maryland: Its resources, industries, and institutions, Baltimore, p. 68, 1893.

4/ Distribution.- The ~~outcrop of the~~ Antietam sandstone extends ⁱⁿ as a narrow belt from a point near Stanley northward to the ^{east} ~~margin~~ ^{edge} of the quadrangle. The outcrop has been duplicated at several points by folding and faulting, ~~and~~ The best exposures occur on Stony Run southwest of Stanley; at the ^{mountain} northeastern end of Pine Mountain; on the Three Sisters, and near Compton.

The formation produces a ~~thin~~ sandy soil so filled with quartzitic boulders that it is sterile and poorly adapted for cultivation. Under favorable conditions the Antietam produces foothills of considerable prominence, but the formation is irregular in its topographic expression. Where the rock is vertical, it produces more rugged topography, ~~than where it is either inclined or approaches horizontality.~~

11/ Character.- ~~So far as was observed, this formation is entirely arenaceous.~~ The rock is light in ^{the} color, ^{and some is} often creamy white, and upon weathering ^{it} becomes slightly stained with a pink or reddish color. Typical Antietam sandstone is very dense, tough, and highly lithified, much of the material being ~~actually~~ quartzitic in character. At least

183

Not descriptive

two, and probably three, heavier ^{massive and bold} and more resistant ^{beds} horizons occur within the formation, and produce strong ledges along the crests of Antietam ridges (Fig. 35). ^(See Pl.) These massive zones are separated by somewhat softer and more sandy material. The formation is medium bedded but is highly fractured and broken throughout. ^{and} For this reason, only in rare instances does it produce ^{Seldom} rock ledges, ^{numerous} in proportion to the resistant nature of the rock. It weathers and erodes with difficulty, although where the rock is excessively fractured, it may produce little or no effect upon the topography, as in the valley of Chub Run, one mile northeast of Marksville. Even with considerable transportation, its debris fails to become rounded, and is angular, chunky, and irregular (Fig. 35). ^(See Pl.)

? = ?

? = ?

In a few places, large ^{irregular} masses of secondary quartzite breccia occur near the contact of the Antietam and the Tomston ^{with} dolomite, or along the ^a fault zone. This ^{It} breccia consists of angular fragments of quartzite tightly compacted and recemented together, ^{and} the rock which occurs in large irregular masses, is ^a apparently a talus breccia. Presumably the recementation ^{ed} occurred in comparatively recent times as a result of ^{by} circulating waters highly charged with silica. The most conspicuous mass of this breccia occurs on Jeremys Run, about one mile northeast of Vaughn ^(See Pl.) (Fig. 35). The brecciated material is a heterogeneous assemblage of rock fragments of varying sizes ^{occurring} which occur in sufficiently large masses to suggest ^{at first glance} that it was a primary sediment, produced at the same time (i.e. Lower Cambrian) as the formation of the Antietam sandstone. Careful study, however, easily convinces the observer that it is of secondary origin, and that it has been produced in recent time.

Tomston

u

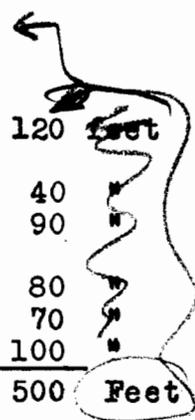
Thickness. - The thickness of the Antietam sandstone ^{from} ranges between 500 ^{to} and 600 feet. The most complete exposure occurs along Stony Run, southwest of Stanley, immediately west of the ^{edge} margin of the quadrangle,

Copy Bull. 17 p. 16 section
where the following sequence was measured by Stose:

Knows
Stales
184
Not
Reference
See B. 17
p. 16

Section of
Antietam sandstone near Standly, Virginia

White crumbly sandstone, upper layers hard, poorly exposed, weathering red to rusty and porous, abundant <u>Scolithus</u>	120	feet
Hard white thick-bedded vitreous quartzite, some <u>Scolithus</u>	40	"
Partly covered, probably crumbly sandstone.....	90	"
Hard thick massive beds of bluish-white vitreous quartzite.....	80	"
Covered, probably crumbly sandstone.....	70	"
Hard white vitreous quartzite, some <u>Scolithus</u>	100	"
	500	Feet



Stose, G.W., and others; Manganese deposits of the west foot of the Blue Ridge, Virginia; Virginia Geol. Surv., Bull. 17, p. 16, 1919.

"Slip zones"

?(2 wds)

It is probable, however, that slight slip zones and dislocations in the Antietam at this point prevented a more exact measurement of the full section. ~~from being exact.~~ Elsewhere in the Stony Man ^{area} region, the thickness must be estimated by the width of the (Antietam) outcrop.

Structural Relations

Like
As are

With the other Lower Cambrian formations, the Antietam sandstone is inclined at moderate to steep angles. In the area east of Marksville it is folded to ~~form~~ a subsidiary anticline and a broken syncline, while at Piney Hill the ~~formation~~ ^{it} is nearly horizontal. ~~Its~~ ^{its} contacts with the underlying beds ~~have~~ ^{were} not been observed in this area. ~~It~~ ^{Deformation} is thought ~~however~~ ^{or} to lie conformably above the Harpers shale, and to be disconformably overlain by the Tomstown dolomite.

Mineral Resources.
Economic Material.

and prospects

Several mines (or other workings) of brown iron ore and manganese have been developed along the outcrops of the Antietam sandstone. ~~They~~ commonly occur near ~~its~~ ^{the} contact with the Tomstown ^{dolomite.} At Compton ³ miles north of the quadrangle, ~~directly~~ ^{The workings are} within the quartzite. The nature and structural relations of the ore in these deposits ~~are~~ ^{is} described in ~~another section of~~ ^{the following} this report.

Not in
area, however

Age and Correlation.-

The only observed fossil ^{is} in the Antietam sandstone is Scolithus linearis which may be found commonly in quartzitic float from ^{of} exposed ledges. In a pile of Antietam fragments, about one in five specimens will carry Scolithus. This fossil is thought to be a worm burrow that was filled with material of slightly different character than the enclosing sand into which the burrow was made. The worm tubes are at right angles to the bedding planes of the rock and thus indicate the original attitude of the formation wherever the rock is inclined. Scolithus is a typical Lower Cambrian fossil; hence the Antietam is assigned to the Lower Cambrian. Its southern equivalent is the Erwin quartzite of southwestern Virginia, which forms the upper portion of the Chilhowie formation of Tennessee.

(186)
present

7

Tomstown Dolomite

188

The Tomstown dolomite, a ~~(This) calcareous formation~~, abruptly succeeds the arenaceous Antietam quartzite, ~~in the columnar section and is the lowest and oldest of the ~~limestone~~ beds~~ that underlie the Valley of Virginia.

Definition. - ~~(The Tomstown dolomite)~~ receives its name from Tomstown, in southern Pennsylvania, where the rock was first described by Stose. ~~This formation~~ is the stratigraphic equivalent of the Shady

Stose, G. W.; Sedimentary rocks, ^{of Pennsylvania} in South Mountain; Jour. Geology, Vol. XIV, No. 3, pp. 201-220, 1906; and, Cambro-Ordovician limestones of the Appalachian Valley in southern Pennsylvania; Jour. Geol., Vol. III, No. 8, pp. 698-714, 1908.

dolomite, which occurs at the same horizon from James River southwestward

Keith, Arthur, U.S. Geol. Surv., Geol. Atlas, Cranberry Folio (No. 90), p. 5, 1903.

through Virginia into Tennessee. The name Sherwood limestone has also

Campbell, H.D., The Cambro-Ordovician limestone of the middle portion of the Valley of Virginia; Amer. Jour. Sci., 4th Series, Vol. III, pp. 445-447, 1905.

been applied to this unit, but is now obsolete.

Distribution. - The Tomstown dolomite occurs in two distinct belts in the quadrangle. ^{One} ~~It~~ is found in a zone between Stanley and Hershberger Hill in the ^{southwestern} western portion of the area, and a ^{the other} second belt extends ^{into} from the Luray reservoir northward to Jeremys Run. ^(See p. 1.) Beyond which ^{This} (point) the formation is cut out by ^a faulting. ~~It does not seem to be present in the area between Blaineville and Mt. Calvary Church, where the Antietam sandstone has been overthrust upon the Waynesboro shale.~~

So far as is known, there are no ^{good} definite exposures of the Tomstown dolomite ~~within~~ this quadrangle, with the possible exception of

Southwestern

see above occurs

?

20

good distinctive

a single ledge along the northeastern side of the valley of Chub Run, about ~~g~~ three quarters of a mile northeast of Marksville. It is not, possible, therefore, to describe the ^{character of the local occurrences} local character of the rocks, and ~~its~~ ^{the} lithology in adjacent ^{areas} regions must serve to indicate its character in the ~~the~~ Stony Man region. The Tomstown ^{has} ~~does~~ not produce ^{locally} a distinctive ^{local} soil, largely because it ~~is~~ ^{is} situated as to ^{be covered by} receive the alluvial material spread out at the foot of the Blue Ridge. In other regions the Tomstown dolomite produces a red, unctuous clay soil.

Character.- ^{The} ~~This~~ formation is a coarsely crystalline, white to gray dolomite in which ~~many~~ ^{are} limestone lenses are common. The limestone ^{is} blue, and the dolomite is generally light gray to white. Both ~~varieties~~ ^{rocks} are (readily weathered and) easily eroded. The formation is irregularly bedded, ~~and~~ ^{is} cleavage and minor jointing are common ~~secondary~~ features in ~~the~~ rock.

Thickness.- ~~As a result of the lack of exposure within this area,~~ ^{no} measured ~~(section of)~~ ^{the} thickness of the Tomstown ~~can be made for this~~ ^{could not be measured in} ~~area~~ ^{region} ~~region~~ ^{could not be measured in}

In Mary- ~~ness is~~ ~~can be in~~ ^{prevailing dips of all the Paleozoic rocks in Page} ^{at least} ^{the entire series has been so involved in} ^{are overturned (and dip northwest)} ^{folded} ⁱⁿ ^{foldings}

Structure is incli
~~Succession of Paleozoic rocks across Page valley has been so up~~ ^{and} ~~volved in folds (that) the prevailing dips are to the southeast, and~~ ^{though} ~~some of the members are actually overturned. (In the area) Immediately~~ northeast of Marksville, the Tomstown occurs in a shallow syncline bounded at the northwest by the underlying Antietam sandstone and

light gray
 All-
 is

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 attaches
 revision

(P13)

at the southwest by a fault. ~~Because of the extreme difference in resistance to weathering between the dolomite and the Antietam sandstone,~~ the latter has acted as a competent bed in the folding of the area, and in places has been overthrust upon the weaker calcareous rocks.

~~(The) actual contacts between the Tomstown and the formations above and below are completely concealed.~~ In other areas, however, these contacts are conformable, and it is presumed that similar relations obtain beneath the thick veneer of residual debris that blankets the Tomstown outcrop, in this area.

Mineral Resources. -
Economic Material.

In several places along its belt of outcrop, local deposits (workings) of brown iron and manganese ore have been developed, such as those near Stanley and at Compton near the eastern edge of Page Valley. The ore in these deposits is a residual concentration derived from the bedrock and concentrated at the surface near the contact of the Tomstown and Antietam formations. Further discussion of the nature and character of the deposits will be made in a later section of this report.

Age and Correlation. -

As known in Virginia, the Tomstown, or Shady, dolomite is sparingly fossiliferous. Several varieties of trilobites have been found in the Shady at ^{Avs} Anstinville, ^{Wythe} Wythe County. Other fossil forms, chiefly Salterella, have been reported from the Shady in north-central Virginia, and beds correlated with the Tomstown in eastern Pennsylvania are known to contain Lower Cambrian fossils. On the basis of these fossils, ^{found elsewhere and} remains and the stratigraphic position of the formation, the unit is assigned to the Lower Cambrian. It directly overlies the ^{sandstone} arenaceous Cambrian formations and is the northern equivalent of the Shady dolomite, named from Shady, Johnson County, Tennessee.

Antietam

Southwestern Va — and Tenn —

The Waynesboro Formation

The Waynesboro formation is a series of red and variegated shales and sandstones known throughout the Appalachian region from Pennsylvania to Tennessee. It directly overlies the Tomstown, or Shady dolomite.

Definition.- ^{It} (~~The Waynesboro formation~~) was named from Waynesboro, Pennsylvania, where the formation is well exposed. ~~A similar~~

Stose, G.W., ^{Sedimentary rocks of South Mountain, Pennsylvania: Jour Geology,} ~~Stose, G.W.; (op. cit., pp. 202-220.~~ vol. 14, no. 3, pp. 201-220, 1906.

unit exposed near Buena Vista (in Virginia has been called the Buena Vista shale, while the names Rome and Watauga have been applied to

Campbell, H.D., ^{The Cambro-Ordovician limestone of the middle portion of the Valley of Virginia; Amer. Jour. Sci., 4th. Ser., vol 20, pp. 445-447, 1905.} ~~(op. cit.) pp. 445-447.~~

Hayes, C.W., ^{The overthrust faults of the southern Appalachians; Bull. Geol. Soc. Amer., Vol. II, p. 143, 1891.}

Keith, Arthur, ^{U.S. Geol. Surv. Geol. Atlas, Cranberry Folio (No. 90), p. 3, 1903.}

~~this formation in southeastern Virginia and Tennessee. For the region in Virginia from James River northward, the name Waynesboro formation is applicable. To the west of this unit south of James River, Virginia, the name Rome ("Watauga") is used.~~ ^{formation is called the formation}

Woodward, Herbert, P., ^{The age and nomenclature of the Rome ("Watauga") formation of the Appalachian Valley; Jour. Geol., Vol. XXXVII, p. 596, 1929.}

Distribution.- The Waynesboro formation extends in a continuous belt, about a third of a mile wide, from the western boundary of the quadrangle through Stanley, Blaineville, Kimball (Fig. 33), and Vaughn to a point about one mile south of the northern boundary.

190
Not
but
correlation

P.C. 180
vs 11 a?

See 11.

Structural Relations.- The ~~Waynesboro formation occurs in the~~
~~belt of Cambrian rocks paralleling the west foot of the Blue Ridge.~~
 Throughout most of this belt ^{bssds} ^{generally} The rocks are steeply inclined to the
 southeast, and some of the ~~easternmost lower~~ layers of the Waynesboro
 are thought to ^{more} ~~overlie western and younger~~ horizons. This curious
 reversal of dip appears to obtain throughout the central part of
 Page Valley, where the entire sequence of rocks is ^{overturned.} ~~folded so as to~~
 develop ~~southward~~ ^{eastward} dips.

Because of the lack of exposures, the upper and lower
 contacts of the Waynesboro formation are obscured. It is not known,
 therefore, whether these contacts are conformable, although It is
 presumed, by analogy with adjacent regions, that ^{the formation is} conformable rela-
 tions occur at both contacts.

Mineral Resources.- Economic Material. ^{minerals} ~~no~~ materials of Economic ^{do not} importance occur
 in the Waynesboro formation in this region. ^{area} ~~The~~ residual soil/
 however, has been utilized ^{near} Stanley for ocher.

Age and Correlation.- The Waynesboro (formation) and its direct
 equivalent, the Rome ("Watauga") formation, ^{contain few in other areas.} have fossils, ~~in~~ sparing
 quantities. Chief of ^{these} ~~the~~ fossils are trilobites, especially the
 genus Olenellus, which is commonly ^{assigned to the} ~~described as a~~ typical Lower
 Cambrian ~~trilobite~~. On this evidence, the Waynesboro is assigned
 to the Lower Cambrian. It is underlain by the Tomstown dolomite and
 overlain by the Elkbrook limestone. Its ^{is} equivalence ^{to} with the
 Watauga and Rome formations of southwestern Virginia and Tennessee .
 has already been noted.

Silurian &
 Ordovician
 younger and more western
 197
 19?

193
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194
 to vs
 with
 Rome
 unit

The Elbrook Limestone

The Elbrook limestone overlies the Waynesboro shale, and, as a continuous unit, extends from Pennsylvania southward to southwestern Virginia.

Definition.- The Elbrook formation takes its name from Elbrook, in southern Pennsylvania, where it was described and studied by Stose. The unit occurs widely throughout northern and central

Stose, G.W., Sedimentary rocks of South Mountain, Pennsylvania, Jour. Geol. Vol. XIV, p. 209, 1906.

parts of the Valley region in Appalachian Virginia, and, in southwestern Virginia and Tennessee, the formation grades into shales and dolomites to which other names have been applied (Honaker, Nolichucky, etc.). It is overlain by the Conococheague limestone of Ozarkian age.

Part of Conococheague

Distribution.- The outcrop of this formation continues as a single belt from the northern to the western margin of the quadrangle. The width of this belt is approximately one mile, and (the formation is exposed at a number of isolated points, especially along road cuts. This formation does not produce any distinctive especial topography or soil, and its outcrop blends with those of the other valley formations.

Character.- The Elbrook limestone is a dark, thin-bedded limestone, somewhat platy in character, and containing few dolomitic members. In its most typical expression, the rock is thinly laminated and fine-grained with layers of light-gray limestone separated by thin, shaly members that possibly represent dolomites with much of the lime leached out by weathering. In

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beds

are

a few places the limestones are ^{usually} dark, almost black, ^{which when} and where quarried, ^{produce} a fine, dense material ^{for road construction}.

Where the rock has been deeply altered by surface weathering, ^{has been} the ^{line} ^{becomes} leached out, ^{yielding} and a typical residual product ^{which} consists of soft, yellow, ocherous shale, not unlike the shaly beds of the underlying Waynesboro.

A peculiar residual product marks certain ^{portions} of the contact of the ^{with the overlying} Elbrook and Conococheague formations. This material consists of saddle-shaped masses of brown ^{to} reddish sandstones that are composed of tiny quartz ^{glistening hexagonal} crystals, rather than of quartz grains. The sandstone glistens markedly in the sunlight, and under a lense the hexagonal quartz crystals are seen to be almost perfectly formed. Apparently, the crystals were developed ^{by deposition of silica on} from irregular or rounded quartz grains by secondary silicification, possibly in the process of weathering. ^{are} The masses ^{or saddle-shaped} (have a saddle, or) selliform, (shape) and the rock is quite brittle and dense. This material occurs in many

areas upon the outcrop of the upper portion of the Elbrook limestone. In this quadrangle ^{in this} the most characteristic occurrence is about three-quarters of a mile northeast of Hawksbill Church. ^{It is} ^{possibly} that ^{this} ^{residual materials} these residuals belong to the basal beds of the Conococheague dolomite, but ^{it is} they are commonly associated with the ^{outcrop} of the upper beds of the Elbrook.

Thickness. - The thickness of the Elbrook formation ^{can not be} is not ^{determined in this area} definitely known, but it apparently reaches a maximum in this vicinity of 1,300 to 1,800 feet. ^{No opportunity, however, to} ^{was had?} measure the thickness in the local area is known.

Structural Relations. - Many of the exposures of the Elbrook limestone show ledges that are ^{dip} inclined to the southeast ^{as are}

Economic

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02

Do they not so belong?

opportunity
was has
is known to occur?

only not?

those of other Paleozoic rocks in the overturned sequence of Page Valley. Some evidence of fracturing and minor dislocations is visible in exposed ledges. The actual contacts of this formation with the underlying ~~Waynesboro~~ and ^{The} overlying Conococheague dolomite have not been observed; ^{but} they are probably disconformable.

195
is re?

Mineral Resources.-

~~Economic Products.~~ Several limestone quarries have been opened worked in this formation. All utilize the same ^{bed} seam, or zone, of limestone, and the rock is locally used for road ^{metal} surfacing as well as ^{and} for ^{a source of} material for agricultural lime. The quarries are small and are operated ^{intermittently} (only part of the year). Further description of ^{them} (these quarries) and of the economic possibilities of this formation will be found in a subsequent ^{section} chapter.

(196)
Products
Materials
3/2 p. 175
12-1922

(197)
?

Age and Correlation.-

~~No Fossils occur in this limestone in the ^{is} local area. In southern Virginia, however, an Upper Cambrian trilobite (Crepicephalus) has been found in a shaly bed correlated with the Elbrook. On this and other evidence, ^{From fossils} the age of this formation ^{elsewhere it is known} is taken to be Upper Cambrian. It is the equivalent ^{To} of the Honaker dolomite and, possibly ^{also to} of the Nolichucky shale of southwestern Virginia and Tennessee.~~

Check B.Y.C. map

will be found in the section on Economic Resources.
will be found on pp. —

Ozarkian System

General Statement

The Ozarkian System is a thick series of calcareous rocks that overlies the Cambrian system (restricted), and ^{occurs} is known in many parts of the United States, especially in the Appalachian and Ozark regions.

The name for this system of rocks was proposed in 1911 by ~~E. O.~~ Ulrich of the United States Geologic Survey,

Ulrich, E. O., Revision of the Paleozoic Systems; Geol. Soc. America Bull., Vol. 22, pp. 627-9, 649-50, 1911.
629, 650

~~and the system has been elevated to a position parallel to that of the Cambrian and Ordovician systems, and intermediate between them. The material contained in the Ozarkian System consists of thick-bedded limestone and dolomite, and a maximum of at least 4,500 feet of Ozarkian sediment is known in Virginia. There has been considerable reluctance to accept this system as a major member of the standard geologic column, and by many authors, Ozarkian rocks are still described as uppermost Cambrian sediments.~~

Evidence is accumulating, however, to indicate the need for a distinct Ozarkian System, and the use of the term, as proposed by Ulrich, has been adopted in this report.

The Conococheague formation is the only Ozarkian sediment in the Stony Man area. With the overlying Beckmantown, or Canadian, beds (Stonehenge, Nittany, and Bellfountain), the Conococheague formation is often referred to as "Cambro-Ordovician".

192
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199
C
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Fig C

or comparable?

Why not?

The Conococheague Limestone

The Conococheague limestone rests upon the Elbrook formation and is one of the ~~heavy bedded calcareous~~ ^{soluble and easily eroded} rocks responsible for the ^{development} ~~production~~ of the ^{Page} Valley of Virginia (Figs. 89, 95). ~~It was formerly included in the "Shenandoah limestone"~~ ^{See Pls. .)}

~~early writers~~

creation & development Pls. 89, 93

Why?

Definition. This formation was named from its occurrence in Pennsylvania where the rocks were first studied and are well displayed. ~~It is known in the northern Appalachian region~~

Stose, G.W., ~~Geology~~ ^{Sedimentary rocks of South Mountain, Pennsylvania: Jour. Geology, vol. 14, p. 210, 1906.}

~~under this name and is widely exposed throughout the Appalachian Valley.~~

Distribution. The Conococheague formation crops out in the Stony Man quadrangle in a wide belt that extends across the central portion of Page Valley. This belt is ^{about} ~~approximately~~ ³ ~~three~~ miles wide near the western and central portions of the Paleozoic outcrop, but narrows northward until it is about one mile wide at the northern edge of the ^{quadrangle} ~~local~~ area. The rock is well exposed along the ^{largest} ~~deeper~~ stream courses and in ^{some} ~~incidental~~ road cuts. Good exposures ^{are} ~~may be~~ found in the valley of Pass Run near Springfield ^{and} ~~as well as~~ along Hawksbill Creek, immediately south of Luray.

Character. The Conococheague formation consists of a thick mass of limestone ^{with 1255} ~~and~~ dolomite ^(See Pl. .) ~~(Fig. 89)~~ the former occupying a ^{larger} ~~greater~~ part of the unit (than the latter). The ^{in general} ~~formation as a~~ whole is medium bedded, and the limestone ^{beds} ~~lenses~~ are heavier and more massive than the dolomitic beds. A distinctive character-

Pl. 89
The greater part of the ...
larger

istic of the formation is the presence of argillaceous bands. ~~that are~~ ^{ing} interbedded with the limestone. As these clay ^{by beds} zones are ^{resistant to deformation} ~~softer~~ than the enclosing limestone layers, they ^{were} ~~have been more~~ intensely crinkled as a result of the ^{during} ~~deformation~~ ^{folding of the strata.} to which the entire unit has been subjected. On a weathered surface the crinkly edges of the ^{contorted bands} clay seams stand out in sharp relief, above the associated limestone zones, the contrast producing a ribbon-like appearance that is ^{a diagnostic feature.} ~~an easily recognized feature~~ (See Pl. ^(C) ~~Fig. 89~~). The limestones are prevailing blue and some of them are ^{relatively} ~~fairly~~ almost pure calcium ^{carbonate} ~~rocks~~. Other lenses containing more magnesian and dolomitic materials are also present.

Pl. (89)

The Conococheague formation normally produces a deep residual soil that is fertile ^{favorable} and ~~(favorably located)~~ ^{part of the formation} for cultivation. The local ~~outcrop~~, however, is partially covered by flood-plain and alluvial debris, so that it does not appear in its most useful capacity. The natural soil from the Conococheague formation is (somewhat) less rich, ^{red, and} ~~and~~ unctuous, than Beckmantown soil, ^{from the younger (Canadian) limestones.} ~~(which is deeper and slightly redder in color).~~

not used in Conococheague

A distinctive feature of the Conococheague formation in Virginia is the presence of thin ~~seams or zones~~ ^{of containing} through which quartz sand grains ^(are distributed). In some places the sand is sufficiently abundant ~~so as~~ to produce a distinct sandstone; elsewhere the ^{sand} material occurs ^{is scattered through} ~~admixed~~ with the limestone, as a dense, (solid) rock. It should be noted that ~~The masses of~~ ^{composed of} the quartz crystal sandstone ^{is described under} which occurs ~~in the outcrop of~~ the Elbrook formation, ^{near} ~~is close to the~~ Conococheague contact. Although the ~~sandstone residuals~~ are thought to be ^{part of} ~~derived from~~ the Elbrook limestone, ^{may} it is equally possible that they are developed ^{be in} ~~from one of~~ the basal Conococheague sandstones ^{of the} limestone?

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Thickness.- ~~The total thickness of this formation is difficult to ascertain because the beds have been folded and overturned.~~ ^{Just} ~~throughout Page Valley.~~ ^{almost} Immediately north of the quadrangle, however, ^{shows} a ^{fairly} complete section of ~~the rock~~ is exposed near Rileyville, where ^{to} ~~between 1,500 and 2,000 feet~~ of limestone and dolomite ^{which is} are thought to be long to the Conococheague formation. This measurement is approximate but ~~nearly~~ ^{in this area.} closely approaches the actual thickness. ~~Elsewhere, in Virginia, similar thicknesses of the formation occur.~~

Structure.- The Conococheague limestone has been intimately folded in the deformation of this ^{general} region, and it is difficult to find continuous exposures wherein ~~the rocks are horizontal.~~ ^{of beds} Many ~~(of the)~~ exposures exhibit the formation in an overturned position, with stratigraphically lower ^s beds overlying higher horizons.

The contact of ~~this formation~~ with the underlying Elbrook limestone has not been observed. It is thought, however, to be disconformable, as is its contact with the overlying Stonehenge limestone.

Age and Correlation.- ~~No fossils were obtained from the Conococheague formation in this region.~~ ^{not found in} ~~nearby (regions), however,~~ ^{From areas} ~~occasional~~ ^{a few} fossils are known, especially Cryptozoon (probably Cryptozoon proliferum) and rare trilobites (Tellerina). From its ^{position,} stratigraphic ^{its} and ~~from the fossils it contains,~~ the Conococheague is regarded as being of Lower Ozarkian age. It is probably the partial equivalent of the Copper Ridge and ~~Jonesboro~~ formations of southwestern Virginia and Tennessee, and of the Potsdam and Hoyt formations of northern New York State. ^{geologists} ~~By many authors it is de-~~ ^{scribed} as Upper Cambrian, or ~~"Cambro-Cambrian"~~.

Mineral Resources -
Not structures?

Why?

stet

Canadian System

General Statement

The Canadian System, as defined by Ulrich, includes

Ulrich, E.O.; Revision of the Paleozoic Systems, Geol. Soc. America Bull., Vol. 22, pp. 627-629, 649-50, 1911.

650

16
100

geological
geologic

Fig. 13
C

that part of the geologic ^{al} column which lies above the Ozarkian ^{as defined by him,} and below the Ordovician ^{as} System ^{by him} (restricted). Included in the local Canadian ^{system in this quadrangle includes} section are the Stonehenge, Nittany, and Bellefonte formations, all of which are thick-bedded, massive limestones and dolomites. ^{geologists consider these} ~~By many authors this succession of rocks is described as Lower Ordovician, and it is~~ ^{To be} equivalent to the Beekmantown ^{formation} of New York State. ~~The Canadian System is amply represented in the local area, and in other parts of Virginia, for which reason the Virginia Geological Survey has accepted the Canadian as a full-fledged geologic system.~~ ^{of this report} The ~~present~~ authors ^{incline} are somewhat less receptive to this interpretation [?] than to the view that the Canadian and Ozarkian systems together comprise one distinct and identifiable unit to which the name Ozarkian might well be assigned. ^{Fig. C, Plate XIII (See Fig.)}

?
?
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? Supporting evidence?

(B) fine typing Check heading portion with 149 #43.
Stonehenge Limestone *proving ms* *See 24-4* *(ms)*

The Stonehenge limestone is the basal formation of the Beekmantown group, and ~~underlies the Nittany dolomite~~ (Fig. 94).
(See Pl.)

Definition *It was* This formation is named from Stonehenge in central Pennsylvania, where it is well exposed along the Nittany arch.

F. Butts, Charles; Geologic section of Blair and Huntington Counties, central Pennsylvania; Amer. Jour. Sci., 4th series, Vol. 46, pp. 523-37, 1918. *P.C.*

Its occurrence throughout Virginia is somewhat irregular, and ^{the formation} ~~it~~ so strongly resembles the overlying and underlying formations that it has not been generally recognized as a distinct unit.

Character and Thickness The Stonehenge limestone is a thick-bedded, blue-gray limestone that is ^{very} ~~closely~~ similar to the ^{overlying} Nittany dolomite ^{above}. The most distinctive feature of ^{the Stonehenge} ~~this~~ formation is a peculiar interlamination of ^{thin beds or layers of} dolomite and limestone ^(such) ~~on a very fine scale~~ ^{forming} ~~so as to produce~~ a rock that has a crinkly or wavy surface when eroded at right angles to the bedding. This structure is similar to that developed in the underlying Conococheague limestone, but the alternating laminae of dolomite and limestone are much thinner in the Stonehenge than in the ~~earlier Conococheague formation~~.

The thickness ^{to be} ~~of this portion of the Beekmantown~~ is estimated ^{as} about 100 feet, and the formation ^{next} ~~creeps out adjacent to the Nittany dolomite which lies above it~~. Its areal distribution is approximately the same as that of the lower Nittany beds ^{which overlies it}. There is ~~it has~~ an excellent exposure about 3 miles southwest of Luray Caverns, immediately west of the quadrangle, along the country road which crosses Mud Pike ^{Other exposures occur} ~~two miles due south of Hamburg, and is also exposed~~ along Hawksbill Creek immediately north of Luray, and at Springfield.

P.L. 24
yielding formations
giving

Age and Correlation

This formation is identical in character

with ~~to~~ the Stonehenge limestone of central Pennsylvania, which is the

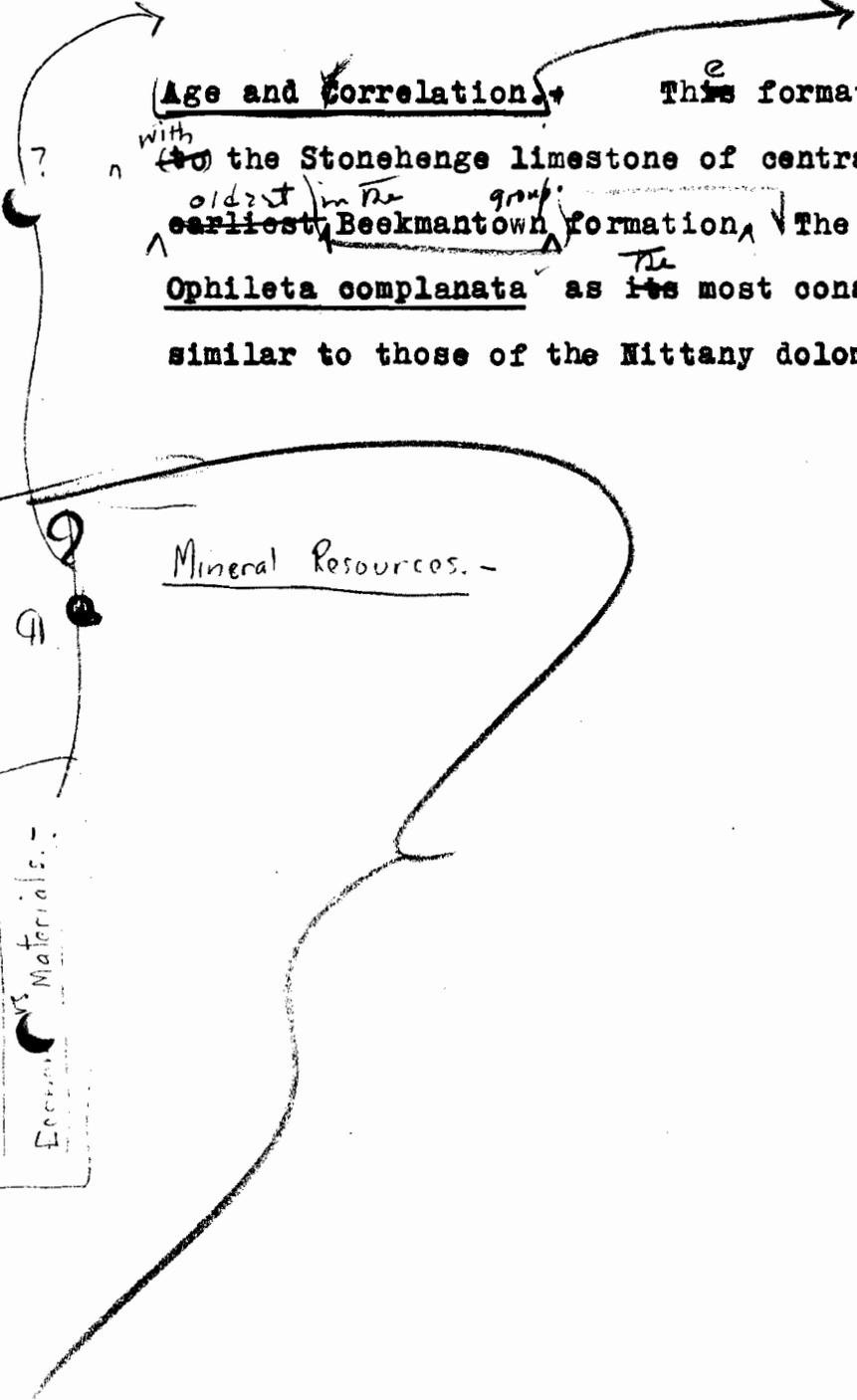
oldest ^{in the group} earliest Beekmantown formation. The rock is fossiliferous, with

Ophileta complanata as its most conspicuous form. ^{It contains} Other gastropods,

similar to those of the Nittany dolomite, ~~also occur~~.

Mineral Resources.

Mineral Resources.
Economic Materials.



61?

Nittany Dolomite

→ Definition

The Nittany dolomite was named from Nittany Valley in central Pennsylvania, ~~and it is~~ ^{The middle formation} ~~one of the three~~ Beekmantown group

Ulrich, E.O., Revision of the Paleozoic Systems; ~~Geol. Soc. Amer.~~ ^{Soc.} ~~Vol.~~ ^{Geol.} ~~22,~~ ^{22,} p. 658, 1911.

Bull.

representatives in this quadrangle (~~Fig. 95~~). (See Pl. .)

Distribution The ~~local outcrop~~ ^{more than half a mile} of the Nittany formation occurs in a continuous belt ~~over a half mile~~ wide which extends from the western ^{edge} margin of the quadrangle through Luray and Oak Hill to the northern edge of the area. The best exposures (~~of the Nittany~~) occur at Rileyville immediately north of the quadrangle; other exposures are found at Oak Hill, in Luray Caverns, and along Dry Run. The formation produces low country except for those portions of its outcrop which are strewn with cherty debris (~~Fig. 49~~). It develops a characteristic red clay soil that is more favorably located for cultivation than ^{that} ~~the soil~~ ^{derived from} ~~developed upon~~ the Conococheague formation. A characteristic of Nittany exposures is the ~~presence of many tiers of~~ ledges of ~~bedrock~~ ²⁶ that crop out where the residual soil has been stripped off by erosion.

Character The Nittany formation consists chiefly of gray to blue dolomite ^{beds} interbedded with ~~zones of~~ limestone and ~~of~~ vaughanite. In most of ~~the exposures~~ it is more or less thinly bedded, and commonly ~~is~~ very dense. Often the rock appears to be finely laminated or ribbony in structure. The purer ~~beds~~ ^{beds} break with a subconchoidal fracture, and on weathered surfaces ~~the rock~~ ^{becomes} ~~(is apt to become)~~ chalky. ~~Where eroded or dissolved, it shows a smooth, water-worn, or furrowed surface.~~

Pl. (95)

Pl. Not here

24

6-1? water worn water worn water worn

kind of rock?

An obvious characteristic of this formation is the production of abundant chert upon ~~favorable~~ portions of its outcrop. This chert is gray ^{to} white, ~~in color, (and is)~~ dense, massive, and commonly jagged. It occurs in great abundance where the rock is nearly horizontal, ^{it} and is best developed along the western margin of the quadrangle, both north and south of Luray. The chert fragments range from a few inches to several feet in diameter and ^{they} appear to have been produced during the weathering of the formation. A few fossils occur in the chert ~~fragments~~, but they are poorly preserved and difficult to detect.

Thickness The ~~entire~~ thickness of the Beekmantown group is estimated to be about 1,500 feet, in this area, and the Nittany dolomite probably accounts for about 600 to 700 feet of this total. There are several places where partial sections may be measured, but at no one point ~~within~~ the quadrangle was it possible to make a complete measurement of the Beekmantown group. A section of Beekmantown limestone and dolomite, however, is available along the creek at Rileyville, about ~~two~~ miles north of the quadrangle, where the following sequence occurs:

(insert section on following page; page -)

Structural Relations The ~~contacts of the Nittany with the Beekmantown members above and below it are entirely conformable~~ ^{is} ^{with adjacent} ~~actu-~~ally ^{actual} these contacts are difficult to determine, making it sometimes impossible ^{in places} to distinguish the ^{individual} members of this group near ~~the~~ contacts.

Insert here section from p. 147

Beekmantown formations

x P

See Beekmantown ^{b. 71} (for style)

152a +53 +49

See style guide at bottom

the paper in --- County.

Stones River group
Lenoir
Mosheim

Beekmantown Section of the near Rileyville, Va.

(This section was measured along Nelson Run from Shenandoah River to a point ~~one~~ half mile east of Rileyville, Va. The rocks are well exposed, almost vertical, and strike N30°E. The Mosheim limestone is exposed along Shenandoah River, and the Stonehenge member of the Beekmantown crops out near the railroad crossing over the creek.)

Lenoir	Dark, knotty limestone	limestone	(not measured)
Mosheim	limestone	.....	18 feet
	Pure, dove-colored vaughanite; beds 3 ^{to} 4 feet thick	.....	18 feet
Bellefonte	limestone	(760 feet)	..... 760 feet
	Dark-gray, thinly laminated dolomite, weathers brown	.....	73 "
	Interbedded, crinkly dolomite and vaughanite	.....	163 "
	Massive, dove vaughanite	.....	11 "
	Dense, gray dolomite	.....	13 "
	Crinkly dolomite and limestone; dark vaughanite	.....	135 "
	Massive vaughanite	.....	10 "
	Crinkly dolomite and limestone; dark vaughanite	.....	355 "
Nittany	dolomite	(587 feet)	..... 587 feet
	Gray dolomite; bands of cavernous black chert	.....	195 "
	Dolomite and very light-gray vaughanite	.....	72 "
	Interbedded, gray dolomite and dark vaughanite	.....	70 "
	Blue limestone and dolomite; vaughanite bluish	.....	250 "
Stonehenge	formation	(105 feet)	..... 105 feet
	Finely laminated, rather ^{thin} heavy-bedded dolomite	.....	105 → 1,472
Conococheague	formation	.....	(not measured)
	Interbedded limestone and dolomite	.....

1/2-? (railway) Lenoir Mosheim Beekmantown Group

STYLE GUIDE

- Ozarkian system
- Stones River group
- Lenoir
- Mosheim
- Beekmantown group
- Bellefonte
- Nittany
- Ozarkian system
- Conococheague

Thickness

Feet	Feet
18	18
73	91

154 ~~154~~
Is This
Clear To
Read?

Locally
The Nittany dolomite ~~is~~ ^{dips to the southeast} locally ^{dips} inclined to the southeast, but the overturned folds in Page Valley indicate that some of the dips are entirely reversed.

202
See also
pp. 193, 195

Mineral Resources. - Economic Material. The Nittany dolomite was formerly burned for lime near Hamburg, not far from the western ^{edge} border of the quadrangle. A few small quarries ~~along its belt of outcrop~~ suggest that attempts ^{have} (to use the material for ^{locally} road construction, ~~have~~ been made, ~~but have not proved successful.~~

203
in Canada
as

Age and Correlation. - The Nittany dolomite of the Stony Man ~~re-~~ ^{area} ~~gion~~ corresponds to the ^{Nittany} formation ~~bearing this name~~ in Nittany Valley, Pennsylvania, where it is the middle member of the Canadian System. It is one of the most widespread horizons in North America, ^{being} and ~~is~~ found from the St. Lawrence Valley to Alabama, and ^{in Canada or New York State} ~~to the~~ ^{as far} west ^{as} in Texas and Oklahoma. It is commonly identified by the gastropods Lecanospira (Ophileta) compacta and species of Roubidouxia which seem to be confined to this formation. Sections of other gastropods may be seen on the weathered surfaces of ^{the rock} ~~Nittany~~ ledges. The identifiable forms, ~~however,~~ are found chiefly in ~~fragments~~ ~~of Nittany chert.~~

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clear?
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The Bellefonte Dolomite

In many parts of the Appalachian region, the Nittany dolomite is the highest member of the Canadian System. In central and northern Virginia, however, dolomitic beds of post-Nittany age intervene between the overlying Mosheim limestone (of Stones River age) and the true Nittany dolomite, and these intermediate beds are correlated with the Bellefonte limestone of Center County, Pennsylvania.

Butts, Charles, ~~op. cit.~~ Geologic section of Blair and Huntington counties, Pennsylvania. Am. Jour. Sci., 4th. ser., vol. 46, pp. 523-537, 1918.

vania.

Distribution. - The Bellefonte dolomite occurs ^{above} ~~at the top of~~ the Nittany dolomite and is directly beneath the Mosheim limestone. Its outcrop, therefore, [?] ~~closely follows those of the overlying and underlying units.~~ ^{these} It crops out in a continuous belt which extends from the western edge of the quadrangle ^{northeastward} through Kibler Hill to Compton, north of the quadrangle, where its ~~exposure~~ forms a precipitous bluff along ^{the} Shenandoah River. The width of the ^{belt} ~~outcrop~~ is about ~~one-half~~ ^a half a mile except in the ~~area~~ immediately north of Luray Caverns where ^{formation} the Bellefonte crops out over a wide ^{also} territory ^{having} and has been duplicated ^{by} through folding. The formation is well exposed along ^{the} South Fork of Shenandoah River near Ruffner Ferry, Bixler Bridge, and Kibler Hill, ~~and~~ exposures are numerous in the lower gorge of Hawksbill Creek. A considerable section of the formation is exposed along Nelson Run, east of Rileyville. (Fig. 96). (See Pl.)

Character. - The Bellefonte dolomite is similar in general character to the Nittany dolomite upon which it rests. The chief lithologic difference is the presence of more abundant vaughanite beds in the Bellefonte, which range from a few inches ^{thick} to zones ~~of~~ nearly 50

Blair

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above
of N. 1/2 9

the South Fork?

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P. 96

a half a mile
a half mile

Insert as indicated on p. (151)

Insert where indicated on next page = X

Section of Beekmantown ^{Formations} ~~Rocks~~ near Bealers Ferry, Va.

This section was measured along Shenandoah River and a northward-flowing tributary ~~one~~ half mile east of Bealers Ferry and ~~one~~ mile northwest of Oak Hill. The rocks are continuously exposed and strike about N30°E., The dips are steep, in places overturned to the south ~~east.~~ east.]

1/2-? near a-1

Ordovician system (Stone River group) Mosheim limestone

Pivensia 80 feet

Light and dark, dense vaughanite 32 feet 32
Beekmantown group Bellefonte dolomite (649 feet)

Thin-bedded, dark, dense, magnesian limestone 200 232
Same, heavier bedded 65 297
Heavy-bedded dolomite, both coarse and fine 87 384
Dense, gray dolomite 38 422
Massively bedded, crinkly dolomite and limestone ... 96 518
Dense, dark gray, wavy vaughanite 9 527
Crinkly dolomite and interbedded limestone 86 613
Dove-colored vaughanite; fractured 8 621
Gray dolomite, heavy bed 13 634
Interbedded dolomite; vaughanite and limestone 41 675
Massive bed of gray dolomite 16 691

Nittany dolomite (700 feet)

Largely covered; gray, massive, dolomite; Nittany chert 250 941
Dolomite; much cavernous chert on outcrop 50 991
Largely covered; scattered dolomite ledges 400 1391

Stonehenge dolomite ~~1000~~

Largely covered; dense limestone and dolomite ledges 100 1491

Ozarkian system

Conococheague dolomite (not measured)

Interbedded limestone and dolomite; Ozarkian chert..

is-indicator^s of the late Canadian age of the formation. (By some authors, the Bellefonte, Nittany and Stonehenge formations are described as Lower Ordovician.) The term Beakmantown group is a convenient designation for the three units, and all belong to the rock series popularly known as the "Valley", or "Shenandoah", limestone.

(206)
 of ()
 Rep. 6

- Bellefonte, Nittany, and Stonehenge formations

Ordovician System

General Statement

The Ordovician ~~System~~ is amply represented in the Stony Man ^{area} region, but, as in the case of Cambrian and ~~"Gambro Ordovician"~~ ^{of Ordovician formations} rocks, the infrequency of ~~its~~ exposures hinders examination of the bed rock.

The earliest ~~Ordovician~~ ^{included in the Ordovician system as tentatively by Ulrich} sediments, which belong to the Stones River Group ^{and} include the Mosheim and Lenoir limestones, ~~that directly overlie the Bellefonte dolomite of Canadian age.~~ As these limestones are very thin, it is not possible to indicate them individually on the accompanying geologic map (Plate I); ~~hence, their joint outcrop is shown with a single symbol.~~ In southwestern Virginia and Tennessee, the Mosheim limestone is overlain by the Murfreesboro limestone, ~~but the latter~~ ^{which} formation appears to be absent in northern ^{west} Virginia.

Throughout central and southern ^{western} Virginia, the Lenoir limestone is ^{overlain} followed by the Blount ^{west} Group which normally consists of the Holston, Whitesburg, and Otseee limestones, and the Athens shale. In ^{the Stony Man} this area, ~~however,~~ the limestone members of the Blount Group are ~~wholly~~ wanting, and the Athens shale is the only local representative of this ^{part} section of the Ordovician System. ~~In the Stony Man region~~ the Athens is directly overlain by a similar aggregate of shaly limestones comprising the Chambersburg formation of Black River age. ~~Elsewhere in Virginia, Louville and Moccasin horizons intervene between the Blount Group and the Chambersburg formation.~~

The Martinsburg shale which occupies the remainder of the Ordovician ~~System~~ ^{and} includes horizons of Trenton, Eden, ^{and} Maysville age, but no equivalents of the Richmond division of uppermost Ordovician

l.c. ?/

Pl. I.

northern ?

long

part

?

l.c. ?

l.c. ?

are
age ~~of~~ known to be present. #/ The total thickness of the local Ordovician System ^{in the Stuyvesant area} is estimated to be between 3,220 and 4,000 feet, three-fourths of which is ~~(contained within the)~~ ^{the} Martinsburg shale.

It should be ^{noted} remembered that the Ordovician System as here described is restricted to ^{formations} ~~horizons~~ above the Beekmantown and below the Silurian System. ~~This restriction excludes several thousand feet of dolomitic limestones~~ ^{of Lower} from the Ordovician as a result of the ^{previously stated} ~~eraction~~ ^{which as} of the underlying Canadian System. By many authors, the rocks described in this report as Canadian are considered to be ^{which} lowermost Ordovician, in which interpretation the local thickness of Ordovician rocks would be considerably amplified. ~~Fig. 13, Plate I~~ (See Fig 13)

l.c.?)?

l.c.?)

l.c.?)

Fig. 13
C

--- This restriction excludes several thousand feet of dolomitic limestones which are described in this report as ^{comprising} ~~being~~ the Canadian system, and which by many ^{geologists} ~~authors~~ are ^{described} ~~considered~~ as lowermost Ordovician, in which interpretation the local thickness of Ordovician rocks would be considerably amplified.

The standard classification of the Ordovician System (restricted) and its representatives in the Stuyvesant area are given in Table.

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Table. ← Classification of
Table of Ordovician Formations

Standard Ordovician Section		Stony Man ^{area} Region		
Upper	Cincinnatian	Richmond	Absent	
		Maysville Eden	Martinsburg shale	
Middle	(Trenton Black River)		Chambersburg limestone	
Lower or Chazy	Blount Group	(Ottosee	Absent	
		(Tellico		
		(Athens - Holston	Athens shale	
	(		Absent
	(Stones River Group	(Lebanon Lenoir Pierce Murfreesboro Mosheim	Lenoir limestone	Absent
			Mosheim limestone	

~~The~~ Mosheim Limestone

The Mosheim limestone is the earliest and, therefore, the lowest representative of the local Ordovician System (restricted). It rests upon the Bellefonte dolomite and is overlain by the Lenoir limestone.

Definition. The Mosheim limestone ^{was} is named from Mosheim, Green County, Tennessee. With the overlying Lenoir limestone, it repre-

Ulrich, E.O., Revision of the Paleozoic Systems: Geol. Soc. America Bull., Vol. 22, pp. 413-14, 538, 543-4, Plate 27, 1911. 547, and

^{sents} ~~forms~~ the northern extension of the group of Ordovician formations known in central Tennessee as the Stones River group. Its outcrop is adjacent to that of Lenoir limestone, ^{the} and as both formations are too thin to ^{be shown on} the accompanying geologic map with a single symbol. ^(See Pl. 1.) The Mosheim ^{is} commonly present throughout the Appalachian ^{Valley} region, but it may be locally absent, or undifferentiated from the Beekmantown ^(below).

Distribution. The Mosheim limestone is found in a very narrow belt in the northwestern corner of the quadrangle, where its ~~outcrop~~ is crossed many times by the meandering South Fork of Shenandoah River. Exposures along the river banks are ^{numerous} common and readily accessible. Near Bixlers Bridge, the outcrop of this formation has been ^{by} duplicated as a result of faulting; elsewhere, ^{it} ~~its outcrop~~ forms a single belt. The best exposures occur at Bealers Ferry, Bixlers Bridge, and along Shenandoah River immediately north of Kibler Hill. The formation produces no special topography ~~and it~~

Kibler Hill is a low elevation near Shenandoah River about ³ three miles west of Vaughn. It should not be confused with Kibler Knob, a much higher summit in the Blue Ridge foothills, about ^{one} one mile northeast of ^K Kamball, and ^{two} two miles south of Vaughn.

208
Not
Pl. 1.

May separately
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deal

~~As the outcrop is~~
is too narrow to produce a distinct soil type; hence, it has small effect upon the scenery and topography of the area.

Character. The Mosheim limestone is a dense, ~~structureless~~, dove-colored rock, ranging from normal ~~gray limestone~~ to pure sub-crystalline ~~vaughanite, the latter varying in color from~~ dove-gray to dark-gray. The formation weathers to ~~produce~~ a bluish surface, and the weathered exposures are ~~seldom smooth, but are~~ ^{which is generally,} covered with tiny flutings and other solution marks. It is rather ~~massively bedded~~, many of the strata ^{beds} ~~being from~~ ^{are} 3 to 4 feet in thickness. The vaughanite beds are much thicker; one zone of ~~this material~~ reaching a thickness of 20 feet. The upper part of the formation is dark-gray dolomite that is finely laminated and medium bedded. There is no essential difference between the vaughanite of the Mosheim and that of the underlying Beekmantown, except that ~~in the latter, the~~ ^{Beekmantown} vaughanite commonly occurs in thinner ^{beds.} zones ~~than in the Mosheim.~~

see p. 148
also ?
dove-gray
dominant ?

dark-gray
-1-7

d (-) 1/3

Thickness. The maximum observed thickness of the Mosheim limestone is about 30 feet, ^{Stone, Mass area} in the Luray region, and complete exposures ^{are} ~~may be~~ found at several localities ^(in the area), especially along the ^{local} ~~country~~ road ^{a half-mile} one-half mile northwest of Kibler Hill.

2
3
7

Structural Relations. Throughout the quadrangle, exposed ^{ledges} ~~ledges~~ of Mosheim ^{dip} ~~are inclined~~ southeastward at moderate angles. In view of the ^{fact that} ~~overturning~~ of many of the folds in Page Valley, the actual inclination of the ~~beds~~ ^{are overturned to the northeast} from their original position is far greater than the apparent dip ~~of the rock~~ indicate. ^s The Mosheim rests ^{conformably} ~~disconformably~~ upon the Bellefonte dolomite, and is overlain by the Lenoir limestone ~~(with a conformable contact)~~. This upper contact is "welded" ^{so that} and it is occasionally possible to break out a hand specimen of rock, one part of which is Lenoir limestone, the

(209)
conf. mainly

other part, Mosheim.

Mineral Resources.
~~Economic Material~~

The Mosheim limestone is of no commercial value, ^{in this area} although about ³ three miles west of the quadrangle

small quarry was formerly opened to ^{for limestone to burn for lime} extract limestone for burning ^{lime}

This quarry, located near Hamburg, has long been abandoned. Elsewhere in Virginia the Mosheim, because of its purity, is one of the

Age and Correlation. The Mosheim limestone contains fossils, the largest of which are gastropods. ~~Since their identification indicates that the formation is of early Chazy age, it is assigned to the Lower Ordovician Series (restricted).~~ Among the more common fossil ^s forms are the following:

- Leperditia cf. fabulitis (Conrad)
- Lophospira cf. perangulata (Hall)
- Maclurea magna (Le Sueur)
- Tetradium cf. cellulosum

These fossils indicate that the Mosheim limestone is of early Chazy, or ^(restricted) early Ordovician, age.

210
Materials
Resources

sp
Le Sueur
Le Sueur

most valuable limestone in the Valley

Lenoir Limestone

~~With the Mosheim, the Lenoir limestone comprises the Stones River Group of Lower Ordovician age in the Stony Man region.~~

Definition.- The Lenoir limestone was named from Lenoir City in Loudon County, Tennessee, where it was studied in 1876 by Safford and Killebrew. This formation overlies the Mosheim limestone,

Safford, J.M., and Killebrew, J.B., The elementary geology of Tennessee, pp. 108, 123, 130-31, 137; 1876. Nashville, Tenn.

and in the ~~Luray region~~ ^{Stony Man area} is overlain by the Athens shale. Throughout central and southern Virginia other formations intervene between the Lenoir and the Athens, of which the Holston limestone is the most common. Locally, however, the Holston is absent, and the Athens rests directly upon the upper beds of the Lenoir limestone.

Distribution.- This formation crops out in a very narrow belt which is crossed several times by ^{The} South Fork of Shenandoah River, and in the area immediately east of Bixler's Bridge the outcrop has been partially cut off by faulting. The best exposures of the Lenoir occur along ^{The South Fork of} the banks of Shenandoah River, a short distance east of Oak Hill Ferry, as well as in ^{cuts} where tributary streams have eroded the limestone. The ~~rock~~ ^{Lenoir} produces no peculiar topography or soil, although where the outcrop is free ^{of} transported debris, its soil is apt to be chocolate-red and cherty. The Bellefonte dolomite, which underlies the Mosheim limestone, produces a slightly more elevated topography than do the ~~shales of the~~ ^{limestone} Athens above the Lenoir. Hence, ^{along} both Mosheim and Lenoir limestones commonly crop out ^{& the} at the break in topography produced by differential erosion of the adjacent formations. This slight topographic ¹⁰⁰ express, however, is not produced by ^{either} the Lenoir or the Mosheim. ^{alone}

Luray region
Stony Man area

~~Handwritten scribbles~~

South Fork

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alone

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Character. The Lenoir limestone is a dark, ~~rather~~ ^{relatively} crystalline, knobby limestone carrying frequent nodular zones of black, ^{knotty} chert. The rock is ^{moderately} fairly coarse grained, ^{and} thin bedded, ^{it} and weathers into irregular slabs that have no consistent shape or thickness. Occasionally there are ^{some} dark, ^{colored} coarsely crystalline zones which resemble the Holston limestone of other localities. The cherty beds occur in abundance and ^{locally} produce considerable debris ~~in favorable portions of the Lenoir outcrop.~~

along in 7 on

~~The surface of the rock has a dark, blue-gray color, and exposures are fairly common. The presence of the Lenoir, however, may be determined where no exposures occur by the presence of its characteristic black, nodular chert. Considerable dark, grainy, limestone is also present. The latter is somewhat coarser than the limestones of the overlying Athens or Chambersburg, and its weathered surfaces are rougher. When tapped together two slabs of this limestone fail to produce the metallic ring which similar fragments of Athens and Chambersburg limestones produce. In an exposure of Lenoir at Mill Creek, a few miles west (of the edge) of the quadrangle, there occurs a zone of dark, coarsely crystalline limestone at the very top of the Lenoir, this zone, which is about 5 feet in thickness, resembles the Holston limestone in general character and position, and it is possible that it is the local equivalent of the Holston.~~

1/

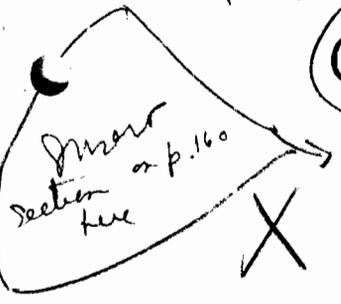
2
3
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360
along in 7 on
p. 165

Thickness. The thickness of the Lenoir limestone (which can be) measured at several localities, ~~appears to vary~~ ^{varies ranges} from 70 to 105 feet. ~~As the formation is generally less than 100 feet thick in Virginia,~~ ^{throughout} its thickness in the Stony Man ^{area} region is typical of the formation.

A section of the Lenoir ^(limb to time) measured near Bealers Ferry ^{is as} follows:

(insert section on following page, (page 168) (page 162))



X (Insert page)

Structural Relations.

Like the other Paleozoic rocks of this region, the Lenoir is involved in the overturned folds of Page Valley. An accessory minor fold, together with a small fault, has produced a second belt of Lenoir in the area between Hawksbill Creek and the western edge of the quadrangle, where an outlying area of Mosheim, Lenoir, and Athens shale has been partially separated from the main outcrop. The contact of the Lenoir with the underlying Mosheim limestone is commonly welded so that it may be preserved in a hand specimen. The contact with the overlying Athens appears to be slightly angular; ~~and~~ unconformable relations exist at Bealers Ferry.

has been
been

Age and Correlation.

Fossils are not common in the Lenoir limestone, but trilobites and brachiopods ^{of} remains are occasionally found. These indicate that the ^{Lenoir} formation can be correlated with the middle Chazy beds of the Lake Champlain district in New York State. A considerable assemblage of ^{unidentifiable} submicroscopic fossil ^{fragments} material ^(broken) occurs in the coarsely crystalline beds. ~~Small fragments of broken shells, ostracods, and other fragmental debris of organic origin,~~ ^{Numerous} suggests that an abundant fauna was living in the seas in which this formation was deposited. ~~The Lenoir limestone (under this name) is known from northern Virginia into Alabama, and it is probable that its~~ ^{is}



215

216

6

Increase This section on p. 161 as initiated

Insert at X on page 162

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243 (tabis)

which begins

Section of ^{and Mosheim} Lenoir limestones near Bealers Ferry Va.

Section of Ordovician formations near Bealers Ferry (Ordovician Section near Bealers Ferry)

County,

Section measured along south bank of Shenandoah River one-half mile east of Bealers Ferry; see section on page

Athens shale (not measured)

Dark ^{colored} calcareous shales ^{containing} graptolites

Lenoir limestone (69 feet)

Dark ^{colored}, knobby, rather coarse ^{-grained} limestone; black chert 11 feet

Dark-gray, medium-bedded, crystalline limestone 6 " 17

Dark ^{colored}, thinly bedded, knobby limestone, weathers blue-gray; ~~both~~ coarse and fine trilobites 38 " 55

Massive, dark ^{colored}, dense, blocky limestone; contains trilobites; ^{contact with Mosheim limestone below} 14 " 69

(Welded contact) -grained; contains

Mosheim limestone 32 ~~feet~~ 101

Light and dark ^{colored} dense vaughanite

Bellefonte dolomite (not measured)

Dark ^{colored} fine-grained limestone and dolomite

relatively as rather

Rickman's First Foot

H

~~geographic range extends as far north as Pennsylvania.~~ A partial

list of Lenoir fossils includes the following species:

- Hebertella cf. vulgaris (Raymond)
- Plectorthis sp. undet.
- Plaesiomys platys (Billings)
- Dinorthis pectinella (Emmons)
- Maclurea magna (Le Sueur)
- Homotelus sp. undet.
- Illaenus sp. undet.

Locality?
HPW?

Le vs La

The Athens Shale

The Athens, Chambersburg, and Martinsburg ^{formations} shale together constitute a thick, shaly series ~~whose local extent is largely~~ restricted to the extreme northwestern corner of the quadrangle between Shenandoah River and Massanutten Mountain.

?
? Is this
? essential?

Definition. The Athens shale ^{was} named from Athens, Tennessee.

Hayes, C.W.; U.S. Geol. Survey Atlas, Kingston Folio (No. 4), p. 2, 1894.

~~is the basal member of this series and~~
is the horizon formerly known as the Lexington limestone and the

Campbell, J.L.; Geology of Virginia; Am. Jour. Sci., 3rd ser. Vol. 18, p. 24, 1879.

Liberty Hall formation of central Virginia. The term Athens,

Campbell, H.D.; The Cambro-Ordovician limestones of the middle portion of the Valley of Virginia; Amer. Jour. Sci., 4th. ser., Vol. 20, pp. 445-7, 1905.

Why bring in the Athens?

~~however, has been so widely used as to have gained priority over other~~
~~(formational) names.~~ The Athens rests with a slight unconformity upon the Lenoir limestone and is overlain by the Chambersburg limestone.

not
? see p. 1165
near bottom

Distribution. This formation occurs in a narrow belt about 800 feet wide along the meandering course of ^{the} South Fork of Shenandoah River. Its outcrop is widened by folding and faulting to a zone nearly a mile wide. Between Ruffner Ferry and Bixler's Bridge

It produces rolling country, ~~along the river,~~ and its natural soil is dark, with splintery fragments ^{of shale} scattered through it. It produces good pasturage ~~and fair agricultural soil.~~ (See Pl. 98) In a few places, where the formation is more than usually calcareous, ^{sinks} have been developed at the surface by collapse of underground drainage channels.

Pl. 98
Tr. 10
X p. 121

Color
sink-holes
not distribution

Character. The Athens shale is essentially thin bedded, containing few zones in which the ^{beds} strata are ^{more than} over 8 inches thick. (See Pl.) (Fig. 99). The thicker beds are ^{They} limestone lenses, ^{which} weather ^{into} into a ^{ish} blue-gray ~~color and are~~ dense, fine-grained, and jet black on fresh surfaces. In weathering, they produce platter-shaped fragments ^{with} (which have) rounded edges, ^{which} are commonly covered with tiny, wavy "chatter" marks due to minute differences in ^{composition} erosion and weathering. The limestone ^{break with distinct} lenses exhibit good conchoidal fracture. when broken.

The main body of the formation consists of dark-gray to black shale that weathers to a chocolate color, and, ~~on fresh surfaces, has a variegated coloration.~~ Some of the beds consist of thin limestone bands ~~from one-half~~ ^{an inch} to one inch in thickness, regularly interbedded with similar bands of dark ^{colored} shale. Occasionally there are ^{some} more coarsely crystalline limestone ^{beds} zones that are less massive ^{and} but more finely grained than those of the Lenoir limestone below.

Except for occasional ^{local limestone} ledges ^{of the limestones}, exposures of the Athens are relatively ^{rare} uncommon. Where it has been involved in faulting, the formation is platy and has a ^{well-developed} strong cleavage, resembling that of a ^{has a metallic ring} true slate. The rock ^{rings metallicly} when two fragments are lightly tapped together.

Thickness. As measured in adjacent ^{areas} regions, ^{the Athens has} this formation ^{attains} a thickness of ^{from} about 400 to 500 feet. In this area it has been closely folded, and a ^{actual} ~~true~~ measurement of its thickness cannot be obtained.

Structural Relations. The ^{limestone} upper contact of the Athens shale with the overlying Chambersburg ^{limestone} appears to be disconformable, and its ^{underlying limestone} lower contact with the Lenoir at Bealers Ferry suggests a slight

2 words
Pl 99
2 words
dark-gray
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218
has yields a metallic ring
219
real actual

(Chambersburg)

Certain formations which are present elsewhere are ^{missing} omitted, as other units normally intervene both between the Lenoir and the Athens, and between the Athens and the Chambersburg. The local dips indicate that the formation is highly folded and steeply inclined, ~~and at least one fault is known.~~ ~~Disturb its structure~~ immediately south of Bixlers Bridge,

Mineral Resources.
Economic Material.

The Athens shale is quarried along ^{the} Shenandoah River, one mile east of Alma and half a mile south of Lee Highway (U.S. 11). This quarry was opened for road material (to be) used in the surfacing of the Lee Highway; no other quarries in the Athens are known. The formation was prospected for slate near Trinity Chapel, three miles northwest of Luray, but the rock was found to be unsuitable except for ^{very limited} incidental and extremely local use. Although slaty cleavage has developed, the formation does not contain true slate.

Age and Correlation.

The Athens shale may be readily distinguished by the abundance of graptolites which occur in the dark ^{colored} shale facies of the formation. The most typical of the ^{species} graptolites is the widespread Nemagraptus gracilis. Rare brachiopods, trilobites, and ostracods also occur in the limestone layers of the Athens. The Athens shale is correlated with the Normanskill shale of New York, and the Glen Kilm shale of Scotland. Its age is lower Middle Ordovician, and it is one of the most widely distributed members of the

Blount Group of Tennessee.

The most common fossils of the Athens shale are as follows:

- Climacograptus bicornis Hall
- Dicellograptus sextans Hall
- Dicranograptus ramosus Hall
- Diplograptus cf. foliaceus Murchison
- Nemagraptus gracilis Hall
- Triarthrus cf. becki (Eaton)
- Cryptolithus sp. undet.
- Ampyx americanus (Safford and Vogdes)

Locality?
HPW

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form
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Eaton

The Chambersburg Limestone

Definition. The Chambersburg limestone is named from Chambersburg, in Pennsylvania, where it occurs immediately above the Lowville

Stose, G.W.; Sedimentary rocks of South Mountain, Pennsylvania; Jour. Geol., Vol. 14, p. 211, 1906.

limestone of Black River age. ^{It} (~~The Chambersburg~~) is widely displayed in Maryland and Northern Virginia, but its outcrop in the Stony Man quadrangle consists of a narrow belt that follows the general strike of ^{the South Fork of} Shenandoah River adjacent to the outcrop of the Martinsburg shale. The (~~Chambersburg~~) limestone is exposed in several places along ^{South Fork} Shenandoah ~~River~~, especially near Bixlers Bridge and near Bealers Ferry.

Character. ^{The} ~~This~~ formation consists of a thin bedded, bluish-black limestone that is not unlike ^{portions of} the Athens shale below, or ^{beds} (~~members~~) of the Martinsburg shale above. It ^{is} thinly laminated and ~~has a~~ dark, bluish-gray color, ^{are} some of its layers being black and platy. ^(See Pl. 100) A few ~~(of the)~~ beds are nodular or knotty, and are ^(very) similar in character to those of the Lenoir limestone.

Thickness. The Chambersburg limestone is inclined at moderate angles, and produces no distinctive soil nor topographic expression. Its thickness is estimated ^{to be} as about 200 feet, which is considerably less than its thickness on the western side of Massanutten Mountain, where it reaches a maximum of at least 400 feet.

Age and Correlation. In the original description of the Chambersburg limestone, the name was applied to horizons that included the Lowville, but subsequently, the name was restricted to the upper or post-Lowville part of the ^{formation} ~~specimen~~. It belongs to the Black River Group of Middle Ordovician age, and contains scattered fossils that

Pl. 100
Sub. need
Mineral Resources
Glx

identify it. The most characteristic of these are ~~listed~~ as follows:

- ✓ Echinospaerites cf. aurantium
- ✓ Nidulites cf. farus
- Solenopora compacta
- ✓ Christiania trentonensis
- Plectambonitis cf. asper
- Dalmanella cf. subaegosta
- Illaeus cf. americanum
- Receptaculites sp.

Locality 1
APW

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sp. ?

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of the formation is extensively forested, and, in fact, lies wholly within the area of George Washington National Forest.

Character. The Martinsburg shale is a thick aggregate of dark-colored, evenly laminated shale (thin bedded), with which are interbedded lenses of thin, flaggy, sandstone. (See Pl.) In the lower and upper portions of the formation, the sandstone lenses are more abundant and somewhat thicker than in the middle portion where thin layered shales characterize the unit.

Subdivisions. On the basis of its fossil content and, to a lesser degree, upon its lithology, the Martinsburg shale is divisible into three units. These divisions are: (1) The Trenton, (2) Eden, and (3) Maysville members.

Trenton Division. The lowest division of the Martinsburg shale is of Trenton age. Its basal portion consists predominantly of calcareous, gray shales interbedded with a few thin, impure limestone lenses. It disintegrates rapidly under the attack of the weather and produces a more unctuous, yellow, clay soil than the upper portion of the member. Overlying the lowest portion of the Trenton division is a sandy facies phase which consists of several hundred feet of gray-green sandstones that approach the lithologic character of greywackes. The sandstones are cross-bedded, pillowy in weathered exposures, and contain lenses, or zones, of thin arenaceous, green shales. Good exposures of this part of the Trenton occur along the lower slopes of Massanutten Mountain, and the green sandstone is readily accessible at the point where Virginia State Highway No. 821 leaves the margin of the quadrangle.

It is not possible to determine the exact thickness of the Trenton division of the Martinsburg, but it appears likely that it reaches a thickness of 1,000 feet. In adjacent areas in Virginia

97-? Pl. 101

222? 6 57

4 OK

223 6 57

266-?

HPW

one or more beds of metabentonite (altered volcanic ash), are present near the bottom of the formation, but no indication of their presence was observed in the local area. Some horizons of the Trenton are abundantly fossiliferous with such common Trenton fossils as Cryptolithus tessellatus, Prasopora simulatrix, and species of Diplograptus.

Adapt
177
171

Eden Division. - The middle portion of the Martinsburg consists principally of shale that becomes increasingly sandy upward. The shaly Eden member is intermediate in position between the green sandstones of the upper Trenton and the sandy beds of the overlying Maysville division. The shales are thin, fissile, and dark colored, weathering rapidly, however, to a light buff color. Some sandy beds are present as well as lenses of gray shale that weather into pencil-shaped fragments. The Eden crumbles readily and is only exposed in gullies or creek beds. Its soil is yellow or brown and only moderately productive. In the main, the Eden division is a weak unit, and does not produce any distinctive topographic expression. Its exposures occur along the middle of the southeastern slope of Massanutten Mountain.

light buff
-?

Maysville Division. - The upper portion of the Martinsburg formation is designated as Maysville on the basis of its contained fossils. This part of the Martinsburg is much more arenaceous than the middle or Eden division, and contains a considerable body of fine-grained, evenly bedded, greenish sandstones and sandy shales. The thickness of (the upper) portion of the Martinsburg is approximately 1,000 feet and it occurs immediately below the resistant Tuscarora sandstone which caps Massanutten Mountain. The Maysville division is sparingly fossiliferous, and two most distinctive fossils are those of pelecypods, Orthorhynchula linneyi and Byssonichia radiata. A thin bed of sandstone carrying abundant Orthorhynchula invariably occurs at

2000
224
(of Silurian age)

Spines?
MAY

the top of the Maysville throughout ^{in this area} ~~this portion of Virginia.~~

Thickness. The total thickness of the Martinsburg shale ^{in this general region} reaches an estimated maximum of nearly 3,000 feet. This thickness is greater than that found in western Virginia, for the Martinsburg ^{Re formation} has its thickest representation in the Massanutten ^{Mountain} syncline.

Structural Relations. The Martinsburg shale ^{dips} is inclined north-westward, ^{so that} in ~~such~~ fashion that it underlies the Tuscarora sandstone at the top of Massanutten Mountain. Along the contact with the underlying Chambersburg limestone the prevailing dips are southeast ^{ward}. These divergent dips indicate that the formation is tightly folded, and that the overturned structure which characterizes the folds of Page Valley ~~must~~ give way to normal folds within the body of the Martinsburg ^{formation} shales. The contact of the Martinsburg and Chambersburg formations is disconformable. The contact with the Tuscarora sandstone is slightly unconformable, although there is no evidence of pronounced diastrophism as is indicated at the close of Ordovician deposition in Northern Pennsylvania, New Jersey, and southern New York ^{State}.

Do they?
Evidence
Clear to West!

Section of shale & shales

225

Mineral Resources - Economic Minerals

Mineral Resources.
Economic Material. No products of economic importance are derived from the Martinsburg shale ^{formation} of this region.

Age and Correlation. As previously indicated, the Martinsburg shale includes Trenton, Eden, and Maysville horizons of Middle and ^{Late} ~~Upper~~ Ordovician age. This formation ^{and it} may be traced continuously from New Jersey southwestward into southern Virginia, and it constitutes an easily recognizable unit throughout the central and northern Appalachian region. It is the highest, and therefore the youngest, Ordovician sediment ⁱⁿ of the Stony Man ^{area} region. ^{It is} No representatives of the Richmond, or uppermost Ordovician, sedimentation ^s are known in this area.

226

A partial list of Martinsburg fossils includes the following species:

Maysville Division

- ✓ Orthorhynchula linneyi James
- ✓ Byssonychia radiata (Hall)
- Modiolopsis modiolaris Conrad
- Lingula nicklesi (Bassler)

? (-)

Locality?

HPW

Eden Division

- Rafinesquina alternata (Emmons)
- Dalmanella testudinaria (Dalman)
- Zygospira sp. undet.

Trenton Division

- Diplograptus cf. amplexicaulis Hall
- Prasopora simulatrix (Ulrich)
- Plectambonites sericeus (Sowerby)
- Cryptolithus tessellatus (Green)

— (-)

Silurian System

General Statement

Fig 131
E

The Silurian rocks of the Stony Man quadrangle comprise a section about 1,200 feet thick which is restricted to the extreme northwestern portion of the area. ^(See Fig.) ~~The basal member~~ ^{The formation} is the resistant Tuscarora sandstone, ^{at} which is overlain ^{successively} by the Bloomsburg shale and the Tonoloway limestone. ~~The latter members are weak~~ ^{rocks that} producing neither distinctive topography nor reliable exposures, and ^{which} their actual presence (within the quadrangle) ~~has been assumed, rather than observed.~~ ^{have not been} Their descriptions ^{of them} in the following pages are based ^a on (upon) exposures examined in adjacent areas.

17

Northwestward

The Silurian System overlies the Ordovician and was deposited during the Silurian Period of geologic history. Although ~~it is a~~ ^h much tinner system than ~~(either)~~ ^{by 2/3} the Cambrian, Ozarkian, Canadian or Ordovician, ~~(yet)~~ ^{the Silurian rocks were} the conditions under which ~~(it was)~~ laid down, and the details of Silurian history, are equally interesting and important in the geologic history of ^{the Appalachian Valley region of} Virginia. In fact, to a large extent, the competent Tuscarora sandstone ^{which} has determined the scenic development of this area. ~~The bold Massanutten Mountains.~~

It is difficult to ^{determine} ascertain the exact nature of the Silurian sequence ^{in this general region} but the following measured section was ^{obtained} made along the road leading from Dietrich, in Fort Valley, ^{northwestward} toward Woodstock.

along the Dietrich-Woodstock road in Fort Valley.

Notes
 27
 A-1
 37

Section ^{of formations} along ^{The} road from Dietrich to Woodstock in Fort Valley, Massanutten Mountains

(Section measured along road leading from Dietrich in Fort Valley, to Woodstock in Shenandoah Valley. Rocks exposed along the roadside and on adjacent stream cuts, strike about N40°E, dip approximately 45°NW. Section measured in western limb of a subsidiary anticline in the general Massanutten fold.)

- Oriskany sandstone (?) 12 feet
- Crumbly, brown limonitic sandstone 12 feet
- Helderberg-Tonoloway ^{formations in} interval covered 280 feet
- Bloomsburg shale 585 feet

- (largely covered) Yellow and red checky, sandy shales; 150 feet
- Yellow and red, sandy shales; red sandstone.. 85 feet
- Covered 90 feet
- Dense, red sandstone; some thin shales laminae 39 feet
- (largely covered) Some reddish-orange sandstones; 21 feet
- Dense, gray sandstone 8 feet
- Red sandstones, shales, and gray sandy zones. 31 feet
- Slabby, red, shaly sandstones 21 feet
- (largely covered) Some reddish sandy shales; 18 feet
- Covered; lower contact uncertain 120 feet

- Tuscarora sandstone 540 feet
- Covered interval 13 feet
- Coarse, gray sandstone cross-bedded; some pebbly zones 47 "
- Massive conglomerate 2 "
- Pink and white coarse sandstone; partly covered 168 "
- Heavy bedded white, coarse, cross-bedded sandstone 128 "
- White and pinkish quartzitic sandstone 30 "
- Covered 14 "
- Brownish, cross-bedded, shaly sandstone 40 "
- Thick Heavy bed of white sandstone 10 "
- Coarse, pinkish-gray, quartzitic sandstone .. 39 "
- Sandstone; weathering brown 35 "
- Coarse, heavy bedded, gray sandstone 14 "

(Base of Tuscarora not exposed; probably just immediately below bottom of measured section)

Thick
 The

~~The~~ Tuscarora Sandstone

The earliest Silurian formation of the Stony Man region, known as the Tuscarora sandstone, is conspicuously displayed on Massanutten Mountain, but does not occur elsewhere within the limits of this quadrangle.

Definition - The Tuscarora sandstone ^{was} is named from its occurrences on Tuscarora Mountain in West Virginia. ~~In southwestern Virginia~~

Darton, N.H. ⁶ U.S. Geological Survey, Geologic Atlas, Monterey Folio (No. 61), 1899.

and Tennessee, an analogous formation is known as the Clinch sandstone, and either name is available for the local unit. Because the name Tuscarora has been widely used in ^{northwestern} ~~northern~~ Virginia and Maryland, and as the term Clinch has been restricted to more southerly exposures of this ^{formation} horizon, it seems desirable to use Tuscarora sandstone in this report. The name "Massanutten sandstone", applied by Darton, to the clastic

Darton, N.H. ⁶ Notes on the stratigraphy of a portion of central Appalachian Virginia; Amer. Geologist, Vol. 10, p. 14, 1892.

Silurian rocks of Massanutten Mountain, is not sufficiently definitive to be available.

Distribution. The Tuscarora sandstone crops out along the crest of Massanutten Mountain and forms the conspicuous summit known as Kennedy Peak. Many ^{good} fine exposures of the rock occur in the vicinity of this peak, and ledges ^{of it} (of the sandstone) are visible along the crest of the main Massanutten ridge. ~~(Fig. 102)~~ Conspicuous boulders and other residual debris from these ledges choke the stream courses on both flanks either flank of the mountain. ~~to~~ the sandstone ^{does not} occurs nowhere else in the quadrangle, the length of its local outcrop is scarcely three miles.

East of
Geologist
p. 18
P/102
Q 3

7
P/102

Character

The Tuscarora formation is practically homogeneous throughout, being chiefly a white granular sandstone. At the base occur massive conglomerate beds containing quartz pebbles as large as an inch in diameter. Many of the beds show cross-bedding. The rock is commonly white to light gray, but upon weathering, it is stained pink due to oxidation of the small content of iron in it. Most of it consists of beds ranging from ¹ ~~one~~ to ³ ~~three~~ feet in thickness. Some of the beds are about ⁵⁰ ~~fifty~~ feet thick and they make bold ledges and ridges. The beds in the upper part of the formation are thinner and resistant ledges are less abundant than in the lower part. (Continue with manuscript, starting with "Where the rock is extensively exposed ~~to the weather~~)

See also City and copies

→ ~~with typed copies~~ ^{massive} ~~±~~ for this page 163

Character. ^ε This formation is a thick aggregate of quartzitic sandstone and conglomerate. Its color is commonly white to light gray ^{but upon} ~~which~~ ^{it} in weathering assumes a pinkish stain as ^{due to} a result of oxidation of iron. ^{Some} ~~at~~ ^{in it.} the very base of the formation occur massive beds (that are) ^{conglomeratic} distinctly conglomerate, carrying quartz pebbles ^{as large as} up to one ^{an} inch in diameter. Many of the beds show evidence of cross-bedding, and a massive stratification exists throughout the entire rock. ^{beds in the} The upper portion of the formation ^{are thin} is less heavily stratified, and resistant ledges are less frequent ^{abundant} than in the lower portion. Some of the individual strata attain thicknesses of nearly 50 ^{thick} feet, and ^{make bold ledges and ridges.} exert a profound effect upon the topography.

The Tuscarora is practically a homogeneous sandstone ^{throughout} from top to bottom with no pronounced break in structure or lithology. The great mass of the formation ^{most of it} consists of beds ranging from one to ³ three feet in thickness, and its most distinctive lithologic type ^{being chiefly} is a white granular sandstone. Where the rock is extensively ex-

posed to the weather, the surface of the sandstone becomes hardened ^{but this hardening appears to be a superficial phenomenon} until it resembles that of a quartzite, rather than associated with either the deformation or the deposition of the rock. The most resistant member ^{of the unit} occurs about 450 feet from the bottom, and ^{a prominent} is a massive stratum of pebbly sandstone; it is the chief ridge maker. Where the rock is cross-bedded, the secondary lamination ^{generally} is at moderate angles ^{to} with the true bedding, but it seldom varies more than 30° or 40° degrees from the normal stratification.

Thickness. - The thickness of this ^ε formation ranges ^{from} between 500 ^{to} and 600 feet ^{along} in the western rim of Massanutten Mountain. About 4 miles ^{western} beyond the edge of the quadrangle a measured section ^{of} 540 feet ^{thick} of Tuscarora sandstone was studied.

Surface Relations. - ^{Topographic expression} This formation is one of the most conspicuous

Whole p. repetition

ridge-makers ⁱⁿ of the entire Appalachian ^{Valley} region. Occurring ^{between} above ^{where} (the) soft Ordovician shales ^{above} and below ~~equally weak Silurian beds,~~ it has acted as a competent member in the folding of this region, and it ^{erosion} produces ^{rugged topography} mountainous ^{is exposed,} country wherever the rock ^{most} nears the surface. The several Massanutten ridges, as well as ~~a majority~~ of the other mountains of the folded Appalachians, ^{Valley} ~~are produced by~~ the Tuscarora, or Clinch, sandstone. ~~The~~ ridges ^{are on} are generally steep-sided, sharp-crested, and heavily wooded, and ~~its exposures and topographic effects are quite similar wherever the rock is exposed.~~

Not related

(and found)

Structural Relations.

^{underlying} Martinsburg shale ^{of the} Tuscarora sandstone ^{with} overlies the ~~exact~~ contact was observed at several places, there ~~was found~~ no evidence of the strong structural unconformity which occurs at this horizon in Pennsylvania, and ~~southern New York~~ ^{State}. Throughout the Appalachian region, the basal Silurian sandstones rest directly upon Upper Ordovician shales, and only slightly ^{disconformable} relations occur. ~~In the local area,~~ ^{in two quadrangles} the Tuscarora rests upon the Maysville division of the Martinsburg, no representative of Richmond age ^{is} ~~being present,~~ ^{Shale. Although} Despite the absence of the latter, almost no change in attitude is apparent between the upper portion of the Martinsburg and the lower beds of the Tuscarora.

The base of the Tuscarora sandstone is well exposed along the Edinburg road in Fort Valley, at the point where the road crosses Kerns Mountain. ^{Here} (At this point) the lower 20 feet of the formation consist of quartzitic sandstones that are cross-bedded, and contain numerous strong, pebbly zones, ^{one} one of which (the basal member) contains quartz pebbles from ¹ one to ² two inches in diameter. The sandstone rests upon a series, at least 80 feet thick, of heather-colored soft, shaly sandstones, the upper portion of which is rather ^{thin} heavy bedded, and grades downward into the soft, clayey, buff sands and shales of

slight slightly

228

Edinburg road

Edinburg road

~~underlying~~

the ¹Maysville. No Orthorhynchula was found near this contact, and it is possible that a slight unconformity occurs between the Tuscarora and Maysville units. No Juniata beds were observed, unless the heather-colored sandstones are of this age. [#]The upper contact of this ²~~formation~~ ^{Tuscarora} is more difficult to determine, for the sandstones of the ~~Tuscarora~~ are overlain by, or grade upward into, shaly beds of Cayuga age.

The Tuscarora sandstone dips northwestward ~~at an angle of~~ about 45 ~~(degrees)~~ to pass underneath the valley of Passage Creek in the central area of the Massanutten range. The formation is uniformly inclined and shows little or no evidence of minor folding. Apparently the outcrop of ~~this unit~~ has been slightly offset by folding immediately east of Kennedy Peak.

100
degrees
Massanutten

Age and Correlation. - So far ~~as was~~ observed, ~~no fossils~~ ^{were not} ~~for other~~ organic remains occur in the Tuscarora sandstone ⁱⁿ of this ^{area} region. Occasionally, ~~quartzitic pebbles on the floodplain of Shenandoah River~~ are found to contain the fossil form Scolithus, a species of which (Scolithus verticalis) is known in the Clinch sandstone of other regions. It is equally possible, however, that these pebbles were derived from the Antietam ~~sandstone~~, which contains an analogous species, Scolithus linearis.

42
P. 2
shale

In this report, the ^{bssd} ~~entire interval~~ from the top of the Martinsburg ^{shale} to the ^{base} ~~base~~ of the Bloomsburg shale ^{are included in} is ~~designated by~~ the name Tuscarora sandstone. It is possible, ~~however~~, that this interval may contain a thin section of Clinton rocks, ^{west} Farther south in Virginia, The Tuscarora (Clinch) sandstone is overlain by ~~an equal thickness of similar sandstone~~, the Cacapon and Keefer formations of Clinton age. Neither of these units has been identified in the Stony Man ^{area} ~~section~~, a ~~fact which either demonstrates their local absence,~~

contact

186 +80
or indicates that their local representation is not distinguishable
from the underlying Tuscarora sandstone.

The Bloomsburg Shale

South western

Repetition

The Bloomsburg shale directly overlies the Tuscarora sandstone with no observed Clinton representatives intervening. In western and southern Virginia, distinctive rock formations of Clinton age overlie the Tuscarora, or Clinch, sandstone. These are the Cappon and Keefer sandstones, which appear to be locally absent.

Definition. - The Bloomsburg shale was named ~~in 1883~~ by I.C. White from its occurrence at Bloomsburg, Columbia County, Pennsylvania.

Luzerne
2nd. Pa.
SP

White, I.C.; The geology of the Susquehanna River region in the six counties of Wyoming, Lackawanna, Luzerne, Columbia, Montour, and Northernberland, Pennsylvania; Second Penn. Geol. Survey, Report G 7, p. 106, 1883. (:) Pennsylvania

At the type locality, the formation consists of interbedded sandstone and shale, and a similar character is preserved in Virginia, where, however, the formation is somewhat more shaly and is locally called the Bloomsburg shale.

Distribution. - The Bloomsburg shale and the overlying Tonoloway and Helderburg formations are thought to crop out along the northwestern slope of Massanutten Mountain. So far as ^{was} observed, no (surface) ledges or other exposures of these formations occur within the limits of this quadrangle; yet elsewhere in Massanutten Mountain they crop out in the interval between the Tuscarora sandstone and the Romney shale. The descriptions, therefore, of these formations are made from exposures outside the limits of this quadrangle.

Character. The Bloomsburg shale consists of a series of red and green shales alternating with red and orange ^{colored} sandstones. The formation as a whole is thin to medium bedded, and is weak in its surface outcrop. The shaly beds are strongly colored, and break into chunky fragments that are not especially fissile. The sandstone lenses are

??

(See Pl. 2.)

Pl. (103)

coarse ^{grained} ~~textured~~, ~~porous~~, and commonly are orange-red in color (Fig. 103).

Many of the ~~sandstone~~ lenses are several feet thick, although an interlamination of shale and sandstone characterizes the exposed portion of the formation. The best exposures of the Bloomsburg occur in stream beds on the western side of Fort Valley, (and along the upper part of Passage Creek Valley.)

Fort Valley and Passage Creek Valley are the same

?

Thickness. The thickness of the Bloomsburg shale is difficult accurately to determine. On the western side of the Massanutten range, a thickness of 350 feet was observed below the Tonoloway limestone, and an additional 200 feet, largely covered, intervened before the top of the Tuscarora sandstone was reached. It is thus estimated that the formation has a thickness of at least 550 feet.

200

Structural Relations. The Bloomsburg shale is folded with adjacent rocks in the southeastern rim of ^{The} Massanutten ^{Mountains} syncline, where in ^{Series} the entire Paleozoic Group dips northwestward at (an angle of) about NW. 35 (degrees). The upper contact of the Bloomsburg with the overlying Tonoloway limestone is disconformable. Although the contact with the underlying Tuscarora sandstone is not clearly defined, it must ^{likewise} (similarly) be disconformable in view of the local absence of Clinton beds.

Mineral Resources

Age and Correlation. The Bloomsburg shale is of Cayuga age and belongs to the Upper Silurian Series. It is the equivalent of the Bloomsburg sandstone of Maryland and Pennsylvania, and is also present in the ^{Valley?} Appalachian ridges of northwestern Virginia. Elsewhere

l.c.?

229

Appalachian Valley ridges

In the northern Appalachian region the Bloomsburg shale is overlain by the Wills Creek sandstone, but no rocks occur in the local section that can (be) definitely determined to be Wills Creek. At the very top of Bloomsburg occurs a thin bed of greenish sandstone about 4 feet ^{thick} (in thickness). It is barely possible that this ^{bed} stratum is the local equivalent of the Wills Creek formation, although no fossils were found to verify the possibility.

?

~~the~~ Tonoloway Limestone

Western

Northwestern

The Tonoloway limestone is one of the most persistent, although poorly exposed, formations in ^{west-}central and northern Virginia. As its outcrop generally occurs along the slopes of ^{steep}Silurian ridges, the rock produces no distinctive topography and has few exposures; ~~its presence is thus difficult to detect except in favored locations.~~

Definition. The ~~Tonoloway~~ limestone was named from Tonoloway Ridge, Washington County, Maryland, ^{where it} where it is well exposed and ^{was} was

Stose, G.W., and Schwartz, C.K.; U.S. Geol. Survey, Geologic Atlas, Pawpaw-Hancock Folio. (No. 179), p. 55, 1912.

first studied. Unless a ^{portion} part of the ^{Ordovician}Keyser formation ^{is in} can be ascribed to the Silurian System, it is ~~the~~ the uppermost Silurian formation in Virginia.

Massanutten Mountain range beyond north-west of

Distribution. ~~Since no outcrops of the Tonoloway limestone occur in the Stony Man quadrangle, the following description of the formation is taken) from (its) exposure along the northwestern rim of the Massanutten range some ^{four} miles ^{from} the ^{margin} edge of the quadrangle.~~

Character. The Tonoloway limestone consists of thin-bedded, gray-black, clayey limestone, with interbedded shale laminae ^{between the} limestone members. ^{the}In ^{the} lower part of the formation, ^{contains} ~~distinct~~ shaly beds are present, ^{which} but ^{these} become thinner as the top ^{toward} (of the formation) is ~~exposed~~. ^{By bedding planes of} Many of the limestones are strongly marked with mud cracks, ^(See Pl. .) that are strikingly exposed on the surface of ledges ^(Fig. 104). They ^{Edinburg - Ft. Valley} markings are prominent in the exposures along the road ^(that leads) from Edinburg ^{into} to Fort Valley. A few of the Tonoloway limestones are coarse ^{- grained} and crystalline; some are knobby and reticulated.

67

Pl. (104)

The following measured sections show the general character of this formation in ^{near-by part of} ~~the~~ ^{Mountain.} Massanutten ~~range.~~

Longe
Mass. Blk. 2

Tr. and water
level sections (pp 185-186)
as indicated →

(Insert sections on two following pages, pages 185 and 186)

The formation weathers rapidly, and its ~~outcrop~~ ^{is} is covered with boulders from the Tuscarora ledges above. ~~Since~~ it has no distinctive topographic expression, its presence in the quadrangle is largely assumed. Where ~~it~~ ^{the formation} is gently folded, its ~~outcrop~~ ^{area} is wide and, if ~~cleared~~, makes good pasture and fair agricultural land.

at Bull
25-300

Thickness and Structure. - The thickness of the Tonoloway limestone is about 130 feet ^{where} ~~as~~ measured on the west side of Fort Valley. This

Tr to p. 186
1/2 in. indicates

230

Section of Tonoloway limestone along ^{the} Edinburg-^{Fort} Valley road, ~~#~~
County, Va.

Fort Valley =
Section along Edinburg Road

(This section was measured along the road leading from Fort Valley to Edinburg, about 3.5 miles west of the main road in Fort Valley.)

<i>Devonian system</i>	Helderberg Group	128 feet
<i>Silurian system</i>	Tonoloway limestone	143 feet

Covered; ^{some} occasional slabby limestone float ..	40 feet
Coarsely crystalline limestone	8 "
Covered; largely shale float	10 "
<i>-grained</i> Fine blue, dense, reticulated limestone	8 "
Platy, dense limestone; some shaly beds	20 "
Platy, reticulated, mud-cracked limestone ...	20 "
Covered	6 "
Covered; sandy, and clayey gray limestone ...	20 "
Knobby, arenaceous limestone	18 "

Bloomsburg shale 243 feet

Orange-red sandstones and shales; ostracods .. 243

(Base of section obscured)

limestone with mud cracks

ostracods
codas

See p. 193, etc

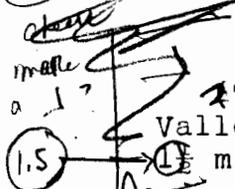
232

Tr. to p. 186
as indicated

slates

Section of Tonoloway limestone along Fort Valley Mt. Jackson road,
County, Va.

(231)



Mount

Fort Valley
Section along Mt. Jackson Road

This section was measured along the abandoned road from Fort Valley to Mt. Jackson along the headwaters of Passage Creek about 1 1/2 miles east of Moreland Gap.

Helderberg	Helderberg Group	139 feet
Delmar	Tonoloway limestone	153 feet
	- ^{grained} Fine, dense, gray, reticulated limestone ..	8 feet
	Covered	25 "
	Fissile, buff, calcareous shales	37 "
	Thin, platy, slabby limestone, argillaceous ..	35 "
	Thin, slabby, limestones and shales, mud-cracked ..	31 "
	Very thin-bedded, platy limestones	17 "
	Bloomsburg shale	110 feet
	Red, checky shales	145

(Base of section obscured)

Virginia
The Appalachian Valley in
232
code
cod
cod a

thickness is comparable ^{to} ~~with~~ its known thickness ^{elsewhere} in ~~other portions~~
~~of~~ ^{Valley in} Appalachian Virginia. The formation occurs in the ~~folded~~ Massa-
nutten ~~syncline~~ ^d, and it is presumed that ^{in this area it dips} the rocks are inclined
gently to the northwest ^{along the southeast limb of the fold.} So far as ~~was determined~~, its contacts with
adjacent formations ^{appear to be} are conformable.

Mineral Resources -

Age and Correlation.

The age of the Tonoloway limestone is de-
termined by its stratigraphic position and fossil content. The
formation is assigned to the uppermost Silurian, ~~and belongs to the~~
~~Cayuga Group~~. It contains fossil in limited numbers, chief of
which is the ostracode, Ieperditia alta. ^{mineral resource} No material of economic
value is known to occur within this formation.

The Devonian System

General Statement

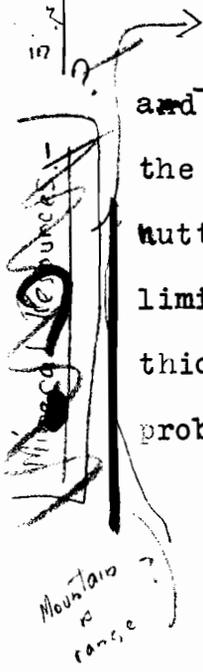
Devonian rocks have the smallest areal outcrop in the Stony
 Man quadrangle of any of the various systems, and ^{being} ~~are~~ limited to ~~an~~
~~area~~ of about one square mile in the extreme northwestern corner of
 the quadrangle. ^{area Fig. F, Plate III (See Fig.)} Only that part of the local area which lies in
 Fort Valley ^(Pl. A) ~~(Fig. 110)~~, is underlain by Devonian rock, ^s and ^{not there are} very few
 exposures. ^{area Fig. 110 (See Pl.)} ~~(of the rocks) may be found in this outcrop.~~

The Devonian System begins with the Helderberg Group, which
 consists of about 140 feet of irregularly bedded, dark ^{colored} limestone
 and shales. This group is overlain by a small thickness of yellow
 and olive shales, representing the Onondaga ^{formation} horizon. ^{Next} Above these
 shales, ~~and extending to the~~ ^{northwest} ~~corner of the quadrangle,~~ ^{is} ~~(occurs)~~ the
 black "Romney" shale, ~~which contains horizons of Marcellus, Hamilton,~~
 Genesee, and possibly Portage age.

~~No economic products are known from the local Devonian rocks,~~
 and ~~their~~ topographic expression is negative, being responsible for
 the deep synclinal floor ^{of} Fort Valley ^{in the} ~~center~~ ^{middle} of the Massa-
 chusetts ^{Mountains} ~~range~~. The total thickness of ~~Devonian rocks within~~ the
 limits of the quadrangle does not exceed 800 feet, although the full
 thickness of all Devonian rocks that crop out ~~within~~ the quadrangle
 probably reaches 1,600 feet.

in extent
Fig. 13
F
Pl. 110
(15)

loc. 7
or
cont.



} = ?
APW

General Features

~~The~~ Helderberg Group

A thin series of limestones ^{known as the Helderberg group,} overlies the Tonoloway limestone and underlies the Onondaga shale of Middle Devonian age. These limestones have not been differentiated in the ^{Stony Man quadrangle} ~~present report~~ and are therefore described under a single heading, ~~as the Helderberg group.~~

234

~~Definition~~

The rocks ^{thus} designated as Helderberg correspond in age and stratigraphic position to the Helderberg formations of ^{Early} ~~Lower~~ Devonian age ⁱⁿ of New York ~~State~~. Their ~~outcrop~~ ^{area} in the Stony Man quadrangle is ^{very} extremely small, ~~actually~~ consisting of a narrow belt of about one-eighth of a mile ⁱⁿ width along the inner slope of Massanutten Mountain. ~~Their total length of outcrop within the quadrangle is about one-quarter of a mile, so that the actual area of the Helderberg is relatively (minute).~~ ^{very small} So far as is known, ~~no~~ exposure of any member of this group ^{is known} ~~occurs~~ within the limits of the quadrangle or ⁱⁿ immediately adjacent thereto. Several exposures of Helderberg limestones occur on Passage Creek, about ⁴ four miles southwest of Kennedy Peak, ^{and others} (while exposures of these rocks) are ^{found} ~~also visible~~ on the northwestern side of Fort Valley in creek beds that have been cut through the overlying residual debris.

very small

n 7/

No definition given by author

In northwestern Virginia, the Helderberg ^{group has been} ~~representatives may~~

~~be~~ separated into ~~four distinct units~~, the Keyser limestone at the base, overlain successively by the Coeymans, New Scotland, and Be-craft limestones. The local sequence of Helderberg rocks does not agree in thickness or character with the more ^{north?} westerly sections where these subdivisions are evident, and until further study has been made of the Helderberg ^{group} in Massanutten Mountain, it seems ^{advisable} ~~wise~~ to consider the beds as a single unit.

north westerly?

group

and thickness

Character. Exposed sections of the Helderberg group occur along the roads ^{mt.} (leading from Fort Valley to ~~Mount~~ Jackson and Edinburg,) several ~~at~~ ^{at} ~~Fort Valley, Mt. Jackson and Ft. Valley, Edinburg~~ ^{Mount}

Where does this belong up to H.P.W.?

Clear (S) of a bracket: June 1st on p. 197 X

of the Helderberg Group

The Fort Valley - Mount Section along Mt. Jackson Road (See also section, page .)

Devonian system

Diagonal First Feet (not measured)

Onondaga shale		(not measured)
Helderberg Group		139 feet
Becraft limestone		5 feet
Coarse, crystalline, gray, coralline limestone, massive		5 feet
New Scotland shale (?)		21 feet
Mealy sandstone and calcareous shales; largely covered		21 "
Keyser limestone (?)		
Dark, ^{colored} sub-crystalline, cherty limestone	5	→
Fine, knobby, reticulated, gray limestone	11	"
Coarse, gray, dense limestone	2	"
Gray, limy, knotty shales	4	"
Knobby, gray, dense limestone, cherty	8	"
Gray to dark, cherty limestone, thin-bedded	26	"
Dark-gray, coarse, cherty limestone	57	→
Devonian system		153 feet

-grained

-colored

Delaware system

2-grained

Tentative only

Identification of members of the Helderberg Group with recognized stratigraphic units must be considered to be tentative only.

miles northwest of Kennedy Peak. In these sections, a coarse, ^{-grained} crystalline, gray limestone forms the topmost member of the group, and with has a thickness of between 5 and 10 feet, The rock is massive, and in character and position suggests the Becraft limestone of northwestern Virginia, but no distinctive Becraft fossils were observed in the small exposure which was examined.

Beneath this limestone occurs a mealy sandstone that is underlain by thin-bedded, dark ^{-colored} limestones containing several zones of more crystalline material, together with a chert-bearing, knobby, reticulated limestone not ^{unlike} greatly different from the Tonoloway limestone. Stratigraphically below the rocks previously described is a covered interval, ^{then} that is followed by beds assigned to the Tonoloway limestone of Upper Silurian age. The total thickness, ~~therefore,~~ of rocks of the Helderberg group does not exceed 140 feet and is possibly ^{only about} (as thin as) 75 feet.

Just p. 196

Repetition

~~This unit is poorly exposed.~~ The rocks weather readily and the ~~outcrops~~ outcrops are covered with a deep, yellow soil through which are scattered alluvial fragments of the Tuscarora sandstone as well as minor quantities of black chert ^{derived} developed from the lower ^{st beds} ~~most~~ member. ~~The contacts of the Helderberg group were not visible, but it is probable that both upper and lower contacts are disconformable.~~

Minerals

Repetition

Age and Correlation. The Tonoloway limestone is commonly overlain by the irregularly bedded Keyser limestone, (and) the lower portion-

All 13 feet of the local Helderberg section is tentatively assigned to the Keyser. No representatives of ^{limestones} The Coeymans or New Scotland were ^{not} definitely identified in the ^{local} sections observed, nor were diagnostic Helderberg faunas observed in the section. It is largely on the basis of lithology that Becraft and Keyser correlations in the Helderberg have been tentatively ^{made} designated.



2 wts

s?

Both Helderberg and Tonoloway limestones of Massanutten Mountain ^{area} were originally grouped together as the "Lewistown limestone" by Spencer, who published a partial section, measured near Seven Fountains, Fort Valley, which is here ^{given} repeated:

of "Lewistown limestone"
Section at Seven Fountains

Why include here?

Romney shale.....	.....	Not measured
"Monterey sandstone", coarse conglomerate.....	.....	1 foot
"Lewistown limestone".....	.....	94 feet
Yellow shale.....	.....	6 feet
Fossiliferous, blue limestone; medium bedded.....	.....	25 "
Gray, earthy limestone.....	.....	2 "
Shaly limestone; much chert.....	.....	20 "
Compact gray limestone.....	.....	10 "
Variiegated clay shale; limy.....	.....	30 "

Spencer, A.C.; ~~op. cit.~~ The geology of Massanutten Mountains in Virginia: 54 pp., Washington, D.C., 1897.

Oriskany Sandstone(?) ^{the} Valley region

Throughout much of Appalachian Virginia, the Helderberg group is overlain by the Oriskany sandstone, which ~~intervenes between the Beecraft limestone and the Onondaga shale.~~ In two of the three exposures of Helderberg rocks that were examined in Fort Valley, no sandstone was found at the horizon of the Oriskany. In ^a ~~one~~ section, however, along the road ~~from~~ ^{to} Dietrich ~~to~~ Woodstock, a thin zone of crumbly, brown sandstone was ~~observed~~ which may correspond to the Oriskany sandstone. The tentative identification is based upon the stratigraphic position of the sandstone, and on ~~the additional fact that~~ ^{a small} prospect pit for brown iron ore, was located within the ~~sandstone outcrop.~~ ^{mountain} Elsewhere in the Massanutten syncline, the Oriskany

In ^{the} (many) parts of Appalachian Virginia, the Oriskany sandstone contains ^{supplies} workable quantities of brown iron ore. (oxide)

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Sandstone is a prominent stratigraphic horizon, attaining thicknesses of from 10 to 40 feet.

Onondaga Shale

about the Heldberg group and

Definition. A thin series of shaly beds ^{shale} at the base of the Romney is thought to be of Onondaga age, corresponding to the Onondaga shale of the northern Appalachian region, and to the Onondaga limestone of New York and Pennsylvania.

Character. The Onondaga shale consists of a thin series of yellowish clay shales, ^{which} These shales weather readily and are soft and relatively unconsolidated. They vary from a buff to a greenish color, ^{gray} and grade upward into the dark ^{Romney} or black shales. of "Romney" age. The formation is not exposed to view within the limits of the Stony Man quadrangle, but ^{Stales} ledges in Fort Valley not far from the ^{northwestern} quadrangle boundary ^{of the} are thought to belong to the Onondaga. Its outcrop is assumed to cross the extreme northwestern corner of the local area but ^{the formation} is not differentiated on the geologic map (Plate I), from that of the "Romney" shale. A maximum thickness of 100 feet is assigned to ^{it} this unit.

Age and Correlation. Elsewhere in Virginia, the Onondaga shale is abundantly fossiliferous, carrying many brachiopods, trilobites, and ostracods. No collections were made of fossils from this formation in Fort Valley, but a typical Onondaga ostracod, Bollia unguis, was identified.

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ostracod

Virginia Resources

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"Romney" Shale

the Romney shale

Although ~~this formation~~ ~~is~~ ~~one~~ of the most conspicuous sedimentary units in the northern Appalachian Valley region, its outcrop in the Stony Man quadrangle covers only a fraction of a square mile in the extreme northwestern corner of the area. (See Pl.)

Definition. The name Romney was originally applied to a

Darton, N.H.; Notes on the stratigraphy of a portion of central Appalachian Virginia; Amer. Geologist, Vol. 10, 1892, p. 17,

black shale of Devonian age, occurring at Romney, Hampshire County, West Virginia. The name, however, has been ~~transferred~~ *applied to similar* from the original locality to shales in many other parts of the Appalachian Virginia, ~~and~~ *Valley region in* It is doubtful if ~~it~~ *the name* has always been properly applied; in fact, it seems likely that many shales designated as "Romney" do not agree, except in physical character, with the true Romney shale. For this reason, the name "Romney" may be considered *used for* a convenient but not *an* exact *in an* ~~appellation~~ *since* for the black shales of Middle and Upper Devonian age.

Character. The local "Romney" shale consists of a thick section of black, fissile, carbonaceous shales that are dark chocolate to black ~~(in color)~~ *they*, but which weather to lighter hues. The shales are fine *grained*, soft, and contain *but little* scarcely any calcareous material. ~~The rock is largely a single unit of shaly material, and weathers to form a poor, unproductive soil.~~ *homotaxious*

Pl. 1105

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Use " - " ?

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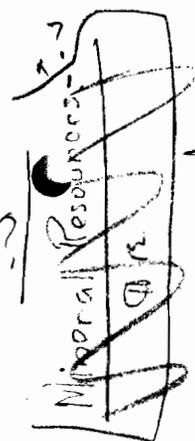
This formation disintegrates readily and hence produces few ~~natural~~ outcrops. ~~Its debris is sterile, and is~~ commonly filled with tiny fragments and splinters of the underlying shale. As a result, the ~~outcrop of the "Romney"~~ ^{it} is largely uncultivated and supports a meager growth of small trees. The formation has been intimately folded, and contains many small folds and faults that are too ^{small} ~~minute~~ to be mapped.

that are not of sufficient size

Thickness. Only the lower ~~part~~ ^Σ of this formation occurs in the Stony Man quadrangle, but its ~~total~~ ^{Thickness} representation in ~~the~~ ^{Mountain} Massanutten ~~Range~~ reaches a maximum of at least 1,000 and probably ^{is} 1,500 feet. No opportunity accurately to measure its thickness ^{was} found, because of the ¹⁰⁷ contorted nature of the ~~exposed~~ shales.

at Butt 500-750-1000

Age and Correlation. The "Romney" shale of the local area is thought to include representatives of the Marcellus, Hamilton, and Genesee horizons of New York ~~State~~. It is sparingly fossiliferous; ~~although~~ brachiopods and other small marine fossils may be found, ~~in exposed ledges~~. The Marcellus member consists of dark ^{color} shales which grade upward into dark-green shales and sandstones. The ~~latter~~ ^{sandstone is} are well exposed in the upper valley of Passage Creek a few miles ^{beyond} from the western ^{side} margin of the quadrangle. Genesee horizons have not been certainly identified, and if present, are associated with Naples (early Portage) ~~blackish~~ shales at the top of the "Romney."



Quaternary Deposits

General Features

quadrangle

The Quaternary rocks of the Stony Man region consist of unconsolidated surface materials, ^{which} they overlie all of the other rock systems ~~which are solidified and highly lithified.~~

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The chief ^{materials} Quaternary rocks are gravels, sands, clays, and associated deposits of recent origin. ^{(See Pls. (See Pls. (Figs. 45, 46).)} These rocks may be grouped into three types: ~~(1)~~ Transported gravel and sand; ~~(2)~~ residual chert, clay, and loam; and ~~(3)~~ calcareous fluvial deposits.

P/s. (AS) (AK)
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222
p 176

Sand and gravel

The gravels and sands are largely composed of the insoluble residue^s of older rocks, together with ^{the} ~~these~~ products of stream erosion which have not been reduced to fine size and washed away in suspension. ^{by local streams} Most of the transported gravels ^{occur} exist ^{as} in alluvial fans, ~~whose location and characteristics have previously been described.~~

secular form

The gravels (which occur) in these deposits are composed of very resistant materials, chiefly sandstone, greenstone, and igneous rocks derived from the Blue Ridge. In the northwestern corner of the quadrangle, they are derived from the Tuscarora sandstone. The fragments are commonly ^{half-rounded} (half-round) ^{resistant} ~~as to~~ sub-round, although some are angular; ² ~~Their~~ shape depending ³ upon ^{distance they have been transported} the ~~length of transportation~~ and the ~~inherent~~ resistance of the rock. The streams along the western foot of the Blue Ridge are choked with boulders of granite and sandstone, and the ^{amount} ~~quantity~~ of alluvial material spread out by these streams is tremendous. ~~(Fig. 108).~~

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rounded vs round

The sand deposits are ^{occasionally} chiefly composed of pure quartz grains derived from the weathering and erosion either of ancient sandstone or of igneous rocks. In some sands derived from the

P/108

crystalline rocks, magnetite is a common accessory, and black grains of this heavy mineral appear as ⁵ ~~placer-like accumulations~~ [?] ~~is concentrated~~ on the surface of the deposits. No magnetite occurs in sands derived wholly from Paleozoic sediments. Smaller quantities of fine detrital material occur with the sands and gravels on the floodplains of Shenandoah River and its larger tributaries. The ~~surfaces of these areas is covered with stream deposits,~~ and a wide fluvial plain occurs immediately south of Luray.

along Hawksbill Creek → Residual materials

The residual soils, chert, clay, and loam, of ~~Quaternary origin~~ are widely developed in the broad area of Page Valley, chiefly on the ~~outcrop~~ of the ^{low and} Cambrian Ordovician limestones. ^{By} Deposits of this type are products of rock decomposition, and when ^{FE} free from chert or other ~~foreign~~ debris are very fertile and productive. The residual clays and loams of the limestone ^{range} vary in thickness from a few inches to tens of feet, and the soil grades imperceptibly downward into a sub-soil that merges in turn with the solid bedrock. ^{Along} On the outcrop of certain zones with the ^{low and} Cambrian Ordovician ^{limestones} large quantities of chert occur, thereby impairing the fertility and ~~productiveness~~ of the ^{Along} local soil. ^{On} the shales of

Silurian and Devonian age, the residual materials are much thinner and are filled with tiny shale splinters that tend to ~~produce~~ induce a sterile soil. ^{affected by} (readily ~~subject to~~ drought.)

The calcareous fluvial deposits consist chiefly of travertine, a secondary formation of calcium carbonate deposited ~~from solution~~ by ^{water} ground and surface waters. The surface ^{deposits} forms are frothy in appearance, and ^{have been developed} develop along the ~~courses of~~ streams that flow for ^{some} distances across limestone ⁵ outcrops.

which form or both?
See maps

Deposits
Accumulations
Sorts
Materials
Soils

(some)

0.06
24
drought

some is considerable

NOT possible

absolutely

Caution

The [?]sub-surface forms include the ~~(many underground)~~ deposits ^{below the surface} ~~of stalagmites and stalactites in the local caves (and caverns)~~

The beautiful "formations" of Luray Caverns are of Quaternary age. ~~(Figs. 55-58)~~ (See Pls. ^{Fossils})

Few fossils have been observed in the Quaternary deposits of this region. A few snail shells and plant leaves occur in the larger masses of ^{surface} travertine, and occasionally bones or other remains of ancient mammals are found in the ~~residual clays or transported~~ surface deposits of northern Virginia, ^{but} ~~None of the latter, however,~~ has been reported from this ^{area} region. Flints made by the Indians are occasionally found in Quaternary deposits but ^{they} are of comparatively recent origin.

More detail?

Pls. (56-63)

3

3

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