C A C A P O N S A N D S T O N E

[Roy Jay Holden]

[1930?]

See

1) Va Acad Sci Proc 1929/30 p. 23

2) R1034

Cacapon Sandstone

The Cacapon sandstone as a formation name was first used by Darton and Taff 1./ in 1896 in the Piedmont folio for a red

1./ Darton, N. H. and Taff, J. A. (1896), Piedmont Folio, W. Va. - Md., U. S. Geol. Sur., Geol. Atlas, Folio 28.

Silurian sandstone which overlies the white Massanutten Medina and underlies the white Rockwood (Clinton). Darton later used this name in the Franklin folio (No. 32) the Monterey folio (No. 61). This red sandstone is present in the Staunton quadrangle but in the Staunton folio (No. 14), published in 1894, Darton did not map it as a separate unit. He maps the Cacapon sandstone on Sideling Hill and in Jack Mountain, which occur on the eastern side of the Monterey quadrangle and extend northeastward into the Staunton quadrangle, and therefore recognizes that this formation is present in the Staunton quadrangle.

This formation is composed chiefly of ferruginious sandstone, but in places includes considerable brown shale, particularly in the lower portion. The sandstone is dark red and contrast strongly with the overlying and underlying white sandstones and is, therefore, an excellent lithologic marker separating these two similar formations.

The position of its outcrop in the topography is near the crest of the ridges. Both of the white sandstones are somewhat more resistant to erosion than the Cacapon and, accordingly, it is one of these which forms the actual crest with the Cacapon, forming a sloping bench on one side of the crest.

This formation not only extends across the northwestern portion of the State through a distance of more than 300 miles, but is present in the adjacent portion of Tennessee and extends

northwestward into West Virginia and possibly also into Maryland and Pennsylvania. Southwest of New River it diminishes in thickness and throughout southwestern Virginia it is so thin that it has either not been recognized or in previous mapping has not been regarded of sufficient importance to consider it a separate formation. Northeast of New River it is a conspicuous feature in most of the Alleghany ridges which carry beds of Silurian age. Its greatest known development is in Bath County, Virginia, where it has thicknesses up to 630 feet. It is known to be present in the West Virginia counties of Monroe, Greenbrier, Pocahontas, Pendleton, Grant, Hardy, and Mineral.

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The description of this formation given in the Piedmont folio is, in part, as follows:

"This sandstone (Cacapon) is a red, flaggy rock, somewhat similar to the sandstone of the Juniata formation, and of a brighter red-brown color,------ The thickness of the sandstone averages about 300 feet, as nearly as could be estimated from a number of partial measurements. No complete cross-section exposures were found."

The description given in the Franklin folio is as follows:

"This formation is a thin series of red beds overlying the Tuscarora quartzite.-----. The beds consist of hard, thin-bedded, deep reddish-brown sandstones with occasional thin intercalations of red or buff shales. Usually the sandstones are slabby and weather in fragments from 1 to 2 inches in thickness, but some of the beds are somewhat more massive. The thickness varies considerably, lessening toward the southwest. Owing to scarcity of continuous exposures across the formation, but few measurements were made and these were only approximations. The thick-

ness appears to be about 350 feet in the vicinity of Elkhorn Rock, but it is less in the Long Ridge ranges. Just east of Hopeville the thickness is estimated at 300 feet, and it may be slightly greater in a gap 6 miles south. In the vicinity of Mackville it is very much less, but no fair approximation could be made. Six miles south of Circleville a fairly satisfacotry estimate was 135 feet.

The Cacapon sandstone usually outcrops in a talus of slabby red sandstone fragments with a few scattered exposures of the middle and lower beds. Sometimes the sandstones are so red that they are thought to be iron ore, but their sandstone nature is clearly evident throughout."

The description given in the Monterey folio is in part as follows:

"This formation is a series of red, flaggy beds overlying the Tuscarora quartzite,----- The rock consists of hard thin-bedded, deep reddish-brown sandstone with thin intercalations of red or buff shales. The sandstones are slabby and weather out in fragments from 1 to 2 inches in thickness, but occasionally some of the fragments are more massive. The thickness varies considerably, lessening locally at a few points. Owing to the scarcity of continuous exposure of the Cacapon formation, only a few precise measurements were made, but fairly frequent approximations were practicable. The least thickness observed from the north was in Vanderpool Gap where there are about 400 feet of red sandstone with intercalated gray and buff shales, overlying the Tuscarora quartzite. In the gorge east of Crabbottom post-office the thickness is about 550 feet. In the gorge of Crab Run, across the north end of Bear Mountain, the

thickness appears to be 500 feet, but possibly some of the reddish lower beds belong to the Tuscarora formation.

In the Little Mountain ridge west of the Crabbottom Valley the thickness appears to diminish rapidly to the southward, and although the exposures in Mill Gap and Lower Gap are not decisive there appear to be less than 100 feet of the Cacapon beds in the section. In the ridges west of the Warm Spring Valley, Cacapon exposures are in most cases unsatisfactory, but the formation is seen to have thickened again. The most complete series of outcrops is in the gap west of Hot Springs, where there are exposed above the Tuscarora quartzite 630 feet of Cacapon beds, comprising 60 feet of red and brown slabby sandstones, 20 feet of olive shale, and 50 feet of red slabby sandstone, merging upward into 265 feet of shales with red sandstone intercalations, and these in turn giving place to 240 feet thick, red, slabby beds at the top of the formation. The unusual thickness of the formation in this vicinity appears to be due to the 265 feet of shaly beds, which were not observed to be so thick elsewhere. The formation is thick on Warm Springs Mountain, extending to the crest at some localities and covering a wide area on the slopes of Little Piney and Little Mare mountains.

At Panther Gap the formation consists of 150 feet of red slabby sandstones with thin beds of shale partings and a 15-foot bed of buff shale at the top, 165 feet in all. The overlying gray sandstone and shales are classified as a portion of the Rockwood formation."

In the Pocahontas, Tazewell, Bristol, and Estillville folios, which describe quadrangles in southwestern Virginia, there is no mention of any red sandstone in the position of the Cacapon

although that formation is generally present in these regions, and is conspicuous in the Pocahontas quadrangle.

In the Morristown folio, which describes the quadrangle in Tennessee contiguous to the southwestern portion of Virginia, Arthur Keith describes as a part of the Clinch sandstone a few beds of red sandstone. It is possible that these are to be correlated with the Cacapon.

In the Mercersburg-Chambersburg folio, which describes a quadrangle in Pennslyvania, located a short distance northeast of Frederick county, Virginia, G. W. Stose says that the Cacapon sandstone is not recognizable in that quadrangle and that this formation is represented by a part of the Clinton shale of that region. However at the approximate position of the Cacapon he describes a red sandstone, and the description tallies with that of the Cacapon.

He said,

"About 100 feet below this sandstone Clinton quartzite is a zone of red sandstone and quartzite, the chief bed of which is a compact red quartzite with conchoidal fracture, so hard and massive as to form minor ridges on the mountain slope. This bed is sufficiently ferruginous elsewhere in Pennsylvania to be an ore of iron and is described in the reports of the Second Pennsylvania Geological Survey under the name 'block ore'. There are other thin-bedded red sandstones containing shale pebbles and pebble casts interbedded in the shale. These layers form thin slabs with shiny red surfaces on which are numerous unidentified trails of animals or plant impressions and a variety of other peculiar markings, some of which resemble mud flows,

small ripple marks, and raindrop impressions."

The field studies by the writer on the Cacapon were for the purpose of finding out the possibilities of iron ore in it, and not for the purpose of measuring the thickness of the formation nor for mapping its limits. Consequently satisfactory data is not at hand for describing its thickness and distribution as a formation. The following statements are based on descriptions published by others, on the detail fragmental sections given below and on other random observations by the writer.

The Cacapon sandstone outcrops chiefly between the great limestone valley and the eastern border of the flat lying sediments of the coal fields. Rarely does the outcrop have any considerable breadth. It appears chiefly in the crests of mountain ridges with outcrops a few rods wide. In the southwestern part of the State in Lee county it has been recognized only in two ridges about two miles apart. In the region of Bath county this distance becomes forty miles. In the vicinity of Frederick county it is also forty miles.

This formation was once a flat lying sediment and has attained its present attitude by faulting and folding. On the borders of the areas of its outcrop the beds are generally not appreciably thinner and the attitude also shows that they now extend, or formerly extended, farther to the northwest and to the southeast than the present positions of their outcrops. In consequence of crustal shortening both by folding and by thrust faulting the width of the area over which the Cacapon now outcrops has been materially reduced over the width of the area in which this formation was laid down as a flat-lying sediment.

In the mountains bordering the great limestone valley on the northwest, the Cacapon is generally present and is commonly dipping to the southeastward under other formations. Apparently it never extended far to the southeast of the northwestern side of the limestone valley, as it is generally absent in the Valley ridges which carry other Silurian formations. It is absent from Cove mountain north of Wytheville and from the Draper mountain anticline. In the Roanoke Mountain syncline it has not been seen in position but talus fragments occur near the point where the State highway crosses the western ridge of this structure. Along this highway there are nearly continuous exposures of the Silurian white sandstone, and there is no place for more than a thin thickness of the Cacapon. It has not been recognized in the Massanutten Mountain syncline. However, in Botetourt County it is present in the Purgatory Mountain syncline. Here it is strongly developed within two miles of the Cambrian ridges of the Blue Ridge. This is the most southeasterly outcrop of the Cacapon and lies ten miles to the southeast of the northwest border of the Great Valley. It has not been recognized in the Massanutten mountain syncline. However, in Botetourt county it is present in the Purgatory mountain syncline. Here it is strongly developed within two miles of the Cambrian ridges of the Blue Ridge. This is the most southeastly outcrop of the Cacapon and lies ten miles to the southeast of the northwest border of the great valley.

On the northwestern border of the area of Cacapon outcrops the northwesternly limits of the formation are, in general, less definite. In Lee county it is definitely absent from the foothills of the Cumberland mountain and its most northwesternly outcrop is seven miles to the southeast of the Cumberland Front.

At the lower narrows of the New River in Giles county it is strongly developed in Peters mountain on the Virginia-West Virginia state line. In Pocahontas county, West Virginia, it is present in the Browns mountain anticline and dips northwestward under younger sediments. In Pendleton county, West Virginia, and in the southern part of Grant county, West Virginia it outcrops along the North Fork of the Potomac in thicknesses of 100 to 300 feet dipping northwestward under younger sediments. In the central and northern parts of Grant county, and in the southwestern part of Mineral county, West Virginia, it is present along New Creek mountain, dipping under the Alleghany Front with a thickness of 300 feet.

The Cacapon has not been sufficiently studied to give its distribution in Virginia in detail, but in general the location and character of its chief outcrops by counties in Virginia are outlined below.

The Cacapon is present in Wallen Ridge and in Powell mountain in Lee county. At Hunter Gap, five miles southeast of Jonesville this formation has a thickness of 47 feet, but carries few ferruginous beds.

In Scott county the Silurian is present only in the southern part of the county in Clinch mountain. The Cacapon is either absent from this series or is so thin that it has not been recognized.

In western Washington county the Cacapon seems to be likewise absent from Clinch mountain. Two miles north of Mendota near the top of the Clinch sandstone there are a few red beds, which may possibly represent the Cacapon. In northern Washington county the Cacapon appears to be present in Clinch mountain in

small thicknesses. Seven miles west of Saltville, there are red sandstone beds with a thickness of 3 feet, which were considered as belonging to the Cacapon. The limits of these beds were not seen and the total thickness is probably greater.

In southern Tazewell county in Short mountain, a spur of Clink mountain, there are heavy red sandstone beds with a thickness of 4 feet. These have the typical appearance of the Cacapon and quite clearly represent that formation. In central Tazewell county in the crest of Paint Lick mountain there are 20 feet of strata, chiefly red sandstone, which clearly belong to the Cacapon. In eastern Tazewell county the Cacapon may be expected in East River mountain, in Buckhorn mountain, in Rich mountain, and in Garden mountain.

In Bland county it is present in East River mountain. Three miles south of Bluefield it has a conspicuous outcrop and has a probable thickness of thirty feet or more. In southern Bland county, eight miles north of Wytheville, it is present in Walker mountain with a thickness of about 10 feet. It may be expected in Round mountain, in Rich mountain, and in Buckhorn mountain, and with stronger developments in the northern ridges of the county than in the southern ridges.

In Giles county it is present in both the upper and lower narrows of the New River, and, in general, in these mountains which form the serrate border mountain of the transverse valley of New river. In the upper narrows it is present in Gap mountain and in Spruce Run mountain. In the Gap mountain the total thickness of the Cacapon is 71 feet. Eight miles southwest of the upper narrows in the Little Walker creek gap, the Cacapon shows a total thickness of 51 feet. In the lower narrows in

Peters mountain the full section is also exposed and shows a total of 154 feet.

In Montgomery county it is known only in the northern border of the county in Sinking Creek mountain.

In Craig county it is present in Sinking Creek mountain, in Bald mountain, and in Potts mountain, and may be expected in Johns Creek mountain.

In Roanoke County in Cove mountain on the northern border of the county there is a talus of red sandstone. Local residents report the red sandstone present in position in quantity in the crest of the mountain. In Catawba mountain where the highway crosses between Catawba and Masons Cove the Cacapon is shown by talus blacks.

In Botetourt county it is present in the southern border of the county in Purgatory and Mays mountains, and in a number of smaller mountains on the north of these. In the Roaring Run gap of Mays mountain it is chiefly thick-bedded sandstone, the exposed thickness being 77 feet, with the top concealed. In the Eagle Rock gorge there is exposed 8 feet of thick-bedded red sandstone. It is also present in North mountain and in Rich Patch mountain. In the Roaring Run gap of the latter mountain there is an exposed thickness of 156 feet with the top of the formation concealed.

In Alleghany county it occurs in Potts mountain, in Sweet Springs mountain, in the Rich Patch anticline, in several small mountains to the east and northeast of Covington, in North mountain, and in Mill mountain. In Laurel Ridge on the northern line of the Rich Patch anticline, the Cacapon has a thickness of 133 feet.

In Rockbridge county it occurs in Little North mountain, in Brattans mountain, in North mountain, in Mill mountain, and in Sideling Hill. In the North River gap of Little North mountain there is a thickness of red sandstone of about 30 feet. In the gorge where this same stream flows through Brattans mountain there is a thickness of 124 feet. In Panther Gap of Mill mountain two miles north of Goshen there is a thickness of 53 feet, which is largely red sandstone. Darton gives a total thickness of the Cacapon in Panther Gap as 165 feet.

In Augusta county the Cacapon is present in Little North mountain, in Sideling Hill, and in Walker mountain. In Buffalo Gap of Little North mountain there is a thickness of about 13 feet.

In Bath county it is present on the southern border of the county in Mill mountain, in Sideling Hill, and in Walker mountain. It occurs on the crest of Tower Hill. It is present on both limbs of Hot Springs and the Back Creek anticlines. In Warm Springs mountain immediately south of Warm Springs the writer measured 120 feet of the Cacapon with the base of the formation not exposed. On the northern limb of the Hot Springs anticline, Darton gives 630 feet as the total thickness.

In Highland county the Cacapon occurs on both limbs of the Wilson Run, and of the Back Creek anticlines. Darton gives thicknesses of from 400 to 500 feet for these occurrences.

In Rockingham county the Cacapon sandstone is probably present in Little North mountain, but the characteristic red beds are almost wanting. In Brooks Gap there is to be seen a thickness of red sandstone of only two feet.

In Shenandoah county the Cacapon sandstone is probably

present in Little North mountain and in the small mountains in the northern corner of the county, but probably only in meager development.

In Frederick county it has been seen by the writer only in Great North mountain, and here in only scanty development. In Buck Run Gap there is a definite thickness of 22 feet.

The following detailed sections of the Cacapon were taken by the writer with the specific purpose of determining the possibility of minable iron ore in this formation. The red sandstones of the Cacapon had been prospected in various places for iron ore and many inquiries came to the writer as to the iron ore possibilities in these beds. Prior to studying these sections in datail these red beds impressed the writer as being an iron cemented sandstone which had little possibility as an iron ore. In order that this should not be a mere matter of judgement as to the iron content, the redder beds were sampled in considerable detail. The samples were generally taken in the form of chips about one inch in diameter from the outcrop rock. In its best development the individual red beds of this formation have thicknesses of one foot or more. Such beds are generally of fairly uniform composition. Where such is the case, and where the beds seem to have only moderate iron content, only a few chips were taken for each bed. Where the iron content seemed high, the chips were taken at one-inch to two-inch intervals. The iron determinations on these samples were made by Penniman and Brown of Baltimore.

Lee County

Hunters Gap, Powell Mountain

This section is located on the southeastern slope of Powell mountain 5 miles southeast of Jonesville. Strata above the 3 foot red sandstone were concealed.

Thickness Feet	Inches	Kind of Rock	Percentage of metallic iron
3		red sandstone	8.10
6		thin bedded and shaly sandstone	
1		red sandstone	5.67
10		thin bedded shaly red sandstone	
	8	red sandstone	4.08
8		shale with stem like structures and track like impressions on ripple marked surface of basal beds.	
1		red sandstone	4.95
14		shaly and concealed	
2		shale	
1	6	limonitic, with one third inch oval cavaties	
40		Clinch sandstone white 2" to 8" bedded	
15		Clinch sandstone white thicker bedded, contains Arthrophycus harlani,- forms the crest of Powell mountain.	

Lovelady Gap

This section is located in the eastern end of the county near Lovelady Gap on the southeast side of Wallen Ridge about 4 miles west of Jasper. The strata above and below these 4 feet were concealed.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
1		red sandstone	10.95
1		red sandstone	11.16

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
1		red sandstone	11.12
1		red sandstone	10.33

Tazewell County
Short Mountain

This section is located in the southern corner of the county on top of Short mountain, a spur of Clinch mountain, 6 miles south of Pounding Mill. The outcrop has a thickness about ten feet of red sandstone. The samples were taken from the upper beds of the outcrop.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
	10	red sandstone	16.85
	10	red sandstone	15.43
	4	red sandstone	15.51
	8	red sandstone	15.13
	8	red sandstone	14.55
	8	red sandstone	11.42

Paint Lick Mountain

This section is located in Tazewell county on the crest of Paint Lick mountain three quarters of a mile west of the highway and 2 miles southeast of Pounding Mill. The strata above the 25 feet concealed are Rockwood. The 20 foot red sandstone belongs to the Cacapon. The details of the Cacapon in this mountain are given in the two sections following.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
5		white conglomeratic crossbedded sandstone	
	6	gray shale	
		ferruginous shale	
	11	red shale used for paint	

Thickness Feet	Inches	Kind of rock
1	10	gray shale
	1	ferruginous shale
	7	yellowish white sandstone
25		concealed
20		red sandstone

Paint Lick Mountain

This section is located on the crest of Paint Lick Mountain about 2 miles southeast of Pounding Mill and adjacent to the highway. This section is taken from a natural outcrop in gently dipping strata. The limonitic beds are probably altered carbonate.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
1	8	red sandstone	18.87
1	8	red sandstone, limonitic	17.57
1	8	red sandstone	13.39
1	8	red sandstone, limonitic	13.87
1	8	red sandstone, limonitic	9.88
2	4	thin bedded, shaly	
6		concealed	
1	8	red sandstone	20.67
1		red sandstone	19.48
2		reddish sandstone	

Paint Lick Mountain.

This section is located on the crest of the west end of Paint Lick mountain on the property of Geo. W. Gilespie. There is a continuous exposure in a prospect trench 30 feet long by 3 feet deep. The upper portion of the section down to the 2 feet concealed is Cacapon, while the beds below this are considered as belonging to

the Clinch. This section shows 19 inches of beds which leave sufficient iron to make them an ore

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
2	2	whitish sandstone	
2	5	red shaly sandstone	
3	10	partly concealed, shaly	
	4	red sandstone	23.41
	5	shale	
	2	red hematite	46.59
	5	red hematite	42.03
	4	red hematite	46.25
	2	red sandstone	26.78
	5	shaly	
	11	concealed, probably shaly	
	4	red sandstone	24.83
	4	shaly	
5		concealed	
	5	red sandstone	16.54
	6	red sandstone	11.84
1	1	red sandstone	14.63
	2	red sandstone	27.08
	8	red sandstone	39.08
2		concealed	
5		white quartzite and sandstone	
3		concealed	
2		pinkish sandstone	

Wythe County

Cove Mountain

In the gap of Cove mountain 3 miles north of Wytheville there is no trace of the material which resembles the Cacapon. This section in continuous exposure shows.

51 feet	Sandstone and flint (Giles formation)
183 feet	White sandstone in one foot beds
44 feet	White sandstone with interbedded red sandstone

In this section there is no trace of the Rockwood shale which is present in the upper narrows section 31 miles northeast of this point. The 183 feet represents the Rockwood or Rockwood and Clinch. The 44 feet is Clinch or transition beds to the Bays.

Bland County

In Walker Mountain 5 miles north of the preceding section the Cacapon is well developed but unfavorable for measuring. Some of the beds are limonitic. The thinning of the Cacapon to the southeast is not as striking as these two sections would indicate as these two points were formerly farther apart as a thrust fault of some magnitude lies between them.

Pulaski County

Little Walker Creek

This section is located on the Giles county line in the Little Walker Creek Gap of Walker mountain, 8 miles northeast of Dublin. The section and samples were taken in the creek bed. The shale at the top is considered Rockwood and white sandstone at the base is considered Clinch. This gives the total thickness of the Cacapon as 54 feet. The striking feature here is the relatively high iron content of the series. The most significant feature is the 4 inches of iron carbonate.

Thickness Feet	Inches	Kind of Rock	Number of pieces in sample	Percentage of metallic iron
		shale		
4		red sandstone		
1	7	red sandstone	6	18.34
1		red sandstone	1	17.40
2		red sandstone	1	19.78
2		red sandstone	1	23.69
	8	red sandstone	5	21.07
25		red sandstone and shale 1" to 4" beds		
	6	white sandstone		
	9	red sandstone		
	5	red sandstone	3	24.36
	10	red sandstone	8	25.72
1	7	red sandstone	12	24.08
	11	red sandstone	10	25.98
	4	iron carbonate	1	53.91
1	10	whitish gray fine grained sandstone		
1	10	shaly sandstone, thick bedded		
1	1	reddish white sandstone		
3	3	red sandstone 4" beds		
1	4	red sandy shale		
3	3	shaly sandstone, thinbedded		
2	6	white sandstone		

Giles County

Lower Narrows of New River

This section is located in the New River Gap of East River - Peters mountain 14 miles northwest of the preceeding section. The Rockwood is not given in the table below but is to be seen in the section.

It consists of a thickness of 145 feet of strata which is chiefly white sandstone. Near the top there is four feet of reddish sandstone. Twenty-five feet from the bottom there is eight feet of shale and thin bedded sandstone. All of the table below down to the 180 feet of Clinch is Cacapon

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
1		red sandstone	22.68
1	1	red sandstone	18.24
3	7	reddish gray sandstone with some shale	
	7	red sandstone	14.29
1	1	red sandstone	14.17
	6	red sandstone	12.99
	9	red sandstone	16.27
1	2	shale and thin bedded red sandstone	
	9	red sandstone	19.37
	10	thin bedded red sandstone and gray shale	
	5	red sandstone	15.09
	4	red sandstone	11.46
2	11	thin bedded red sandstone and shaly sandstone	
	4	red sandstone	11.47
	6	gray shale and sandstone thin bedded brown sandstone and gray shale	
	1	red sandstone	19.90
	5	shale	
	1	red sandstone	19.56
2	8	thin bedded brown sandstone and gray shale	
	5	red sandstone	19.36
1	7	thin bedded sandstone and shale	

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
	5	red sandstone	15.70
2	4	shaly sandstone	
	8	red sandstone	19.06
1	1	gray shale	
	3	red sandstone	15.78
	1	gray shale	
	2	red sandstone	15.36
1	7	gray shale	
1	2	gray shale and thin bedded sandstone	
	6	red sandstone	16.01
	10	red sandstone	19.14
2	11	gray shale and thin bedded reddish sandstone	
1	2	red sandstone	7.98
	10	red sandstone	20.36
55		gray shale with a few thin beds of gray sandstone	
3		thin bedded gray sandstone	
1	9	gray shale	
7	6	shaly sandstone	
11		shale	
4		gray and red sandstone, thin bedded	
3		shale and red sandstone	
1	3	red sandstone	20.51
	4	red sandstone	20.06
1	8	red sandstone	19.86
12		concealed	
14		gray shale and sandstone	
1		reddish sandstone	

Thickness Feet	Inches	Kind of Rock	Percentage of metallic iron
2		shale	
180		Clinch sandstone, a grayish white sandstone., thick to thin bedded with a few bands of conglomerate sandstone and with one foot of grayish-black shale near the middle.	

Montgomery County

Upper Narrows of the New River, General Section

This section is located at the common corner of Montgomery, Pulaski, and Giles Counties in the upper narrows of New River, where that stream cuts through Walker-Gap mountain. This is the most complete section known to the writer in the state of Virginia. With the exception of the 64 feet of Lewistown limestone there is a continuous exposure from the Romney to the 50 feet concealed at the base of the Clinch. From the base of the Lewistown limestone to the top of the 32 feet of red sandstone there is 246 of Rockwood. From the base of the Rockwood to the top of the 7 feet of white sandstone there is 71 feet of Cacapon. Below the Cacapon there is 172 feet of Clinch sandstone. The pinkish sandstone underneath the 50 feet concealed is the Bays. The section below gives details of the Cacapon.

Thickness Feet	Kind or rock	Formation
	Black shale	Romney
27	Porous sandstone	Oriskany
64	Concealed	Lewistown
77	White sandstone	Rock-wood
24	White sandstone, thick bedded, resistent to weathering.	
59	White sandstone similar to the 55' below but less resistant to weathering.	

Thickness Feet	Kind of rock	Formation
55	White sandstone, thick bedded	
16	White sandstone, thin bedded, with some shale.	Rockwood
15	Shale with thin beds of white sandstone.	
32	Red sandstone, thick bedded, thin bedded or shaly	
18	Shale with few beds of red sandstone	Cacapon
17	Fine grained sandstone, bedding indistinct, red with irregular yellowish gray patches.	
4	Whitish sandstone with vertical red structures.	
7	White sandstone 4" to 10" beds	
22	Shaly sandstone	
45	White sandstone, thick bedded	Clinch
6	White sandstone, thin bedded	
82	White sandstone, thick bedded	
50	Concealed	
20	A sandstone, dark pinkish, cross bedded.	Bays

Upper Narrows of New River, Detail of Cacapon

This section shows the Cacapon of the above general section in more detail and gives the iron percentages.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
2		red sandstone	16.59
2		red sandstone	14.98
1		red sandstone	17.78
	6	gray sandstone	
	3	shale	
2		red sandstone, thin bedded	20.54

Thickness Feet	Inches	Kind or rock	Percentage of metallic iron.
1		red sandstone, thin bedded	22.19
1	5	red sandstone	16.52
	6	pale red sandstone	
1		red sandstone, thick bedded	13.96
2		red sandstone, thick bedded	15.25
2		red sandstone, thick bedded	21.03
2		red sandstone, thick bedded	21.19
2		shale	
1		red sandstone	19.97
	6	shale	
	4	red sandstone	22.65
	6	pink fine grained sandstone	
1		red sandstone	25.41
1		red sandstone	22.97
2		shale	
2		red sandstone	24.36
2		red sandstone	21.32
1		red sandstone	21.74
11	8	shale with a few beds of red sandstone	
	4	red sandstone	19.54
14		shale and red sandstone	
	1	red sandstone	10.69
7		variegated red and white sandstone	
1		red sandstone	12.10
4		variegated red and white sandstone	

Botetourt County

Mays Mountain

This section is located on the western limb of the Mays

mountain anticline 4 miles southeast of Saltpeter Cave in the gorge of Back creek north of Rich Hill. The outcrop is continuous over the thickness sampled. The base of the Cacapon is definitely marked by the variegated sandstone. The upper bed sampled is probably near the top of the formation and the 40 feet concealed presumably represents chiefly Rockwood shale.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
40		White sandstone, Rockwood, concealed	
1	1	red sandstone thick bedded	14.60
2	2	red sandstone thick bedded	18.13
3	3	red sandstone thick bedded	16.49
2	2	red sandstone thick bedded	17.28
2	5	red sandstone thick bedded	16.75
1	1	red sandstone	15.44
1	1	red sandstone	16.21
2	6	red sandstone thick bedded	16.56
2	2	red sandstone thick bedded	15.39
1	1	red sandstone thick bedded	16.03
2	2	red sandstone thick bedded	17.99
1	4	red sandstone thick bedded	17.14
2	11	red sandstone thick bedded	15.03
2	2	red sandstone	14.82
2	2	red sandstone	13.61
	9	red sandstone	14.82
4	10	red sandstone	15.66
2	2	red sandstone thick bedded	16.81
2	2	red shaly sandstone	

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
5	5	red sandstone thick bedded	15.06
1	5	red sandstone	17.06
27		concealed	
1	10	grayish white sandstone	
2	6	sandstone, variegated red and white with vertical structures.	

Eagle Mountain

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron.
5	5	red sandstone thick bedded	15.06
1	5	red sandstone	17.06
27		concealed	
1	10	grayish white sandstone	
2	6	sandstone, variegated red and white with vertical structures.	

Eagle Mountain.

This section is located 6 miles northwest of the preceeding section on the southwest side of the James River gap at Eagle Mountain. Sampled from continuous outcrop of beds 2 to 5 inches thick. The upper and lower limits of the formation were not located.

Thickness Inches	Kind of rock	Percentage of metallic iron.
10	red sandstone	13.38
10	red sandstone	14.67
10	red sandstone	13.68
10	red sandstone	12.72
10	red sandstone	12.81
10	red sandstone	11.55
10	red sandstone	2.46
10	red sandstone	7.97
10	red sandstone	12.91
10	red sandstone	6.97

Roaring Run Gap

This section is located on the southeast slope of Rich Patch mountain 8 miles northeast of the preceeding section. The upper limit of the Cacapon is in the 29 feet concealed. The base is formed by the 3 feet of variegated sandstone.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
		White sandstone, Rockwood	
29		concealed	
5		red sandstone	7.33
3		reddish shaly sandstone	
20		brown shaly sandstone	
3		red sandstone	16.36
3		red sandstone	12.85
4		red shaly sandstone	
3		red sandstone, cross bedded 20°	4.83
3		red sandstone, thick bedded	6.85
6		red sandstone, thick bedded	15.88
3		red sandstone	17.60
2	6	red shaly sandstone, thin bedded	
20		gray shale and sandstone	
18		concealed	
1		red sandstone	17.39
3		red crumbling shale	
1	6	red sandstone	16.39
6		red sandstone	17.85
3		red sandstone, thin bedded	
3	2	red sandstone	17.82
3		red sandstone, thin bedded	16.27
6		red shale and sandstone	
3		red sandstone in 5" beds, ripple marked	19.21
2	6	red crumbling shale	
10		gray shale with traces of fossils	
1		red shaly sandstone, cross bedded	

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
10		pinkish sandstone	
3		sandstone, variegated red and white with vertical structures.	
58		gray shales and sandstones	
		White sandstone, Clinch	

Alleghany County

Rich Patch, Laurel Ridge

This section is located about 4 miles southeast of Covington and 2 miles southwest of Rich Patch mines.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
		White sandstone	
1	6	iron ore Rockwood	
23		shale	
2		red sandstone, thick bedded	11.03
2		red sandstone, thick bedded	12.76
4		red sandstone, thick bedded	16.38
3		red sandstone, thick bedded	10.91
2		red sandstone, thick bedded	11.66
3		red sandstone, thick bedded	9.78
3		red sandstone, thick bedded	11.16
2	2	red sandstone, thick bedded	11.97
3		red sandstone, thick bedded	13.93
3		red sandstone, thick bedded	14.65
1	6	red sandstone, thick bedded	14.78
4		red sandstone thick bedded	12.83
2		red sandstone, thin bedded	8.96
3		red sandstone, thin bedded	14.49
45		concealed, probably gray shale	

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
3		red sandstone	16.66
3		red sandstone	13.93
4		red sandstone	15.15
3		red sandstone	12.17
25		shaly red sandstone	
3		red sandstone	18.74
3		red sandstone	17.79
3		red sandstone	15.19
3		red sandstone	15.78

Augusta County

Buffalo Gap

This section is located in Buffalo Gap of Little North mountain 10 miles west of Staunton on the east side of the gap.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
3		brown shale	
1	4	red sandstone	5.32
7		gray shales with few fossils and 2" beds of red sandstone	
2		red sandstone thick bedded	7.57
2	2	red sandstone thick bedded	10.57
8		concealed	
15		brownish shale with 3" to 8" beds of gray sandstone	
25		Clinch white sandstone thick bedded	

Buffalo Gap

This section is across the gap from the previous section and 15 rods west of it.

Thickness Feet	Kind of rock
160	White sandstone, Rockwood
93	concealed
10	gray sandstone, thin bedded and gray shale
3	shaly pinkish sandstone
5	pinkish sandstone
6	red and gray sandstone, 3" to 4" beds.
	Cacapon red sandstone, thick bedded
10	shale with abundant pelecypods and brachiopods concealed
	Thrust fault with the above on the Lewistown. limestone.

Rockbridge County

Goshen Pass No. 1

This section is located 4 miles southeast of Goshen in Goshen Pass of Little North mountain about a mile from the north-east end of the pass in the bed of North River in gently dipping strata.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
100		white sandstone, Rockwood	
3		red sandstone, folded	
1		red sandstone	14.96
1		red sandstone	15.20
1		red sandstone	10.73
6		concealed	
1	2	red sandstone	9.93
1	8	red sandstone	11.55
1		red sandstone	10.31
1	2	red sandstone	10.94
	8	red sandstone	10.49

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
	10	red sandstone	9.66
1		red sandstone	9.93
		close folding, thickness doubtful	
1	2	red sandstone	8.75
	10	red sandstone	10.09
1	11	red sandstone	12.07
1	4	red sandstone	11.59
1	2	red sandstone	9.93
	10	red sandstone	10.73
1	1	red sandstone	11.85
1	5	red sandstone	11.51

Goshen Pass, No. 2

This section is located in Goshen pass one half mile northeast of the preceeding section in strata dipping 60° to the northwest.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
3		red sandstone	5.09
32		concealed	
2		red sandstone	7.17
8		concealed	
2		red sandstone	5.19
23		concealed	
1	6	red sandstone	13.21
	10	red sandstone	15.71
	5	red sandstone	13.03
	10	red sandstone	13.36
24		concealed	
2		red sandstone	11.18

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
1		concealed	
2		red sandstone	10.82
3		red sandstone	12.15
2		red sandstone	10.45
1		red sandstone	11.85
2		red sandstone	11.91
10		concealed	
3		red sandstone	12.84
58		concealed	
		white sandstone, meager outcrop probably Clinch	

Panther Gap

This section is located 2 miles northeast of Goshen in Panther gap of Mill mountain on the southeast side of Mill creek in strata dipping 43° to the southeast.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
3	4	red sandstone, cross bedded 20°	8.97
1		red sandstone	8.97
3	4	red sandstone	8.27
10		concealed	
2		red sandstone	9.54
2		red sandstone	9.80
3		red sandstone, thin bedded	11.09
5		red sandstone, thin bedded	9.99
4		red sandstone, thicker bedded, cross bedded	8.61
9		concealed	
4		red sandstone, thick bedded	13.48
3		pinkish sandstone	

Bath County

Warm Spring Mountain

This section is located 2 miles southeast of Warm Springs on the southeast side of Warm Spring mountain adjacent to the highway.

Thickness Feet	Inches	Kind of rock		Percentage of metallic iron.
10		thick bedded white sandstone		
8		concealed		
4		thick bedded white sandstone		
25		concealed	Rockwood	
24		thick bedded white sandstone		
20		concealed		
10		gray shale		
1		red sandstone thinbedded		15.59
2		red sandstone thin bedded		
1		red sandstone thin bedded		13.58
2	2	red sandstone thin bedded		15.75
2		red sandstone thin bedded		15.63
1		red sandstone		16.76
1	6	red sandstone thick bedded		17.18
1	10	red sandstone thick bedded		16.78
1		shaly red sandstone		
	10	red sandstone		18.46
1		concealed		
1	2	red sandstone, somewhat shaly		16.35
1	10	red sandstone		18.13
1		red sandstone		18.62
1	8	red sandstone		17.52
2		concealed		
1	8	red sandstone		18.06

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
1	5	red sandstone thick bedded	16.86
1	6	red sandstone thick bedded	16.17
5		concealed	
1		red sandstone	16.46
75		brown shale with few fossils	
1		red sandstone	14.81
6		concealed	
1		red sandstone	11.29
2		red sandstone	10.72

Rockingham County

Brock's Gap

This section is located 4 miles northwest of Broadway in Brock's gap of Little North mountain. the 96 feet and the 534 feet of limestone belong to the Lewistown limestone.

Thickness Feet	Kind of rock	Percentage of metallic iron
35	Oriskany sandstone	
20	concealed, probably sandy limestone	
96	limestone with much flint	
534	limestone, thick bedded at top and thin bedded and shaly below	
400	partly concealed, partly sandstone	
50	white sandstone, resistent to weathering	
120	partly concealed, mostly gray shale but contains a 2' bed of red Cacapon sandstone which carries 5.69 per cent of metallic iron. A sample from a float bowlder gave 9.40 per cent metallic iron.	
508	white sandstone, Clinch. (Massanutten)	
1050	shale, Martinsburg.	

Frederick County

Duck Run Gap

This section is located 17 miles southwest of Winchester in Duck Run gap of Great North mountain.

Thickness Feet	Inches	Kind of rock	Percentage of metallic iron
2		white sandstone	
1		red sandstone	4.68
	6	concealed	
	6	red sandstone	27.68
3		white sandstone	
	6	red sandstone	22.42
	6	red shaly sandstone	12.17
1	6	red shaly sandstone, variegated	
2		red sandstone	4.32
4		concealed, probably shaly	
2		white sandstone	
2		red sandstone, variegated	
	8	white sandstone, cross bedded	
1	6	reddish sandstone	
	10	white sandstone	
1	6	reddish sandstone	3.85
1		white sandstone	
1	2	red sandstone	10.46
40		white sandstone in 1' beds, continuous exposure	

As a result of the study of these detailed sections, and in the light of the iron determinations made on these samples, it appears that this work has not discovered beds which are both sufficiently rich in the iron and of sufficient thickness to form a workable iron ore under present commercial conditio s. On the other hand

this work has convinced the writer that this is not merely an iron cemented sandstone but that it has possibilities which may enable it to be used as an iron ore at some future time after our richer iron deposits have been exhausted. This study has shown that there are beds of sufficient richness to serve as an iron ore under present commercial conditions. The sections whose record appears above are widely scattered and intervals of ten to twenty or more miles sometimes intervene between adjoining sections. It is not probable that this rather superficial examination of the Cacapon outcrops has located the richest beds or the thickest of the beds of higher iron content. It is not improbable that more careful examination will show better material than the writer has found.

Elsewhere in this volume there is a discussion of iron-bearing sedimentary beds, but it is appropriate here to give briefly the writer's views on the origin of these red beds. If this red sandstone everywhere consisted of rounded quartz grains, each of which was in contact with its neighbor, and there were hematite in the intergranular spaces only, one might appropriately believe that the quartz sand was first laid down as such and that the iron was introduced subsequently in solution and precipitated in the intergranular spaces. It is not impossible, nor indeed improbable that this was the mode by which this formation originated. Indeed, some of the basal beds have a variegated appearance and more or less vertical distribution of the iron through the individual beds and leave the general appearance which one might expect in case the sand were first deposited and an iron solution filtered over this. However, in the case of beds which have an iron content as high as some of the beds on Paint Lick Mountain and in

other places where the hematite or siderite constitutes the greater part of the beds and the quartz the minor part, it is obvious that the iron is not merely cement inserted subsequent to deposition of the quartz, but that it is a primary constituent deposited at the same time as the quartz. Such being the case, this matter of origin has an important bearing on the possibility of this material as an iron ore. If iron has been deposited in one place as a major constituent with the non-iron minerals as a minor constituents, it is only a question of degree and not of kind which would produce an iron ore body of greater thickness and with less impurities than is now known.

The writer has seen these red sandstones nowhere except on surface outcrops and knows of no place where this formation has been cut at depth in drill holes. Accordingly, all the material which the writer has seen is oxidized material. The question arises as to whether or not below the water table these red beds do not have a different mineral composition. The appearance of the outcrop material is of such a character that the writer is rather strongly inclined to the opinion that below the water table these red beds in general are essentially the same as they are on the outcrop; that is to say, they are composed essentially of quartz and hematite, and that these beds were deposited for the most part under oxidizing conditions. The presence of undoubted iron carbonate in the Little Walker Creek section shows definitely that there was one bed at least in which the iron is in the ferrous condition. The limonitic phase carrying cavities in Hunters Gap section of Powell Mountain and similar phases in the Walker Mountain section in Bland County indicate that iron carbonate beds occurred in other localities as well as that of Little Walker Creek. The presence of

iron carbonate beds shows that the conditions of precipitation outlined above did not prevail universally over the areas in which the Cacapon sandstone was formed. If these beds are largely hematite, as has been assumed, it is not improbable that they were deposited under arid or near-arid conditions, or at least under conditions which were not favorable to plant life. The common explanation of the origin of bedded iron carbonate is that it was deposited with the iron in the ferric condition along with organic matter, that the organic matter exerted a reducing action on the ferric iron, and that carbon dioxide formed from the organic matter united with the ferrous iron formed by this reduction, to form the iron carbonate. It is easy to imagine the semi-arid conditions, with occasional conditions in which vegetation was growing at the time the iron was deposited, and that such vegetation deposited along with the iron would produce the necessary organic matter to produce the iron carbonate from the hematite.

(To be inserted in the most appropriate place.)

The age of the Cacapon is definitely determined as Silurian by its location between the formations which are agreed on as being Silurian. The internal evidence of the age of the Cacapon is meager. The red beds, in common with most other red beds, are not fossiliferous or only sparingly so. The only fossils seen by the writer in the red beds themselves are tracks and these are rare. They consist of two parallel rows of imprints like foot prints with the rows less than half an inch apart. These occur on the bedding surfaces and appear to have been made in shallow water or on wet shore sands. The gray shales are locally fossiliferous and careful search would probably reveal satisfactory forms or age determinations. In the Buffalo Gap section there are a few brachiopods and pelecypods. In the Warm Springs Mountain section there are other forms including a trilobite. These fossils according to Dr. P. E. Raymond, show that the beds containing them are not older than the Silurian.

Section on top of Purchase Ridge at a point 4 miles west of Natural Tunnel where State highway crosses this ridge.

13 fet. - gray shale with 2" beds of shaly sandstone; Anoplotheca hemispherica in top beds and 3 ft. above base.

10 ft. - Gray and purplish shale

10 ft. - thin-bedded, ripple-marked red sandstone

1 ft. - yellow-gray shale

6 ft. - red conglomeratic sandstone, ripple-marked, thin-bedded.

10-20ft. - concealed; thickness uncertain on account of faulting

8-20ft. - white sandstone in 1 ft. and thinner beds

6 ft. - red shale

6 ft. - concealed

8 ft. - red shaly sandstone

6 ft. - red shaly sandstone with vertical structures

1½ ft. - shale with indistinct vertical structures

65 ft. - white Clinch sandstone

-- - - - Martinsburg shale

The dividing line between the Cacapon and the overlying Clinton should probably be placed in the ten feet of gray and purplish shale. The dividing line between the Cacapon and the underlying Clinch is placed at the top of the 65 feet white sandstone.