VIRGINIA DIVISION OF MINERAL RESOURCES

PUBLICATION 108

ANALYSES OF CARBONATE ROCKS - NORTHERN VIRGINIA

William F. Giannini

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES
Robert C. Milici, State Geologist

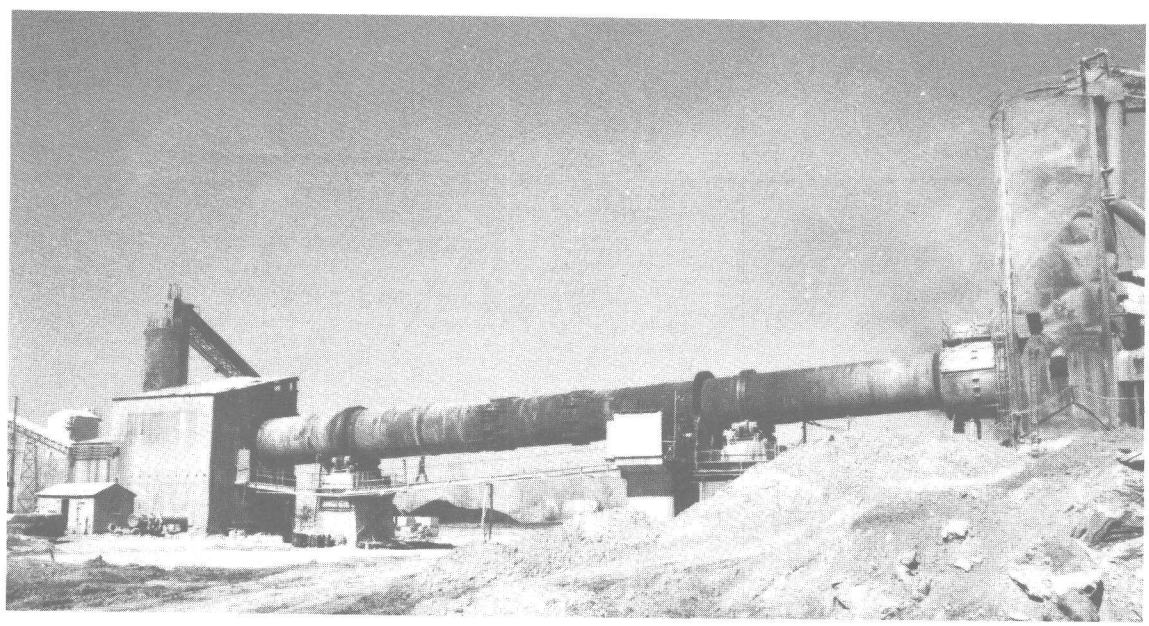
CHARLOTTESVILLE, VIRGINIA
1991

VIRGINIA DIVISION OF MINERAL RESOURCES

PUBLICATION 108

ANALYSES OF CARBONATE ROCKS - NORTHERN VIRGINIA

William F. Giannini



COMMONWEALTH OF VIRGINIA

DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES
Robert C. Milici, State Geologist

CHARLOTTESVILLE, VIRGINIA
1991

FRONT COVER: Rotary kiln, used to produce quicklime from high-calcium limestone of the New Market Limestone, W.S. Frey Company, Inc.

VIRGINIA DIVISION OF MINERAL RESOURCES

PUBLICATION 108

ANALYSES OF CARBONATE ROCKS - NORTHERN VIRGINIA

William F. Giannini

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF MINES, MINERALS AND ENERGY
DIVISION OF MINERAL RESOURCES
Robert C. Milici, State Geologist

CHARLOTTESVILLE, VIRGINIA
1991

DEPARTMENT OF MINES, MINERALS AND ENERGY
RICHMOND, VIRGINIA
O. Gene Dishner, Director

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF PURCHASES AND SUPPLY
RICHMOND, VIRGINIA

Copyright 1991, Commonwealth of Virginia

Portions of this publication may be quoted if credit is given to the Virginia Division of Mineral Resources

CONTENTS

	Page
Abstract	1
Introduction	1
Sampling procedure	3
Analyses and conclusions	15
Chemical analyses	15
Reflectance values	15
Chlorine analyses	15
Trace element tests	16
Economic potential	16
Acknowledgements	17
References cited	17
References for geology (Figures 12-47)	18
Appendix I: Chemical analyses of carbonate rocks, Clarke County (1945, 1955, and 1964)	97
Appendix II: Chemical analyses of carbonate rocks, Frederick County (1884, 1897, 1939, 1945, 1965, 1966, 1973, and 1985)	98
Appendix III: Chemical analyses of carbonate rocks, Loudoun County (1907, 1928, and 1964)	101
Appendix IV: Chemical analyses of carbonate rocks, Shenandoah County (1945)	102
Appendix V: Chemical analyses of carbonate rocks, Warren County (1945)	102
Appendix VI: Percentage of calcite in 224 carbonate-rock samples from 42 active quarries and mines in Virginia (1964)	102
Appendix VII: Number of samples plotted versus percent insoluble residue for each sample - 224 carbonate-rock samples from 42 active quarries and mines in Virginia (1964)	102
Appendix VIII: Percentage of samples plotted versus percentage of absorption for 224 carbonate-rock samples collected from 42 active quarries and mines in Virginia (1964)	103
Appendix IX: Ternary plot of insoluble material in 224 carbonate-rock samples from 42 active quarries and mines in Virginia (1964)	103
Appendix X: References for Appendices I-IX	103

ILLUSTRATIONS

Figure		Page
1.	Map indicating area sampled	1
2.	Map showing the carbonate-rock belts sampled in northern Virginia and location of operations currently producing carbonate-rock products	2
3.	Map showing locations for 77 carbonate-rock samples tested for reflectance values	6
4.	Map showing locations for 42 carbonate-rock samples analyzed for chlorine content	6
5.	Map showing locations for 30 carbonate-rock samples used for semiquantitative trace-element analyses	9
6.	Ternary diagram, carbonate-rock uses by composition	9
7.	Ternary diagram, carbonate-rock classification by composition	9
8.	Old lime kiln, Frederick County	17
9.	Travertine-marl deposit along Redbud Run	17
10.	Diagram, explanation and key for 21 topographic maps which show carbonate-rock sample locations, carbonate-rock formations and age, faults, quarries, mines, travertine-marl pits, and lime kilns	19
11.	Northern half of Waterford quadrangle (215A)	20
12.	Southern half of Waterford quadrangle (215A)	21
13.	Northern half of Lincoln quadrangle (215C)	24
14.	Southern half of Lincoln quadrangle (215C)	25
15.	Northern half of Leesburg quadrangle (215D)	28
16.	Southern half of Round Hill quadrangle (216A)	30
17.	Northern half of Berryville quadrangle (216B)	32
18.	Southern half of Berryville quadrangle (216B)	33

19. Northern half of Ashby Gap quadrangle (216C) 36
20. Southern half of Ashby Gap quadrangle (216C) 37
21. Northern half of Bluemont quadrangle (216D) 41
22. Northern half of Stephenson quadrangle (217A) 44
23. Southern half of Stephenson quadrangle (217A) 45
24. Northern half of Winchester quadrangle (217B) 51
25. Southern half of Winchester quadrangle (217B) 52
26. Northern half of Stephens City quadrangle (217C) 55
27. Southern half of Stephens City quadrangle (217C) 56
28. Northern half of Boyce quadrangle (217D) 59
29. Southern half of Boyce quadrangle (217D) 60
30. Northern half of Hayfield quadrangle (218A) 64
31. Southern half of Hayfield quadrangle (218A) 65
32. Northern half of Capon Springs quadrangle (218B) 67
33. Southern half of Capon Springs quadrangle (218B) 68
34. Northern half of Mountain Falls quadrangle (218C) 70
35. Southern half of Mountain Falls quadrangle (218C) 71
36. Northern half of Middletown quadrangle (218D) 73
37. Southern half of Middletown quadrangle (218D) 74
38. Southern half of Wardensville quadrangle (219D) 77
39. Southern half of Point of Rocks quadrangle (221D) 79
40. Northern half of White Hall quadrangle (223C) 81
41. Southern half of White Hall quadrangle (223C) 82
42. Northern half of Inwood quadrangle (223D) 85
43. Southern half of Inwood quadrangle (223D) 86
44. Northern half of Ridge quadrangle (224A) 89
45. Southern half of Ridge quadrangle (224A) 90
46. Northern half of Gore quadrangle (224D) 93
47. Southern half of Gore quadrangle (224D) 94

TABLES

Page
1. Geologic name and age of carbonate rocks sampled 2
2. Summary of carbonate-rock analyses, 6 active operations in northern Virginia 3
3. Summary of chemical analyses (mean, high, low, and range) of carbonate rocks (Cambrian through Devonian and Quaternary), northern Virginia, Valley and Ridge province 4
4. Summary of chemical analyses (mean, high, low, and range) of carbonate rocks (Precambrian), northern Virginia, Piedmont province 5
5. Summary of chemical analyses (mean, high, low, and range) of carbonate rocks (Triassic), northern Virginia, Piedmont province 5
6. Summary of 77 reflectance tests on carbonate rocks with brightnesses of 70 percent or higher, northern Virginia area 7
7. Summary of 42 chlorine analyses on carbonate rocks, northern Virginia area 8
8. Summary of 30 semiquantitative trace-element analyses on carbonate rocks, northern Virginia area 10
9. Chemical analyses, carbonate-rock samples, Waterford (215A) quadrangle, Loudoun County 22
10. Reflectance analyses, carbonate-rock sample, Waterford (215A) quadrangle, Loudoun County 22
11. Chlorine analyses, carbonate-rock samples, Waterford (215A) quadrangle, Loudoun County 22
12. Semiquantitative trace-element analyses, carbonate-rock samples, Waterford (215A) quadrangle, Loudoun County 23
13. Chemical analyses, carbonate-rock samples, Lincoln (215C) quadrangle, Loudoun County 26
14. Reflectance analyses, carbonate-rock samples, Lincoln (215C) quadrangle, Loudoun County 26
15. Chlorine analyses, carbonate-rock samples, Lincoln (215C) quadrangle, Loudoun County 26
16. Semiquantitative trace-element analyses, carbonate-rock sample, Lincoln (215C) quadrangle, Loudoun County 27

17. Chemical analyses, carbonate-rock samples, Leesburg (215D) quadrangle, Loudoun County 29
18. Chemical analyses, carbonate-rock sample, Round Hill (216A) quadrangle, Clarke County 31
19. Chemical analyses, carbonate-rock samples, Berryville (216B) quadrangle, Clarke County 34
20. Reflectance analyses, carbonate-rock samples, Berryville (216B) quadrangle, Clarke County 35
21. Chemical analyses, carbonate-rock samples, Ashby Gap (216C) quadrangle, Clarke County 38
22. Reflectance analyses, carbonate-rock samples, Ashby Gap (216C) quadrangle, Clarke County 39
23. Chlorine analyses, carbonate-rock samples, Ashby Gap (216C) quadrangle, Clarke County 39
24. Semiquantitative trace-element analyses, carbonate-rock samples, Ashby Gap (216C) quadrangle, Clarke County.. 40
25. Chemical analyses, carbonate-rock samples, Bluemont (216D) quadrangle, Loudoun County 42
26. Chlorine analyses, carbonate-rock sample, Bluemont (216D) quadrangle, Loudoun County 42
27. Semiquantitative trace-element analyses, carbonate-rock sample, Bluemont (216D) quadrangle, Loudoun County . 43
28. Chemical analyses, carbonate-rock samples, Stephenson (217A) quadrangle, Clarke and Frederick Counties 46
29. Reflectance analyses, carbonate-rock samples, Stephenson (217A) quadrangle, Clarke County 48
30. Chlorine analyses, carbonate-rock samples, Stephenson (217A) quadrangle, Frederick and Clarke Counties 48
31. Semiquantitative trace-element analyses, carbonate-rock samples, Stephenson (217A) quadrangle, Clarke County.. 49
32. Chemical analyses, carbonate-rock samples, Winchester (217B) quadrangle, Frederick County 53
33. Chlorine analyses, carbonate-rock samples, Winchester (217B) quadrangle, Frederick County 53
34. Semiquantitive trace-element analyses, carbonate-rock samples, Winchester (217B) quadrangle, Frederick County. 54
35. Chemical analyses, carbonate-rock samples, Stephens City (217C) quadrangle, Frederick, Clarke, and Warren Counties 57
36. Reflectance analyses, carbonate-rock sample, Stephens City (217C) quadrangle, Frederick County 58
37. Chemical analyses, carbonate-rock samples, Boyce (217D) quadrangle, Clarke and Warren Counties 61
38. Reflectance analyses, carbonate-rock samples, Boyce (217D) quadrangle, Clarke County 63
39. Chemical analyses, carbonate-rock samples, Hayfield (218A) quadrangle, Frederick County 66
40. Chemical analyses, carbonate-rock samples, Capon Springs (218B) quadrangle, Frederick County 69
41. Chemical analyses, carbonate-rock samples, Mountain Falls (218C) quadrangle, Frederick and Shenandoah Counties 72
42. Chemical analyses, carbonate-rock samples, Middletown (218D) quadrangle, Frederick, Shenandoah, and Warren Counties 75
43. Chemical analyses, carbonate-rock sample, Wardensville (219D) quadrangle, Shenandoah County 78
44. Chemical analyses, carbonate-rock samples, Point of Rocks (221D) quadrangle, Loudoun County 80
45. Reflectance analyses, carbonate-rock samples, Point of Rocks (221D) quadrangle, Loudoun County 80
46. Chlorine analyses, carbonate-rock samples, Point of Rocks (221D) quadrangle, Loudoun County 80
47. Chemical analyses, carbonate-rock samples, White Hall (223C) quadrangle, Frederick County 83
48. Chlorine analyses, carbonate-rock samples, White Hall (223C) quadrangle, Frederick County 83
49. Semiquantitative trace-element analyses, carbonate-rock samples White Hall (223C) quadrangle, Frederick County. 84
50. Chemical analyses, carbonate-rock samples, Inwood (223D) quadrangle, Frederick and Clarke Counties 87
51. Reflectance analyses, carbonate-rock sample, Inwood (223D) quadrangle, Clarke County 87
52. Chlorine analyses, carbonate-rock samples, Inwood (223D) quadrangle, Frederick County 87
53. Semiquantitative trace-element analyses, carbonate-rock sample, Inwood (223D) quadrangle, Frederick County.... 88
54. Chemical analyses, carbonate-rock samples, Ridge (224A) quadrangle, Frederick County 91
55. Chlorine analyses, carbonate-rock samples, Ridge (224A) quadrangle, Frederick County 91
56. Semiquantitative trace-element analyses, carbonate-rock samples, Ridge (224A) quadrangle, Frederick County 92
57. Chemical analyses, carbonate-rock samples, Gore (224D) quadrangle, Frederick County 95
58. Reflectance analyses, carbonate-rock sample, Gore (224D) quadrangle, Frederick County 95
59. Chlorine analyses, carbonate-rock samples, Gore (224D) quadrangle, Frederick County 95
60. Semiquantitative trace-element analyses, carbonate-rock samples, Gore (224D) quadrangle, Frederick County 96

ANALYSES OF CARBONATE ROCKS - NORTHERN VIRGINIA

William F. Giannini

ABSTRACT

During the period of March 1981 through November 1982, 466 carbonate-rock samples were collected from the northern Virginia area covered by the Winchester and Frederick 0.5° x 1° sheets (1:100,000 series maps). Analytical results indicate the existence of carbonate rocks potentially suitable for markets requiring materials possessing high purity, high reflectance, low chlorine, and lacking deleterious components. The limestone and dolostone rocks, including marble, also qualify as aggregate materials in asphalt or concrete for construction. The included results for 366 carbonate-rock analyses by other writers during the period from 1884 through 1985 supplement the present data. Information in this publication is presented to inform private individuals, companies, consultants, and governmental agencies about carbonate-rock resources and to indicate general areas where potential economic resources occur.

INTRODUCTION

Samples of limestone, magnesian limestone, dolostone, marble, dolostone marble, limestone-dolostone conglomerate, and travertine-marl were collected north of 39°latitude in Clarke, Frederick, and portions of Loudoun, Shenandoah, and Warren Counties from road and railroad cuts, quarries, travertine-marl pits, and natural outcrops (Figure 1). The samples represent seven geologic time periods, 18 formations, three groups, and deposits (Table 1). Marble, dolostone marble, and limestone-dolostone conglomerate occur in three belts in the Piedmont province. All other carbonates sampled in northern Virginia occur in belts in the Valley and Ridge province.

Samples were analyzed by laboratories of the Virginia Division of Mineral Resources, the Virginia Department of Transportation, the Virginia Council of Highway Investigation and Research, and the U.S. Bureau of Mines Research

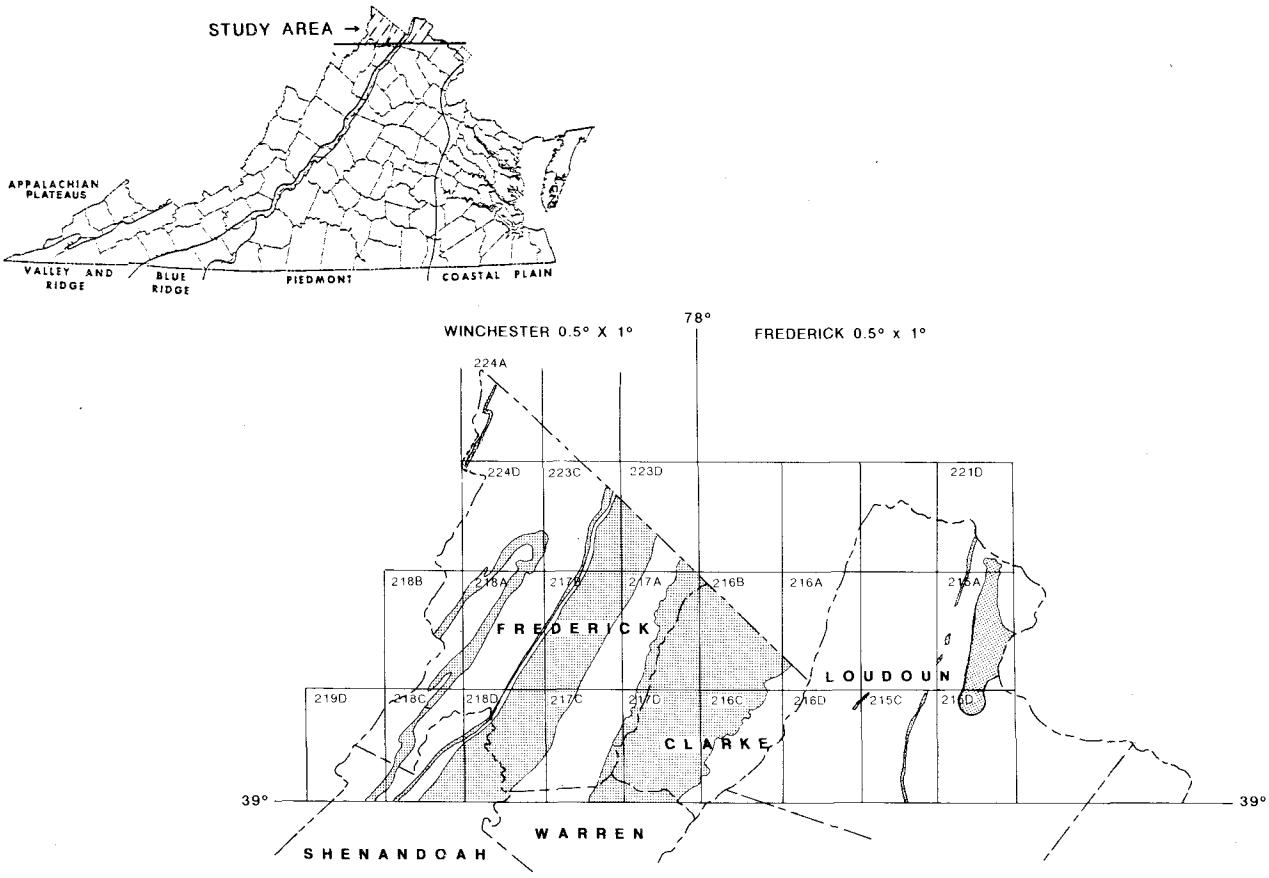


Figure 1. Maps indicating area studied in Virginia and showing the 21, 7.5-minute quadrangles covering the carbonate-rock belts (shaded) sampled.

Table 1. Geologic name and age of carbonate rocks sampled.

Group, Formation, or Deposit Name	Age
Travertine-marl deposits	Quaternary
Newark Supergroup limestone conglomerate - (marble)	Triassic
Ridgeley Sandstone (limestone unit)	
Licking Creek Limestone	Devonian
Keyser Limestone	
Tonoloway Limestone	Silurian
Edinburg Limestone	
Lincolnshire Limestone	
New Market Limestone	Ordovician
Pinesburg Station Dolomite	
Rockdale Run Formation	
Stonehenge Limestone	
Conococheague Formation	
Elbrook Formation	Cambrian
Waynesboro Formation	
Shady Dolomite	
Fauquier Formation (Swift Run) - (marble)	Precambrian

Centers at University, Alabama, and Reno, Nevada. A summary of tests by the Virginia Department of Highways and Transportation (1991) and the Virginia Division of Mineral Resources on samples from the six currently active carbonate-rock operations in northern Virginia (Figure 2) is presented in Table 2. Summaries of chemical analyses by the Virginia Division of Mineral Resources, of reflectance values, chlorine content, and trace-element analyses by the U.S. Bureau of Mines, on all or portions of the 466 carbonate-rock samples from northern Virginia begin with Table 3 and continue through Table 8. Overview maps precede summary tables and show locations for 77 carbonate-rock samples tested for reflectance values (Figure 3), 42 samples analyzed for chlorine content (Figure 4), and 30 used for trace-element analyses (Figure 5).

The uses and classifications of carbonate rocks referred to in this publication are based on composition and are shown by ternary diagrams (Figures 6 and 7).

Twenty-one 1:50,000-scale topographic maps show; locations of the 466 samples, distribution of carbonate-rock units, major faults, six active and 41 abandoned carbonate-rock quarries, two abandoned mines,13 abandoned travertine-marl pits, and three active and 28 abandoned lime kilns. Each map precedes corresponding tables (beginning with Table 9) that present ten-part chemical analyses, reflectance values, chlorine content, and trace-element analyses on the portion of the 466 samples tested from the area covered by the map.

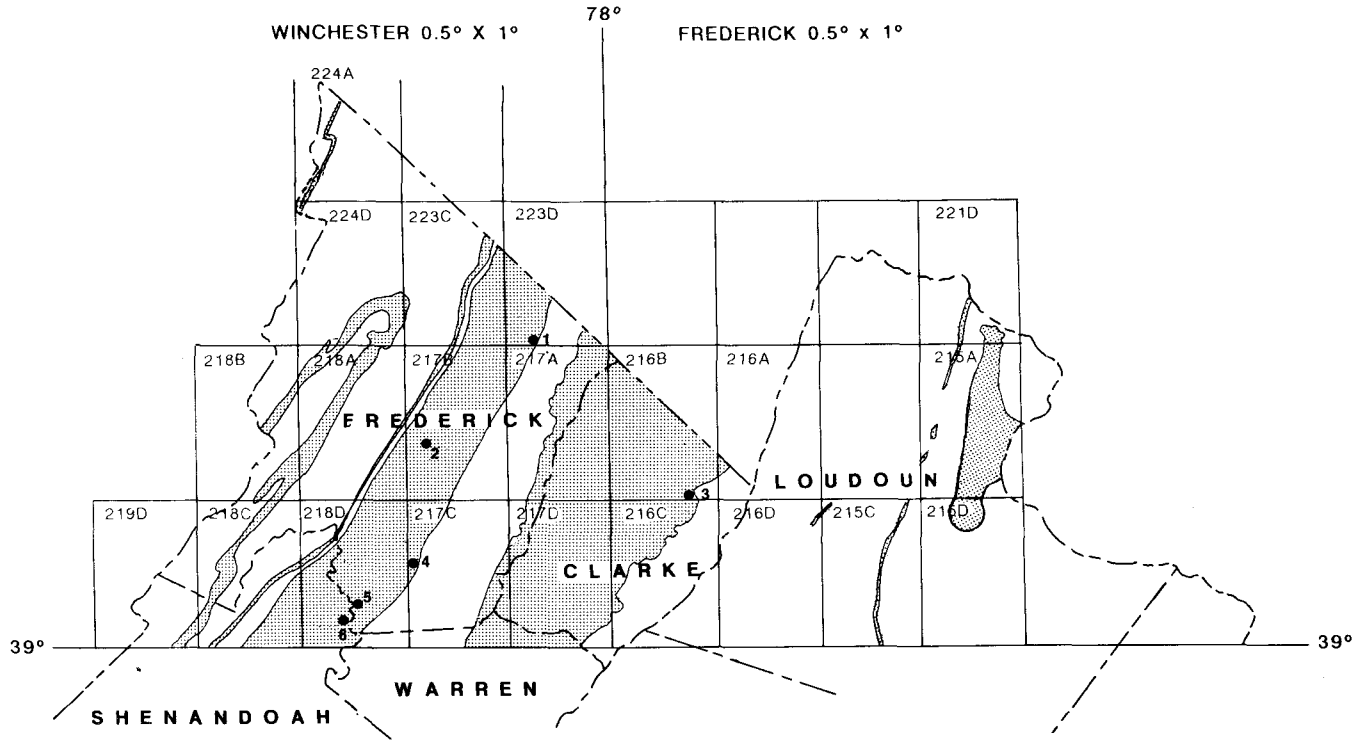


Figure 2. Map showing the carbonate-rock belts (shaded) sampled in northern Virginia and the location of the 6 operations currently producing carbonate-rock products (see Table 2 - map modified after Le Van and Harris, 1971): 1. W.S. Frey, Inc., Clearbrook; 2. Stuart M. Perry, Inc., Winchester; 3. Stuart M. Perry, Inc., Berryville; 4. Shenvalley Lime Corp., Stephens City; 5. Genstar Stone Products Co., Middletown; 6. Chemstone Corp., Strasburg.

Table 2. Summary of carbonate-rock analyses from 6 active operations in northern Virginia, Valley and Ridge province (Frederick-Winchester 0.5° x 1° sheets).

Operation, Location, Map and Sample Number, and 7.5-minute Quad. Name	Formation(s) of Major Production and Rock-Type	Composition (Weight percent)						Specific Gravity	Percent Absorption	Los Angeles Abrasion Loss (percent)		
		$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	S			A	B	C
1, 3 W. S. Frey Co., Inc. Clearbrook 217A-2 Stephenson quad.	New Market Limestone, limestone	99.33	.00	.36	.07	.12	.01	2.70	.3	-	22.7	-
2, 3 Stuart M. Perry, Inc. Winchester (see 2 below) Winchester quad.	Conococheague Formation, limestone, magnesian limestone	68.36	16.10	14.10	1.40	1.30	-	2.72	.1	-	17.3	-
1, 3 Stuart M. Perry, Inc. Berryville 216B-42 Berryville quad.	Shady Dolomite, dolostone	53.54	45.10	.71	.44	.08	.00	2.84	.2	-	18.8	17.4
1, 3 Shenvalley Lime Corp. Stephens City 217C-1 Stephens City quad.	New Market Limestone limestone (Shenvalley sells lime products from purchased quicklime-Genstar sells aggregates, this location)	98.80	.44	.39	.07	.14	.01	2.74	.3	-	21.0	-
1, 3 Genstar Stone Products Co. Middletown 218D-1 Middletown quad.	New Market Limestone, limestone	99.43	.00	.26	.04	.04	.03	2.70	.2	-	31.7	-
1, 3 Chemstone Corp. Strasburg 218D-53 Middletown quad.	New Market Limestone, limestone	98.85	.62	.25	.03	.09	.01	2.68	.3	-	23.6	-

1-Chemical analyses, Virginia Division of Mineral Resources (1981-85) 3-Physical analyses by Virginia Department of Transportation (1991)
2-Chemical analyses from Butts and Edmundson (1966)

An appendix contains 142 chemical analyses of northern Virginia carbonate rocks published from 1884 through 1985 (Appendices I through V). Also included are graphs showing percentage of calcite, percentage of insoluble residue, percentage of absorption, and a ternary plot of insoluble material in 224 carbonate samples taken from 42 Virginia quarries and mines (Sherwood, W. C. and Newlon, H., Jr., 1964) (Appendices VI through IX). Appendix X is a reference list for all appendices. Information in the appendices is as originally presented by the authors and descriptions of the sample locations may be affected by changes of road numbers, road locations, or city boundaries.

SAMPLING PROCEDURE

Chip samples to 3 inches were taken across continuous carbonate-rock exposures that were in-place with only two exceptions. The samples represent the various lithologies and the stratigraphic thickness, to the nearest foot, of that portion of a carbonate-rock formation sampled at each location. Channel samples approximately 3 inches wide and 3 inches deep were taken from marl deposits. Distance between sample locations along the strike of the formations averages approximately one mile but smaller distances normally exist between locations across strike. Attempts were made to obtain representative material from each formation by taking one or more samples from the various lithologic units. The same formation was usually sampled on both sides of a fold or fault. Collecting minimal thicknesses of carbonate-rock sample was often the only choice to complete the sampling in an area. Collecting pieces of carbonate-rock float was necessary at two sample locations (215A-11 and 216D-2, Tables 9 and 25). Chert and shale were not sampled with the carbonate-rock containing them; however, the presence of these materials is recorded in tables of this publication under the heading, *Rock Type*.

Approximately half of each sample was crushed and/or ground to 100- and 325-mesh sizes and portions of this material were used for the various tests. The remaining portions of the ground carbonate-rock material from the 466 carbonate-rock samples collected from northern Virginia are stored at the office of the Virginia Division of Mineral Resources in Charlottesville.

Table 3. Summary of chemical analyses, Cambrian through Devonian limestones, magnesian limestones, dolostones and Quaternary travertine-marls, in northern Virginia, Valley and Ridge province (Frederick-Winchester 0.5° X 1° sheets, Figure 1) (analyses in Appendix are not included).

Name, Rock Type, and Age of Group, Formation, or Deposit Sampled.	Number of Samples	*Chemical Analyses (weight percent) Summary																	
		Mean $CaCO_3$	Std. Dev.	High $CaCO_3$	Low $CaCO_3$	Range $CaCO_3$	Mean $MgCO_3$	Std. Dev.	High $MgCO_3$	Low $MgCO_3$	Range $MgCO_3$	Mean SiO_2	Std. Dev.	High SiO_2	Low SiO_2	Range SiO_2	Mean Fe_2O_3	Mean Al_2O_3	Mean S
Travertine-marl deposits Quaternary	15	82.46	16.79	97.34	44.70	52.84	.79	.67	2.00	.00	2.00	12.22	11.98	32.23	.76	31.47	1.13	2.36	.06
Limestones (undifferentiated) Devonian-Silurian	2	74.93	18.28	87.86	62.00	25.86	5.94	.66	6.41	5.47	.94	14.28	14.63	24.63	3.94	20.69	1.32	2.47	.03
Ridgeley Sandstone (limestone unit) Devonian	1	91.07	-	-	-	-	.45	-	-	-	-	7.12	-	-	-	-	.53	.20	.01
Licking Creek Limestone (limestone) Devonian	9	87.47	9.85	97.70	68.54	29.16	2.28	3.16	9.61	.00	9.61	7.42	5.72	16.51	1.46	15.05	.84	1.16	.04
Keyser Limestone (limestone) Devonian-Silurian	11	87.33	5.52	96.18	77.26	18.92	2.64	1.34	4.75	.00	4.75	7.27	3.90	13.56	2.54	11.02	.71	1.35	.06
Tonoloway Limestone (limestone) Silurian	13	83.50	7.78	93.09	70.12	22.97	3.72	2.91	8.62	.00	8.62	9.32	4.51	17.69	3.70	13.99	.86	1.69	.11
Tonoloway Limestone (magnesian limestone) Silurian	1	26.84	-	-	-	-	22.61	-	-	-	-	32.36	-	-	-	-	6.65	8.11	.19
Edinburg Formation (Liberty Hall, Lantz Mills) (limestone) Ordovician	43	88.74	4.68	97.03	81.69	15.34	15.34	2.19	8.13	.00	8.13	6.33	3.80	15.38	1.02	14.36	.49	1.00	.05
Lincolnshire Limestone (limestone) Ordovician	28	94.66	4.48	99.73	84.06	15.67	1.47	1.73	6.80	.00	6.80	2.57	2.92	11.85	.14	11.71	.29	.50	.03
New Market Limestone (dolostone) Ordovician	6	61.72	1.30	62.80	59.76	3.04	35.85	2.20	38.74	33.13	5.61	1.38	.78	2.71	.62	2.09	.31	.41	.01
New Market Limestone (limestone) Ordovician	44	97.56	2.73	99.49	88.89	10.60	1.32	2.33	8.53	.00	8.53	.65	.42	1.76	.22	1.54	.09	.20	.01
New Market Limestone (magnesian limestone) Ordovician	3	82.43	2.19	83.84	80.39	3.45	14.46	1.94	16.03	12.29	3.74	1.90	1.17	2.96	.64	2.32	.23	.56	.05
Pinesburg Station Dolomite (dolostone) Ordovician	2	57.41	3.49	59.88	54.94	4.94	37.20	9.75	39.76	34.63	5.13	3.61	.85	4.21	3.01	1.20	.63	.72	.02
Rockdale Run Formation (dolostone) Ordovician	38	54.95	7.61	64.87	50.05	14.82	38.97	3.62	44.01	31.02	12.99	4.36	2.18	8.76	1.03	7.73	.60	.63	.02
Rockdale Run Formation (limestone) Ordovician	40	90.16	4.71	99.12	81.18	17.94	3.34	2.47	9.13	.00	9.13	4.58	2.40	9.58	.56	9.02	.34	.80	.04
Rockdale Run Formation (magnesian limestone) Ordovician	8	74.32	7.39	86.86	64.25	22.55	20.00	7.14	29.11	12.22	16.89	3.91	2.12	6.72	1.10	5.62	.43	.78	.03
Stonehenge Limestone (limestone) Ordovician	28	87.77	7.25	97.39	59.94	37.45	3.18	1.60	5.46	.00	5.46	6.36	4.31	22.43	2.19	20.24	.55	1.18	.04
Stonehenge Limestone (magnesian limestone) Ordovician	2	76.95	3.36	79.33	74.57	4.76	13.62	.64	14.07	13.16	.91	6.90	3.55	9.41	4.39	5.02	.80	.89	.06
Conococheague Formation (limestone) Cambrian	43	85.34	7.44	96.98	68.81	28.17	4.30	2.72	9.88	.00	9.88	7.46	4.40	17.12	1.31	15.81	.64	1.24	.14

*Analyses by Virginia Division of Mineral Resources, Charlottesville, Virginia.

Table 3. (continued)

Name, Rock Type, and Age of Group, Formation, or Deposit Sampled.	Number of Samples	*Chemical Analyses (weight percent) Summary																	
		Mean $CaCO_3$	Std. Dev.	High $CaCO_3$	Low $CaCO_3$	Range $CaCO_3$	Mean $MgCO_3$	Std. Dev.	High $MgCO_3$	Low $MgCO_3$	Range $MgCO_3$	Mean SiO_2	Std. Dev.	High SiO_2	Low SiO_2	Range SiO_2	Mean Fe_2O_3	Mean Al_2O_3	Mean S
Conococheague Formation (magnesian limestone) Cambrian	15	73.82	10.12	83.05	55.24	27.81	15.54	5.33	26.02	10.44	15.58	7.23	3.24	12.94	2.93	10.01	.82	1.32	.05
Conococheague Formation (dolostone) Cambrian	10	49.18	8.55	55.43	43.68	11.75	38.41	3.51	44.57	32.76	11.81	8.26	4.38	14.90	1.66	13.24	1.41	1.40	.09
Elbrook Formation (limestone) Cambrian	10	85.20	7.74	95.91	73.03	22.88	6.14	2.86	9.54	.00	9.54	6.10	4.61	14.44	2.29	12.15	.52	1.00	.08
Elbrook Formation (magnesian limestone) Cambrian	14	61.71	23.35	83.89	21.34	62.55	18.45	6.34	29.55	10.66	18.89	12.79	12.38	36.54	.82	35.72	2.18	2.64	.10
Elbrook Formation (dolostone) Cambrian	12	48.56	5.16	55.65	40.22	15.43	37.20	4.35	43.51	30.95	12.56	9.66	4.95	16.00	4.04	11.96	1.54	1.63	.04
Waynesboro Formation (limestone) Cambrian	4	93.20	4.04	99.09	90.01	9.08	4.62	3.31	7.54	.00	7.54	1.52	1.20	3.27	.58	2.69	.20	.22	.01
Waynesboro Formation (magnesian limestone) Cambrian	6	72.55	18.63	86.68	35.77	50.91	15.91	6.59	28.06	10.38	17.68	6.93	7.45	21.21	1.31	19.90	1.32	1.75	.09
Waynesboro Formation (dolostone) Cambrian	10	51.97	6.06	60.08	40.61	19.47	38.10	3.36	43.60	34.20	9.40	6.71	5.19	16.03	2.22	13.81	1.30	1.06	.03
Shady Dolomite (dolostone) Cambrian	15	53.13	1.29	56.69	51.35	5.34	43.90	1.04	45.11	42.54	2.57	1.71	1.22	3.71	.08	3.63	.74	.27	.00
Shady Dolomite (limestone) Cambrian	3	95.21	2.02	97.47	93.59	3.88	2.92	1.52	4.05	1.20	2.85	1.26	.40	1.51	.80	.71	.15	.21	.02

*Analyses by Virginia Division of Mineral Resources, Charlottesville, Virginia.

Table 4. Summary of chemical analyses, Precambrian marbles in northern Virginia, Piedmont province (Frederick 0.5° x 1° sheet, Figure 1) (analyses in appendix are not included).

Name, Rock Type, and Age of Group, Formation, or Deposit Sampled.	Number of Samples	*Chemical Analyses (weight percent) Summary																	
		Mean $CaCO_3$	Std. Dev.	High $CaCO_3$	Low $CaCO_3$	Range $CaCO_3$	Mean $MgCO_3$	Std. Dev.	High $MgCO_3$	Low $MgCO_3$	Range $MgCO_3$	Mean SiO_2	Std. Dev.	High SiO_2	Low SiO_2	Range SiO_2	Mean Fe_2O_3	Mean Al_2O_3	Mean S
Fauquier Formation (marble) Precambrian	17	63.80	14.64	90.58	49.76	40.82	33.25	13.99	45.00	7.75	37.25	1.96	1.77	7.59	.48	7.11	.48	.38	.00

*Analyses by Virginia Division of Mineral Resources, Charlottesville, Virginia.

Table 5. Summary of chemical analyses, Triassic limestone-dolostone conglomerates in northern Virginia, Piedmont province (Frederick 0.5° x 2° sheet, Figure 1) (analyses in appendix are not included).

Name, Rock Type, and Age of Group, Formation, or Deposit Sampled.	Number of Samples	*Chemical Analyses (weight percent) Summary																	
		Mean $CaCO_3$	Std. Dev.	High $CaCO_3$	Low $CaCO_3$	Range $CaCO_3$	Mean $MgCO_3$	Std. Dev.	High $MgCO_3$	Low $MgCO_3$	Range $MgCO_3$	Mean SiO_2	Std. Dev.	High SiO_2	Low SiO_2	Range SiO_2	Mean Fe_2O_3	Mean Al_2O_3	Mean S
Newark Group (limestone-dolostone conglomerate) Triassic	13	65.29	8.54	83.61	54.98	28.63	21.70	12.18	37.56	1.96	35.60	8.71	4.51	19.46	4.70	14.76	1.33	1.82	.00

*Analyses by Virginia Division of Mineral Resources, Charlottesville, Virginia.

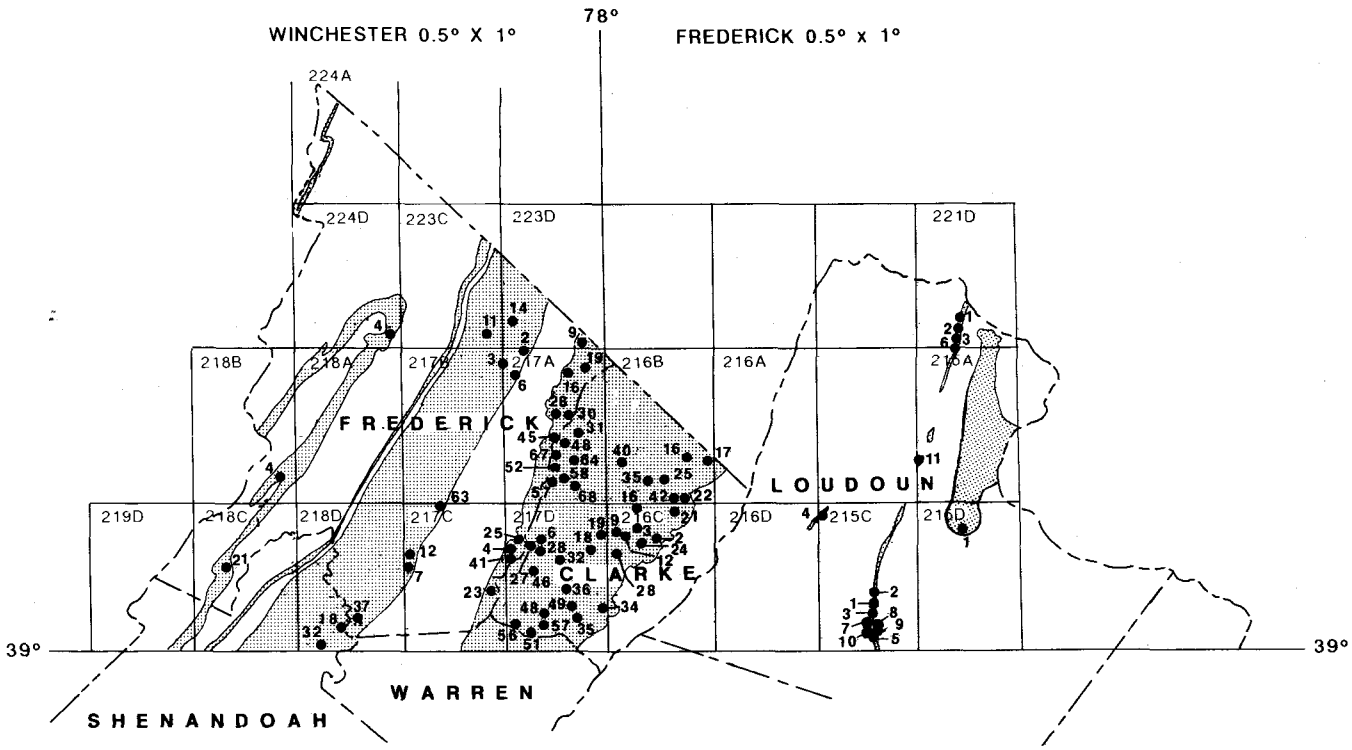


Figure 3. Overview map showing locations (black dots) for 77 carbonate-rock samples tested for reflectance values (Table 6). Number and letter on each 7.5-minute quadrangle corresponds to those on quadrangles beginning with 215A, Figure 11, and continuing through Figure 47. Carbonate-rock belts are shown as shaded areas.

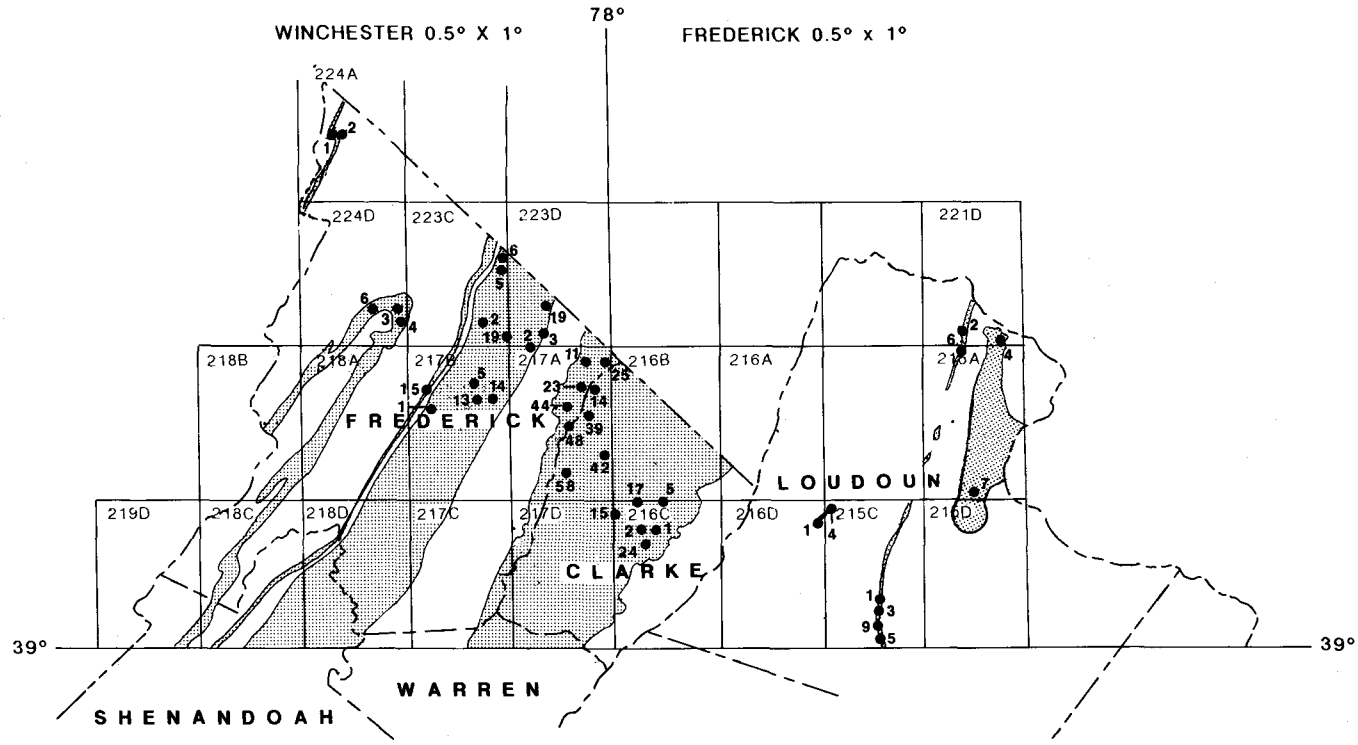


Figure 4. Overview map showing locations (black dots) for 42 carbonate-rock samples analyzed for chlorine content (Table 7). Number and letter on each 7.5-minute quadrangle corresponds to those on quadrangles beginning with 215A, Figure 11, and continuing through Figure 47. Carbonate-rock belts are shown as shaded areas.

Table 6 - Summary of reflectance tests on 77 carbonate-rock samples with brightnesses of 70 percent or higher, northern Virginia area (see quadrangles beginning with 215A, Figure 11, for sample locations) (Frederick-Winchester 0.5° x 1° sheets).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation	Age	Rock Type	*Brightness (Percent)	*Tint (Percent)	*Whiteness (Percent)	**$CaCO_3$ (Percent)	**$MgCO_3$ (Percent)	Repository Number
215A-6	Waterford	Loudoun	4	Fauquier	Precambrian	Marble	73.1	3.4	59.4	59.09	38.59	R-20062
215A-11	Waterford	Loudoun	1	Fauquier	Precambrian	Marble	86.7	0.0	86.7	49.77	41.92	R-20067
215C-1	Lincoln	Loudoun	8	Fauquier	Precambrian	Marble	78.3	3.6	64.0	57.13	37.42	R-20068
215C-2	Lincoln	Loudoun	4	Fauquier	Precambrian	Marble	91.3	0.0	91.3	82.21	14.73	R-20069
215C-3	Lincoln	Loudoun	6	Fauquier	Precambrian	Marble	88.3	0.0	88.3	58.81	40.51	R-20070
215C-4	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	74.4	8.1	42.0	58.42	39.54	R-20071
215C-5	Lincoln	Loudoun	10	Fauquier	Precambrian	Marble	77.2	2.1	68.7	56.17	41.70	R-20072
215C-7	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	86.9	0.6	84.7	82.24	15.41	R-20074
215C-8	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	91.3	1.2	86.6	87.95	10.64	R-20075
215C-9	Lincoln	Loudoun	3	Fauquier	Precambrian	Marble	92.2	1.2	87.5	90.58	7.75	R-20076
215C-10	Lincoln	Loudoun	1	Fauquier	Precambrian	Marble	85.5	3.7	70.7	83.41	14.47	R-20077
215D-1	Leesburg	Loudoun	2	Newark Group	Triassic	Marble	71.7	0.6	69.2	59.83	31.02	R-20078
216B-16	Berryville	Clarke	1	Elbrook	Cambrian	Dolostone	76.7	7.0	48.8	54.91	38.63	R-18886
216B-17	Berryville	Clarke	4	Elbrook	Cambrian	Limestone	83.3	2.2	74.6	87.33	9.44	R-18872
216B-22	Berryville	Clarke	2	Shady	Cambrian	Dolostone	75.8	12.6	25.4	53.46	45.03	R-20005
216B-25	Berryville	Clarke	2	Elbrook	Cambrian	Limestone	72.2	5.7	49.5	81.02	9.54	R-18874
216B-35	Berryville	Clarke	1	Elbrook	Cambrian	Magnesian Limestone	70.9	3.4	57.1	52.38	29.55	R-18897
216B-40	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	78.0	1.0	74.0	84.02	4.86	R-18893
216B-42	Berryville	Clarke	30	Shady	Cambrian	Dolostone	79.8	1.1	75.4	53.54	45.10	R-20006
216C-2	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	79.2	3.9	63.6	99.06	.00	R-18903
216C-3	Ashby Gap	Clarke	2	Shady	Cambrian	Limestone	70.3	1.4	64.6	94.57	3.52	R-18904
216C-9	Ashby Gap	Clarke	1	Elbrook	Cambrian	Limestone	83.3	2.4	73.7	90.25	5.07	R-18909
216C-12	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Dolostone	71.1	7.0	43.0	40.61	34.21	R-20009
216C-16	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Dolostone	72.5	2.3	63.4	54.65	34.53	R-18913
216C-21	Ashby Gap	Clarke	4	Shady	Cambrian	Dolostone	83.3	1.8	76.0	53.76	42.60	R-18918
216C-24	Ashby Gap	Clarke	5	Shady	Cambrian	Dolostone	80.2	0.0	80.2	53.95	43.03	R-18921
216C-28	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Dolostone	77.0	6.7	50.0	54.35	37.48	R-20012
217A-2	Stephenson	Frederick	2	New Market	Ordovician	Limestone	75.8	0.5	73.9	99.33	.00	R-18767
217A-3	Stephenson	Frederick	3	New Market	Ordovician	Limestone	76.9	1.6	70.6	99.02	.00	R-18768
217A-6	Stephenson	Frederick	5	New Market	Ordovician	Limestone	72.2	0.1	72.0	98.99	.00	R-18769
217A-16	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	70.5	4.2	53.6	55.07	39.38	R-18930
217A-19	Stephenson	Clarke	3	New Market	Ordovician	Limestone	70.9	0.1	70.6	99.23	.00	R-18649
217A-28	Stephenson	Clarke	4	New Market	Ordovician	Limestone	72.8	0.3	71.7	99.44	.00	R-18939
217A-30	Stephenson	Clarke	2	New Market	Ordovician	Limestone	76.7	1.4	71.3	91.60	7.07	R-18648
217A-31	Stephenson	Clarke	1	New Market	Ordovician	Limestone	78.3	0.8	75.3	99.33	.00	R-18940
217A-45	Stephenson	Clarke	1	New Market	Ordovician	Limestone	75.0	0.6	72.7	98.56	.00	R-18951
217A-48	Stephenson	Clarke	10	New Market	Ordovician	Limestone	77.2	0.8	74.1	99.39	.00	R-18953
217A-52	Stephenson	Clarke	2	New Market	Ordovician	Dolostone	75.5	0.2	74.6	62.80	34.03	R-18957
217A-57	Stephenson	Clarke	2	New Market	Ordovician	Magnesian Limestone	78.9	0.0	78.9	83.84	15.05	R-18652
217A-58	Stephenson	Clarke	2	New Market	Ordovician	Limestone	87.8	0.0	87.8	99.49	.00	R-18961
217A-64	Stephenson	Clarke	4	New Market	Ordovician	Limestone	75.3	0.0	75.3	98.04	1.47	R-18965
217A-67	Stephenson	Clarke	1	New Market	Ordovician	Dolostone	71.1	0.3	69.9	60.41	38.22	R-18646
217A-68	Stephenson	Clarke	1	New Market	Ordovician	Limestone	84.2	0.0	84.2	99.32	.00	R-18968
217C-7	Stephens City	Frederick	3	New Market	Ordovician	Limestone	75.3	0.9	71.7	98.07	.00	R-18816
217C-12	Stephens City	Frederick	1	New Market	Ordovician	Limestone	82.2	1.5	76.2	99.05	.00	R-18814
217C-23	Stephens City	Clarke	6	New Market	Ordovician	Limestone	71.1	1.4	65.4	97.11	1.28	R-20017
217C-63	Stephens City	Frederick	2	New Market	Ordovician	Limestone	70.0	0.9	66.5	98.24	1.26	R-20054
217D-4	Boyce	Clarke	3	New Market	Ordovician	Limestone	73.9	0.0	73.9	98.40	.00	R-18633
217D-6	Boyce	Clarke	2	Rockdale Run	Ordovician	Limestone	81.7	0.0	81.7	97.44	.00	R-18635
217D-18	Boyce	Clarke	5	Conococheague	Cambrian	Limestone	83.3	1.3	78.2	95.06	.05	R-18661
217D-19	Boyce	Clarke	2	Elbrook	Cambrian	Limestone	82.8	0.7	79.9	95.91	.00	R-18663
217D-25	Boyce	Clarke	1	New Market	Ordovician	Limestone	80.0	0.8	77.0	98.21	.00	R-18670
217D-27	Boyce	Clarke	1	New Market	Ordovician	Limestone	76.1	4.7	57.2	98.08	1.34	R-18665
217D-28	Boyce	Clarke	3	Rockdale Run	Ordovician	Limestone	91.1	0.0	91.1	94.35	2.82	R-18975
217D-32	Boyce	Clarke	3	Conococheague	Cambrian	Limestone	83.3	0.1	82.7	81.80	7.36	R-18978
217D-34	Boyce	Clarke	5	Shady	Cambrian	Dolostone	83.3	4.6	64.7	53.51	45.07	R-18979
217D-35	Boyce	Clarke	2	Waynesboro	Cambrian	Dolostone	76.4	8.4	42.7	41.95	35.33	R-18666
217D-36	Boyce	Clarke	1	Elbrook	Cambrian	Limestone	78.3	0.2	77.5	75.05	7.73	R-18664
217D-41	Boyce	Clarke	3	New Market	Ordovician	Limestone	88.3	0.1	88.0	99.37	.00	R-18982
217D-46	Boyce	Clarke	1	Stonehenge	Ordovician	Limestone	80.0	0.0	80.0	92.12	4.95	R-18987
217D-48	Boyce	Clarke	1	Conococheague	Cambrian	Magnesian Limestone	73.9	1.0	69.7	78.19	13.54	R-18988
217D-49	Boyce	Clarke	3	Conococheague	Cambrian	Magnesian Limestone	76.7	0.2	75.8	71.18	24.17	R-18989
217D-51	Boyce	Clarke	2	Conococheague	Cambrian	Magnesian Limestone	71.1	2.8	60.0	71.72	17.92	R-18991
217D-56	Boyce	Clarke	5	Conococheague	Cambrian	Magnesian Limestone	77.2	0.6	75.0	71.73	22.22	R-18995
217D-57	Boyce	Clarke	2	Conococheague	Cambrian	Limestone	82.2	2.4	72.6	74.85	8.22	R-18996
218B-4	Capon Springs	Frederick	2	Keyser	Silurian	Limestone	73.7	4.0	57.8	85.34	2.04	R-20091
218C-21	Mountain Falls	Frederick	4	Licking Creek	Devonian	Limestone	71.1	3.7	56.4	90.23	1.99	R-19053
218D-18	Middletown	Shenandoah	3	New Market	Ordovician	Limestone	75.8	0.5	73.9	99.05	.00	R-19023
218D-32	Middletown	Shenandoah	3	New Market	Ordovician	Limestone	71.3	0.5	69.3	99.39	.00	R-19034
218D-37	Middletown	Frederick	2	New Market	Ordovician	Limestone	72.8	0.8	69.4	98.85	.00	R-18835

Table 6. (cont'd.).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation	Age	Rock Type	*Brightness (Percent)	*Tint (Percent)	*Whiteness (Percent)	**$CaCO_3$ (Percent)	**$MgCO_3$ (Percent)	Repository Number
221D-1	Point of Rocks	Loudoun	2	Swift Run	Precambrian	Marble	86.7	0.1	86.2	54.03	42.52	R-20092
221D-2	Point of Rocks	Loudoun	4	Swift Run	Precambrian	Marble	86.1	2.6	75.7	53.18	44.79	R-20093
221D-3	Point of Rocks	Loudoun	2	Swift Run	Precambrian	Marble	81.4	5.6	59.2	50.66	42.67	R-20094
223C-11	White Hall	Frederick	3	Elbrook	Cambrian	Magnesian Limestone	75.0	3.6	60.5	80.21	12.48	R-18790
223D-9	Inwood	Clarke	2	New Market	Ordovician	Limestone	73.3	0.8	70.0	97.86	1.36	R-19042
223D-14	Inwood	Clarke	4	Conococheague	Cambrian	Limestone	82.8	4.1	66.4	80.92	1.22	R-20098
224D-4	Gore	Frederick	5	Licking Creek	Devonian	Limestone	77.8	1.9	70.2	95.91	1.12	R-18679

*Reflectance tests by U.S. Bureau of Mines Tuscaloosa Research Center, University, Alabama.
**Chemical analyses by Virginia Division of Mineral Resources, Charlottesville.

Table 7. Summary of chlorine analyses for 42 carbonate-rock samples, northern Virginia area (see maps beginning with 215A, Figure 11, for sample locations) (Frederick-Winchester 0.5° X 1° sheets).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation, Group, or Deposit	Age	Rock Type	*Chlorine Content Percent(ppm)	**$CaCO_3$ (Percent)	**$MgCO_3$ (Percent)	Repository Number
215A-6	Waterford	Loudoun	4	Fauquier	Precambrian	Marble	.0027 (27)	59.09	38.59	R-20062
215A-7	Waterford	Loudoun	5	Newark Group	Triassic	Limestone Conglomerate	.0078 (78)	83.61	4.74	R-20063
215C-1	Lincoln	Loudoun	8	Fauquier	Precambrian	Marble	.0036 (36)	57.13	37.42	R-20068
215C-3	Lincoln	Loudoun	6	Fauquier	Precambrian	Marble	.0064 (64)	58.81	40.51	R-20070
215C-4	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	.0031 (31)	58.42	39.54	R-20071
215C-5	Lincoln	Loudoun	10	Fauquier	Precambrian	Marble	.0043 (43)	56.17	41.70	R-20072
215C-9	Lincoln	Loudoun	3	Fauquier	Precambrian	Marble	.0058 (58)	90.58	7.75	R-20075
216C-1	Ashby Gap	Clarke	2	Shady	Cambrian	Limestone	.01 (100)	93.59	4.05	R-18902
216C-2	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	.0028 (28)	99.06	.00	R-18903
216C-5	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Dolostone	.024 (240)	54.10	40.10	R-18906
216C-15	Ashby Gap	Clarke	5	Conococheague	Cambrian	Magnesian Limestone	.011 (110)	81.79	10.44	R-18912
216C-17	Ashby Gap	Clarke	2	Elbrook	Cambrian	Limestone	.0052 (52)	90.51	6.39	R-18914
216C-24	Ashby Gap	Clarke	5	Shady	Cambrian	Dolostone	.014 (140)	53.95	43.03	R-18921
216D-1	Bluemont	Loudoun	1	Fauquier	Precambrian	Marble	.0044 (44)	53.43	45.00	R-20081
217A-2	Stephenson	Frederick	2	New Market	Ordovician	Limestone	.004 (40)	99.33	.00	R-18767
217A-11	Stephenson	Clarke	3	Lincolnshire	Ordovician	Limestone	.0048 (48)	99.06	.07	R-18925
217A-14	Stephenson	Clarke	10	Rockdale Run	Ordovician	Limestone	.0086 (86)	86.75	6.62	R-18928
217A-23	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	.058 (580)	57.27	40.75	R-18934
217A-25	Stephenson	Clarke	3	New Market	Ordovician	Limestone	.0054 (54)	89.20	8.27	R-18936
217A-39	Stephenson	Clarke	3	Rockdale Run	Ordovician	Dolostone	.013 (130)	50.05	40.86	R-18946
217A-42	Stephenson	Clarke	2	Stonehenge	Ordovician	Limestone	.0035 (35)	82.00	3.98	R-18949
217A-44	Stephenson	Clarke	3	Edinburg	Ordovician	Limestone	.0028 (28)	95.69	.00	R-18645
217A-48	Stephenson	Clarke	10	New Market	Ordovician	Limestone	.0038 (38)	99.39	.00	R-18953
217A-58	Stephenson	Clarke	2	New Market	Ordovician	Limestone	.023 (230)	99.49	.00	R-18961
217B-1	Winchester	Frederick	5	Elbrook	Cambrian	Dolostone	.034 (340)	55.65	36.05	R-18689
217B-5	Winchester	Frederick	4	Conococheague	Cambrian	Dolostone	.037 (370)	47.73	37.42	R-18848
217B-13	Winchester	Frederick	1	Deposit	Quaternary	Marl	.0021 (21)	86.22	1.30	R-18850
217B-14	Winchester	Frederick	1	Deposit	Quaternary	Travertine	.0008 (8)	97.08	1.69	R-18860
217B-15	Winchester	Frederick	2	Helderberg or Cayuga	Devonian-Silurian	Limestone	.012 (120)	62.00	5.47	R-18846
221D-2	Point of Rocks	Loudoun	4	Fauquier	Precambrian	Marble	.0063 (63)	53.18	44.79	R-20093
221D-4	Point of Rocks	Loudoun	4	Newark Group	Triassic	Dolostone Conglomerate	.029 (290)	54.98	37.56	R-20095
223C-2	White Hall	Frederick	4	Stonehenge	Ordovician	Limestone	.0061 (61)	87.98	1.96	R-18695
223C-5	White Hall	Frederick	4	New Market	Ordovician	Limestone	.0072 (72)	95.39	2.76	R-18779
223C-6	White Hall	Frederick	4	Edinburg	Ordovician	Limestone	.0076 (76)	87.37	5.17	R-18777
223C-19	White Hall	Frederick	5	Stonehenge	Ordovician	Limestone	.0063 (63)	95.46	.95	R-20097
223D-3	Inwood	Frederick	4	New Market	Ordovician	Magnesian Limestone	.0062 (62)	83.05	12.29	R-18801
223D-19	Inwood	Frederick	12	New Market	Ordovician	Limestone	.0056 (56)	93.69	4.49	R-20099
224A-1	Ridge	Frederick	2	Keyser	Silurian	Limestone	.015 (150)	88.29	2.49	R-18693
224A-2	Ridge	Frederick	1	Licking Creek	Devonian	Limestone	.017 (170)	80.81	5.05	R-18692
224D-3	Gore	Frederick	3	Keyser	Silurian	Limestone	.018 (180)	85.82	3.03	R-18678
224D-4	Gore	Frederick	5	Licking Creek	Devonian	Limestone	.027 (270)	95.91	1.12	R-18679
224D-6	Gore	Frederick	10	Tonoloway	Silurian	Limestone	.024 (240)	86.99	7.31	R-18680

*Chlorine analyses by U.S. Bureau of Mines, Reno Research Center, Reno, Nevada.
**Chemical analyses by Virginia Division of Mineral Resources, Charlottesville.

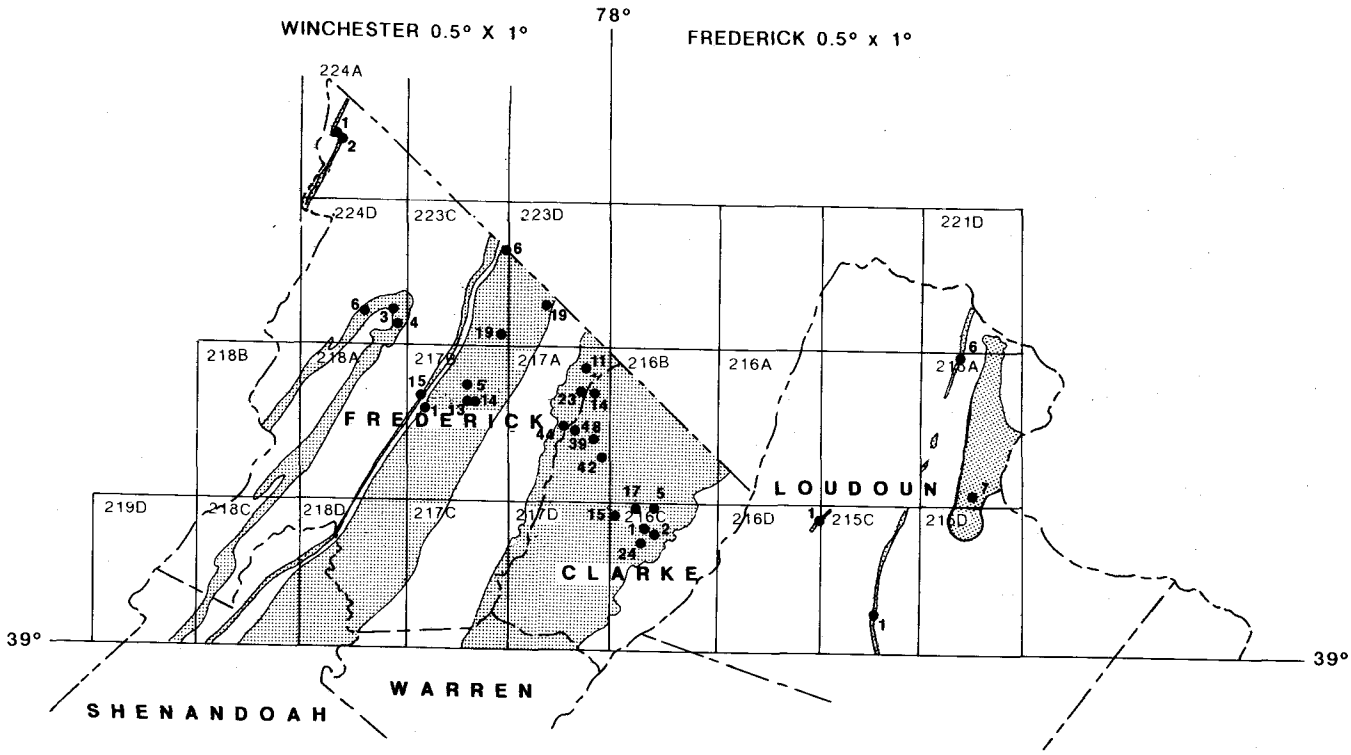


Figure 5. Overview map indicating locations (black dots) for 30 carbonate-rock samples used for semiquantitative trace-element analyses (Table 8). Number and letter on each 7.5-minute quadrangle correspond to those on quadrangles beginning with 215A, Figure 11, and continuing through Figure 47. Carbonate belts shown as shaded areas.

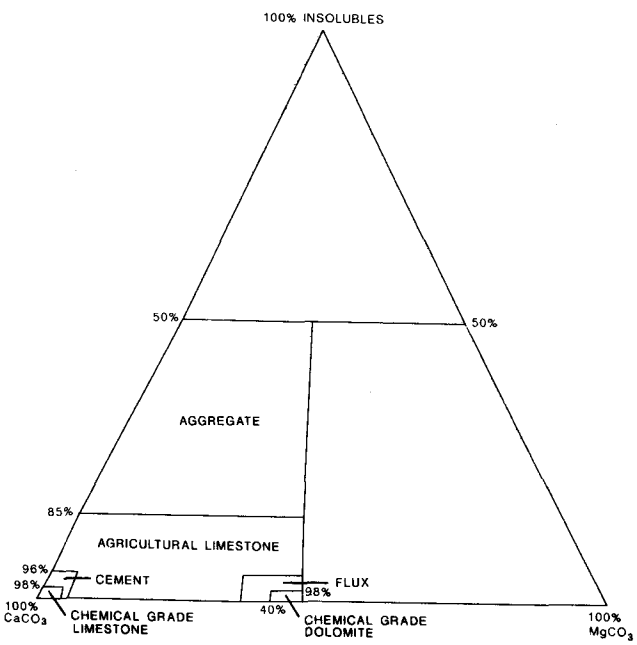


Figure 6. Carbonate-rock uses by composition (modified from Hershey and Maher, 1985).

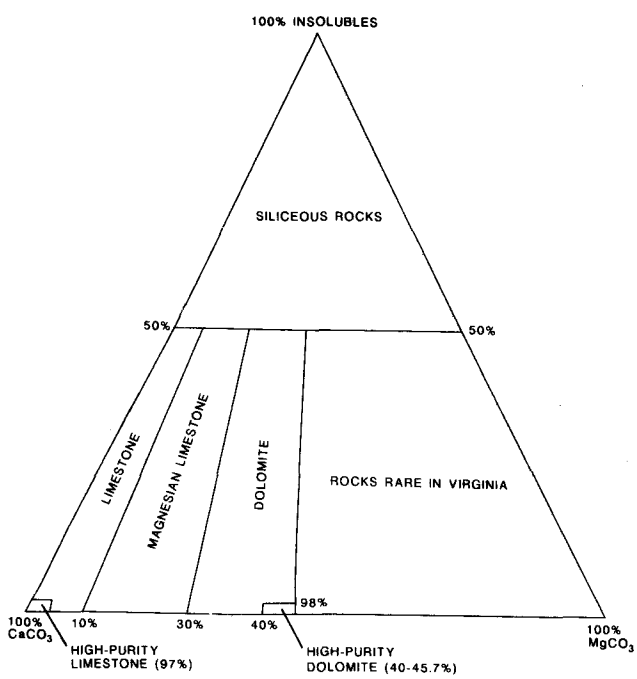


Figure 7. Carbonate-rock classification by composition (modified from Hershey and Maher, 1985).

Table 8. Summary of semiquantitative spectographic analyses of 30 northern Virginia carbonate-rock samples (see quadrangles beginning with 215, Figure 11, for sample locations) (Frederick-Winchester 0.5° X 1° sheets).

Map-Sample No.			Waterford-215A-6		Waterford-215A-7		Lincoln-215C-1		Ashby Gap-216C-1		Ashby Gap-216C-2		Ashby Gap-216C-5	
Rock Type			Marble		Limestone Conglomerate		Marble		Limestone		Limestone		Dolostone	
Formation(Group, deposit)			Fauquier		Newark		Fauquier		Shady		Waynesboro		Waynesboro	
Age			Precambrian		Triassic		Precambrian		Cambrian		Cambrian		Cambrian	
County			Loudoun		Loudoun		Loudoun		Clarke		Clarke		Clarke	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .004	(40)	< .004	(40)	< .0005	(5)	< .001	(10)	< .0005	(5)	< .0005	(5)
Al	.001	(10)	> 5.	(50,000)	1.	(10,000)	.6	(6,000)	.3	(3,000)	.09	(900)	.4	(4,000)
As	.009	(90)	< .02	(200)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	.06	(600)	.008	(80)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0002	(2)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	.004	(40)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	7.	(70,000)	1.	(10,000)	.8	(8,000)	.2	(2,000)	.02	(200)	1.	(10,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	>10.	(100,000)	3.	(30,000)	>10.	(100,000)	2.	(20,000)	.5	(5,000)	>10.	(100,000)
Mn	.0008	(8)	.7	(7,000)	.08	(800)	.03	(300)	.007	(70)	.007	(70)	.06	(600)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .02	(200)	< .007	(70)	< .02	(200)	< .007	(70)	< .007	(70)	< .02	(200)
Ni	.0002	(2)	.006	(60)	< .0004	(4)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< 1.	(10,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .008	(80)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0007	(7)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	>10.	(100,000)	4.	(40,000)	2.	(20,000)	.6	(6,000)	.2	(2,000)	2.	(20,000)
Sn	.0006	(6)	< .01	(100)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.01	(100)	.02	(200)	.003	(30)	.4	(4,000)	.009	(90)	.007	(70)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	.7	(7,000)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	.003	(30)	< .0006	(6)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

Table 8. (cont'd.).

Map-Sample No. -			Ashby Gap-216C-15		Ashby Gap-216C-17		Ashby Gap-216C-24		Bluemont-216D-1		Stephenson-217A-11		Stephenson-217A-14	
Rock Type -			Magnesian Limestone		Limestone		Dolostone		Marble		Limestone		Limestone	
Formation(Group, deposit) -			Conococheague		Elbrook		Shady		Fauquier		Lincolnshire		Rockdale Run	
Age -			Cambrian		Cambrian		Cambrian		Precambrian		Ordovician		Ordovician	
County -			Clarke		Clarke		Clarke		Loudoun		Clarke		Clarke	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .0005	(5)	< .003	(30)	< .002	(20)	< .0008	(8)	< .003	(30)	< .0006	(6)
Al	.001	(10)	.6	(6,000)	.4	(4,000)	.2	(2,000)	.2	(2,000)	.2	(2,000)	.6	(6,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	.01	(100)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.7	(7,000)	.2	(2,000)	1.	(10,000)	.2	(2,000)	.02	(200)	.4	(4,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	.01	(100)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	4.	(40,000)	3.	(30,000)	>10.	(100,000)	>10.	(100,000)	2.	(20,000)	3.	(30,000)
Mn	.0008	(8)	.02	(200)	.01	(100)	.1	(1,000)	.02	(200)	< .001	(10)	.01	(100)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .007	(70)	< .007	(70)	< .02	(200)	< .02	(200)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)	< .0005	(5)	< .0002	(2)	< .0002	(2)	< .0003	(3)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	2.	(20,000)	2.	(20,000)	.6	(6,000)	.5	(5,000)	.07	(700)	2.	(20,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.03	(300)	.05	(500)	.0006	(6)	.0005	(5)	.009	(90)	.02	(200)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

Table 8. (cont'd.).

Map-Sample No. -			Stephenson-217A-23		Stephenson-217A-39		Stephenson-217A-42		Stephenson-217A-44		Stephenson-217A-48		Winchester-217B-1	
Rock Type -			Dolostone		Dolostone		Limestone		Limestone		Limestone		Dolostone	
Formation(Group, deposit) -			Rockdale Run		Rockdale Run		Stonehenge		Edinburg		New Market		Elbrook	
Age -			Ordovician		Ordovician		Ordovician		Ordovician		Ordovician		Cambrian	
County -			Clarke		Clarke		Clarke		Clarke		Clarke		Frederick	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .001	(10)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0006	(6)	< .0007	(7)
Al	.001	(10)	.2	(2,000)	.3	(3,000)	> 2.	(20,000)	.5	(5,000)	.1	(1,000)	.6	(6,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	.004	(40)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0002	(2)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.2	(2,000)	.9	(9,000)	2.	(20,000)	.4	(4,000)	.007	(70)	1.	(10,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	>10.	(100,000)	>10.	(100,000)	2.	(20,000)	.8	(8,000)	.5	(5,000)	>10.	(100,000)
Mn	.0008	(8)	.007	(70)	.01	(100)	.07	(700)	.08	(800)	< .002	(20)	.04	(400)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .008	(80)	< .01	(100)	< .007	(70)	< .007	(70)	< .007	(70)	< .01	(100)
Ni	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	.3	(3,000)	3.	(30,000)	4.	(40,000)	1.	(10,000)	.07	(700)	2.	(20,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.005	(50)	.002	(20)	.03	(300)	.05	(500)	.004	(40)	.001	(10)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

Table 8. (cont'd.).

Map-Sample No. -			Winchester-217B-5		Winchester-217B-13		Winchester-217B-14		Winchester-217B-15		White Hall-223C-6		White Hall-223C-19	
Rock Type -			Dolostone		Marl		Travertine		Limestone		Limestone		Limestone	
Formation(Group, deposit) -			Conococheague		Deposit		Deposit		(Undifferentiated)		Edinburg		Stonehenge	
Age -			Cambrian		Quaternary		Quaternary		Devonian-Silurian		Ordovician		Ordovician	
County -			Frederick		Frederick		Frederick		Frederick		Frederick		Frederick	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .0005	(5)	< .001	(10)	< .002	(20)	< .001	(10)	< .002	(20)	< .0005	(5)
Al	.001	(10)	.9	(9,000)	.8	(8,000)	.2	(2,000)	> 3.	(30,000)	.7	(7,000)	.2	(2,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	.009	(90)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	.02	(200)	.008	(80)	.003	(30)	.01	(100)	< .002	(20)
Be	.0001	(1)	< .0002	(2)	< .0001	(1)	< .0001	(1)	.0005	(5)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	.001	(10)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	3.	(30,000)	.4	(4,000)	.05	(500)	2.	(20,000)	.3	(3,000)	.1	(1,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	>10.	(100,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)
Mn	.0008	(8)	.06	(600)	.03	(300)	.06	(600)	.1	(1,000)	.02	(200)	.004	(40)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .02	(200)	< .007	(70)	< .007	(70)	< .007	(70)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0003	(3)	< .0003	(3)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	4.	(40,000)	4.	(40,000)	.3	(3,000)	>10.	(100,000)	3.	(30,000)	1.	(10,000)
Sn	.0006	(6)	< .0007	(7)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.001	(10)	.006	(60)	.005	(50)	.01	(100)	.05	(500)	.02	(200)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .05	(500)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0008	(8)	< .0001	(1)	.003	(30)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

Table 8. (cont'd.).

Map-Sample No. -			Inwood-223D-19		Ridge-224A-1		Ridge-224A-2		Gore-224D-3		Gore-224D-4		Gore-224D-6	
Rock Type -			Limestone		Limestone		Limestone		Limestone		Limestone		Limestone	
Formation(Group, deposit) -			New Market		Keyser		Licking Creek		Keyser		Licking Creek		Tonoloway	
Age -			Ordovician		Silurian		Devonian		Silurian		Devonian		Silurian	
County -			Frederick		Frederick		Frederick		Frederick		Frederick		Frederick	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .001	(10)	< .004	(40)	< .003	(30)	< .003	(30)	< .002	(20)	< .002	(20)
Al	.001	(10)	.2	(2,000)	.6	(6,000)	.9	(9,000)	.6	(6,000)	.07	(700)	.3	(3,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .004	(40)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.05	(500)	.6	(6,000)	1.	(10,000)	.6	(6,000)	.05	(500)	.4	(4,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	4.	(40,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)	.6	(6,000)	>10.	(100,000)
Mn	.0008	(8)	< .0008	(8)	.1	(1,000)	.04	(400)	.05	(500)	.02	(200)	.03	(300)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .007	(70)	< .007	(70)	< .007	(70)	< .007	(70)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)	< .0003	(3)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	.3	(3,000)	3.	(30,000)	5.	(50,000)	3.	(30,000)	.2	(2,000)	1.	(10,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.006	(60)	.02	(200)	.01	(100)	.03	(300)	.01	(100)	.03	(300)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0007	(7)	< .0002	(2)	< .0003	(3)	< .0001	(1)	.001	(10)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

ANALYSES AND CONCLUSIONS

Chemical Analyses

Knowledge of the chemistry of carbonate rocks is essential to determine the economic potential of these materials, especially the high purity limestones and dolostones. The Virginia Division of Mineral Resources' laboratory performed chemical analyses for 10 elements on each of 466 carbonate samples. Samples were crushed to 95 percent passing the 325-mesh size and composited; 2 grams were mixed with 2 grams of chromatographic cellulose and pressed into 1.25-inch pellets under 25 tons pressure. Pellets were analyzed using a Diano XRD 700 wavelength dispersive X-ray fluoresence unit. A flow-proportional counter, coarse collimator, and pulse height discriminator were used for all analyses and corrections for back-ground levels, dead time, and drift were made.

The New Market Limestone formation of Ordovician age contains thicknesses of limestone to 225 feet. One section, 160 feet thick, averages 98.25 percent $CaCO_3$ and occurs just north of Interstate Highway 81, west of State Road 629, and about 2 miles northeast of Strasburg, Shenandoah County (Figure 37 and Appendix IV), and is an exceptional body of chemical-grade limestone. Another significant occurrence of the New Market Limestone is 1.5 miles northwest of Middletown, Frederick County. The outcrop width of the synclinal belt crossing State Road 627 is approximately 900 feet with a stratigraphic thickness at least 100 feet averaging 98.02 percent $CaCO_3$ (Figure 37 and Appendix II). Total reserves for the New Market on both sides of State Road 627 along a northeasterly strike for about 4500 feet is approximately 15,000,000 short tons with a minimum content of 96 percent $CaCO_3$.

The Waynesboro and Conococheague formations of Cambrian age and the Stonehenge, Rockdale Run, Lincolnshire, and Edinburg units of Ordovician age in northern Virginia all contain high purity limestone intervals, however, thicknesses are not sufficient for mining or quarrying. An exception is the occurrence of thin sections of high-purity Lincolnshire Limestone in contact with high-purity New Market Limestone in certain quarries. The Keyser Limestone of Silurian age and the Licking Creek Limestone of Devonian age, also have very thin units of high purity limestone. Quaternary travertine-marl deposits exhibit high purity zones, however, they generally qualify for agricultural use only.

Shady Dolomite dolostone of Cambrian age averages 42.44 percent $MgCO_3$ in a section 200 feet thick, along the north edge of the Shenandoah River and beside State Road 621 about 1 mile west of Shepherd Ford, Clarke County (Figure 13 and Appendix I). High purity Shady Dolomite dolostone also occurs in the northeastern portion of Warren County (Figure 29 and Table 37). Five other formations contain high-purity dolostone intervals, however, lack of adequate thicknesses prevents the economic development of these formations for chemical-grade rock. High purity sections in the Rockdale Run Dolomite of Ordovician age occur in Clarke, Frederick, Shenandoah, and Warren counties. The Pinesburg Station Dolomite of Ordovician age and the Waynesboro Formation, of Cambrian age, contain high purity dolostone units in Clarke County. The Elbrook Formation of Cambrian age has sections of chemical-grade dolostone in Shenandoah and Frederick counties as does the Conococheague Formation of Cambrian age in Shenandoah County.

Results of the ten-part chemical analyses on the 466 carbonate-rock samples collected in northern Virginia begin with Table 9 and continue through Table 57.

Reflectance Values

Carbonate rocks with reflectance values of 70 percent brightness or above may have potential as a filler or extender in paint, plastic, rubber, linoleum, and as a coating or filler in paper. Reflectance is a comparative measurement to a standard equaling 100 percent and is reported as percent brightness, tint, and whiteness. The U.S. Bureau of Mines, Tuscaloosa Research Center, University, Alabama, tested 115 carbonate samples from the 466 collected in northern Virginia, using a Photovolt Corporation reflectance spectrophotometer and a magnesian carbonate primary standard. Only 77 samples tested above 70 percent brightness. Results of the reflectance tests begin with Table 10, quadrangle 215A. Each sample to be tested was chosen from 100-mesh size material after a visual comparison to one of the same mesh size and known to reflect 70 percent brightness. Each was forwarded to the Tuscaloosa Research Center for analysis. The sample was pulverized to 325-mesh size and pressed into a briquette. Brightness percent was determined by reflecting a green filtered light from the briquette, tint was determined by using brightness percent minus the percent reflection through a blue filter, and whiteness percent was derived by calculation as follows:

$$\text{Brightness} - (\text{Tint} \times 4) = \text{Whiteness}$$

Testing procedure was adapted from the "Pulverized Limestone Association Method of Test S-68T, Determination of Dry Brightness of Ground Limestone, 1984."

Precambrian marble in the Fauquier Formation, Loudoun County, has reflectance values to 92.2 percent brightness. High purity limestones in the Rockdale Run Formation and the New Market Limestone test to 91.1 and 87.8 percent brightness respectively. Dolostone in the Shady and limestone in the Elbrook and Conococheague formations test to 83.3 percent brightness values. Devonian limestone has reflectance values to 77.8 percent brightness and Silurian limestone to 73.7 percent.

Chlorine Analyses

Chlorine content is important if a carbonate raw material is to be used in the manufacture of cement. If the content in raw-cement mix exceeds 0.1 percent by weight or

1000 parts per million, operating problems involving build-ups within the preheater of the cement kiln may result. Quality of the finished cement may also be adversely affected if the chlorine content exceeds the allowable limit (Honkala, A. N., 1983, personal communication). Chlorine also promotes corrosion of steel which has a detrimental effect on the tension wires in prestressed concrete. The U.S. Bureau of Mines, Reno Research Center, Reno, Nevada, analyzed 42 carbonate-rock samples. Samples were selected along a northwest-southeast traverse and represent each formation and deposit in the area. Some formations were analyzed on both sides of a fault or the limbs of a fold. Each sample was ground to 97 percent minus 100-mesh size per a modification of chlorine analyses prescribed by Standard of the American Society for Testing and Materials C114-82a and chlorine determinations were made by the silver-silver sulfide specific ion electrode titration method (Laver, A. E., 1983, personal communication). Results of chlorine analyses begin with Table 11, quadrangle 215A.

Generally, Cambrian and Ordovician dolostones have the highest chlorine content (.013 - 0.58 percent or 130 - 580 ppm). Limestones of the same age have a lower chlorine content (.0028 - .023 percent or 28 - 230 ppm) and marbles in the Fauquier Formation of Precambrian age even lower (.0027 - .0078 percent or 27-78 ppm). The Devonian and Silurian limestones contain higher amounts (.012 - .027 percent or 120 - 270 ppm) of chlorine than the Cambrian and Ordovician limestones. Triassic limestone-dolostone conglomerates tested within the same range as the Devonian and Silurian limestones (.0078 - .029 percent or 78 - 290 ppm); the higher chlorine content reflects a higher dolostone content in the conglomerate. Quaternary age fresh-water travertine-marl possesses the lowest chlorine content (.0008 - .0021 percent or 8 - 21 ppm) of the 42 carbonate samples analyzed.

Trace Element Tests

Semiquantitative trace element analyses may provide clues to the deleterious components, the presence of possible mineral deposits, and also depositional environment of carbonate rocks. The Reno Research Center conducted a 39-element, semiquantitative spectrographic analyses on 30 carbonate-rock samples, selected along a northwest-southeast section. Limestone and dolostone samples from each carbonate-rock formation, group, and deposit along the section were analyzed and results are presented in Tables 12 through 60. The 16 elements not detected in the 30 carbonate rock-samples tested include antimony, boron, cadmium, cobalt, gallium, gold, lanthanum, molybdenum, palladium, scandium, sodium, tantalum, tellurium, vanadium, yttrium, and zirconium.

Semiquantitative analyses revealed only one carbonate sample with above normal trace elements. A Precambrian dolostone marble (sample 215A-6) tested relatively higher than other carbonate samples in arsenic, barium, iron, manganese, nickel, lead, platinum, silica, tin, titanium, and zinc (Table 12).

The strontium content is higher in limestones (.004 - 1.0 percent or 40 - 10,000 ppm) and is less in the marbles and dolostone marbles (.0005 - .04 percent or 5 - 400 ppm), travertine-marls (.005 - .006 percent or 50 - 60 ppm), and dolostones (.0006 - .007 percent or 6 - 70 ppm) of northern Virginia. The element niobium is higher in the dolostones tested (.01 - .02 percent or 100 - 200 ppm) than in the limestones (.007 - .008 percent or 70 - 80 ppm).

ECONOMIC POTENTIAL

Companies have extracted high-purity material from the Middle Ordovician-age New Market Limestone since about 1880. Reserves of this rock occur in the area covered by this report (Butts and Edmundson, 1966). Markets for crushed high-purity or high-calcium material involve uses as a flux stone in the manufacture of glass and steel, as agricultural limestone and a filler-supplement in fertilizer and animal feed, as a coal mine dust suppressor, and as acid control stone. A significant and growing market for high-purity limestone is for control of sulfur and nitrogen emissions from stacks of coal-fired boilers. At least 15 coal-fired electric power plants are scheduled to be constructed in Virginia during the "environmental decade" (1990-2000). Growth is occurring in markets involving uses related to high reflectance characteristics of high-purity carbonate-rock products. A market which may experience growth is the use of calcium carbonate precipitated from limestone to produce paper. Markets for crushed limestone also include non-chemical uses in the construction industry as an aggregate stone for uses such as, in mortar and concrete and as an asphalt-filler material.

Demand for calcined lime, both quick and hydrated, produced from high-purity limestone continues to increase (Sweet, 1990). Leading uses are in water and sewage treatment plants, in asphalt, the removal of sulfur from stack gases, paper and pulp mills, and in construction. Production of lime in northern Virginia dates back to perhaps the 1830s, when it was produced by farmers using small bank kilns constructed with stone (Figure 8). This type of kiln was used to calcine limestone for agricultural use as a soil conditioner. A modern rotary-type lime kiln is shown in photograph on the front cover of this publication.

High-purity Shady Dolomite dolostone in Clarke County is suitable for refractory grade dolomite (Sweet and Giannini, 1985). High-purity dolostone for use as a flux stone in glass making and magnesian agricultural material exists abundantly in the Valley and Ridge province of northern Virginia. Formations best suited for these uses are the Shady Dolomite, Pinesburg Station Dolomite, and Rockdale Run Formation. The Shady also has potential as a filler material based on reflectance values, in paint, plastic, rubber, linoleum, and paper.

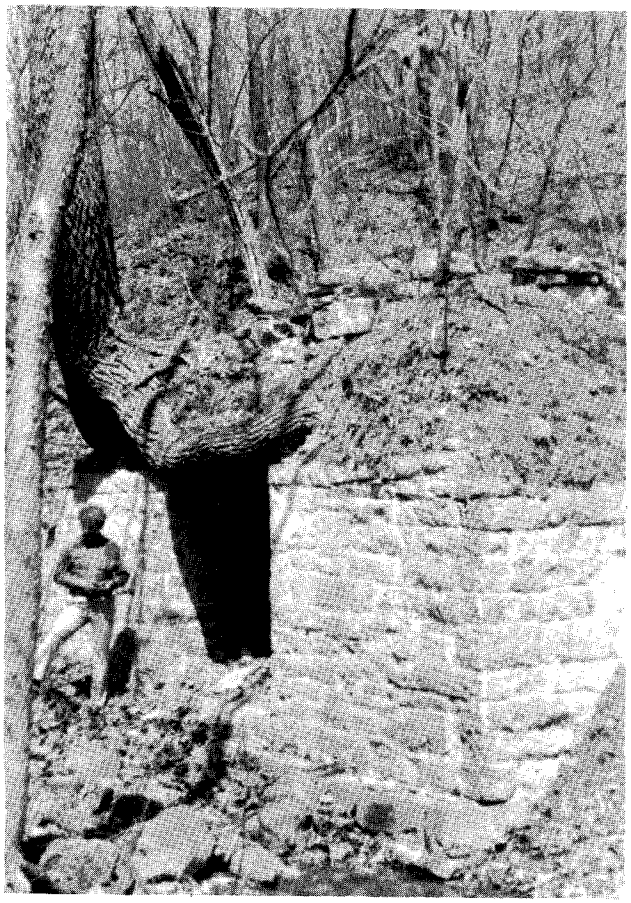


Figure 8. Old lime kiln constructed of sandstone near Star Tannery on the north side of State Road 600, Frederick County, Virginia (see Figure 35, quadrangle 218C - photograph by H. W. Webb, 1986).

Extensive reserves of limestone, dolostone, and limestone-dolostone conglomerate that exist in the area sampled are suitable for potential uses other than those requiring high-purity carbonate-rock material. Carbonate rocks of Silurian and Devonian age in western Frederick and Shenandoah counties are present in large quantities and are potential sources of aggregate stone. Fauquier Formation marble in Loudoun County has potential as fillers and extenders in paint, plastic, rubber and linoleum, and in paper as fillers and coatings, based on reflectance values; however, known reserves are limited. Travertine-marl deposits have been excavated for agricultural purposes for many years in Clarke and Frederick counties and the last productive site in northern Virginia, Frederick County, closed in 1985 (Figure 9) (Hubbard and others, 1985). Numerous deposits remain but future development appears doubtful.

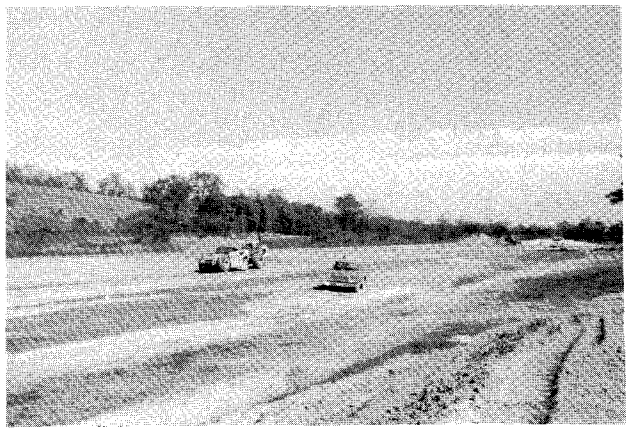


Figure 9. Travertine-marl deposit along Redbud Run, 1 mile north of Winchester, Virginia (see quadrangle 217B, Figure 24, for location).

ACKNOWLEDGEMENTS

Special thanks are given to Oliver M. Fordham for organizing and administering the testing program and to Jacqueline L. Kennamer for her assistance organizing the mass of analytical data and sample-processing procedures. The monotonous task performed by Charles B. and Edwin W. Marshall of preparing the carbonate-rock samples for testing is appreciated. Patricia W. Marshall is acknowledged for organizing the numerous tables containing the analytical data and processing the manuscript. All land owners are thanked for their cooperation and allowing access to the writer to sample the carbonate rocks.

REFERENCES CITED

Butts, Charles, and Edmundson, R. S., 1966, Geology and mineral resources Frederick County: Virginia Division of Mineral Resources Bulletin 80, 142 p.

Hershey, R. E., and Maher, S. W., 1985, Limestone and dolomite resources of Tennessee: Tennessee Division of Geology Bulletin 65, 2nd Edition, 252 p.

Hubbard, D. A., Jr., Giannini, W. F., and Lorah, M. M., 1985, Travertine-marl deposits of the Valley and Ridge Province of Virginia-A preliminary report: Virginia Division of Mineral Resources, Virginia Minerals, v. 31, n. 1, p. 1-8.

Pulverized Limestone Association, 1984, Determination of dry brightness of ground limestone: Method 5-68T, p. 19-21.

Sherwood, W. C., and Newlon, Howard, Jr., 1964, Statewide survey for reactive carbonate aggregates, Virginia: Virginia Council of Highway Investigation and Research, 18 p.

Figure 8. Old lime kiln constructed of sandstone near Star Tannery on the north side of State Road 600, Frederick County, Virginia (see Figure 35, quadrangle 218C - photograph by H. W. Webb, 1986).

Extensive reserves of limestone, dolostone, and limestone-dolostone conglomerate that exist in the area sampled are suitable for potential uses other than those requiring high-purity carbonate-rock material. Carbonate rocks of Silurian and Devonian age in western Frederick and Shenandoah counties are present in large quantities and are potential sources of aggregate stone. Fauquier Formation marble in Loudoun County has potential as fillers and extenders in paint, plastic, rubber and linoleum, and in paper as fillers and coatings, based on reflectance values; however, known reserves are limited. Travertine-marl deposits have been excavated for agricultural purposes for many years in Clarke and Frederick counties and the last productive site in northern Virginia, Frederick County, closed in 1985 (Figure 9) (Hubbard and others, 1985). Numerous deposits remain but future development appears doubtful.

Figure 9. Travertine-marl deposit along Redbud Run, 1 mile north of Winchester, Virginia (see quadrangle 217B, Figure 24, for location).

ACKNOWLEDGEMENTS

Special thanks are given to Oliver M. Fordham for organizing and administering the testing program and to Jacqueline L. Kennamer for her assistance organizing the mass of analytical data and sample-processing procedures. The monotonous task performed by Charles B. and Edwin W. Marshall of preparing the carbonate-rock samples for testing is appreciated. Patricia W. Marshall is acknowledged for organizing the numerous tables containing the analytical data and processing the manuscript. All land owners are thanked for their cooperation and allowing access to the writer to sample the carbonate rocks.

REFERENCES CITED

Butts, Charles, and Edmundson, R. S., 1966, Geology and mineral resources Frederick County: Virginia Division of Mineral Resources Bulletin 80, 142 p.

Hershey, R. E., and Maher, S. W., 1985, Limestone and dolomite resources of Tennessee: Tennessee Division of Geology Bulletin 65, 2nd Edition, 252 p.

Hubbard, D. A., Jr., Giannini, W. F., and Lorah, M. M., 1985, Travertine-marl deposits of the Valley and Ridge Province of Virginia-A preliminary report: Virginia Division of Mineral Resources, Virginia Minerals, v. 31, n. 1, p. 1-8.

Pulverized Limestone Association, 1984, Determination of dry brightness of ground limestone: Method 5-68T, p. 19-21.

Sherwood, W. C., and Newlon, Howard, Jr., 1964, Statewide survey for reactive carbonate aggregates, Virginia: Virginia Council of Highway Investigation and Research, 18 p.

Sweet, P.C., 1990, Mineral industry in Virginia – 1989: Virginia Division of Mineral Resources, Virginia Minerals, v. 36, n. 4, p. 29-35.

Sweet, P. C., and Giannini, W. F., 1985, Refractory grade dolomite in Virginia: Virginia Division of Mineral Resources, Virginia Minerals, v. 31, n. 1, p. 13-14.

Virginia Department of Transporation, 1991, List n. A-5, Results of quality test on commercially produced coarse aggregates, p. II-167 through II-174.

REFERENCES FOR GEOLOGY (FIGURES 11-47)

Butts, Charles, 1933, Geologic map of Appalachian Valley of Virginia with explanatory text: Virginia Geological Survey Bulletin 42, 56 p.

Butts, Charles, 1939, Virginia Division of Mineral Resources Field Map n. 218-C-3.

Butts, Charles, and Edmundson, R. S., 1936-1940, Geology of the Winchester, Virginia-West Virginia 15-minute quadrangle: Virginia Division of Mineral Resources field map n. 210.

Edmundson, R. S., and Nunan, W. E., 1973, Geology of the Berryville, Stephenson, and Boyce quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 34, 112 p.

Gathright, T. M., II, and Nystrom, P. G., 1974, Geology of the Ashby Gap quadrangle, Virginia: Virginia Division of Mineral Resources Report of Investigations 36, 55 p.

Le Van, D. C., and Harris, W. B., 1971, Mineral Resources of Virginia: Virginia Division of Mineral Resources, map, 1 sheet.

Mack, Tinsley, 1965, Characteristics of the Everona Formation in Virginia: Virginia Division of Mineral Resources Information Circular 10, 16 p.

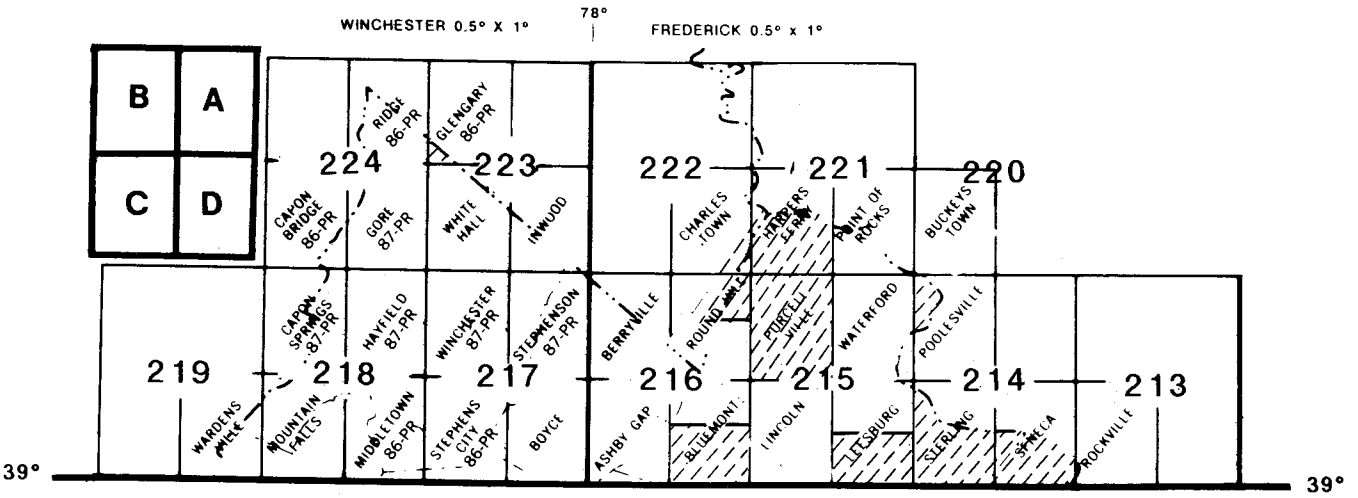
Monroe, W. H., 1942, Manganese deposits of Cedar Creek Valley, Frederick and Shenandoah counties, Virginia: U.S. Geological Survey Bulletin 936-E, p. 111-141.

Parker, P. E., 1968, Geologic investigation of the Lincoln and Bluemont quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 14, 23 p.

Toewe, E. C., 1966, Geology of the Leesburg quadrangle, Virginia: Virginia Division of Mineral Resources Report of Investigations 11, 52 p.

Leavy, B. D., Froelich, A. J., and Abram, E. C., 1983, Bedrock map and geotechnical properties of rocks of the Culpeper basin and vicinity, Virginia and Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map 1-1313-C.

Lee, K. Y., 1979, Triassic-Jurassic geology of the northern part of the Culpeper basin, Virginia and Maryland: U. S. Geological Survey Open-File Report 79-1557, Part 1, 10 p.



EXPLANATION

Geologic Period	Unit Symbol	Group, Formation, or Deposit Name
Quaternary	Qa	Travertine-marl deposit
Triassic	Trncg	Newark Supergroup (limestone conglomerate)
Devonian	DS	Undifferentiated Devonian- Silurian carbonate rocks
	Dhl	Helderberg Limestone
	Dri	Ridgley Sandstone (limestone unit)
	Dlc	Licking Creek Limestone
	Dnc	New Creek Limestone
Silurian	DSk	Keyser Limestone
	Scy	Cayuga Limestone
	Stl	Tonoloway Limestone
Ordovician	Oo	Oranda Formation
	Oe	Edinburg Formation
	Ol	Lincolnshire Limestone
	On	New Market Limestone
	Ops	Pinesburg Station Dolomite
	Orr	Rockdale Run Dolomite
	Ost	Stonehenge Limestone
Cambrian	Ꞓco	Conococheague Formation
	Ꞓe	Elbrook Formation
	Ꞓw	Waynesboro Formation
	Ꞓs	Shady Dolomite
Precambrian	pꞒs	Swift Run Formation (Fauquier)

KEY

Symbols and Descriptions
-Carbonate formation contacts
-Faults: exposed or approximate (solid); covered or inferred (dashed); U, up-thrown side; T, upper sheet; arrows indicate direction of relative movement.
- Active quarries: do, dolostone; ls, limestone.
-Abandoned quarries: do, dolostone; ls, limestone.
-Abandoned travertine-marl pit.
-Abandoned mine entrance: do, - dolostone; ls, limestone.
-Carbonate-rock sample location: 22, sample number; 215A-22 complete sample number, Waterford quad.
-Active lime kiln site: 2, number of kilns at site.
- Abandoned lime kiln site: 5, number of kilns at site.

Figure 10. Diagram, explanation, and key for the 21 quadrangles (scale 1 inch equals 50,000 inches) arranged numerically from number 215A (Waterford) to 224D (Gore). Hachured zones were not sampled because carbonate rocks are not known to occur in the area.

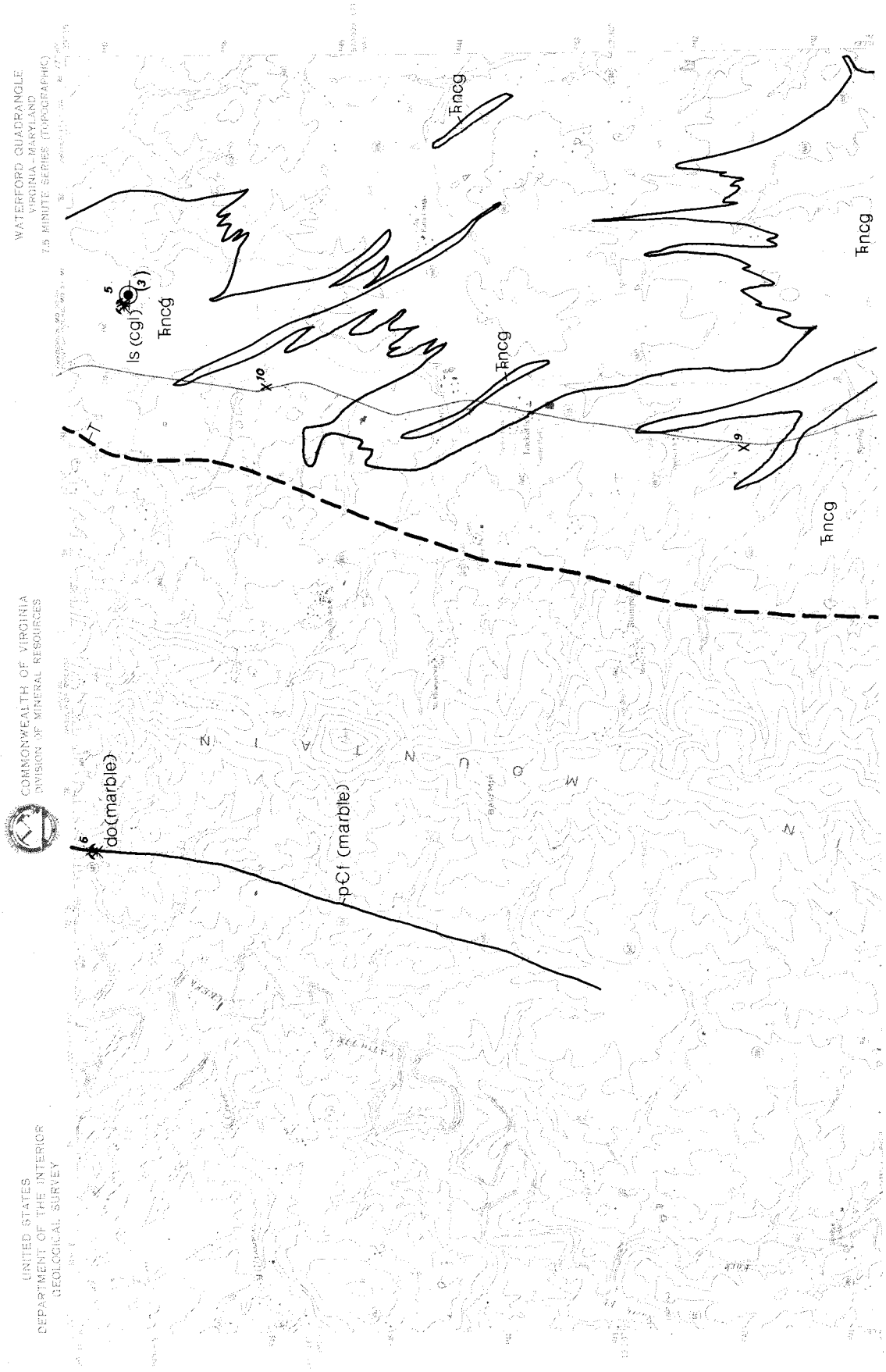


Figure 11. Northern half of Waterford quadrangle (215A) showing carbonate-rock sample locations.

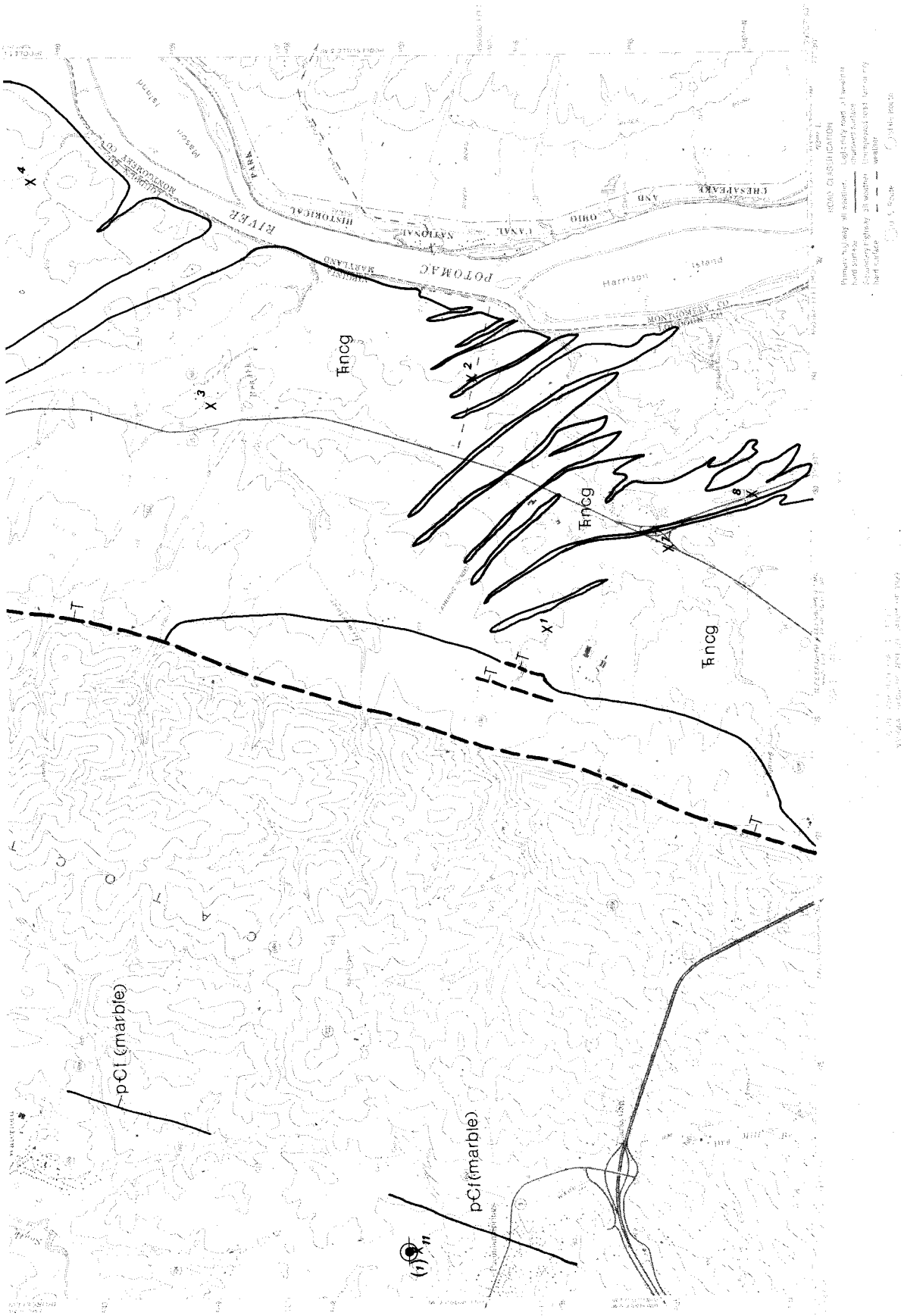


Figure 12. Southern half of Waterford quadrangle (215A) showing carbonate-rock sample locations.

215A

215A

Table 9. Chemical analyses of carbonate-rock samples, Waterford quadrangle (215A), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
215A-1	Waterford	Loudoun	3	Newark	Triassic	Limestone Conglomerate	77.87	1.96	13.71	1.62	3.46	1.20	.01	.16	.02	.00	R-20057
215A-2	Waterford	Loudoun	2	Newark	Triassic	Magnesian-Limestone Conglomerate	70.95	18.59	7.05	.81	1.51	.50	.47	.09	.04	.00	R-20058
215A-3	Waterford	Loudoun	3	Newark	Triassic	Magnesian-Limestone Conglomerate	65.83	24.00	6.68	.93	1.56	.77	.08	.12	.03	.00	R-20059
215A-4	Waterford	Loudoun	1	Newark	Triassic	Magnesian-Limestone Conglomerate	67.11	25.85	5.00	.63	1.00	.32	.04	.05	.00	.00	R-20060
215A-5	Waterford	Loudoun	3	Newark	Triassic	Dolostone Conglomerate	58.06	30.52	7.31	1.10	1.65	.59	.65	.11	.00	.00	R-20061
215A-6	Waterford	Loudoun	4	Fauquier	Precambrian	Marble	59.09	38.59	1.28	.57	.38	.07	.00	.02	.00	.00	R-20062
215A-7	Waterford	Loudoun	5	Newark	Triassic	Limestone Conglomerate	83.61	4.74	7.55	1.02	1.92	.86	.16	.10	.04	.00	R-20063
215A-8	Waterford	Loudoun	4	Newark	Triassic	Magnesian-Limestone Conglomerate	68.62	11.50	12.66	1.86	3.43	1.40	.28	.20	.04	.00	R-20064
215A-9	Waterford	Loudoun	4	Newark	Triassic	Dolostone Conglomerate	56.30	36.15	4.96	.85	1.21	.44	.00	.09	.00	.00	R-20065
215A-10	Waterford	Loudoun	1	Newark	Triassic	Dolostone Conglomerate	58.24	34.45	4.72	.75	1.11	.27	.37	.08	.01	.00	R-20066
215A-11	Waterford	Loudoun	2	Fauquier	Precambrian	Marble (float)	49.77	41.92	7.59	.54	.15	.00	.00	.01	.00	.00	R-20067

Table 10. Reflectance analyses of carbonate-rock sample with brightness of 70 percent or higher, Waterford quadrangle (215A), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
215A-11	Waterford	Loudoun	2	Fauquier	Precambrian	Marble (float)	86.7	0.0	86.7	49.77	41.92	R-20067

Table 11. Chlorine analyses of carbonate-rock samples, Waterford quadrangle (215A), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation Group, or Deposit	Age	Rock Type	Chlorine Content Percent(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
215A-6	Waterford	Loudoun	4	Fauquier	Precambrian	Marble	.0027 (27)	59.09	38.59	R-20062
215A-7	Waterford	Loudoun	5	Newark	Triassic	Limestone Conglomerate	.0078 (78)	83.61	4.74	R-20063

Table 12. Semiquantatitive trace-element analyses of carbonate-rock samples, Waterford quadrangle (215A), Loudoun County.

Map-Sample No.	-	Waterford-215A-6		Waterford-215A-7	
Rock Type	-	Marble		Limestone Conglomerate	
Formation(Group, deposit)	-	Fauquier		Newark	
Age	-	Precambrian		Triassic	
	**Detection Limits				
Elements	Percent	(ppm)			
Ag	.0005	(5)	< .004	(40)	< .004 (40)
Al	.001	(10)	> 5.	(50,000)	1. (10,000)
As	.009	(90)	< .02	(200)	< .009 (90)
*Au	.002	(20)	< .002	(20)	< .002 (20)
*B	.003	(30)	< .003	(30)	< .003 (30)
Ba	.002	(20)	.06	(600)	.008 (80)
Be	.0001	(1)	< .0001	(1)	< .0002 (2)
Bi	.01	(100)	< .01	(100)	< .01 (100)
Ca	.05	(500)	>10.	(100,000)	>10. (100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005 (5)
*Co	.001	(10)	< .001	(10)	< .001 (10)
Cr	.0003	(3)	.004	(40)	< .0003 (3)
Cu	.0006	(6)	< .0006	(6)	< .0006 (6)
Fe	.0006	(6)	7.	(70,000)	1. (10,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002 (2)
*La	.01	(100)	< .01	(100)	< .01 (100)
Li	.002	(20)	< .002	(20)	< .002 (20)
Mg	.0001	(1)	>10.	(100,000)	3. (30,000)
Mn	.0008	(8)	.7	(7,000)	.08 (800)
*Mo	.0001	(1)	< .0001	(1)	< .0001 (1)
*Na	.3	(3,000)	< .3	(3,000)	< .3 (3,000)
Nb	.007	(70)	< .02	(200)	< .007 (70)
Ni	.0002	(2)	.006	(60)	< .0004 (4)
P	.7	(7,000)	< .7	(7,000)	< .7 (7,000)
Pb	.002	(20)	< .008	(80)	< .002 (20)
*Pd	.0001	(1)	< .0001	(1)	< .0001 (1)
Pt	.0006	(6)	< .0007	(7)	< .0006 (6)
*Sb	.06	(600)	< .06	(600)	< .06 (600)
*Sc	.0004	(4)	< .0004	(4)	< .0004 (4)
Si	.0006	(6)	>10.	(100,000)	4. (40,000)
Sn	.0006	(6)	< .01	(100)	< .0006 (6)
Sr	.0001	(1)	.01	(100)	.02 (200)
*Ta	.02	(200)	< .02	(200)	< .02 (200)
*Te	.04	(400)	< .04	(400)	< .04 (400)
Ti	.03	(300)	.7	(7,000)	< .03 (300)
*V	.005	(50)	< .005	(50)	< .005 (50)
*Y	.001	(10)	< .001	(10)	< .001 (10)
Zn	.0001	(1)	.003	(30)	< .0006 (6)
*Zr	.003	(30)	< .003	(30)	< .003 (30)

***Trace Element Percent (Parts per million)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

215C

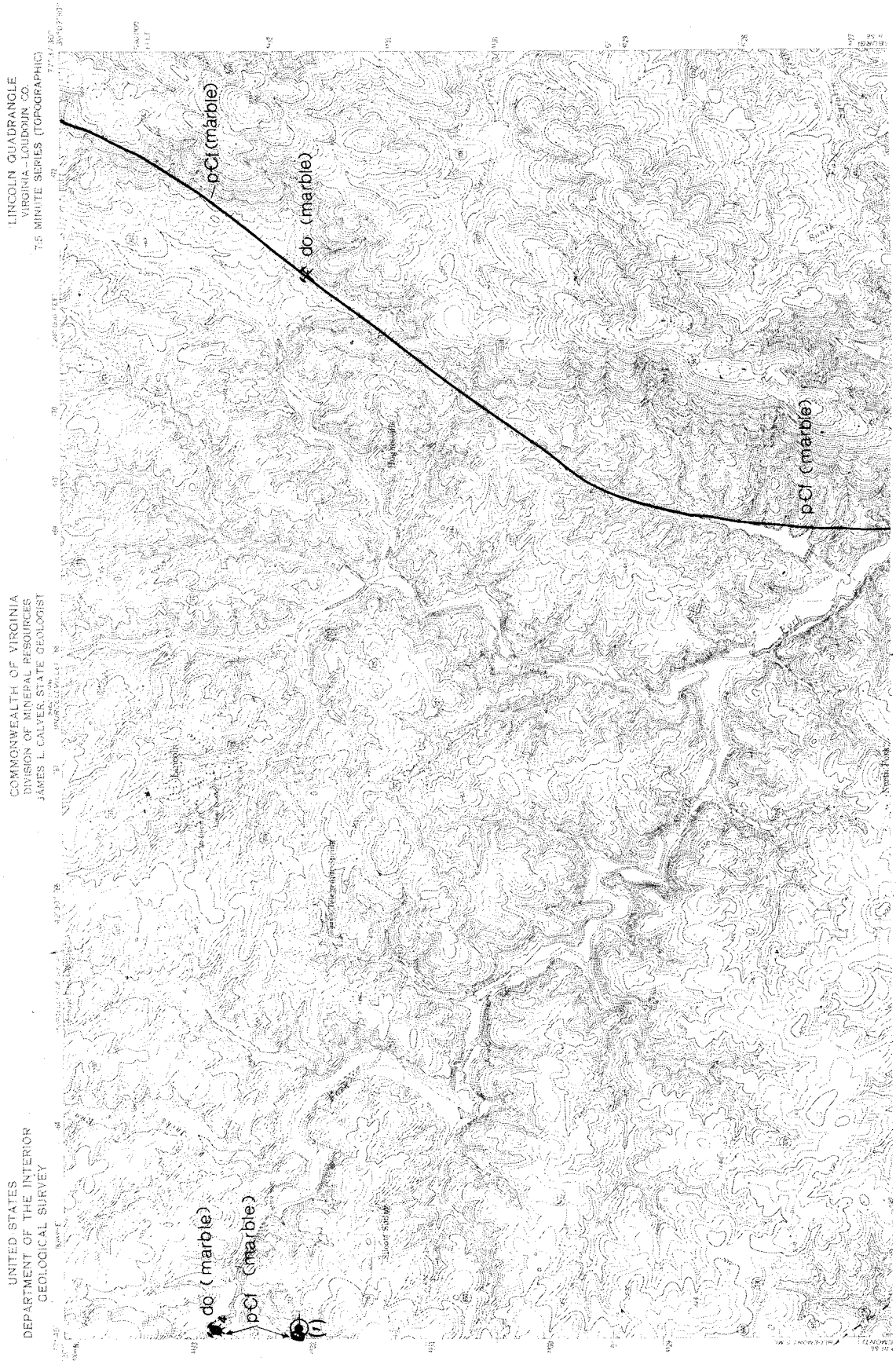


Figure 13. Northern half of Lincoln quadrangle, (215C) showing carbonate-rock sample location.

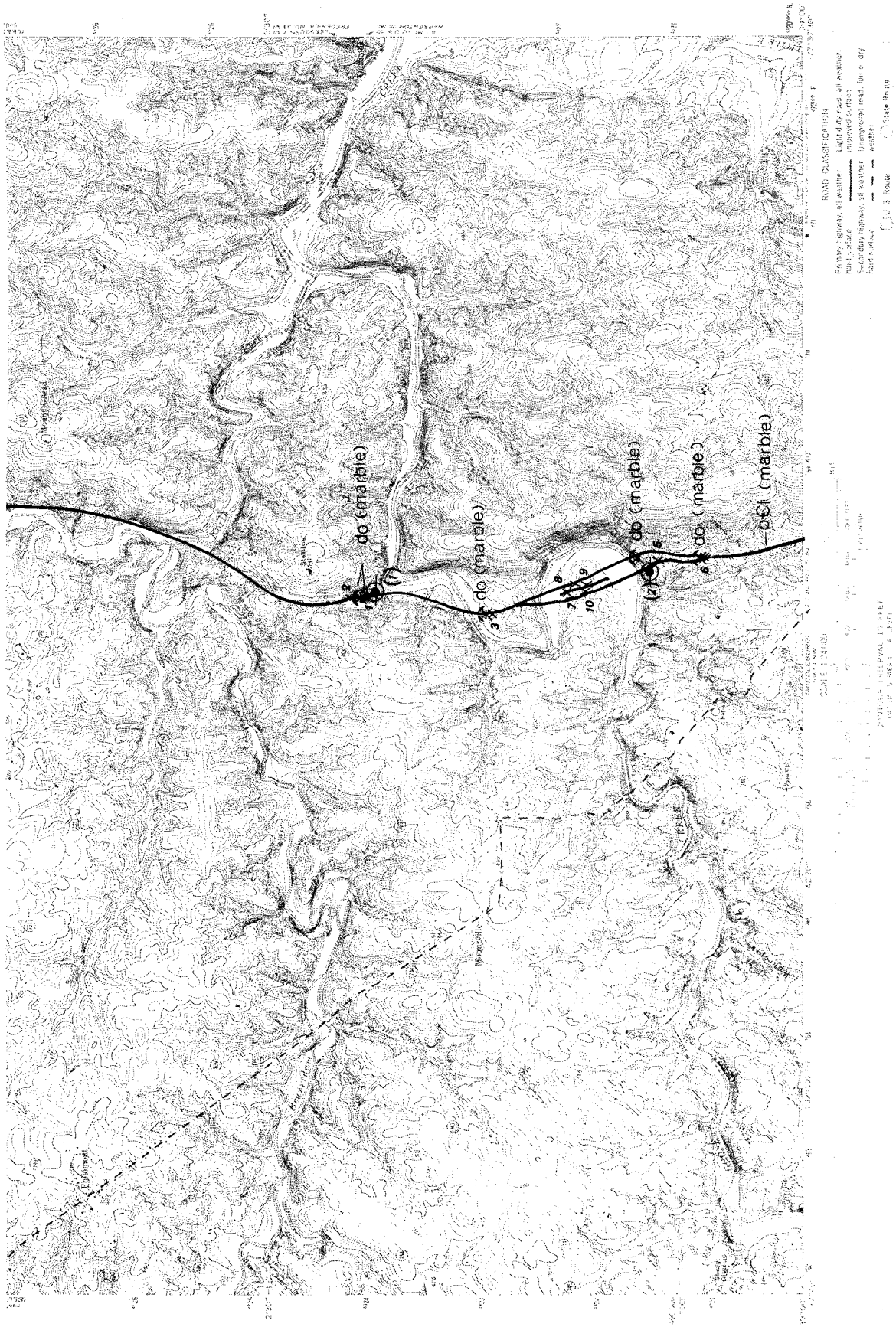


Figure 14. Southern half of Lincoln quadrangle (215C) showing carbonate-rock sample locations.

215C

Table 13. Chemical analyses of carbonate-rock samples, Lincoln quadrangle (215C), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
215C-1	Lincoln	Loudoun	8	Fauquier	Precambrian	Marble	57.13	37.42	3.01	.90	1.13	.29	.00	.07	.05	.00	R-20068
215C-2	Lincoln	Loudoun	4	Fauquier	Precambrian	Marble	82.21	14.73	1.93	.49	.46	.10	.03	.02	.03	.00	R-20069
215C-3	Lincoln	Loudoun	6	Fauquier	Precambrian	Marble	58.81	40.51	.48	.15	.04	.00	.00	.00	.00	.00	R-20070
215C-4	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	58.42	39.54	1.30	.38	.23	.11	.00	.02	.00	.00	R-20071
215C-5	Lincoln	Loudoun	10	Fauquier	Precambrian	Marble	56.17	41.70	.87	.84	.27	.12	.00	.02	.00	.00	R-20072
215C-6	Lincoln	Loudoun	1	Fauquier	Precambrian	Marble	54.14	42.59	1.83	.81	.43	.15	.00	.03	.03	.00	R-20073
215C-7	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	82.24	15.41	1.29	.28	.58	.16	.00	.02	.02	.00	R-20074
215C-8	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	87.95	10.64	.87	.25	.22	.02	.00	.01	.03	.00	R-20075
215C-9	Lincoln	Loudoun	3	Fauquier	Precambrian	Marble	90.58	7.75	1.20	.28	.12	.01	.01	.01	.04	.00	R-20076
215C-10	Lincoln	Loudoun	1	Fauquier	Precambrian	Marble	83.41	14.47	1.48	.22	.29	.10	.00	.01	.02	.00	R-20077

Table 14. Reflectance analyses of carbonate-rock samples with brightnesses of 70 percent or higher, Lincoln quadrangle (215C), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
215C-1	Lincoln	Loudoun	8	Fauquier	Precambrian	Marble	78.3	3.6	64.0	57.13	37.42	R-20068
215C-2	Lincoln	Loudoun	4	Fauquier	Precambrian	Marble	91.3	0.0	91.3	82.21	14.73	R-20069
215C-3	Lincoln	Loudoun	6	Fauquier	Precambrian	Marble	88.3	0.0	88.3	58.81	40.51	R-20070
215C-7	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	86.9	0.6	84.7	82.24	15.41	R-20074
215C-8	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	91.3	1.2	86.6	87.95	10.64	R-20075
215C-9	Lincoln	Loudoun	3	Fauquier	Precambrian	Marble	92.2	1.2	87.5	90.58	7.75	R-20076
215C-10	Lincoln	Loudoun	1	Fauquier	Precambrian	Marble	85.5	3.7	70.7	83.41	14.47	R-20077

Table 15. Chlorine analyses of carbonate-rock samples, Lincoln quadrangle (215C), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation Group, or Deposit	Age	Rock Type	Chlorine Content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
215C-1	Lincoln	Loudoun	8	Fauquier	Precambrian	Marble	.0036	(36)	57.13	37.42	R-20068
215C-3	Lincoln	Loudoun	6	Fauquier	Precambrian	Marble	.0064	(64)	58.81	40.51	R-20070
215C-4	Lincoln	Loudoun	2	Fauquier	Precambrian	Marble	.0031	(31)	58.42	39.54	R-20071
215C-5	Lincoln	Loudoun	10	Fauquier	Precambrian	Marble	.0043	(43)	56.17	41.70	R-20072
215C-9	Lincoln	Loudoun	3	Fauquier	Precambrian	Marble	.0058	(58)	90.58	7.75	R-20076

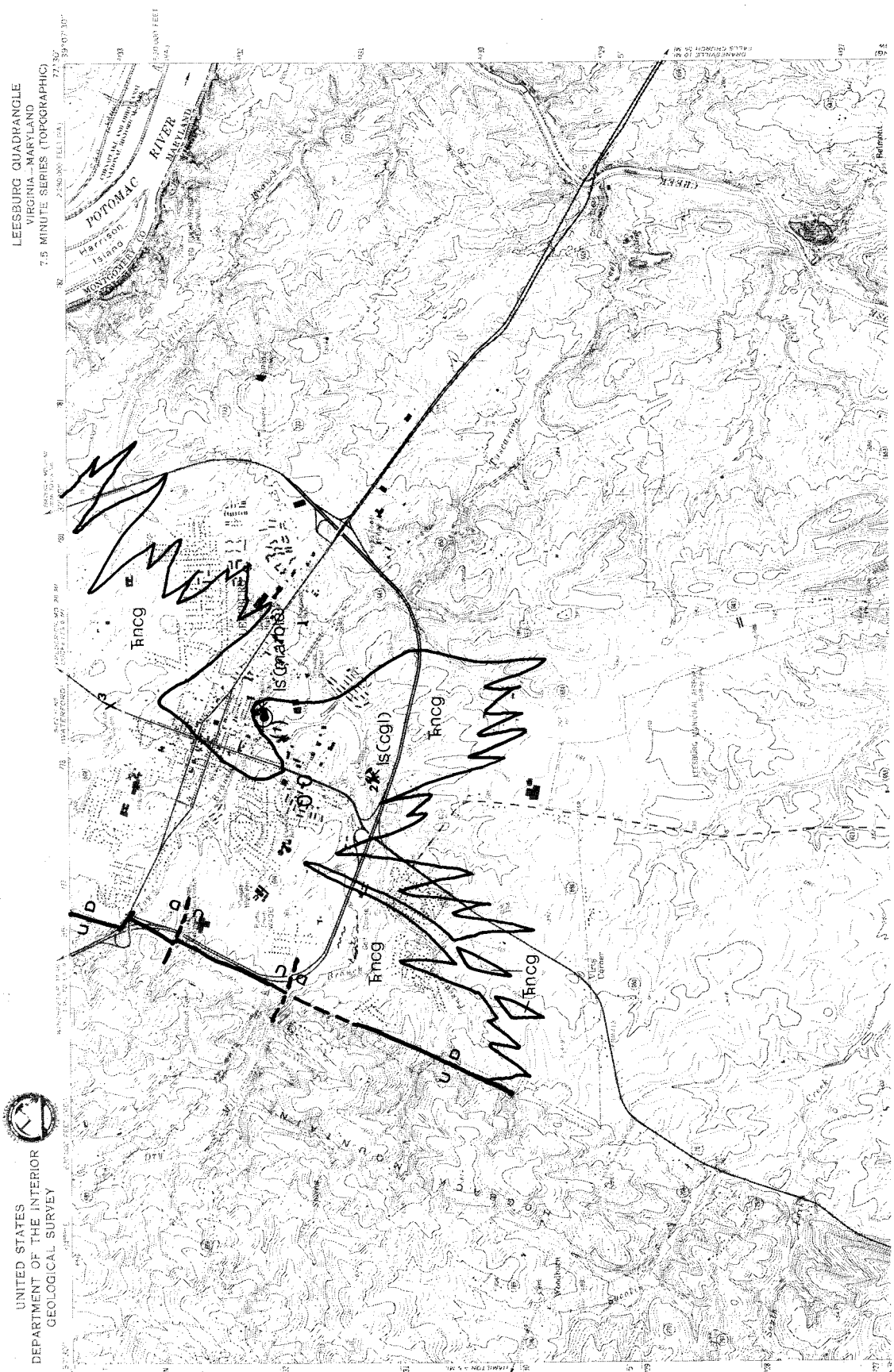
Table 16. Semiquantitative trace-element analyses of carbonate-rock sample, Lincoln quadrangle (215C), Loudoun County.

Map-Sample No.	-	Lincoln-215C-1
Rock Type	-	Marble
Formation(Group, deposit)	-	Fauquier
Age	-	Precambrian

Elements	**Detection Limits Percent	(ppm)	***Trace Element Percent	(Parts per million)
Ag	.0005	(5)	< .0005	(5)
Al	.001	(10)	.6	(6,000)
As	.009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)
Fe	.0006	(6)	.8	(8,000)
*Ga	.0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)
Mg	.0001	(1)	>10.	(100,000)
Mn	.0008	(8)	.03	(300)
*Mo	.0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .02	(200)
Ni	.0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)
Si	.0006	(6)	2.	(20,000)
Sn	.0006	(6)	< .0006	(6)
Sr	.0001	(1)	.003	(30)
*Ta	.02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

215C



215D

Figure 15. Northern half of Leesburg quadrangle (215D) showing carbonate-rock sample locations.

Table 17. Chemical analyses of carbonate-rock samples, Leesburg quadrangle (215D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
215D-1	Leesburg	Loudoun	2	Newark	Triassic	Marble Magnesian-Limestone	59.83	31.02	6.86	.69	1.37	.11	.02	.06	.01	.02	R-20078
215D-2	Leesburg	Loudoun	3	Newark	Triassic	Conglomerate Limestone	66.02	16.16	12.55	1.42	2.56	.95	.16	.15	.03	.00	R-20079
215D-3	Leesburg	Loudoun	3	Newark	Triassic	Conglomerate	61.32	9.56	19.46	2.51	4.64	1.90	.26	.30	.05	.00	R-20080

Figure 16. Southern half of Round Hill quadrangle (216A) showing carbonate-rock sample locations.

216A

Table 18. Chemical analyses of carbonate-rock sample, Round Hill quadrangle (216A), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
216A-1	Round Hill	Clarke	5	Waynesboro	Cambrian	Dolostone	54.97	37.89	5.62	.72	.41	.24	.10	.02	.01	.01	R-18901

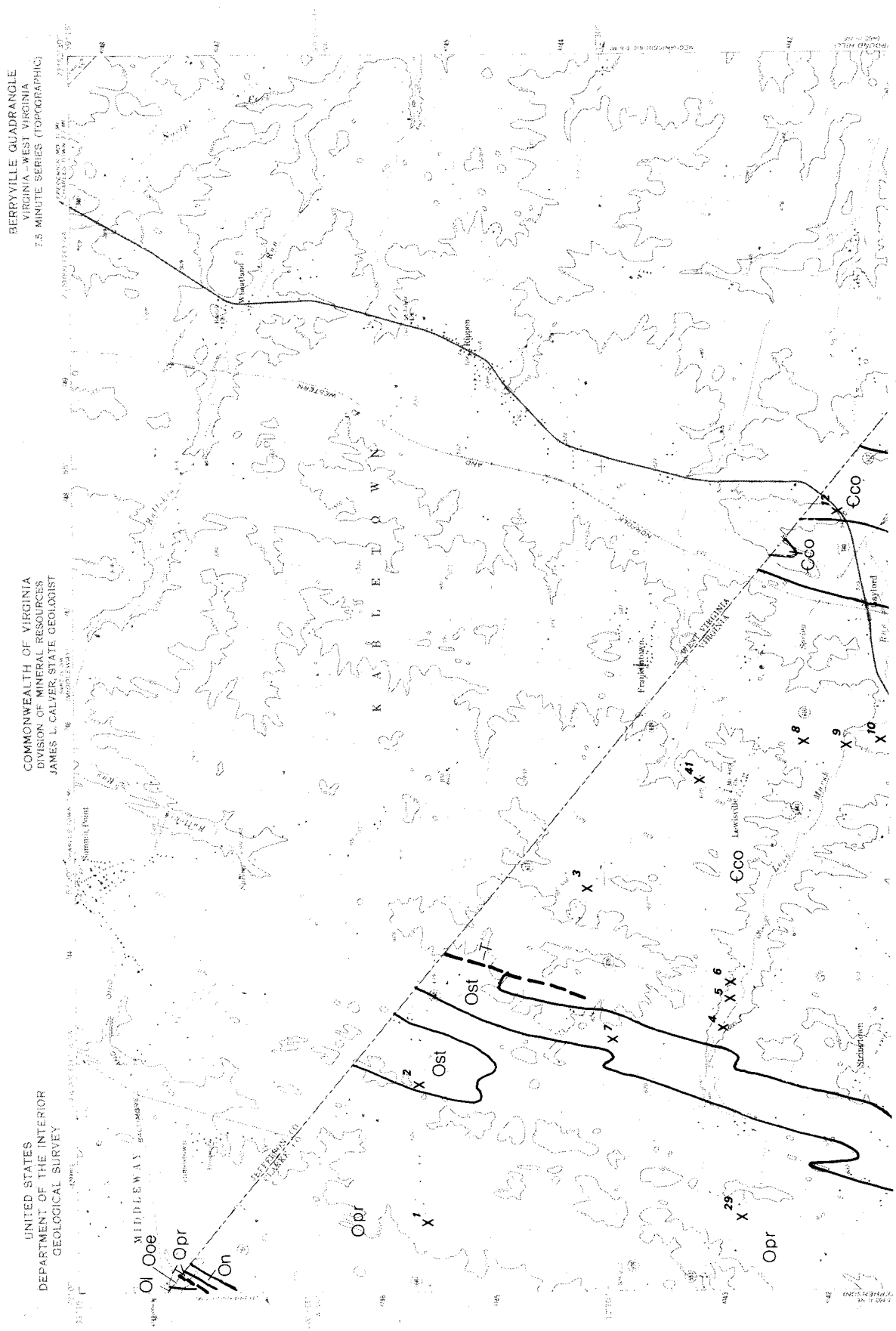


Figure 17. Northern half of Berryville quadrangle (216B) showing carbonate-rock sample locations.

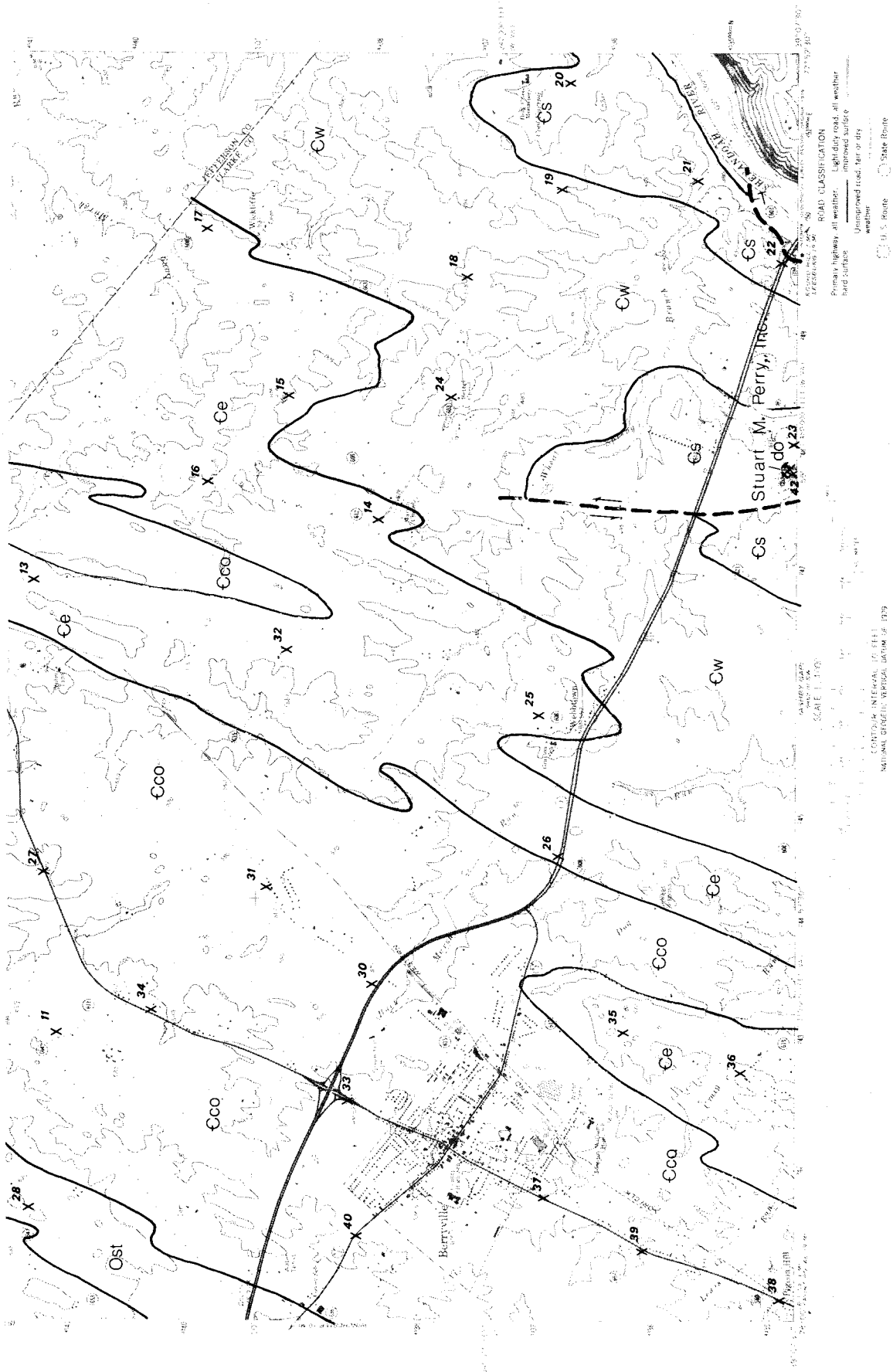


Figure 18. Southern half of Berryville quadrangle (216B) showing carbonate-rock sample locations.

216B

Table 19. Chemical analyses of carbonate-rock samples, Berryville quadrangle (216B), Clarke County.

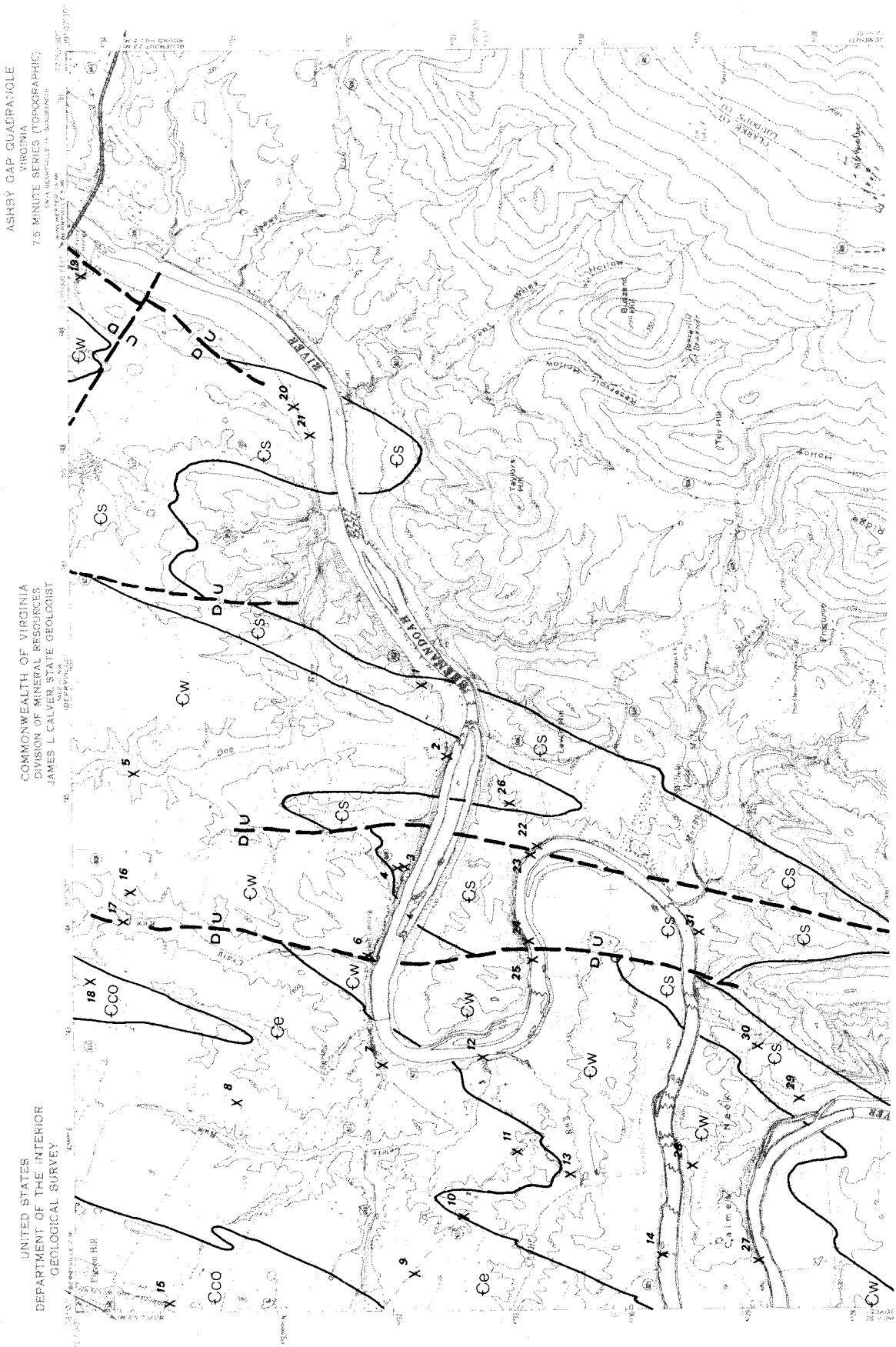
Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
216B-1	Berryville	Clarke	2	Rockdale Run	Ordovician	Limestone	87.68	8.95	2.23	.36	.37	.30	.05	.01	.00	.04	R-18875
216B-2	Berryville	Clarke	3	Stonehenge	Ordovician	Limestone	94.87	1.96	2.38	.19	.22	.15	.20	.01	.02	.01	R-18869
216B-3	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	92.35	1.46	3.96	.38	.91	.68	.09	.04	.01	.12	R-18888
216B-4	Berryville	Clarke	2	Deposit	Quaternary	Marl	81.56	.62	13.71	1.28	1.83	.46	.18	.12	.14	.09	R-20000
216B-5	Berryville	Clarke	3	Deposit	Quaternary	Marl	80.23	.68	14.83	1.20	2.05	.62	.05	.13	.10	.05	R-20001
216B-6	Berryville	Clarke	5	Conococheague	Cambrian	Limestone	87.09	2.32	7.20	.67	1.45	1.09	.01	.06	.07	.04	R-18887
216B-7	Berryville	Clarke	6	Stonehenge	Ordovician	Limestone	89.26	1.33	6.50	.60	1.33	.92	.00	.05	.02	.00	R-18867
216B-8	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	86.24	2.08	6.91	.66	1.15	.95	.00	.05	.00	1.96	R-18877
216B-9	Berryville	Clarke	12	Deposit	Quaternary	Marl	90.85	.00	6.11	1.09	1.36	.36	.03	.07	.10	.04	R-18900
216B-10	Berryville	Clarke	4	Deposit	Quaternary	Marl	76.98	.80	16.01	1.38	3.48	.86	.02	.22	.18	.06	R-20002
216B-11	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	86.01	5.88	5.42	.59	1.12	.77	.05	.06	.02	.07	R-18871
216B-12	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	82.35	4.84	8.70	1.04	1.76	1.09	.01	.10	.04	.08	R-18878
216B-13	Berryville	Clarke	1	Elbrook	Cambrian	Magnesian Limestone	78.08	15.37	3.93	.74	1.04	.79	.01	.05	.00	.01	R-18882
216B-14	Berryville	Clarke	1	Elbrook	Cambrian	Magnesian Limestone	27.87	23.47	32.38	3.43	7.45	4.22	.06	.67	.06	.39	R-20003
216B-15	Berryville	Clarke	2	Elbrook	Cambrian	Magnesian Limestone	21.34	17.97	36.57	7.90	10.26	4.68	.40	.78	.11	.00	r-20004
216B-16	Berryville	Clarke	1	Elbrook	Cambrian	Dolostone	54.91	38.63	5.07	.74	.39	.23	.00	.02	.00	.02	R-18886
216B-17	Berryville	Clarke	4	Elbrook	Cambrian	Limestone	87.33	9.44	2.54	.30	.17	.13	.09	.01	.00	.00	R-18872
216B-18	Berryville	Clarke	2	Waynesboro	Cambrian	Dolostone	51.76	43.60	2.22	1.34	.57	.47	.00	.03	.00	.01	R-18889
216B-19	Berryville	Clarke	4	Waynesboro	Cambrian	Dolostone	60.08	36.06	2.47	.70	.34	.24	.06	.02	.00	.01	R-18870
216B-20	Berryville	Clarke	4	Shady	Cambrian	Dolostone	51.61	43.47	2.45	1.61	.51	.32	.00	.04	.00	.01	R-18873
216B-21	Berryville	Clarke	2	Shady	Cambrian	Dolostone	53.00	44.64	.84	1.31	.10	.05	.05	.01	.00	.00	R-18876
216B-22	Berryville	Clarke	2	Shady	Cambrian	Dolostone	53.46	45.03	.68	.55	.12	.11	.03	.01	.00	.00	R-20005
216B-23	Berryville	Clarke	3	Shady	Cambrian	Dolostone	53.55	45.11	.56	.47	.14	.07	.09	.01	.01	.00	R-18868
216B-24	Berryville	Clarke	3	Waynesboro	Cambrian	Magnesian Limestone	73.85	16.39	5.38	1.35	1.73	.95	.13	.08	.01	.14	R-18884

Table 19. (cont'd.).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
216B-25	Berryville	Clarke	2	Elbrook	Cambrian	Limestone	81.02	9.54	6.33	.64	1.16	1.14	.05	.06	.00	.05	R-18874
216B-26	Berryville	Clarke	4	Elbrook	Cambrian	Magnesian Limestone	78.21	20.51	.82	.31	.06	.05	.00	.00	.03	.01	R-18883
216B-27	Berryville	Clarke	2	Conococheague	Cambrian	Limestone	89.24	1.29	6.95	.49	.98	.79	.00	.04	.00	.22	R-18879
216B-28	Berryville	Clarke	2	Stonehenge	Ordovician	Magnesian Limestone	74.57	13.16	9.41	.84	1.03	.71	.15	.05	.01	.07	R-18866
216B-29	Berryville	Clarke	2	Rockdale Run	Ordovician	Limestone	89.75	3.75	4.18	.47	.90	.72	.14	.04	.03	.02	R-18881
216B-30	Berryville	Clarke	2	Conococheague	Cambrian	Magnesian Limestone	69.81	18.12	8.22	1.18	1.49	.70	.26	.10	.03	.10	R-18896
216B-31	Berryville	Clarke	1	Conococheague	Cambrian	Magnesian Limestone	73.18	13.44	10.12	.94	1.29	.79	.08	.07	.02	.06	R-18891
216B-32	Berryville	Clarke	2	Elbrook	Cambrian	Magnesian Limestone	72.56	21.06	3.88	.84	.80	.77	.00	.04	.02	.04	R-18896
216B-33	Berryville	Clarke	4	Conococheague	Cambrian	Limestone	91.01	6.83	1.50	.33	.16	.14	.00	.01	.01	.02	R-18880
216B-34	Berryville	Clarke	2	Conococheague	Cambrian	Limestone	74.45	4.92	15.75	.88	2.28	1.50	.00	.10	.02	.10	R-18885
216B-35	Berryville	Clarke	1	Elbrook	Cambrian	Magnesian Limestone	52.38	29.55	11.53	2.06	2.17	1.97	.06	.16	.05	.08	R-18897
216B-36	Berryville	Clarke	2	Elbrook	Cambrian	Dolostone	40.22	33.28	16.00	3.02	3.79	3.14	.00	.28	.06	.21	R-18898
216B-37	Berryville	Clarke	7	Conococheague	Cambrian	Limestone	84.60	5.88	6.56	.68	1.20	.79	.10	.07	.03	.09	R-18899
216B-38	Berryville	Clarke	3	Conococheague	Cambrian	Limestone (cherty)	95.52	.69	2.55	.28	.38	.27	.22	.02	.01	.06	R-18894
216B-39	Berryville	Clarke	1	Conococheague	Cambrian	Limestone	68.81	5.80	17.12	1.46	3.70	2.72	.01	.18	.05	.15	R-18892
216B-40	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	84.02	4.86	7.97	.57	1.24	.95	.00	.07	.05	.28	R-18893
216B-41	Berryville	Clarke	2	Conococheague	Cambrian	Limestone	91.60	1.95	4.75	.29	.66	.66	.00	.03	.02	.04	R-18890
216B-42	Berryville	Clarke	30	Shady	Cambrian	Dolostone	53.54	45.10	.71	.44	.08	.10	.02	.01	.00	.00	R-20006

Table 20. Reflectance anaylses of carbonate-rock samples with brightnesses of 70 percent or higher, Berryville quadrangle (216B), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
216B-17	Berryville	Clarke	4	Elbrook	Cambrian	Limestone	83.3	2.2	74.6	87.33	9.44	R-18872
216B-40	Berryville	Clarke	3	Conococheague	Cambrian	Limestone	78.0	1.0	74.0	84.02	4.86	R-18893
216B-42	Berryville	Clarke	30	Shady	Cambrian	Dolostone	79.8	1.1	75.4	53.54	45.10	R-20006



216C

Figure 19. Northern half of Ashby Gap quadrangle (216C) showing carbonate-rock sample locations.

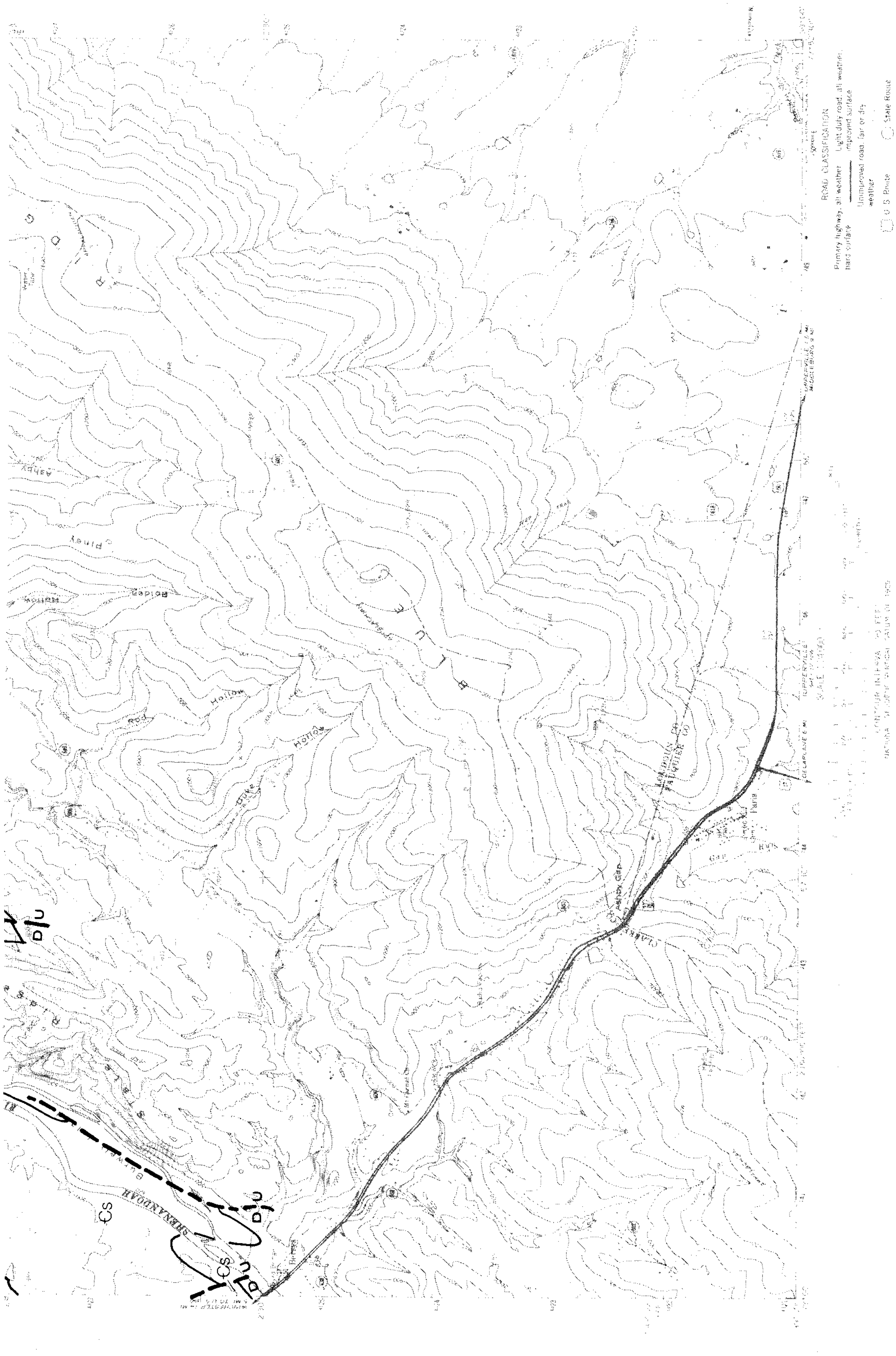


Figure 20. Southern half of Ashby Gap quadrangle (216C) showing carbonate-rock location (no samples collected).

216C

216C

Table 21. Chemical analyses of carbonate-rock samples, Ashby Gap quadrangle (216C), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
216C-1	Ashby Gap	Clarke	2	Shady	Cambrian	Limestone	93.59	4.05	1.51	.20	.29	.20	.08	.02	.05	.02	R-18902
216C-2	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	99.06	.00	.58	.07	.09	.06	.10	.00	.02	.01	R-18903
216C-3	Ashby Gap	Clarke	2	Shady	Cambrian	Limestone	94.57	3.52	1.46	.16	.13	.09	.00	.01	.03	.04	R-18904
216C-4	Ashby Gap	Clarke	1	Shady	Cambrian	Dolostone	53.04	44.67	1.28	.58	.24	.16	.00	.02	.01	.01	R-18905
216C-5	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Dolostone	54.10	40.10	3.57	1.22	.53	.32	.10	.03	.01	.03	R-18906
216C-6	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Magnesian Limestone	75.95	10.38	8.41	1.09	1.95	1.26	.52	.20	.06	.19	R-18907
216C-7	Ashby Gap	Clarke	2	Elbrook	Cambrian	Magnesian Limestone	32.94	27.74	26.31	4.00	5.49	2.89	.04	.43	.06	.05	R-20007
216C-8	Ashby Gap	Clarke	1	Elbrook	Cambrian	Magnesian Limestone	82.19	11.21	4.05	.87	.81	.73	.00	.06	.04	.05	R-18908
216C-9	Ashby Gap	Clarke	1	Elbrook	Cambrian	Limestone	90.25	5.07	2.99	.33	.60	.60	.07	.05	.03	.01	R-18909
216C-10	Ashby Gap	Clarke	1	Waynesboro	Cambrian	Magnesian Limestone	83.54	12.27	3.34	.23	.32	.12	.14	.01	.00	.03	R-18910
216C-11	Ashby Gap	Clarke	2	Elbrook	Cambrian	Dolostone	47.96	40.40	9.23	1.02	.91	.34	.06	.06	.00	.00	R-20008
216C-12	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Dolostone	40.61	34.21	15.87	2.67	3.87	2.24	.07	.26	.05	.12	R-20009
216C-13	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Magnesian Limestone	79.51	17.30	1.94	.37	.40	.38	.01	.03	.04	.01	R-18911
216C-14	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Magnesian Limestone	35.77	28.06	21.21	4.54	5.74	3.61	.34	.42	.16	.15	R-20010
216C-15	Ashby Gap	Clarke	5	Conococheague	Cambrian	Magnesian Limestone	81.79	10.44	5.32	.52	.92	.86	.07	.05	.01	.02	R-18912
216C-16	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Dolostone	54.65	34.53	8.07	.87	.92	.82	.00	.06	.01	.07	R-18913
216C-17	Ashby Gap	Clarke	2	Elbrook	Cambrian	Limestone	90.51	6.39	2.29	.15	.33	.22	.00	.01	.03	.06	R-18914
216C-18	Ashby Gap	Clarke	4	Conococheague	Cambrian	Magnesian Limestone	80.61	11.44	5.21	.60	1.12	.90	.01	.06	.04	.01	R-18915
216C-19	Ashby Gap	Clarke	2	Shady	Cambrian	Dolostone	56.69	42.63	.08	.55	.00	.01	.03	.00	.00	.00	R-18916
216C-20	Ashby Gap	Clarke	2	Shady	Cambrian	Dolostone	53.31	44.90	1.12	.38	.15	.13	.00	.01	.00	.00	R-18917
216C-21	Ashby Gap	Clarke	4	Shady	Cambrian	Dolostone	53.76	42.60	2.34	.53	.44	.29	.00	.03	.00	.00	R-18918
216C-22	Ashby Gap	Clarke	4	Shady	Cambrian	Dolostone	52.74	42.98	2.78	.53	.53	.41	.00	.04	.00	.00	R-18919
216C-23	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Dolostone	54.95	38.53	4.94	.57	.50	.37	.12	.03	.00	.00	R-18920
216C-24	Ashby Gap	Clarke	5	Shady	Cambrian	Dolostone	53.95	43.03	1.50	1.04	.26	.16	.04	.02	.00	.01	R-18921
216C-25	Ashby Gap	Clarke	6	Waynesboro	Cambrian	Limestone	92.49	6.37	.91	.09	.04	.05	.01	.00	.01	.00	R-18922
216C-26	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	91.23	4.74	3.27	.17	.34	.15	.04	.02	.02	.01	R-18923
216C-27	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Limestone	90.01	7.54	1.33	.46	.39	.24	.00	.02	.00	.00	R-20011
216C-28	Ashby Gap	Clarke	2	Waynesboro	Cambrian	Dolostone	54.35	37.48	5.59	1.69	.63	.23	.00	.03	.00	.00	R-20012
216C-29	Ashby Gap	Clarke	3	Shady	Cambrian	Dolostone	51.64	43.50	3.77	.54	.33	.19	.01	.02	.00	.00	R-20013
216C-30	Ashby Gap	Clarke	3	Shady	Cambrian	Dolostone	51.35	43.25	3.17	1.32	.51	.37	.00	.03	.00	.00	R-20014
216C-31	Ashby Gap	Clarke	8	Shady	Cambrian	Limestone	97.47	1.20	.80	.10	.21	.12	.08	.01	.00	.00	R-20015

Table 22. Reflectance analyses of carbonate-rock samples with brightnesses of 70 percent or higher, Ashby Gap quadrangle (216C), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled(ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
216C-2	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	79.2	3.9	63.6	99.06	.00	R-18903
216C-9	Ashby Gap	Clarke	1	Elbrook	Cambrian	Limestone	83.3	2.44	73.7	90.25	5.07	R-18909
216C-21	Ashby Gap	Clarke	4	Shady	Cambrian	Dolostone	83.3	1.8	76.0	53.76	42.60	R-18918
216C-24	Ashby Gap	Clarke	5	Shady	Cambrian	Dolostone	80.2	0.0	80.2	53.95	43.03	R-18921

Table 23. Chlorine analyses of carbonate-rock samples, Ashby Gap quadrangle (216C), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation Group, or Deposit	Age	Rock Type	Chlorine Content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
216C-1	Ashby Gap	Clarke	2	Shady	Cambrian	Limestone	.01	(100)	93.59	4.05	R-18902
216C-2	Ashby Gap	Clarke	4	Waynesboro	Cambrian	Limestone	.0028	(28)	99.06	.00	R-18903
216C-5	Ashby Gap	Clarke	3	Waynesboro	Cambrian	Dolostone	.024	(240)	54.10	40.10	R-18906
216C-15	Ashby Gap	Clarke	5	Conococheague	Cambrian	Magnesian Limestone	.011	(110)	81.79	10.44	R-18912
216C-17	Ashby Gap	Clarke	2	Elbrook	Cambrian	Limestone	.0052	(52)	90.51	6.39	R-18914
216C-24	Ashby Gap	Clarke	5	Shady	Cambrian	Dolostone	.014	(140)	53.95	43.03	R-18921

216C

Table 24. Semiquantitative trace-element analyses of carbonate-rock samples, Ashby Gap quadrangle (216C), Clarke County.

Map-Sample No. -			Ashby Gap-216C-1		Ashby Gap-216C-2		Ashby Gap-216C-5		Ashby Gap-216C-15		Ashby Gap-216C-17		Ashby Gap-216C-24	
Rock Type -			Limestone		Limestone		Dolostone		Magnesian Limestone		Limestone		Dolostone	
Formation(Group, deposit) -			Shady		Waynesboro		Waynesboro		Conococheague		Elbrook		Shady	
Age -			Cambrian		Cambrian		Cambrian		Cambrian		Cambrian		Cambrian	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .001	(10)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .003	(30)	< .002	(20)
Al	.001	(10)	.3	(3,000)	.09	(900)	.4	(4,000)	.6	(6,000)	.4	(4,000)	.2	(2,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	.01	(100)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.2	(2,000)	.02	(200)	1.	(10,000)	.7	(7,000)	.2	(2,000)	1.	(10,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	.01	(100)	< .002	(20)
Mg	.0001	(1)	2.	(20,000)	.5	(5,000)	>10.	(100,000)	4.	(40,000)	3.	(30,000)	>10.	(100,000)
Mn	.0008	(8)	.007	(70)	.007	(70)	.06	(600)	.02	(200)	.01	(100)	.1	(1,000)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .007	(70)	< .007	(70)	< .02	(200)	< .007	(70)	< .007	(70)	< .02	(200)
Ni	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0005	(5)	< .0002	(2)
P	.7	(7,000)	< 1.	(10,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	.6	(6,000)	.2	(2,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)	.6	(6,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.4	(4,000)	.009	(90)	.007	(70)	.03	(300)	.05	(500)	.0006	(6)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

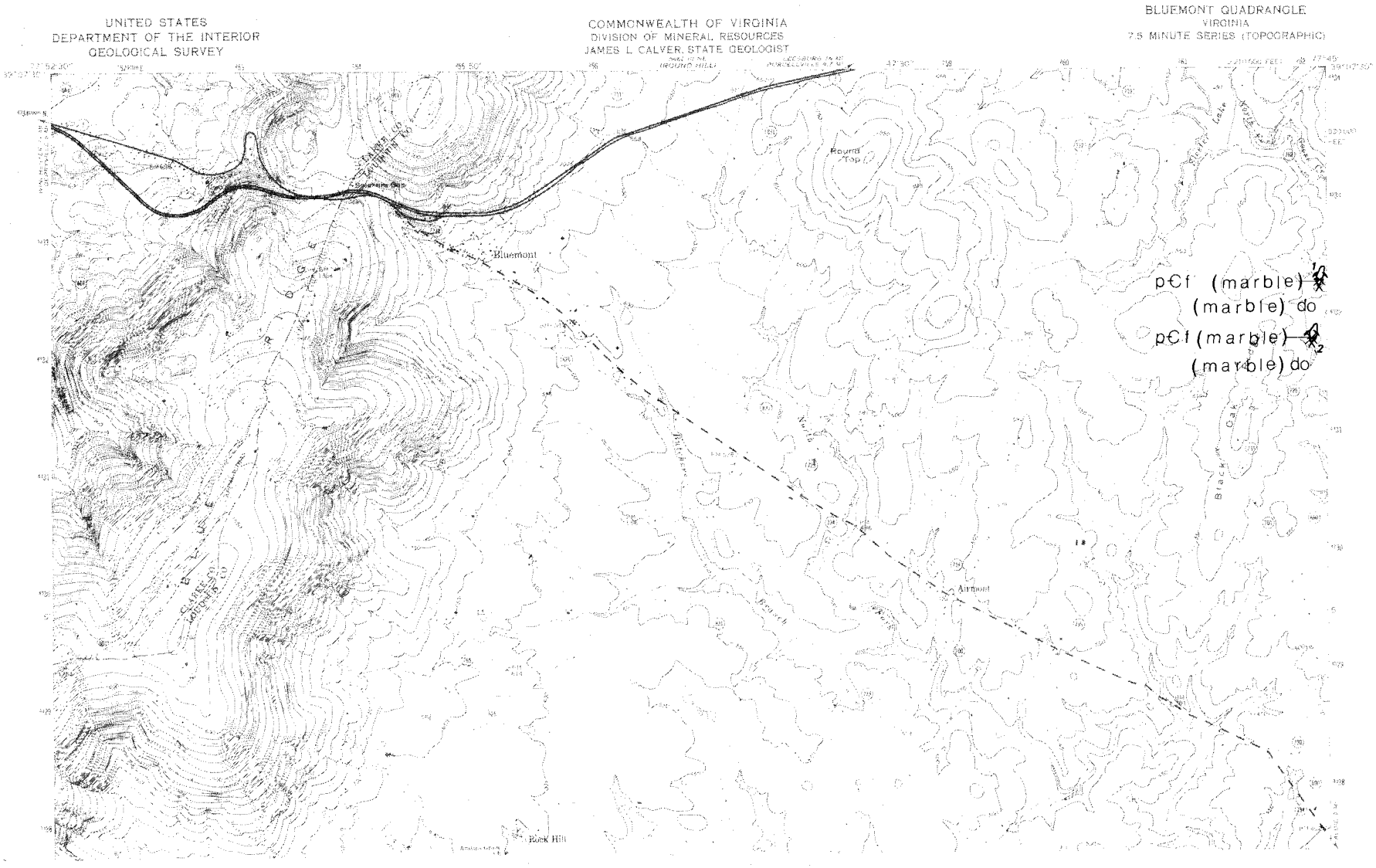


Figure 21. Northern half of Bluemont quadrangle (216D) showing carbonate-rock sample locations.

<u>216D</u>

216D

Table 25. Chemical analyses of carbonate-rock samples, Bluemont quadrangle (216D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
216D-1	Bluemont	Loudoun	1	Fauquier	Precambrian	Marble	53.43	45.00	.86	.31	.26	.11	.00	.02	.00	.00	R-20081
216D-2	Bluemont	Loudoun	1	Fauquier	Precambrian	Marble (float)	53.41	44.99	.82	.40	.30	.05	.00	.02	.00	.00	R-20082

Table 26. Chlorine analyses of carbonate-rock sample, Bluemont quadrangle (216D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation Group, or Deposit	Age	Rock Type	Chlorine Content Percent(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
216D-1	Bluemont	Loudoun	1	Fauquier	Precambrian	Marble	.0044 (44)	53.43	45.00	R-20081

Table 27. Semiquantitative trace-element analyses of carbonate-rock sample, Bluemont quadrangle (216D), Loudoun County.

Map-Sample No.	-		Bluemont-216D-1		
Rock Type	-		Marble		
Formation(Group, deposit)	-		Fauquier		
Age	-		Precambrian		
	**Detection Limits				
Elements	Percent	(ppm)		***Trace Element Percent	(Parts per million)
Ag	.0005	(5)	<	.0008	(8)
Al	.001	(10)		.2	(2,000)
As	.009	(90)	<	.009	(90)
*Au	.002	(20)	<	.002	(20)
*B	.003	(30)	<	.003	(30)
Ba	.002	(20)	<	.002	(20)
Be	.0001	(1)	<	.0001	(1)
Bi	.01	(100)	<	.01	(100)
Ca	.05	(500)	>10.		(100,000)
*Cd	.0005	(5)	<	.0005	(5)
*Co	.001	(10)	<	.001	(10)
Cr	.0003	(3)	<	.0003	(3)
Cu	.0006	(6)	<	.0006	(6)
Fe	.0006	(6)		.2	(2,000)
*Ga	.0002	(2)	<	.0002	(2)
*La	.01	(100)	<	.01	(100)
Li	.002	(20)	<	.002	(20)
Mg	.0001	(1)	>10.		(100,000)
Mn	.0008	(8)		.02	(200)
*Mo	.0001	(1)	<	.0001	(1)
*Na	.3	(3,000)	<	.3	(3,000)
Nb	.007	(70)	<	.02	(200)
Ni	.0002	(2)	<	.0002	(2)
P	.7	(7,000)	<	.7	(7,000)
Pb	.002	(20)	<	.002	(20)
*Pd	.0001	(1)	<	.0001	(1)
Pt	.0006	(6)	<	.0006	(6)
*Sb	.06	(600)	<	.06	(600)
*Sc	.0004	(4)	<	.0004	(4)
Si	.0006	(6)		.5	(5,000)
Sn	.0006	(6)	<	.0006	(6)
Sr	.0001	(1)		.0005	(5)
*Ta	.02	(200)	<	.02	(200)
*Te	.04	(400)	<	.04	(400)
Ti	.03	(300)	<	.03	(300)
*V	.005	(50)	<	.005	(50)
*Y	.001	(10)	<	.001	(10)
Zn	.0001	(1)	<	.0001	(1)
*Zr	.003	(30)	<	.003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

216D

Figure 22. Northern half of Stephenson quadrangle (217A) showing carbonate-rock sample locations.

Figure 23. Southern half of Stephenson quadrangle (217A) showing carbonate-rock sample locations.

217A

Table 28. Chemical analyses of carbonate-rock samples, Stephenson quadrangle (217A), Clarke and Frederick counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
217A-1	Stephenson	Frederick	6	Edinburg	Ordovician	Limestone	90.39	4.49	3.47	.33	.80	.23	.07	.03	.07	.11	R-18766
217A-2	Stephenson	Frederick	2	New Market	Ordovician	Limestone	99.33	.00	.36	.07	.12	.04	.00	.01	.07	.01	R-18767
217A-3	Stephenson	Frederick	3	New Market	Ordovician	Limestone	99.02	.00	.51	.06	.18	.09	.09	.01	.03	.01	R-18768
217A-4	Stephenson	Frederick	4	Rockdale Run	Ordovician	Dolostone	64.87	31.38	2.43	.39	.53	.25	.03	.03	.03	.05	R-18772
217A-5	Stephenson	Frederick	1	Edinburg	Ordovician	Limestone	89.75	4.87	3.92	.32	.65	.21	.11	.03	.10	.06	R-18770
217A-6	Stephenson	Frederick	5	New Market	Ordovician	Limestone	98.99	.00	.50	.10	.16	.07	.16	.01	.00	.01	R-18769
217A-7	Stephenson	Frederick	1	Edinburg	Ordovician	Limestone	89.37	5.48	3.71	.28	.67	.20	.12	.02	.10	.07	R-18771
217A-8	Stephenson	Clarke	1	Rockdale Run	Ordovician	Dolostone	55.63	38.69	3.79	.63	.63	.44	.11	.03	.02	.03	R-18924
217A-9	Stephenson	Clarke	2	New Market	Ordovician	Limestone	99.26	.00	.43	.06	.14	.06	.00	.01	.03	.01	R-18644
217A-10	Stephenson	Clarke	1	Edinburg	Ordovician	Limestone	90.16	4.67	3.87	.28	.62	.15	.12	.02	.03	.08	R-18655
217A-11	Stephenson	Clarke	3	Lincolnshire	Ordovician	Limestone	99.06	.07	.46	.06	.17	.07	.06	.01	.03	.01	R-18925
217A-12	Stephenson	Clarke	4	New Market	Ordovician	Dolostone	62.71	33.13	2.71	.30	.68	.34	.03	.03	.04	.03	R-18926
217A-13	Stephenson	Clarke	2	New Market	Ordovician	Dolostone	62.25	36.32	.62	.26	.22	.11	.16	.01	.03	.02	R-18927
217A-14	Stephenson	Clarke	10	Rockdale Run	Ordovician	Limestone	86.75	6.62	4.47	.42	.89	.66	.03	.04	.07	.06	R-18928
217A-15	Stephenson	Clarke	3	Edinburg	Ordovician	Limestone	91.44	4.77	2.56	.30	.60	.15	.10	.03	.05	.01	R-18929
217A-16	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	55.07	39.38	4.07	.46	.57	.37	.04	.03	.01	.01	R-18930
217A-17	Stephenson	Clarke	1	Edinburg	Ordovician	Limestone	89.94	5.05	4.18	.18	.37	.10	.00	.01	.09	.07	R-18931
217A-18	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	63.34	33.35	2.03	.42	.45	.25	.04	.02	.00	.10	R-18932
217A-19	Stephenson	Clarke	3	New Market	Ordovician	Limestone	99.23	.00	.40	.06	.15	.07	.05	.01	.03	.01	R-18649
217A-20	Stephenson	Clarke	2	Edinburg	Ordovician	Limestone	89.61	5.45	3.69	.31	.58	.16	.03	.02	.08	.07	R-18647
217A-21	Stephenson	Clarke	2	Edinburg	Ordovician	Limestone	87.05	5.82	5.88	.30	.55	.14	.10	.03	.09	.06	R-18656
217A-22	Stephenson	Clarke	1	New Market	Ordovician	Dolostone	62.42	34.68	1.59	.39	.53	.29	.02	.03	.03	.01	R-18933
217A-23	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	57.27	40.75	1.03	.32	.33	.19	.05	.02	.03	.02	R-18934
217A-24	Stephenson	Clarke	3	Rockdale Run	Ordovician	Dolostone	61.99	34.08	2.18	.45	.81	.37	.03	.03	.03	.03	R-18935
217A-25	Stephenson	Clarke	3	New Market	Ordovician	Limestone	89.20	8.27	1.51	.23	.38	.19	.09	.02	.05	.05	R-18936
217A-26	Stephenson	Clarke	2	Edinburg	Ordovician	Limestone	84.71	8.13	5.67	.38	.78	.20	.02	.03	.06	.04	R-18937
217A-27	Stephenson	Clarke	3	Lincolnshire	Ordovician	Limestone	95.21	.00	2.79	.72	.65	.20	.17	.03	.21	.05	R-18938
217A-28	Stephenson	Clarke	4	New Market	Ordovician	Limestone	99.44	.00	.27	.14	.10	.04	.00	.00	.00	.00	R-18939
217A-29	Stephenson	Clarke	2	Lincolnshire	Ordovician	Limestone	99.05	.00	.35	.26	.10	.04	.09	.00	.09	.01	R-18650
217A-30	Stephenson	Clarke	2	New Market	Ordovician	Limestone	91.60	7.07	.90	.09	.21	.09	.00	.01	.02	.01	R-18648
217A-31	Stephenson	Clarke	1	New Market	Ordovician	Limestone	99.33	.00	.36	.03	.12	.06	.07	.01	.02	.01	R-18940
217A-32	Stephenson	Clarke	3	Rockdale Run	Ordovician	Magnesian Limestone	80.14	12.22	5.45	.46	.83	.73	.09	.04	.02	.03	R-18941
217A-33	Stephenson	Clarke	1	New Market	Ordovician	Limestone	94.54	4.36	.59	.06	.20	.10	.04	.01	.07	.03	R-18654
217A-34	Stephenson	Clarke	2	Edinburg	Ordovician	Limestone	89.27	5.87	4.19	.15	.31	.07	.06	.01	.04	.02	R-18942
217A-35	Stephenson	Clarke	2	New Market	Ordovician	Magnesian Limestone	80.39	16.03	2.11	.22	.78	.36	.00	.04	.04	.06	R-18943

Table 28. (cont'd.)

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217A-36	Stephenson	Clarke	1	Rockdale Run	Ordovician	Dolostone	55.37	41.95	1.73	.28	.39	.22	.00	.02	.03	.02	R-18653
217A-37	Stephenson	Clarke	3	New Market	Ordovician	Limestone	98.11	.42	.80	.07	.32	.14	.10	.01	.00	.03	R-18944
217A-38	Stephenson	Clarke	3	Lincolnshire	Ordovician	Limestone	95.52	2.79	1.03	.08	.33	.15	.07	.02	.00	.00	R-18945
217A-39	Stephenson	Clarke	3	Rockdale Run	Ordovician	Dolostone	50.05	40.86	7.69	.78	.42	.17	.00	.02	.00	.01	R-18946
217A-40	Stephenson	Clarke	8	Rockdale Run	Ordovician	Limestone	85.78	5.69	5.81	.49	1.14	.77	.06	.04	.07	.14	R-18947
217A-41	Stephenson	Clarke	3	Rockdale Run	Ordovician	Limestone	86.92	4.62	6.29	.43	1.00	.56	.04	.05	.03	.05	R-18948
217A-42	Stephenson	Clarke	2	Stonehenge	Ordovician	Limestone	82.00	3.98	9.43	1.05	2.15	.98	.21	.09	.08	.04	R-18949
217A-43	Stephenson	Clarke	1	Lincolnshire	Ordovician	Limestone	94.79	.00	2.70	.97	.62	.22	.00	.03	.50	.17	R-18950
217A-44	Stephenson	Clarke	3	Edinburg	Ordovician	Limestone	95.69	.00	3.00	.38	.64	.15	.02	.03	.07	.02	R-18645
217A-45	Stephenson	Clarke	1	New Market	Ordovician	Limestone	98.56	.00	.85	.10	.30	.13	.00	.01	.04	.01	R-18951
217A-46	Stephenson	Clarke	1	New Market	Ordovician	Dolostone	59.76	38.74	1.05	.16	.17	.08	.02	.01	.00	.01	R-18642
217A-47	Stephenson	Clarke	1	New Market	Ordovician	Limestone	99.47	.00	.26	.04	.10	.05	.04	.00	.03	.00	R-18952
217A-48	Stephenson	Clarke	10	New Market	Ordovician	Limestone	99.39	.00	.30	.04	.10	.04	.08	.01	.04	.01	R-18953
217A-49	Stephenson	Clarke	2	Edinburg	Ordovician	Limestone	95.33	1.99	1.90	.18	.36	.13	.02	.01	.06	.02	R-18954
217A-50	Stephenson	Clarke	1	Deposit	Quaternary	Marl	86.88	1.00	8.85	.67	1.58	.33	.11	.12	.36	.09	R-18955
217A-51	Stephenson	Clarke	4	Rockdale Run	Ordovician	Limestone	86.35	4.17	6.57	.48	1.19	.96	.14	.05	.05	.02	R-18956
217A-52	Stephenson	Clarke	2	New Market	Ordovician	Dolostone	62.80	34.03	1.65	.49	.65	.33	.00	.03	.02	.00	R-18957
217A-53	Stephenson	Clarke	1	Lincolnshire	Ordovician	Limestone	96.98	1.19	1.06	.10	.41	.21	.00	.02	.03	.01	R-18958
217A-54	Stephenson	Clarke	8	Rockdale Run	Ordovician	Limestone	95.19	.52	2.66	.25	.70	.55	.05	.02	.05	.01	R-18959
217A-55	Stephenson	Clarke	3	Rockdale Run	Ordovician	Limestone	89.74	1.45	6.48	.38	1.00	.67	.11	.04	.00	.14	R-18960
217A-56	Stephenson	Clarke	2	Lincolnshire	Ordovician	Limestone	96.55	1.70	1.17	.12	.23	.17	.00	.01	.03	.02	R-18651
217A-57	Stephenson	Clarke	2	New Market	Ordovician	Magnesian Limestone	83.84	15.05	.64	.14	.17	.08	.02	.01	.04	.01	R-18652
217A-58	Stephenson	Clarke	2	New Market	Ordovician	Limestone	99.49	.00	.22	.03	.10	.04	.02	.00	.08	.02	R-18961
217A-59	Stephenson	Clarke	8	Rockdale Run	Ordovician	Limestone	89.53	5.12	3.83	.28	.59	.41	.16	.03	.00	.03	R-18643
217A-60	Stephenson	Clarke	2	Stonehenge	Ordovician	Limestone	93.88	1.01	3.97	.28	.47	.32	.03	.02	.01	.01	R-18962
217A-61	Stephenson	Clarke	1	Conoco-cheague	Cambrian	Limestone	70.03	7.03	14.88	1.28	3.68	2.74	.12	.17	.02	.02	R-18657
217A-62	Stephenson	Frederick	1	Rockdale Run	Ordovician	Dolostone	52.25	44.01	3.07	.30	.19	.13	.02	.01	.02	.01	R-18963
217A-63	Stephenson	Clarke	8	Edinburg	Ordovician	Limestone	83.15	4.88	8.60	.64	1.72	.50	.21	.06	.04	.20	R-18964
217A-64	Stephenson	Clarke	4	New Market	Ordovician	Limestone	98.04	1.47	.29	.04	.11	.05	.00	.00	.01	.00	R-18965
217A-65	Stephenson	Clarke	2	Lincolnshire	Ordovician	Limestone	95.53	2.89	1.00	.10	.23	.18	.00	.01	.04	.01	R-18966
217A-66	Stephenson	Clarke	1	Edinburg	Ordovician	Limestone	84.75	1.33	11.29	.70	1.32	.33	.14	.06	.07	.01	R-18967
217A-67	Stephenson	Clarke	1	New Market	Ordovician	Dolostone	60.41	38.22	.67	.24	.21	.11	.09	.01	.02	.01	R-18646
217A-68	Stephenson	Clarke	1	New Market	Ordovician	Limestone	99.32	.00	.39	.05	.14	.06	.00	.01	.02	.01	R-18968
217A-69	Stephenson	Clarke	1	Rockdale Run	Ordovician	Dolostone	54.26	35.71	7.45	.46	1.10	.95	.01	.05	.00	.01	R-20083
217A-70	Stephenson	Clarke	4	Rockdale Run	Ordovician	Limestone	87.33	5.30	4.98	.48	1.02	.83	.00	.04	.01	.01	R-18969
217A-71	Stephenson	Clarke	1	Pinesburg Station	Ordovician	Dolostone	54.94	39.76	4.21	.49	.36	.18	.03	.02	.01	.01	R-18970
217A-72	Stephenson	Frederick	1	Deposit	Quaternary	Marl	93.45	.60	4.57	.28	.70	.17	.00	.03	.02	.17	R-18765

Table 29. Reflectance analyses of carbonate-rock samples with brightnesses of 70 percent or higher, Stephenson quadrangle (217A), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
217A-31	Stephenson	Clarke	1	New Market	Ordovician	Limestone	78.3	0.8	75.3	99.33	.00	R-18940
217A-57	Stephenson	Clarke	2	New Market	Ordovician	Magnesian Limestone	78.9	0.0	78.9	83.84	15.05	R-18652
217A-58	Stephenson	Clarke	2	New Market	Ordovician	Limestone	87.8	0.0	87.8	99.49	.00	R-18961
217A-68	Stephenson	Clarke	1	New Market	Ordovician	Limestone	84.2	0.0	84.2	99.32	.00	R-18968

Table 30. Chlorine analyses of carbonate-rock samples, Stephenson quadrangle (217A), Frederick and Clarke counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine Content Percent(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
217A-2	Stephenson	Frederick	2	New Market	Ordovician	Limestone	.004 (40)	99.33	.00	R-18767
217A-11	Stephenson	Clarke	3	Lincolnshire	Ordovician	Limestone	.0048 (48)	99.06	.07	R-18925
217A-14	Stephenson	Clarke	10	Rockdale Run	Ordovician	Limestone	.0086 (86)	86.75	6.62	R-18928
217A-23	Stephenson	Clarke	2	Rockdale Run	Ordovician	Dolostone	.058 (580)	57.27	40.75	R-18934
217A-25	Stephenson	Clarke	3	New Market	Ordovician	Limestone	.0054 (54)	89.20	8.27	R-18936
217A-39	Stephenson	Clarke	3	Rockdale Run	Ordovician	Dolostone	.013 (130)	50.05	40.86	R-18946
217A-42	Stephenson	Clarke	2	Stonehenge	Ordovician	Limestone	.0035 (35)	82.00	3.98	R-18949
217A-44	Stephenson	Clarke	3	Edinburg	Ordovician	Limestone	.0028 (28)	95.69	.00	R-18645
217A-48	Stephenson	Clarke	10	New Market	Ordovician	Limestone	.0038 (38)	99.39	.00	R-18953
217A-58	Stephenson	Clarke	2	New Market	Ordovician	Limestone	.023 (230)	99.49	.00	R-18961

Table 31. Semiquantatitive trace-element analyses of carbonate-rock samples, Stephenson quadrangle (217A), Clarke County.

Map-Sample No.			Stephenson-217A-11		Stephenson-217A-14		Stephenson-217A-23		Stephenson-217A-39		Stephenson-217A-42		Stephenson-217A-44	
Rock Type			Limestone		Limestone		Dolostone		Dolostone		Limestone		Limestone	
Formation(Group, deposit)			Lincolnshire		Rockdale Run		Rockdale Run		Rockdale Run		Stonehenge		Edinburg	
Age			Ordovician		Ordovician		Ordovician		Ordovician		Ordovician		Ordovician	
	**Detection Limits													
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)											
Ag	.0005	(5)	< .003	(30)	< .0006	(6)	< .001	(10)	< .0005	(5)	< .0005	(5)	< .0005	(5)
Al	.001	(10)	.2	(2,000)	.6	(6,000)	.2	(2,000)	.3	(3,000)	> 2.	(20,000)	.5	(5,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(20)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	.004	(40)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0002	(2)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(10,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.02	(200)	.4	(4,000)	.2	(2,000)	.9	(9,000)	2.	(20,000)	.4	(4,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	2.	(20,000)	3.	(30,000)	>10.	(100,000)	>10.	(100,000)	2.	(20,000)	.8	(8,000)
Mn	.0008	(8)	< .001	(10)	.01	(100)	.007	(70)	.01	(100)	.07	(700)	.08	(800)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .007	(70)	< .007	(70)	< .008	(80)	< .01	(100)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0003	(3)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	.07	(700)	2.	(20,000)	.3	(3,000)	3.	(30,000)	4.	(40,000)	1.	(10,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.009	(90)	.02	(200)	.005	(50)	.002	(20)	.03	(300)	.05	(500)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

217A

217A

Table 31. (cont'd.)

Map-Sample No.	- Stephenson-217A-48
Rock Type	- Limestone
Formation(Group, deposit)	- New Market
Age	- Ordovician

	**Detection Limits			***Trace Element Percent (Parts per million)	
Elements	Percent	(ppm)			
Ag	.0005	(5)	<	.0006	(6)
Al	.001	(10)		.1	(1,000)
As	.009	(90)	<	.009	(90)
*Au	.002	(20)	<	.002	(20)
*B	.003	(30)	<	.003	(30)
Ba	.002	(20)	<	.002	(20)
Be	.0001	(1)	<	.0001	(1)
Bi	.01	(100)	<	.01	(100)
Ca	.05	(500)	>10.		(100,000)
*Cd	.0005	(5)	<	.0005	(5)
*Co	.001	(10)	<	.001	(10)
Cr	.0003	(3)	<	.0003	(3)
Cu	.0006	(6)	<	.0006	(6)
Fe	.0006	(6)		.007	(70)
*Ga	.0002	(2)	<	.0002	(2)
*La	.01	(100)	<	.01	(100)
Li	.002	(20)	<	.002	(20)
Mg	.0001	(1)		.5	(5,000)
Mn	.0008	(8)	<	.002	(20)
*Mo	.0001	(1)	<	.0001	(1)
*Na	.3	(3,000)	<	.3	(3,000)
Nb	.007	(70)	<	.007	(70)
Ni	.0002	(2)	<	.0002	(2)
P	.7	(7,000)	<	.7	(7,000)
Pb	.002	(20)	<	.002	(20)
*Pd	.0001	(1)	<	.0001	(1)
Pt	.0006	(6)	<	.0006	(6)
*Sb	.06	(600)	<	.06	(600)
*Sc	.0004	(4)	<	.0004	(4)
Si	.0006	(6)		.07	(700)
Sn	.0006	(6)	<	.0006	(6)
Sr	.0001	(1)		.004	(40)
*Ta	.02	(200)	<	.02	(200)
*Te	.04	(400)	<	.04	(400)
Ti	.03	(300)	<	.03	(300)
*V	.005	(50)	<	.005	(50)
*Y	.001	(10)	<	.001	(10)
Zn	.0001	(1)	<	.0001	(1)
*Zr	.003	(30)	<	.003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

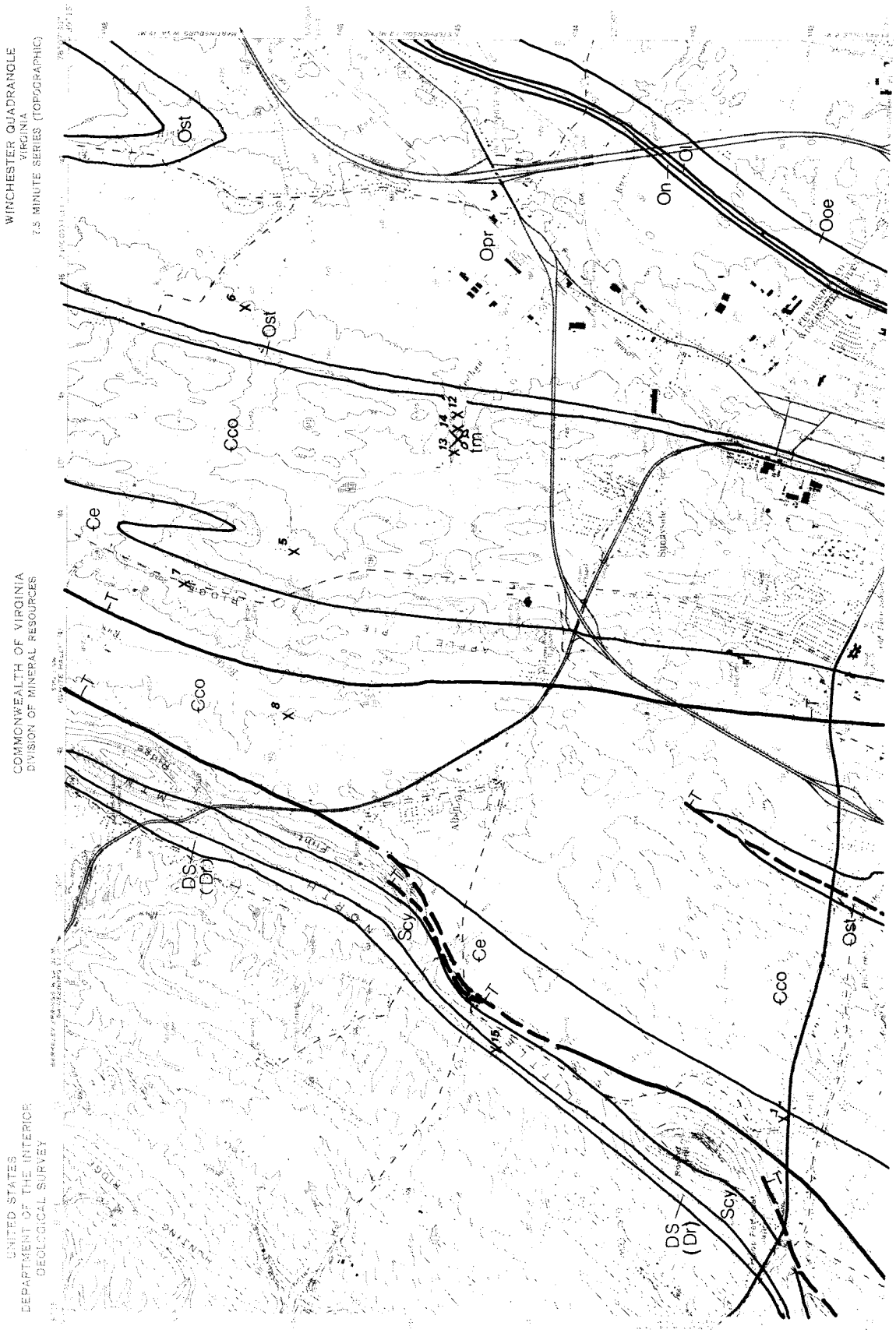


Figure 24. Northern half of Winchester quadrangle (217B) showing carbonate-rock sample locations.

217B

Figure 25. Southern half of Winchester quadrangle (217B) showing carbonate-rock sample locations.

Table 32. Chemical analyses of carbonate-rock samples, Winchester quadrangle (217B), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217B-1	Winchester	Frederick	5	Elbrook	Cambrian	Dolostone	55.65	36.05	4.94	1.22	1.10	.85	.12	.06	.00	.01	R-18689
217B-2	Winchester	Frederick	10	Conococheague	Cambrian	Magnesian Limestone	64.13	19.33	11.25	1.36	2.12	1.44	.07	.12	.02	.15	R-18690
217B-3	Winchester	Frederick	32	Rockdale Run	Ordovician	Limestone	81.18	9.13	6.95	.50	1.17	.83	.00	.06	.05	.14	R-18847
217B-4	Winchester	Frederick	5	Conococheague	Cambrian	Limestone	90.90	7.08	1.31	.34	.12	.06	.07	.01	.07	.04	R-18856
217B-5	Winchester	Frederick	4	Conococheague	Cambrian	Dolostone	47.73	37.42	8.49	2.70	1.78	1.69	.03	.13	.03	.02	R-18848
217B-6	Winchester	Frederick	3	Rockdale Run	Ordovician	Limestone	93.93	2.65	2.20	.20	.39	.32	.24	.02	.00	.05	R-18854
217B-7	Winchester	Frederick	3	Elbrook	Cambrian	Magnesian Limestone	30.65	25.81	28.14	5.12	5.94	3.28	.09	.44	.07	.47	R-18850
217B-8	Winchester	Frederick	2	Conococheague	Cambrian	Limestone	85.67	7.56	4.54	.42	.91	.69	.06	.04	.07	.03	R-18855
217B-9	Winchester	Frederick	15	Conococheague	Cambrian	Limestone	91.61	5.01	1.99	.40	.34	.34	.26	.02	.00	.04	R-18851
217B-10	Winchester	Frederick	8	Conococheague	Cambrian	Limestone	73.09	7.44	14.03	.75	2.26	2.12	.06	.09	.04	.10	R-18857
217B-11	Winchester	Frederick	4	Rockdale Run	Ordovician	Limestone	96.42	.25	2.02	.23	.43	.37	.14	.02	.00	.11	R-18849
217B-12	Winchester	Frederick	1	Deposit	Quaternary	Marl	96.69	.30	2.01	.20	.44	.15	.00	.03	.12	.05	R-18858
217B-13	Winchester	Frederick	1	Deposit	Quaternary	Marl	86.22	1.30	8.91	.58	1.96	.74	.03	.12	.10	.04	R-18859
217B-14	Winchester	Frederick	1	Deposit	Quaternary	Travertine	97.08	1.69	.76	.09	.18	.06	.00	.01	.10	.03	R-18860
217B-15	Winchester	Frederick	2	(Undifferentiated)	Devonian-Silurian	Limestone	62.00	5.47	24.63	2.14	4.03	1.11	.33	.26	.01	.01	R-18846
217B-16	Winchester	Frederick	3	Rockdale Run	Ordovician	Limestone	97.41	.00	1.94	.09	.25	.21	.07	.01	.02	.00	R-18852
217B-17	Winchester	Frederick	1	Conococheague	Cambrian	Limestone	96.98	.00	2.01	.19	.35	.36	.03	.02	.02	.05	R-18853

Table 33. Chlorine analyses of carbonate-rock samples, Winchester quadrangle (217B), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
217B-1	Winchester	Frederick	5	Elbrook	Cambrian	Dolostone	.034	(340)	55.65	36.05	R-18689
217B-5	Winchester	Frederick	4	Conococheague	Cambrian	Dolostone	.037	(370)	47.73	37.42	R-18848
217B-13	Winchester	Frederick	1	Deposit	Quaternary	Marl	.0021	(21)	86.22	1.30	R-18859
217B-14	Winchester	Frederick	1	Deposit	Quaternary	Travertine	.0008	(8)	97.08	1.69	R-18860
217B-15	Winchester	Frederick	2	(Undifferentiated)	Devonian-Silurian	Limestone	.012	(120)	62.00	5.47	R-18846

217B

Table 34. Semquantitative trace-element analyses of carbonate-rock samples, Winchester quadrangle (217B), Frederick County.

Map-Sample No. -			Winchester-217B-1		Winchester-217B-5		Winchester-217B-13		Winchester-217B-14		Winchester-217B-15	
Rock Type -			Dolostone		Dolostone		Marl		Travertine		Limestone	
Formation(Group, deposit -			Elbrook		Conococheague		Deposit		Deposit		(Undifferentiated)	
Age -			Cambrian		Cambrian		Quaternary		Quaternary		Devonian-Silurian	
	**Detection Limits											
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million									
Ag	.0005	(5)	< .0007	(7)	< .0005	(5)	< .001	(10)	< .002	(20)	< .001	(10)
Al	.001	(10)	.6	(6,000)	.9	(9,000)	.8	(8,000)	.2	(2,000)	> 3.	(30,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	.009	(90)
Ba	.002	(20)	< .002	(20)	< .002	(20)	.02	(200)	.008	(30)	.003	(30)
Be	.0001	(1)	< .0001	(1)	< .0002	(2)	< .0001	(1)	< .0001	(1)	.0005	(5)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	.001	(10)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	1.	(10,000)	3.	(30,000)	.4	(4,000)	.05	(500)	2.	(20,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	>10.	(100,000)	>10.	(100,000)	2.	(20,000)	2.	(20,000)	2.	(20,000)
Mn	.0008	(8)	.04	(400)	.06	(600)	.03	(300)	.06	(600)	.1	(1,000)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
Nb	.007	(70)	< .01	(100)	< .02	(200)	< .007	(70)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)	< .0003	(3)	< .0003	(3)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	2.	(20,000)	4.	(40,000)	4.	(40,000)	.3	(3,000)	>10.	(100,000)
Sn	.0006	(6)	< .0006	(6)	< .0007	(7)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.001	(10)	.001	(10)	.006	(60)	.005	(50)	.01	(100)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .03	(300)	< .05	(500)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0008	(8)	< .0001	(1)	.003	(30)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

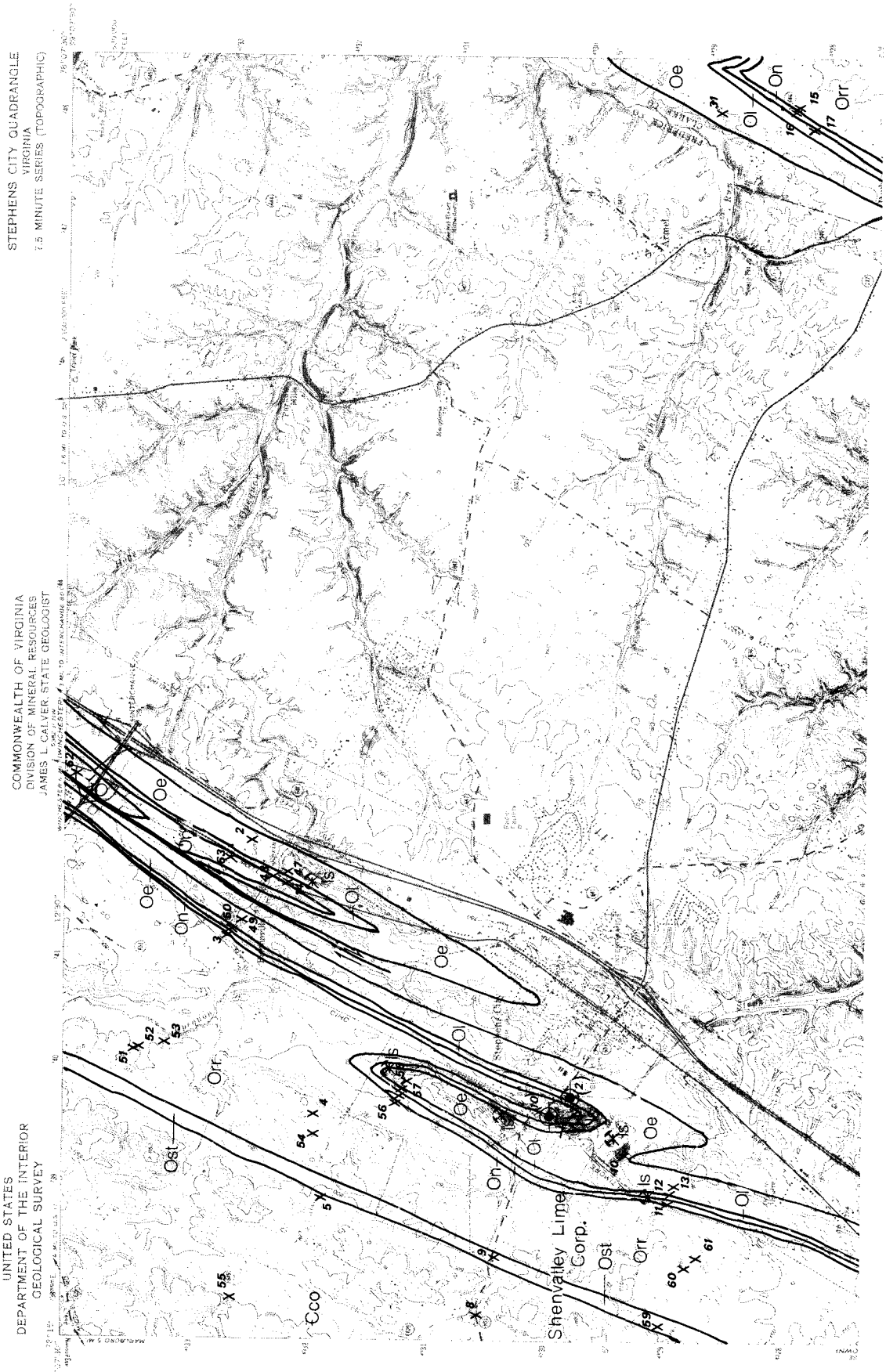


Figure 26. Northern half of Stephens City quadrangle (217C) showing carbonate-rock sample locations.

217C

Figure 27. Southern half of Stephens City quadrangle (217C) showing carbonate-rock sample locations.

Table 35. Chemical analyses of carbonate-rock samples, Stephens City quadrangle (217C), Frederick, Clarke, and Warren counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217C-1	Stephens City	Frederick	80	New Market	Ordovician	Limestone	98.80	.44	.39	.07	.14	.06	.05	.01	.03	.01	R-18691
217C-2	Stephens City	Frederick	2	Edinburg	Ordovician	Limestone	93.35	3.01	2.59	.27	.48	.18	.00	.02	.04	.07	R-18811
217C-3	Stephens City	Frederick	4	New Market	Ordovician	Limestone	96.96	2.42	.35	.06	.11	.06	.00	.01	.03	.01	R-18815
217C-4	Stephens City	Frederick	6	Rockdale Run	Ordovician	Limestone	90.40	6.69	2.06	.20	.33	.23	.06	.01	.01	.02	R-18805
217C-5	Stephens City	Frederick	4	Stonehenge	Ordovician	Magnesian Limestone	79.33	14.07	4.39	.77	.75	.61	.00	.03	.01	.04	R-18808
217C-6	Stephens City	Frederick	1	Lincolnshire	Ordovician	Limestone	87.45	6.80	4.03	.38	.61	.44	.12	.03	.02	.12	R-18817
217C-7	Stephens City	Frederick	3	New Market	Ordovician	Limestone	98.07	.00	1.07	.12	.49	.19	.00	.02	.03	.00	R-18816
217C-8	Stephens City	Frederick	8	Conococheague	Cambrian	Limestone	88.52	4.72	5.06	.39	.59	.52	.01	.03	.04	.12	R-18810
217C-9	Stephens City	Frederick	10	Stonehenge	Ordovician	Limestone	87.42	4.08	6.11	.33	1.01	.84	.09	.05	.02	.06	R-18809
217C-10	Stephens City	Frederick	4	Edinburg	Ordovician	Limestone	91.11	4.62	2.98	.26	.63	.18	.06	.03	.07	.06	R-18807
217C-11	Stephens City	Frederick	1	Rockdale Run	Ordovician	Dolostone	50.97	39.79	6.44	.95	1.19	.55	.00	.07	.02	.01	R-18806
217C-12	Stephens City	Frederick	1	New Market	Ordovician	Limestone	99.05	.00	.57	.08	.20	.09	.00	.01	.01	.00	R-18814
217C-13	Stephens City	Frederick	5	Lincolnshire	Ordovician	Limestone (cherty)	98.00	.85	.79	.07	.14	.06	.00	.01	.07	.01	R-18813
217C-14	Stephens City	Frederick	4	Lincolnshire	Ordovician	Limestone	99.61	.00	.25	.06	.03	.03	.00	.00	.02	.00	R-18812
217C-15	Stephens City	Clarke	3	Rockdale Run	Ordovician	Magnesian Limestone	64.25	28.78	4.30	.55	1.36	.64	.00	.08	.02	.03	R-19347
217C-16	Stephens City	Clarke	6	New Market	Ordovician	Limestone	97.69	.00	1.42	.15	.46	.24	.00	.02	.03	.00	R-19348
217C-17	Stephens City	Clarke	3	Lincolnshire	Ordovician	Limestone	95.90	2.50	1.12	.09	.14	.05	.17	.01	.01	.01	R-19349
217C-18	Stephens City	Clarke	3	Rockdale Run	Ordovician	Magnesian Limestone	75.99	21.54	1.68	.15	.28	.22	.13	.01	.00	.00	R-19350
217C-19	Stephens City	Warren	2	Rockdale Run	Ordovician	Dolostone	57.49	40.59	1.07	.22	.42	.18	.00	.02	.00	.00	R-19351
217C-20	Stephens City	Warren	3	New Market	Ordovician	Limestone	91.66	6.79	1.10	.08	.25	.11	.00	.01	.00	.00	R-19352
217C-21	Stephens City	Warren	2	Lincolnshire	Ordovician	Limestone	89.00	2.78	5.23	.72	1.47	.39	.16	.06	.07	.15	R-19353
217C-22	Stephens City	Clarke	6	Rockdale Run	Ordovician	Dolostone	58.05	38.06	2.61	.41	.46	.37	.00	.02	.00	.02	R-20016
217C-23	Stephens City	Clarke	6	New Market	Ordovician	Limestone	97.11	1.28	1.03	.10	.30	.17	.00	.01	.00	.00	R-20017
217C-24	Stephens City	Clarke	2	Lincolnshire	Ordovician	Limestone	97.86	1.37	.59	.06	.07	.05	.00	.00	.00	.00	R-20018
217C-25	Stephens City	Warren	4	Rockdale Run	Ordovician	Limestone	99.12	.00	.56	.07	.15	.08	.00	.01	.01	.00	R-19354
217C-26	Stephens City	Warren	3	Rockdale Run	Ordovician	Limestone	97.62	.74	1.08	.23	.31	.00	.00	.01	.00	.00	R-20019
217C-27	Stephens City	Warren	4	Rockdale Run	Ordovician	Limestone	84.84	1.91	8.97	1.00	2.26	.72	.12	.11	.05	.01	R-20020
217C-28	Stephens City	Warren	6	Lincolnshire	Ordovician	Limestone	88.24	4.93	4.80	.46	1.09	.30	.03	.04	.04	.07	R-20021
217C-29	Stephens City	Warren	4	Edinburg	Ordovician	Limestone	81.69	6.45	8.06	.80	1.92	.56	.15	.08	.05	.23	R-20022
217C-30	Stephens City	Warren	3	Rockdale Run	Ordovician	Dolostone	62.98	33.83	1.82	.32	.69	.30	.00	.03	.00	.03	R-20023
217C-31	Stephens City	Clarke	3	Edinburg	Ordovician	Limestone	81.79	.99	15.38	.51	1.00	.20	.00	.05	.04	.05	R-20024
217C-32	Stephens City	Clarke	1	Edinburg	Ordovician	Limestone	97.03	1.51	1.02	.13	.23	.04	.00	.01	.02	.00	R-20025
217C-33	Stephens City	Clarke	1	Edinburg	Ordovician	Limestone	77.80	2.41	13.76	1.38	3.34	.91	.15	.14	.09	.01	R-20026
217C-34	Stephens City	Warren	3	Lincolnshire	Ordovician	Limestone	84.06	1.22	11.85	.75	1.35	.30	.23	.07	.08	.09	R-20027
217C-35	Stephens City	Warren	5	New Market	Ordovician	Limestone	98.25	.83	.34	.42	.10	.04	.00	.01	.00	.00	R-20028
217C-36	Stephens City	Warren	10	Lincolnshire	Ordovician	Limestone	89.33	1.59	6.66	.55	1.42	.37	.00	.06	.03	.00	R-20029

Table 35. (cont'd.)

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217C-37	Stephens City	Warren	3	Edinburg	Ordovician	Limestone (shale partings)	79.83	2.43	15.02	.70	1.39	.30	.13	.07	.02	.11	R-20030
217C-38	Stephens City	Warren	2	Rockdale Run	Ordovician	Limestone	89.43	1.50	6.22	.43	1.26	1.09	.00	.06	.00	.00	R-20031
217C-39	Stephens City	Warren	3	Edinburg	Ordovician	Limestone	85.29	1.39	10.92	.68	1.04	.18	.38	.06	.01	.04	R-20032
217C-40	Stephens City	Warren	3	Rockdale Run	Ordovician	Dolostone	58.85	35.37	3.94	.63	.72	.45	.00	.04	.00	.00	R-20033
217C-41	Stephens City	Warren	1	Rockdale Run	Ordovician	Limestone	90.03	1.62	5.95	.41	1.02	.87	.00	.05	.00	.04	R-20034
217C-42	Stephens City	Warren	2	Rockdale Run	Ordovician	Limestone	82.79	5.03	8.61	.68	1.65	1.15	.00	.07	.00	.01	R-20035
217C-43	Stephens City	Warren	5	Stonehenge	Ordovician	Limestone	93.48	1.87	3.26	.31	.59	.42	.04	.03	.00	.00	R-20036
217C-44	Stephens City	Warren	1	Conococheague	Cambrian	Limestone	89.56	3.96	4.49	.28	.96	.71	.00	.04	.00	.01	R-20037
217C-45	Stephens City	Clarke	2	Rockdale Run	Ordovician	Limestone	91.50	2.50	4.54	.25	.67	.49	.00	.02	.00	.03	R-20038
217C-46	Stephens City	Warren	2	Rockdale Run	Ordovician	Dolostone	60.10	34.64	3.49	.54	.69	.51	.00	.02	.00	.00	R-20039
217C-47	Stephens City	Frederick	5	Edinburg	Ordovician	Limestone	88.16	2.57	6.64	.57	1.41	.40	.08	.05	.02	.09	R-20040
217C-48	Stephens City	Frederick	3	New Market	Ordovician	Limestone	97.53	1.64	.56	.09	.13	.05	.00	.01	.00	.00	R-20041
217C-49	Stephens City	Frederick	1	Edinburg	Ordovician	Limestone	84.29	4.85	7.21	.85	1.89	.58	.15	.09	.02	.06	R-20042
217C-50	Stephens City	Frederick	3	Lincolnshire	Ordovician	Limestone	86.42	1.53	9.13	.81	1.46	.40	.03	.07	.09	.04	R-20043
217C-51	Stephens City	Frederick	4	Rockdale Run	Ordovician	Dolostone	52.83	38.92	6.11	.81	.74	.51	.04	.04	.00	.00	R-20044
217C-52	Stephens City	Frederick	4	Rockdale Run	Ordovician	Limestone	93.18	2.54	2.98	.28	.52	.41	.00	.03	.00	.04	R-20045
217C-53	Stephens City	Frederick	6	Rockdale Run	Ordovician	Limestone	88.63	4.86	4.51	.29	.93	.70	.00	.04	.00	.04	R-20046
217C-54	Stephens City	Frederick	4	Rockdale Run	Ordovician	Limestone	90.24	1.76	5.43	.37	1.10	.87	.15	.05	.00	.04	R-20047
217C-55	Stephens City	Frederick	1	Conococheague	Cambrian	Dolostone	43.68	35.27	14.90	1.67	2.52	1.49	.00	.18	.01	.28	R-20048
217C-56	Stephens City	Frederick	3	Rockdale Run	Ordovician	Dolostone	54.83	38.75	4.29	.67	.84	.52	.02	.05	.00	.04	R-20049
217C-57	Stephens City	Frederick	4	Lincolnshire	Ordovician	Limestone (cherty)	96.73	1.33	1.47	.12	.23	.07	.00	.01	.04	.00	R-18818
217C-58	Stephens City	Frederick	3	Edinburg	Ordovician	Limestone	90.96	1.96	5.45	.48	.80	.19	.11	.03	.03	.00	R-18819
217C-59	Stephens City	Frederick	2	Stonehenge	Ordovician	Limestone	81.26	2.44	11.37	.92	2.23	1.63	.00	.11	.02	.02	R-20050
217C-60	Stephens City	Frederick	2	Rockdale Run	Ordovician	Dolostone	55.87	34.62	6.71	1.41	.79	.53	.03	.05	.00	.00	R-20051
217C-61	Stephens City	Frederick	2	Rockdale Run	Ordovician	Limestone	89.98	2.48	5.26	.37	1.05	.76	.04	.05	.00	.02	R-20052
217C-62	Stephens City	Frederick	2	Rockdale Run	Ordovician	Dolostone	52.06	43.85	3.03	.40	.37	.23	.05	.02	.00	.00	R-20053
217C-63	Stephens City	Frederick	2	New Market	Ordovician	Limestone	98.24	1.26	.30	.05	.10	.04	.00	.01	.00	.00	R-20054
217C-64	Stephens City	Frederick	4	Edinburg	Ordovician	Limestone	85.39	5.08	6.82	.59	1.41	.37	.21	.05	.03	.05	R-20055
217C-65	Stephens City	Frederick	3	Rockdale Run	Ordovician	Dolostone	52.36	43.81	2.95	.24	.35	.22	.06	.02	.00	.00	R-20056

Table 36. Reflectance analyses of carbonate-rock sample with brightness of 70 percent or higher, Stephens City quadrangle (217C), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
217C-12	Stephens City	Frederick	1	New Market	Ordovician	Limestone	82.2	1.5	76.2	99.05	.00	R-18814

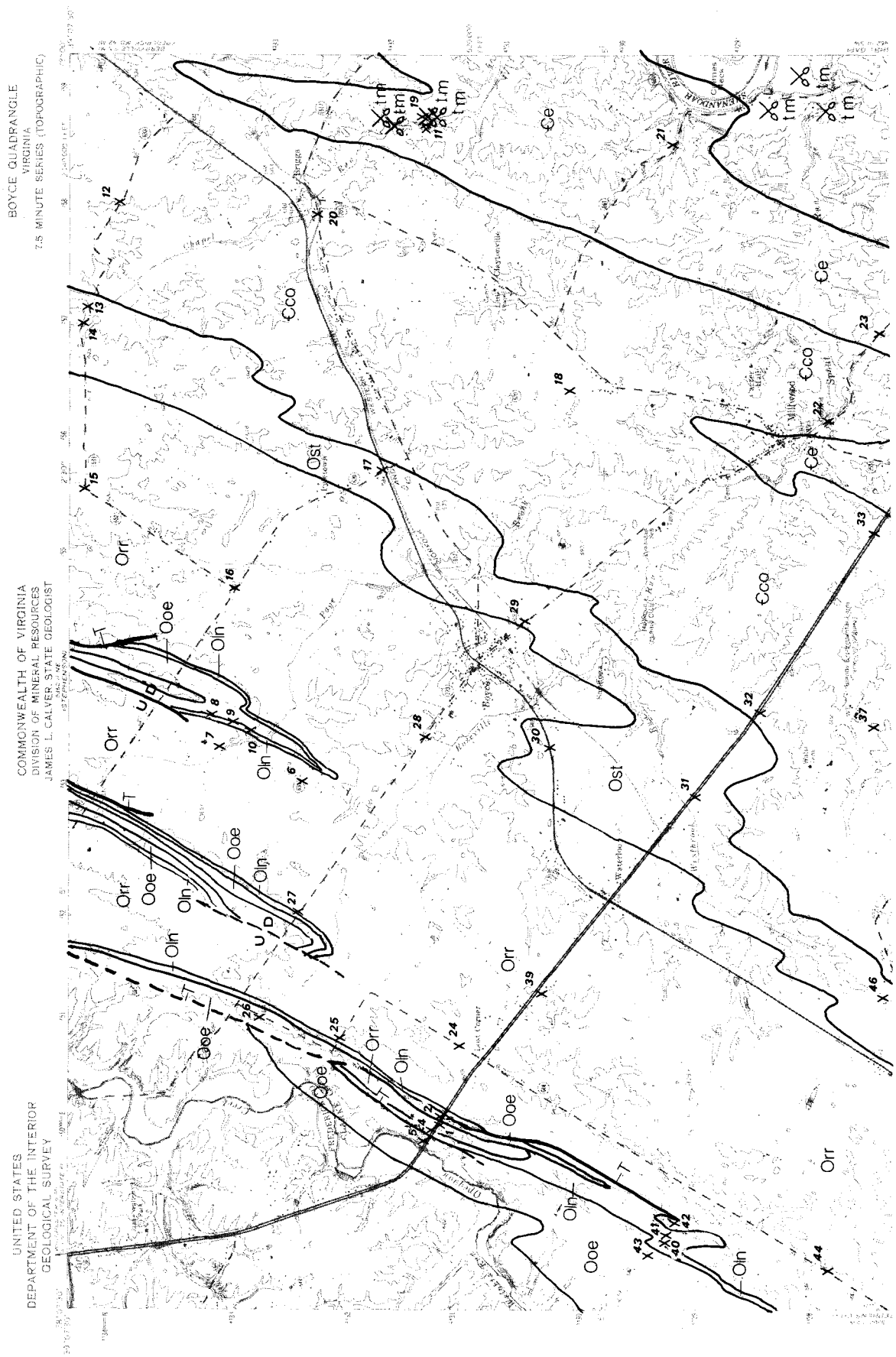


Figure 28. Northern half of Boyce quadrangle (217D) showing carbonate-rock sample locations.

217D

217D

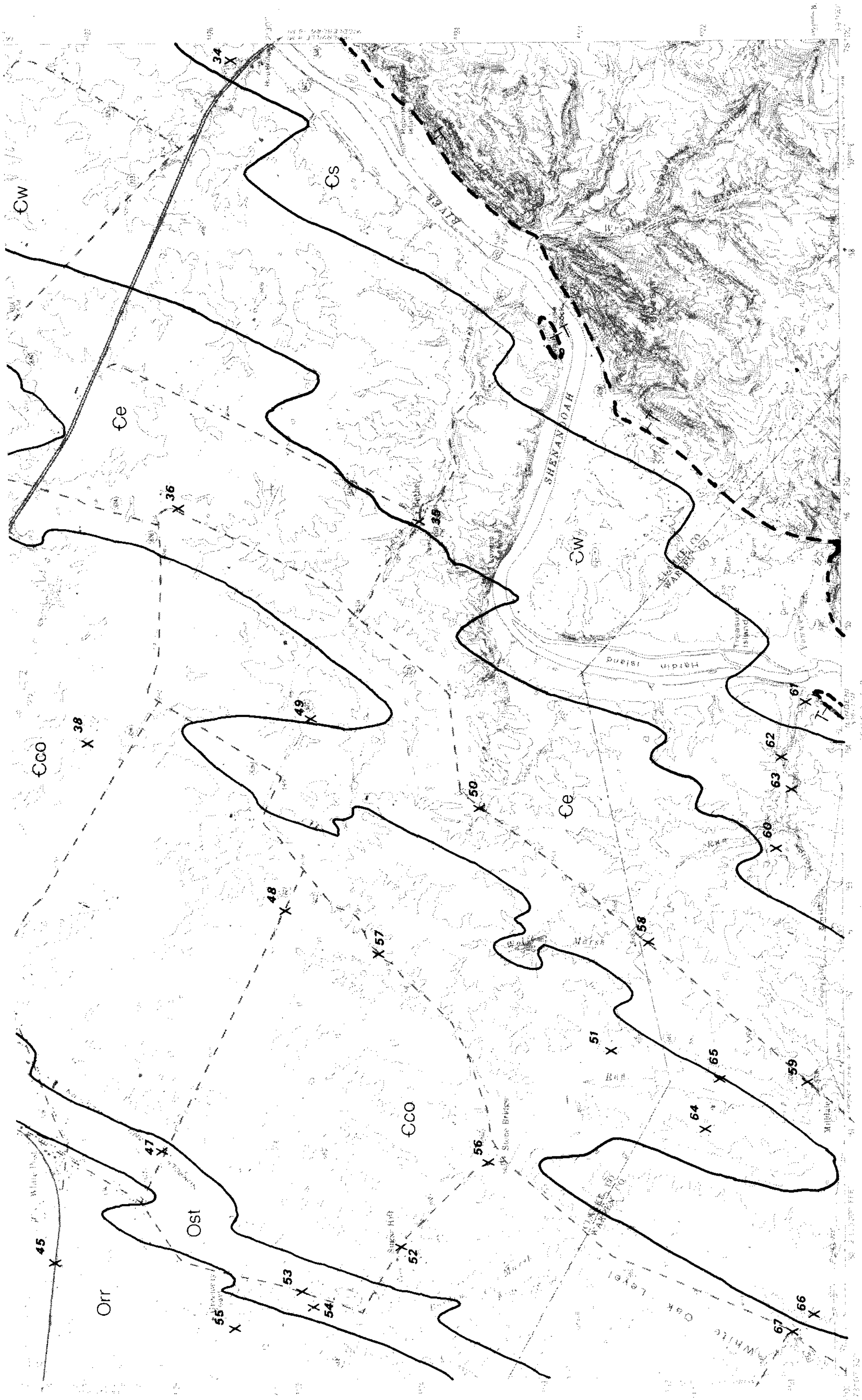


Figure 29. Southern half of Boyce quadrangle (217D) showing carbonate-rock sample locations.

Table 37. Chemical analyses of carbonate-rock samples, Boyce quadrangle (217D), Clarke and Warren counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217D-1	Boyce	Clarke	1	Edinburg	Ordovician	Limestone	82.17	1.02	14.71	.50	1.12	.21	.16	.05	.05	.00	R-18630
217D-2	Boyce	Clarke	1	New Market	Ordovician	Limestone	98.37	.00	1.23	.08	.20	.10	.00	.01	.01	.00	R-18631
217D-3	Boyce	Clarke	3	Rockdale Run	Ordovician	Limestone	84.07	4.86	7.68	.50	1.45	1.05	.21	.06	.00	.12	R-18632
217D-4	Boyce	Clarke	3	New Market	Ordovician	Limestone	98.40	.00	1.03	.09	.24	.08	.11	.01	.04	.00	R-18633
217D-5	Boyce	Clarke	3	Edinburg	Ordovician	Limestone	94.14	.00	4.75	.25	.61	.11	.09	.02	.03	.01	R-18634
217D-6	Boyce	Clarke	2	Rockdale Run	Ordovician	Limestone	97.44	.00	1.90	.09	.23	.13	.19	.01	.00	.00	R-18635
217D-7	Boyce	Clarke	8	Rockdale Run	Ordovician	Dolostone	53.96	40.07	4.05	.61	.73	.52	.00	.03	.01	.01	R-18636
217D-8	Boyce	Clarke	3	New Market	Ordovician	Limestone	88.89	8.53	1.54	.23	.50	.19	.04	.02	.04	.02	R-18637
217D-9	Boyce	Clarke	4	Edinburg	Ordovician	Limestone	83.43	.65	12.40	1.02	1.78	.36	.17	.08	.10	.01	R-18638
217D-10	Boyce	Clarke	2	Deposit	Quaternary	Marl	52.31	2.00	32.23	2.76	8.65	1.08	.13	.50	.27	.05	R-18639
217D-11	Boyce	Clarke	1	Deposit	Quaternary	Marl	92.63	.00	5.41	.40	1.01	.32	.05	.06	.06	.06	R-18640
217D-12	Boyce	Clarke	6	Conococheague	Cambrian	Limestone	86.14	5.84	5.52	.61	.98	.52	.20	.05	.03	.11	R-18658
217D-13	Boyce	Clarke	1	Deposit	Quaternary	Marl	97.04	.00	1.95	.39	.43	.08	.00	.02	.06	.04	R-18641
217D-14	Boyce	Clarke	2	Stonehenge	Ordovician	Limestone	86.74	4.15	5.93	.84	1.49	.64	.11	.06	.01	.03	R-18673
217D-15	Boyce	Clarke	2	Rockdale Run	Ordovician	Limestone	88.82	2.29	7.05	.26	.94	.50	.09	.04	.00	.01	R-18662
217D-16	Boyce	Clarke	4	Rockdale Run	Ordovician	Limestone	87.35	1.97	7.50	.58	1.44	1.05	.00	.06	.03	.02	R-18971
217D-17	Boyce	Clarke	2	Stonehenge	Ordovician	Limestone	81.51	2.01	11.88	.80	1.89	1.57	.22	.10	.01	.02	R-18972
217D-18	Boyce	Clarke	5	Conococheague	Cambrian	Limestone	95.06	.05	2.98	.36	.71	.56	.16	.03	.00	.08	R-18661
217D-19	Boyce	Clarke	2	Elbrook	Cambrian	Limestone	95.91	.00	2.64	.19	.66	.56	.00	.03	.00	.01	R-18663
217D-20	Boyce	Clarke	1	Conococheague	Cambrian	Limestone	80.83	4.01	10.57	1.01	1.91	1.17	.06	.10	.02	.33	R-18973
217D-21	Boyce	Clarke	2	Elbrook	Cambrian	Dolostone	46.55	39.21	11.09	1.22	1.33	.50	.00	.09	.00	.00	R-18659
217D-22	Boyce	Clarke	2	Conococheague	Cambrian	Magnesian Limestone	55.24	26.02	12.94	1.44	2.18	1.97	.06	.12	.00	.02	R-18671
217D-23	Boyce	Clarke	2	Elbrook	Cambrian	Dolostone	43.24	36.42	13.39	1.80	2.67	2.32	.00	.14	.03	.00	R-18669
217D-24	Boyce	Clarke	5	Rockdale Run	Ordovician	Magnesian Limestone	75.53	15.11	6.72	.68	1.14	.75	.01	.05	.01	.01	R-18974
217D-25	Boyce	Clarke	1	New Market	Ordovician	Limestone	98.21	.00	1.03	.15	.41	.15	.00	.02	.04	.00	R-18670
217D-26	Boyce	Clarke	2	Edinburg	Ordovician	Limestone	86.84	1.32	9.66	.64	1.18	.26	.02	.05	.02	.02	R-18668
217D-27	Boyce	Clarke	1	New Market	Ordovician	Limestone	98.08	1.34	.38	.05	.10	.04	.00	.00	.00	.00	R-18665
217D-28	Boyce	Clarke	3	Rockdale Run	Ordovician	Limestone	94.35	2.82	2.17	.08	.23	.19	.15	.01	.00	.00	R-18975
217D-29	Boyce	Clarke	4	Stonehenge	Ordovician	Limestone	82.02	4.55	10.17	.71	1.46	.94	.04	.06	.01	.04	R-18660
217D-30	Boyce	Clarke	2	Stonehenge	Ordovician	Limestone	85.93	5.23	6.38	.52	1.03	.72	.05	.05	.01	.09	R-18976
217D-31	Boyce	Clarke	1	Stonehenge	Ordovician	Limestone	84.67	5.02	7.33	.46	1.40	.91	.03	.07	.00	.11	R-18977
217D-32	Boyce	Clarke	3	Conococheague	Cambrian	Limestone	81.80	7.36	7.79	.51	1.41	.92	.00	.06	.03	.13	R-18978

Table 37. (cont'd.).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217D-33	Boyce	Clarke	24	Conococheague	Cambrian	Dolostone (shale partings)	44.17	36.10	11.84	2.12	2.92	1.99	.26	.18	.00	.43	R-18674
217D-34	Boyce	Clarke	5	Shady	Cambrian	Dolostone	53.51	45.07	.71	.55	.08	.07	.01	.01	.00	.00	R-18979
217D-35	Boyce	Clarke	2	Waynesboro	Cambrian	Dolostone	41.95	35.33	15.89	2.07	2.50	1.83	.04	.18	.03	.01	R-18666
217D-36	Boyce	Clarke	1	Elbrook	Cambrian	Limestone	75.05	7.73	13.67	.85	1.27	1.09	.02	.07	.05	.20	R-18664
217D-37	Boyce	Clarke	45	Conococheague	Cambrian	Limestone	89.20	2.71	5.83	.44	.97	.62	.11	.05	.04	.04	R-18672
217D-38	Boyce	Clarke	2	Conococheague	Cambrian	Magnesian Limestone	81.00	10.79	5.21	.94	1.10	.62	.25	.07	.01	.02	R-18667
217D-39	Boyce	Clarke	3	Rockdale Run	Ordovician	Limestone	89.11	5.40	3.79	.25	.65	.41	.32	.03	.00	.05	R-18980
217D-40	Boyce	Clarke	2	Rockdale Run	Ordovician	Magnesian Limestone	66.89	24.58	5.14	.88	1.57	.61	.10	.08	.00	.15	R-18981
217D-41	Boyce	Clarke	3	New Market	Ordovician	Limestone	99.37	.00	.32	.05	.08	.04	.09	.00	.04	.00	R-18982
217D-42	Boyce	Clarke	2	Rockdale Run	Ordovician	Dolostone	48.23	40.63	8.70	1.00	.82	.56	.01	.05	.00	.00	R-18983
217D-43	Boyce	Clarke	4	Edinburg	Ordovician	Limestone	89.49	2.83	5.33	.54	1.17	.30	.12	.05	.07	.09	R-18984
217D-44	Boyce	Clarke	2	Rockdale Run	Ordovician	Magnesian Limestone	68.92	29.11	1.10	.20	.38	.19	.08	.02	.00	.00	R-18985
217D-45	Boyce	Clarke	4	Rockdale Run	Ordovician	Limestone	82.56	4.95	9.58	.44	1.32	.96	.00	.06	.02	.11	R-18986
217D-46	Boyce	Clarke	1	Stonehenge	Ordovician	Limestone	92.12	4.95	2.34	.11	.24	.22	.00	.01	.01	.01	R-18987
217D-47	Boyce	Clarke	10	Stonehenge	Ordovician	Limestone	88.74	5.46	4.14	.32	.77	.53	.00	.03	.00	.00	R-18865
217D-48	Boyce	Clarke	1	Conococheague	Cambrian	Magnesian Limestone	78.19	13.54	5.67	.80	.91	.77	.06	.04	.00	.01	R-18988
217D-49	Boyce	Clarke	3	Conococheague	Cambrian	Magnesian Limestone	71.18	24.17	2.93	.56	.52	.47	.13	.03	.00	.01	R-18989
217D-50	Boyce	Clarke	2	Elbrook	Cambrian	Magnesian Limestone	75.76	15.42	6.04	.86	.90	.88	.00	.07	.02	.05	R-18990
217D-51	Boyce	Clarke	2	Conococheague	Cambrian	Magnesian Limestone	71.72	17.92	6.63	.90	1.69	.98	.00	.10	.00	.06	R-18991
217D-52	Boyce	Clarke	8	Conococheague	Cambrian	Limestone	87.74	4.97	5.36	.51	.73	.56	.00	.03	.00	.10	R-18992
217D-53	Boyce	Clarke	9	Stonehenge	Ordovician	Limestone	90.20	5.00	3.64	.28	.48	.36	.00	.02	.00	.01	R-18993
217D-54 (Sample not used)																	
217D-55	Boyce	Clarke	5	Rockdale Run	Ordovician	Limestone	93.04	2.83	3.03	.22	.49	.33	.01	.03	.00	.02	R-18994
217D-56	Boyce	Clarke	5	Conococheague	Cambrian	Magnesian Limestone	71.73	22.22	3.57	.82	.78	.72	.08	.05	.01	.03	R-18995
217D-57	Boyce	Clarke	2	Conococheague	Cambrian	Limestone	74.85	8.22	12.87	.66	1.70	1.54	.00	.07	.07	.03	R-18996
217D-58	Boyce	Warren	1	Elbrook	Cambrian	Limestone	78.49	8.31	8.41	.94	1.94	1.51	.06	.12	.02	.19	R-19044
217D-59	Boyce	Warren	4	Elbrook	Cambrian	Limestone	89.18	4.78	4.05	.41	.73	.72	.00	.05	.01	.07	R-19045

Table 37. (cont'd.).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
217D-60	Boyce	Warren	2	Waynesboro	Cambrian	Dolostone	52.32	43.29	2.69	1.12	.28	.28	.00	.02	.00	.00	R-20084
217D-61	Boyce	Warren	7	Shady	Cambrian	Dolostone	52.10	42.54	3.71	.71	.49	.28	.12	.03	.00	.00	R-19046
217D-62	Boyce	Warren	4	Waynesboro	Cambrian	Magnesian Limestone	86.68	11.08	1.31	.33	.34	.22	.00	.01	.01	.01	R-19047
217D-63	Boyce	Warren	2	Deposit	Quaternary	Marl	62.68	1.57	26.71	2.51	4.15	1.80	.08	.36	.10	.03	R-20085
217D-64	Boyce	Warren	3	Conococheague	Cambrian	Magnesian Limestone	76.09	12.13	8.26	.92	1.38	.98	.10	.07	.04	.02	R-19048
217D-65	Boyce	Warren	1	Deposit	Quaternary	Marl	44.70	1.27	39.70	3.83	7.22	1.98	.11	.77	.36	.04	R-20086
217D-66	Boyce	Warren	1	Elbrook	Cambrian	Dolostone	47.89	31.14	12.38	2.33	3.26	2.73	.00	.22	.04	.03	R-19049
217D-67	Boyce	Warren	1	Conococheague	Cambrian	Limestone	89.70	5.42	3.14	.40	.59	.55	.13	.04	.03	.01	R-19050

Table 38. Reflectance analyses of carbonate-rock samples with brightness of 70 percent or higher, Boyce quadrangle (217D), Clarke County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
217D-6	Boyce	Clarke	2	Rockdale Run	Ordovician	Limestone	81.	0.0	81.7	97.44	.00	R-18635
217D-18	Boyce	Clarke	5	Conococheague	Cambrian	Limestone	83.3	1.3	78.2	95.06	.05	R-18661
217D-19	Boyce	Clarke	2	Elbrook	Cambrian	Limestone	82.8	0.7	79.9	95.91	.00	R-18663
217D-25	Boyce	Clarke	1	New Market	Ordovician	Limestone	80.0	0.8	77.0	98.21	.00	R-18670
217D-28	Boyce	Clarke	3	Rockdale Run	Ordovician	Limestone	91.1	0.0	91.1	94.35	2.82	R-18975
217D-32	Boyce	Clarke	3	Conococheague	Cambrian	Limestone	83.3	0.1	82.7	81.80	7.36	R-18978
217D-34	Boyce	Clarke	5	Shady	Cambrian	Dolostone	83.3	4.6	64.7	53.51	45.07	R-18979
217D-36	Boyce	Clarke	1	Elbrook	Cambrian	Limestone	78.3	0.2	77.5	75.05	7.73	R-18664
217D-41	Boyce	Clarke	3	New Market	Ordovician	Limestone	88.3	.01	88.0	99.37	.00	R-18982
217D-46	Boyce	Clarke	1	Stonehenge	Ordovician	Limestone	80.0	0.0	80.0	92.12	4.95	R-18987
217D-57	Boyce	Clarke	2	Conococheague	Cambrian	Limestone	82.2	2.4	72.6	74.85	8.22	R-18996

Figure 30. Northern half of Hayfield quadrangle (218A) showing carbonate-rock sample locations.

Figure 31. Southern half of Hayfield quadrangle (281A) showing carbonate-rock sample locations.

218A

Table 39. Chemical analyses of carbonate-rock samples, Hayfield quadrangle (218A), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
218A-1	Hayfield	Frederick	3	Licking Creek	Devonian	Limestone	68.54	9.61	15.33	1.51	3.43	1.09	.24	.17	.02	.06	R-18683
218A-2	Hayfield	Frederick	30	Tonoloway	Silurian	Limestone	70.12	5.34	17.69	1.76	3.33	1.00	.13	.23	.05	.35	R-18684
218A-3	Hayfield	Frederick	2	Licking Creek	Devonian	Limestone	88.39	.00	9.36	.60	1.18	.33	.04	.06	.02	.01	R-18682
218A-4	Hayfield	Frederick	4	Keyser	Silurian	Limestone	88.57	4.75	4.69	.46	1.05	.37	.00	.05	.04	.03	R-18685
218A-5	Hayfield	Frederick	2	Tonoloway	Silurian	Limestone	84.20	4.65	8.14	.75	1.58	.52	.00	.08	.04	.06	R-18686
218A-6	Hayfield	Frederick	75	Keyser	Silurian	Limestone	81.40	1.32	12.64	1.05	2.51	.75	.13	.15	.00	.05	R-18687
218A-7	Hayfield	Frederick	80	Tonoloway	Silurian	Limestone	93.09	.63	4.52	.49	.85	.29	.00	.05	.01	.07	R-18688
218A-8	Hayfield	Frederick	4	Conococheague	Cambrian	Limestone	88.96	5.68	3.71	.25	.72	.48	.03	.03	.05	.09	R-18776
218A-9	Hayfield	Frederick	2	Conococheague	Cambrian	Dolostone	45.87	36.99	10.95	2.45	1.89	1.57	.04	.14	.04	.06	R-18775
218A-10	(Sample not used)																
218A-11	Hayfield	Frederick	2	Elbrook	Cambrian	Dolostone	50.31	41.27	4.82	2.03	.80	.72	.00	.05	.00	.01	R-18774
218A-12	Hayfield	Frederick	2	Keyser	Silurian	Limestone	93.63	2.07	2.95	.44	.47	.18	.09	.02	.02	.13	R-20087
218A-13	Hayfield	Frederick	5	Tonoloway	Silurian	Limestone	85.96	3.83	7.37	.66	1.26	.49	.15	.07	.03	.19	R-19051
218A-14	Hayfield	Frederick	4	Tonoloway	Silurian	Limestone	83.94	2.20	10.01	1.11	1.69	.53	.21	.11	.03	.16	R-19052

Figure 32. Northern half of Capon Springs quadrangle (218B) showing carbonate-rock location (no samples collected).

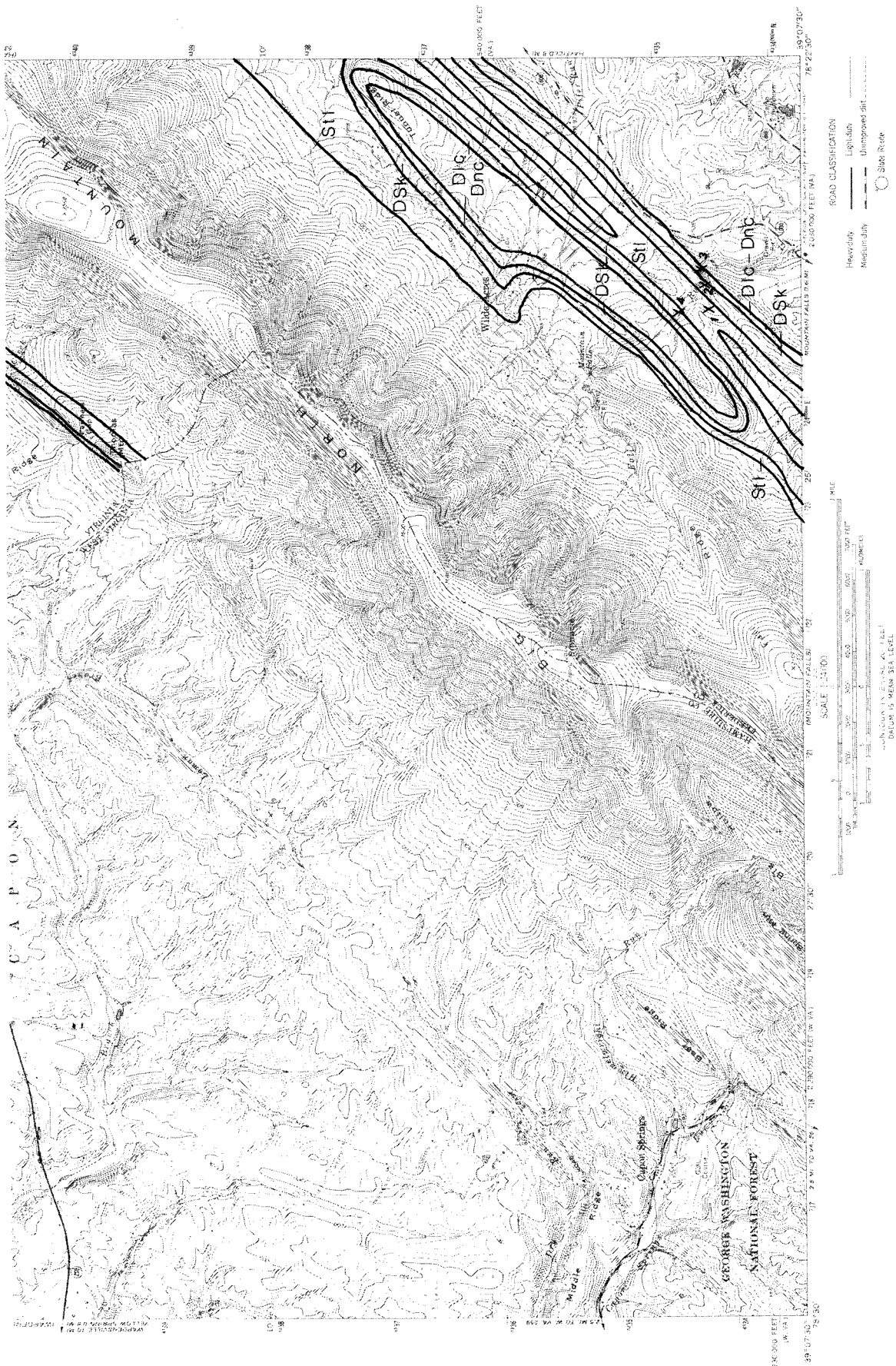


Figure 33. Southern half of Capon Springs quadrangle (218B) showing carbonate-rock sample locations.

Table 40. Chemical analyses of carbonate-rock samples, Capon Springs quadrangle (218B), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
218B-1	Capon Springs	Frederick	15	Tonoloway	Silurian	Limestone	87.12	2.18	7.41	.61	1.71	.66	.09	.09	.02	.11	R-20088
218B-2	Capon Springs	Frederick	12	Keyser	Silurian	Limestone	77.26	3.79	13.56	1.33	2.91	.94	.00	.15	.02	.04	R-20089
218B-3	Capon Springs	Frederick	3	Licking Creek	Devonian	Limestone	96.13	1.56	1.69	.27	.23	.08	.00	.01	.03	.01	R-20090
218B-4	Capon Springs	Frederick	2	Keyser	Silurian	Limestone	85.34	2.04	9.90	.79	1.34	.46	.00	.08	.00	.05	R-20091

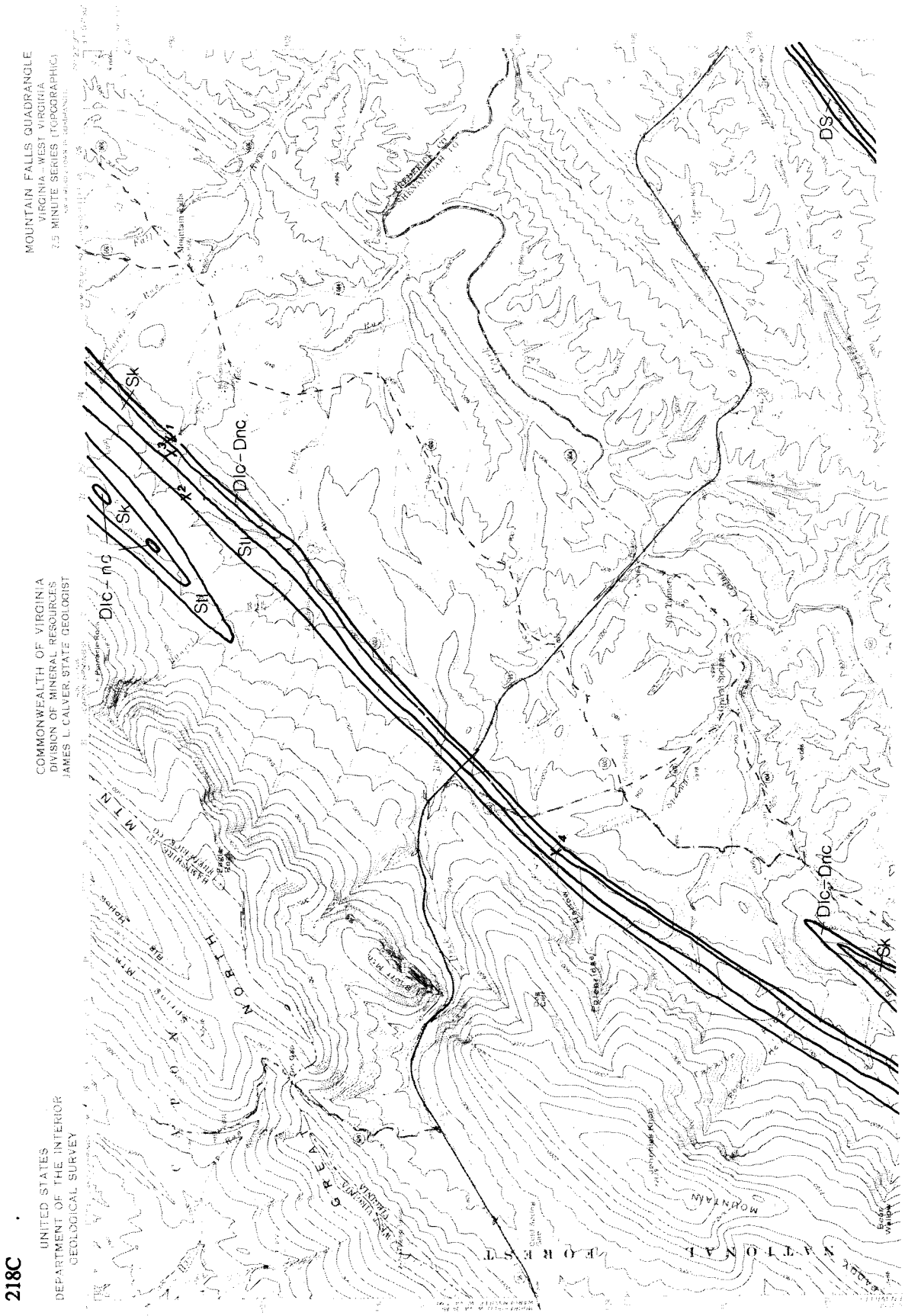


Figure 34. Northern half of Mountain Falls quadrangle (218C) showing carbonate-rock sample locations.

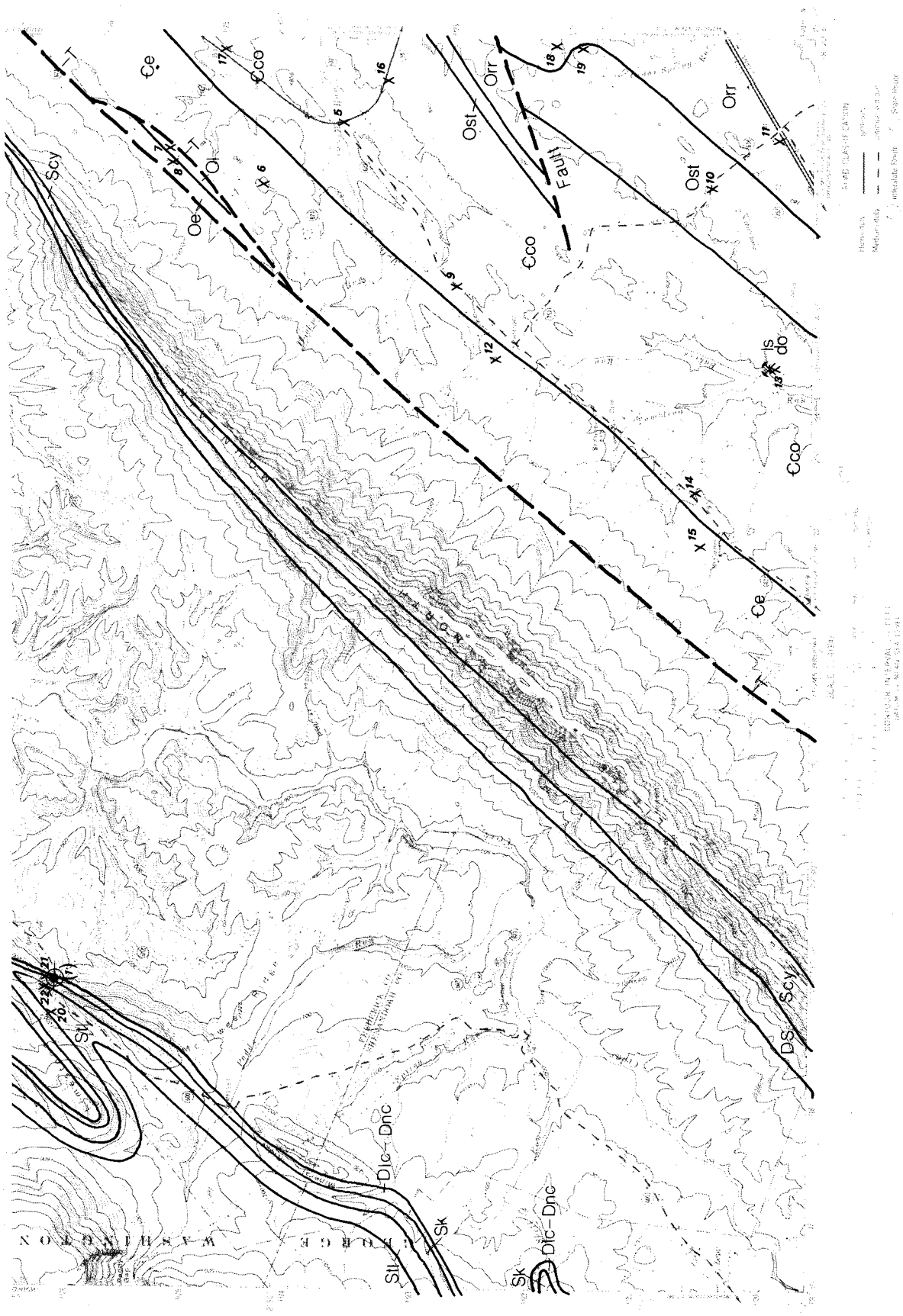


Figure 35. Southern half of Mountain Falls quadrangle (218C) showing carbonate-rock sample locations.

218C

Table 41. Chemical analyses of carbonate-rock samples, Mountain Falls quadrangle (218C), Frederick and Shenandoah counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
218C-1	Mountain Falls	Frederick	2	Licking Creek	Devonian	Limestone	77.71	.00	16.51	1.99	1.27	.40	.09	.11	1.85	.07	R-18761
218C-2	Mountain Falls	Frederick	4	Tonoloway	Silurian	Limestone	87.80	1.48	7.45	.77	1.62	.65	.00	.08	.01	.12	R-18762
218C-3	Mountain Falls	Frederick	1	Keyser	Silurian	Limestone	83.35	3.32	9.65	.83	1.85	.68	.07	.10	.03	.11	R-18763
218C-4	Mountain Falls	Frederick	3	Licking Creek	Devonian	Limestone	91.83	1.24	4.51	1.01	.85	.31	.08	.04	.02	.07	R-18760
218C-5	Mountain Falls	Shenandoah	5	Conococheague	Cambrian	Dolostone	52.86	40.80	4.19	.85	.60	.56	.09	.04	.00	.00	R-19005
218C-6	Mountain Falls	Shenandoah	2	Elbrook	Cambrian	Magnesian Limestone	70.40	15.39	8.93	1.10	2.09	1.65	.19	.13	.06	.06	R-19006
218C-7	Mountain Falls	Shenandoah	2	Lincolnshire	Ordovician	Limestone	90.84	4.63	2.54	.47	.65	.60	.18	.04	.04	.02	R-19007
218C-8	Mountain Falls	Shenandoah	2	Edinburg	Ordovician	Limestone	93.05	.57	4.19	.96	.81	.20	.12	.04	.03	.05	R-19008
218C-9	Mountain Falls	Shenandoah	3	Conococheague	Cambrian	Limestone	88.00	2.60	5.76	.54	1.55	1.33	.03	.08	.02	.08	R-19009
218C-10	Mountain Falls	Shenandoah	2	Stonehenge	Ordovician	Limestone	90.60	1.94	5.00	.45	1.03	.83	.00	.05	.03	.07	R-19010
218C-11	Mountain Falls	Shenandoah	2	Rockdale Run	Ordovician	Dolostone	50.41	36.74	8.76	1.35	1.51	1.12	.00	.08	.02	.00	R-19011
218C-12	Mountain Falls	Shenandoah	2	Elbrook	Cambrian	Limestone	73.03	5.66	14.44	1.24	2.91	2.39	.00	.16	.05	.11	R-19012
218C-13	Mountain Falls	Shenandoah	5	Conococheague	Cambrian	Limestone	77.50	3.53	13.30	.84	2.42	1.92	.08	.10	.06	.25	R-19013
218C-14	Mountain Falls	Shenandoah	2	Conococheague	Cambrian	Dolostone	46.26	37.85	12.44	1.00	1.24	1.06	.07	.06	.01	.01	R-19014
218C-15	Mountain Falls	Shenandoah	2	Elbrook	Cambrian	Magnesian Limestone	77.51	10.66	7.92	.75	1.54	1.43	.00	.09	.04	.07	R-19015
218C-16	Mountain Falls	Shenandoah	4	Conococheague	Cambrian	Limestone	90.82	.00	6.60	.56	1.03	.84	.00	.05	.06	.05	R-19016
218C-17	Mountain Falls	Shenandoah	2	Conococheague	Cambrian	Dolostone	52.91	44.57	1.66	.35	.25	.19	.00	.02	.01	.04	R-19017
218C-18	Mountain Falls	Shenandoah	4	Rockdale Run	Ordovician	Limestone	91.93	1.75	4.59	.29	.75	.61	.00	.03	.02	.02	R-19018
218C-19	Mountain Falls	Shenandoah	2	Stonehenge	Ordovician	Limestone	97.39	.00	2.19	.11	.14	.14	.00	.01	.01	.01	R-19019
218C-20	Mountain Falls	Frederick	5	Tonoloway	Silurian	Limestone	92.70	.00	5.16	.39	1.12	.46	.05	.06	.03	.02	R-18764
218C-21	Mountain Falls	Frederick	4	Licking Creek	Devonian	Limestone	90.23	1.99	5.53	.56	1.12	.44	.00	.05	.09	.01	R-19053
218C-22	Mountain Falls	Frederick	3	Keyser	Silurian	Limestone	96.18	.00	2.54	.37	.51	.20	.07	.02	.05	.05	R-19054

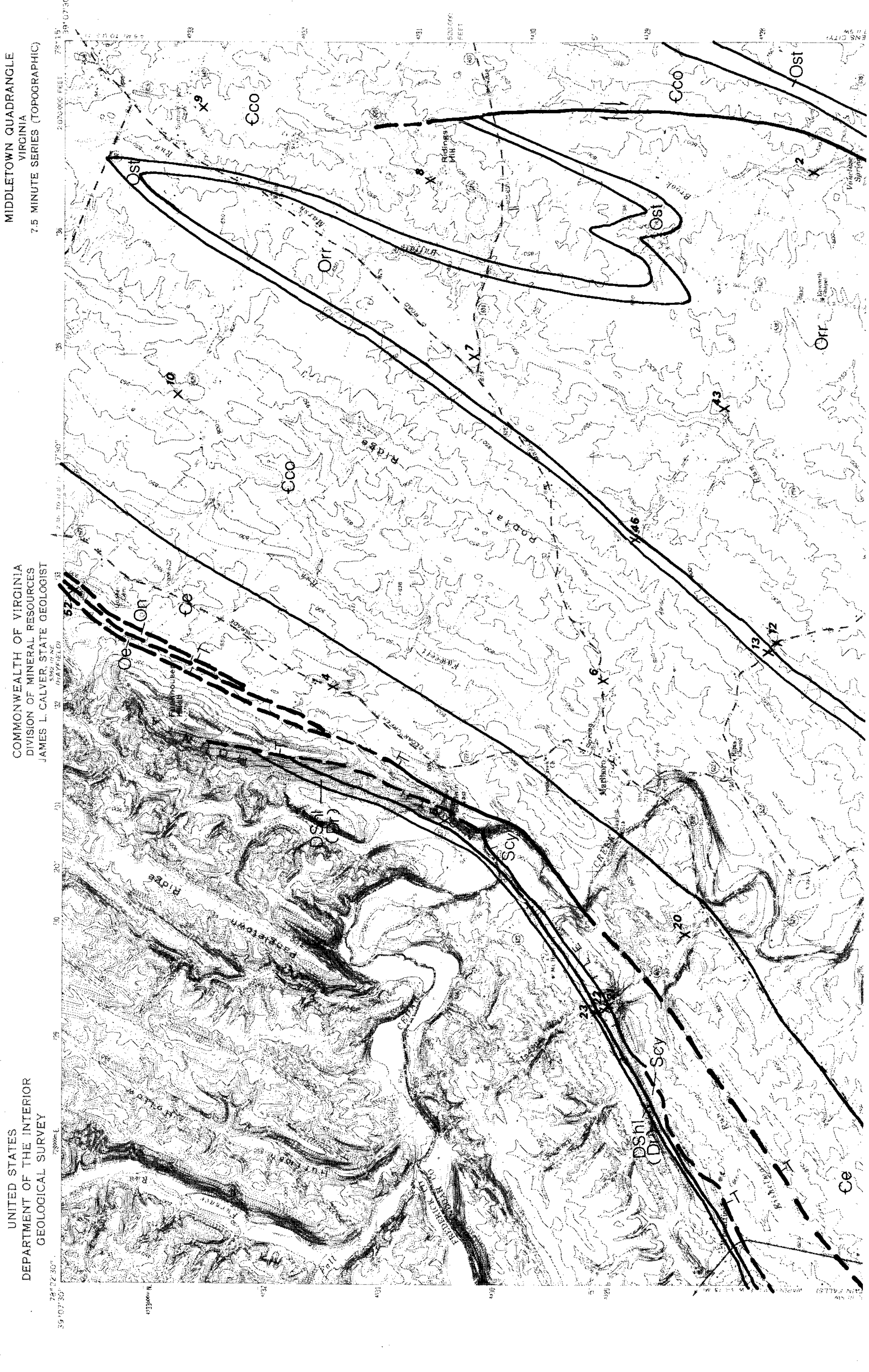


Figure 36. Northern half of Middletown quadrangle (218D) showing carbonate-rock sample locations.

218D

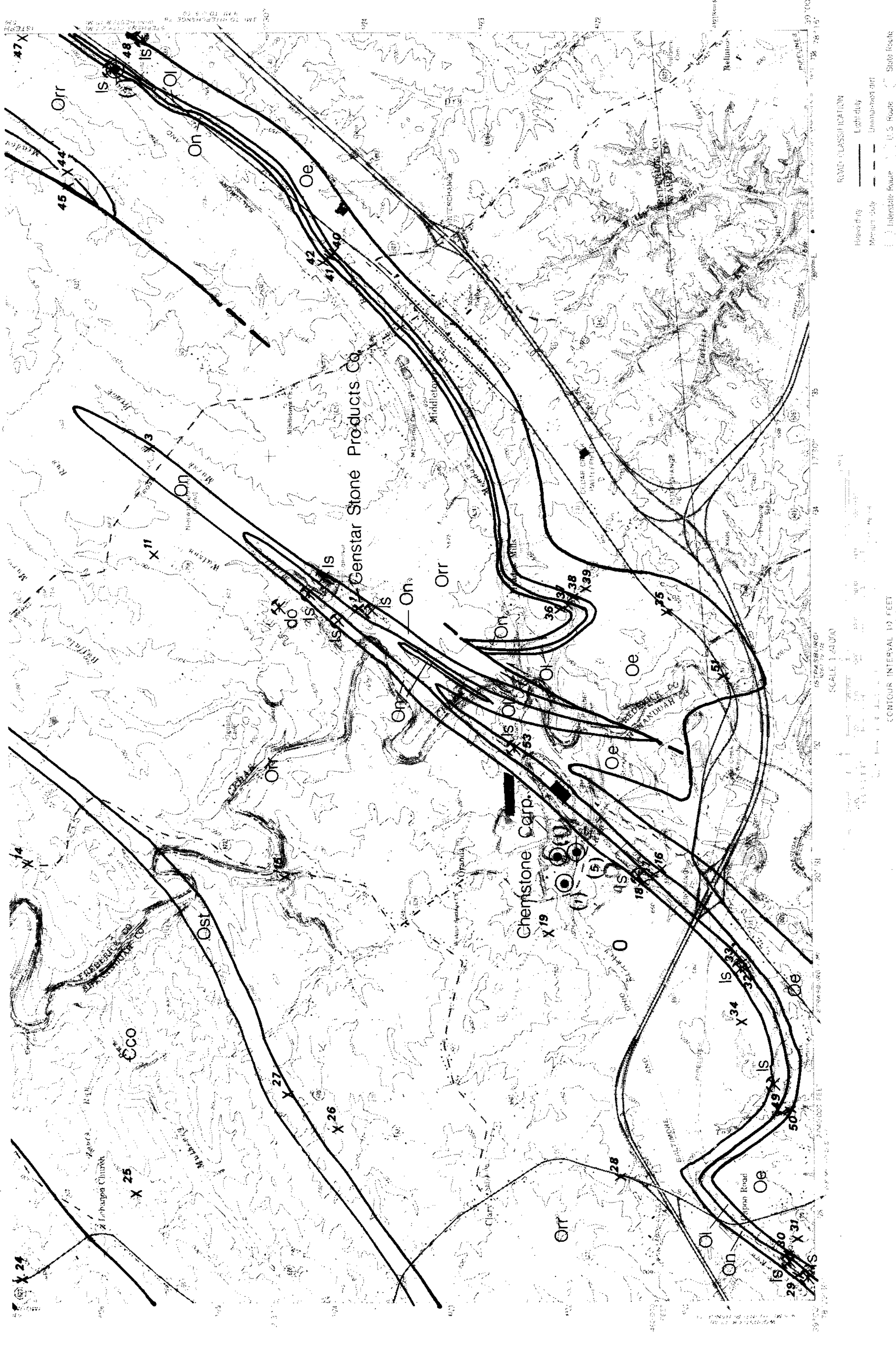


Figure 37. Southern half of Middletown quadrangle (218D) showing carbonate-rock sample locations.

218D

Table 42. Chemical analyses of carbonate-rock samples, Middletown quadrangle (218D), Frederick, Shenandoah, and Warren counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
218D-1	Middletown	Frederick	130	New Market	Ordovician	Limestone	99.43	.00	.26	.04	.08	.04	.09	.00	.02	.03	R-18696
218D-2	Middletown	Frederick	5	Rockdale Run	Ordovician	Dolostone	52.93	38.20	6.72	.82	.62	.53	.12	.04	.00	.02	R-18840
218D-3	Middletown	Frederick	6	Rockdale Run	Ordovician	Limestone (cherty)	95.92	2.75	.85	.09	.17	.06	.03	.01	.09	.02	R-18833
218D-4	Middletown	Frederick	5	Elbrook	Cambrian	Dolostone	51.55	42.32	4.83	.64	.32	.26	.00	.02	.02	.04	R-18820
218D-5	Middletown	Frederick	30	Tonoloway	Silurian	Limestone	70.36	8.62	16.91	1.47	2.31	.62	.20	.17	.02	.03	R-18836
218D-6	Middletown	Frederick	4	Conococheague	Cambrian	Magnesian Limestone	79.17	11.20	6.67	.70	1.16	.97	.00	.06	.00	.07	R-18821
218D-7	Middletown	Frederick	3	Rockdale Run	Ordovician	Dolostone	62.50	31.02	4.41	.59	.76	.50	.16	.04	.00	.02	R-18827
218D-8	Middletown	Frederick	3	Conococheague	Cambrian	Limestone	86.23	1.86	8.27	.67	1.53	1.21	.06	.07	.01	.08	R-18824
218D-9	Middletown	Frederick	1	Conococheague	Cambrian	Limestone	78.78	2.78	13.52	.68	1.96	1.87	.03	.08	.13	.17	R-18831
218D-10	Middletown	Frederick	2	Conococheague	Cambrian	Limestone	81.52	9.54	6.70	.60	.68	.58	.24	.03	.00	.11	R-18822
218D-11	Middletown	Frederick	2	Rockdale Run	Ordovician	Dolostone	50.62	42.63	5.45	.39	.52	.37	.00	.02	.00	.00	R-18826
218D-12	Middletown	Frederick	1	Rockdale Run	Ordovician	Limestone	81.19	8.34	7.86	.45	1.21	.78	.00	.06	.04	.04	R-18837
218D-13	Middletown	Frederick	1	Stonehenge	Ordovician	Limestone	90.58	5.18	2.79	.33	.61	.45	.02	.03	.00	.01	R-18844
218D-14	Middletown	Frederick	1	Conococheague	Cambrian	Limestone	71.28	6.79	14.96	1.04	2.89	2.48	.10	.14	.05	.25	R-18823
218D-15	Middletown	Shenandoah	5	Rockdale Run	Ordovician	Dolostone	54.40	42.61	2.05	.46	.26	.16	.03	.02	.00	.00	R-19020
218D-16	(Sample not used)																
218D-17	Middletown	Shenandoah	1	Lincolnshire	Ordovician	Limestone	99.73	.00	.14	.04	.02	.02	.00	.00	.04	.00	R-19022
218D-18	Middletown	Shenandoah	3	New Market	Ordovician	Limestone	99.05	.00	.61	.07	.12	.06	.05	.01	.02	.00	R-19023
218D-19	Middletown	Shenandoah	1	Rockdale Run	Ordovician	Dolostone	55.45	37.30	5.94	.43	.51	.23	.09	.03	.00	.00	R-20101
218D-20	Middletown	Shenandoah	2	Elbrook	Cambrian	Dolostone	52.29	30.95	11.52	1.59	1.93	1.50	.00	.13	.00	.08	R-20102
218D-21	Middletown	Shenandoah	3	Tonoloway	Silurian	Limestone	75.56	4.69	15.19	1.15	2.29	.67	.22	.18	.01	.03	R-19024
218D-22	Middletown	Shenandoah	3	Keyser	Silurian	Limestone	92.27	4.06	2.57	.42	.32	.11	.19	.02	.03	.02	R-19025
218D-23	Middletown	Shenandoah	21	Licking Creek	Devonian	Limestone (cherty)	97.70	.00	1.46	.26	.16	.07	.27	.01	.05	.01	R-19026
218D-24	Middletown	Shenandoah	2	Elbrook	Cambrian	Dolostone	51.66	43.51	4.04	.50	.12	.14	.00	.01	.00	.02	R-19027
218D-25	Middletown	Shenandoah	1	Conococheague	Cambrian	Magnesian Limestone	83.05	11.27	3.78	.38	.66	.60	.19	.04	.01	.02	R-19028
218D-26	Middletown	Shenandoah	1	Rockdale Run	Ordovician	Dolostone	51.28	43.19	3.77	.38	.61	.52	.22	.03	.00	.00	R-19029
218D-27	Middletown	Shenandoah	1	Stonehenge	Ordovician	Limestone	94.36	.96	3.93	.18	.28	.22	.02	.02	.00	.01	R-20103
218D-28	Middletown	Shenandoah	4	Rockdale Run	Ordovician	Dolostone	51.25	43.03	4.48	.36	.42	.26	.16	.02	.00	.00	R-19030
218D-29	Middletown	Shenandoah	1	New Market	Ordovician	Limestone	99.43	.00	.34	.06	.06	.03	.05	.01	.02	.01	R-19031
218D-30	Middletown	Shenandoah	4	Lincolnshire	Ordovician	Limestone (cherty)	97.28	.00	1.89	.17	.28	.12	.17	.02	.07	.01	R-19032
218D-31	Middletown	Shenandoah	1	Edinburg	Ordovician	Limestone	91.99	.00	5.75	.51	1.29	.34	.00	.04	.06	.01	R-19033
218D-32	Middletown	Shenandoah	3	New Market	Ordovician	Limestone	99.39	.00	.36	.07	.08	.06	.00	.01	.02	.01	R-19034
218D-33	Middletown	Shenandoah	3	Lincolnshire	Ordovician	Limestone (cherty)	98.87	.00	.75	.09	.14	.07	.00	.01	.06	.02	R-19035
218D-34	Middletown	Shenandoah	2	Rockdale Run	Ordovician	Dolostone	55.05	41.11	2.53	.68	.36	.22	.00	.02	.01	.01	R-19036

218D

Table 42. (cont'd.).

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
218D-35	Middletown	Frederick	8	Edinburg	Ordovician	Limestone	91.75	2.42	4.29	.34	.83	.21	.09	.03	.00	.03	R-18841
218D-36	Middletown	Frederick	2	Rockdale Run	Ordovician	Dolostone	55.32	41.98	1.95	.53	.12	.06	.02	.01	.00	.01	R-18834
218D-37	Middletown	Frederick	2	New Market	Ordovician	Limestone	98.85	.00	.50	.09	.16	.08	.31	.01	.00	.00	R-18835
218D-38	Middletown	Frederick	4	Lincolnshire	Ordovician	Limestone (cherty)	97.24	1.04	1.35	.10	.14	.06	.03	.01	.02	.01	R-18845
218D-39	Middletown	Frederick	2	Edinburg	Ordovician	Limestone	84.60	.00	10.84	1.06	2.58	.75	.00	.12	.04	.01	R-18828
218D-40	Middletown	Frederick	2	Lincolnshire	Ordovician	Limestone	95.93	1.81	1.63	.12	.32	.09	.05	.01	.04	.00	R-18843
218D-41	Middletown	Frederick	2	New Market	Ordovician	Limestone	94.16	2.92	1.76	.23	.56	.29	.02	.02	.01	.03	R-18832
218D-42	Middletown	Frederick	2	Rockdale Run	Ordovician	Dolostone	50.35	42.41	5.44	.63	.73	.39	.00	.04	.00	.01	R-18825
218D-43	Middletown	Frederick	2	Rockdale Run	Ordovician	Limestone	89.14	4.29	4.46	.43	.86	.68	.02	.05	.00	.07	R-18842
218D-44	Middletown	Frederick	5	Stonehenge	Ordovician	Limestone	88.79	3.18	6.29	.26	.74	.60	.00	.03	.03	.07	R-18838
218D-45	Middletown	Frederick	2	Conococheague	Cambrian	Dolostone	55.43	40.46	3.32	.36	.25	.16	.01	.01	.00	.00	R-20104
218D-46	Middletown	Frederick	3	Stonehenge	Ordovician	Limestone	88.56	5.02	4.71	.43	.69	.50	.01	.04	.00	.03	R-18829
218D-47	Middletown	Frederick	1	Rockdale Run	Ordovician	Magnesian Limestone	76.03	17.77	5.17	.33	.38	.24	.01	.02	.00	.04	R-18839
218D-48	Middletown	Frederick	3	Edinburg	Ordovician	Limestone	86.29	3.93	6.92	.70	1.41	.38	.15	.06	.04	.12	R-18830
218D-49	Middletown	Shenandoah	6	New Market	Ordovician	Limestone	99.44	.00	.33	.05	.11	.05	.00	.01	.00	.00	R-19037
218D-50	Middletown	Shenandoah	3	Lincolnshire	Ordovician	Limestone	98.92	.00	.50	.07	.10	.05	.29	.00	.05	.01	R-19038
218D-51	Middletown	Warren	3	Edinburg	Ordovician	Limestone	89.20	4.19	4.51	.55	.96	.29	.10	.04	.04	.13	R-19040
218D-52	Middletown	Frederick	2	Edinburg	Ordovician	Limestone	92.53	1.89	3.31	.54	.82	.78	.01	.05	.04	.04	R-19055
218D-53	Middletown	Shenandoah	16	New Market	Ordovician	Limestone	98.85	.62	.25	.03	.09	.04	.09	.01	.00	.01	R-20105

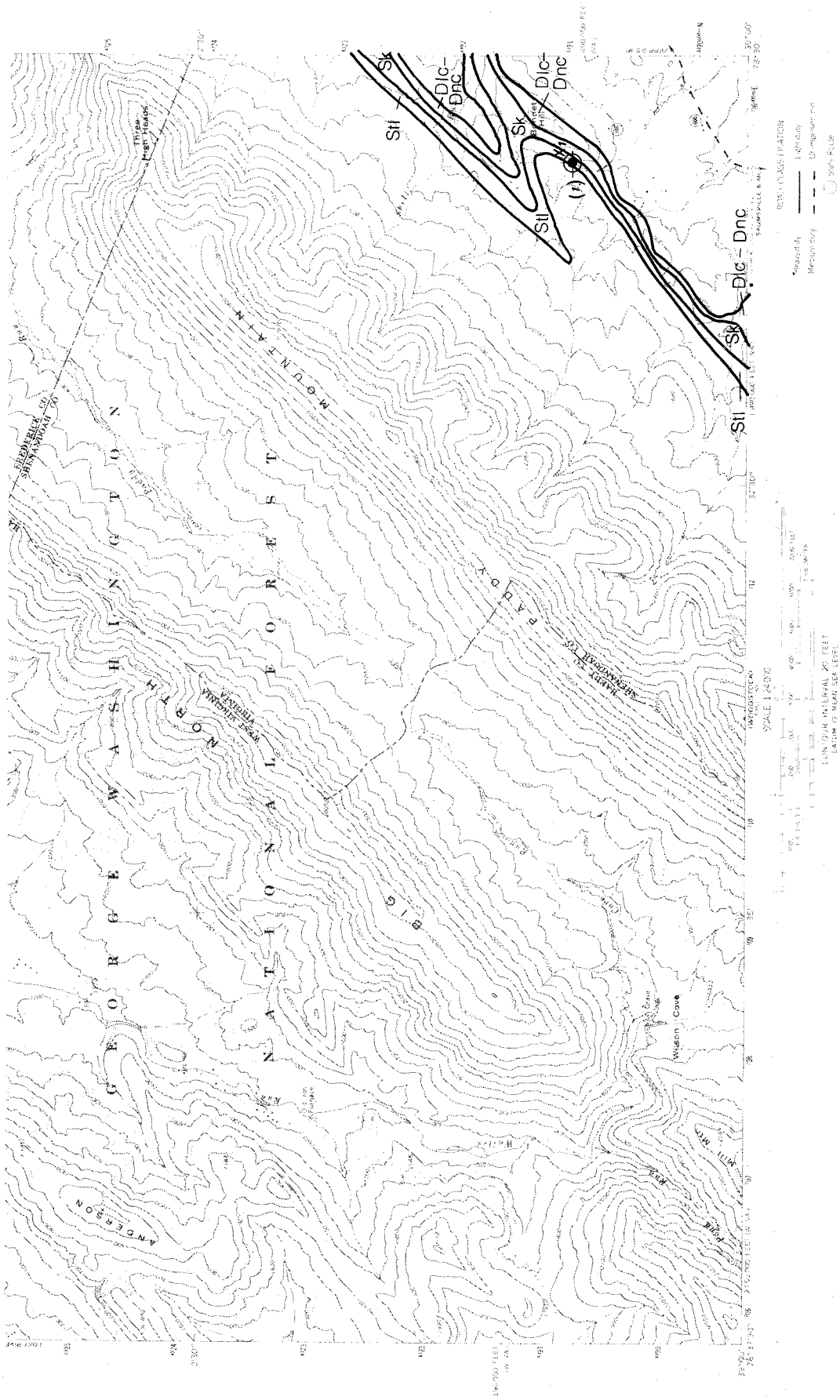


Figure 38. Southern half of Wardensville quadrangle (219D) showing carbonate-rock sample location.

219D

219D

Table 43. Chemical analyses of carbonate-rock sample, Wardensville quadrangle (219D), Shenandoah County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent)										Repository Number
							$CaCO_3$	$MgCO_2$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	
219D-1	Wardensville	Shenandoah	3	Tonoloway	Silurian	Limestone	90.28	.00	7.20	.63	1.18	.46	.12	.06	.03	.03	R-19039

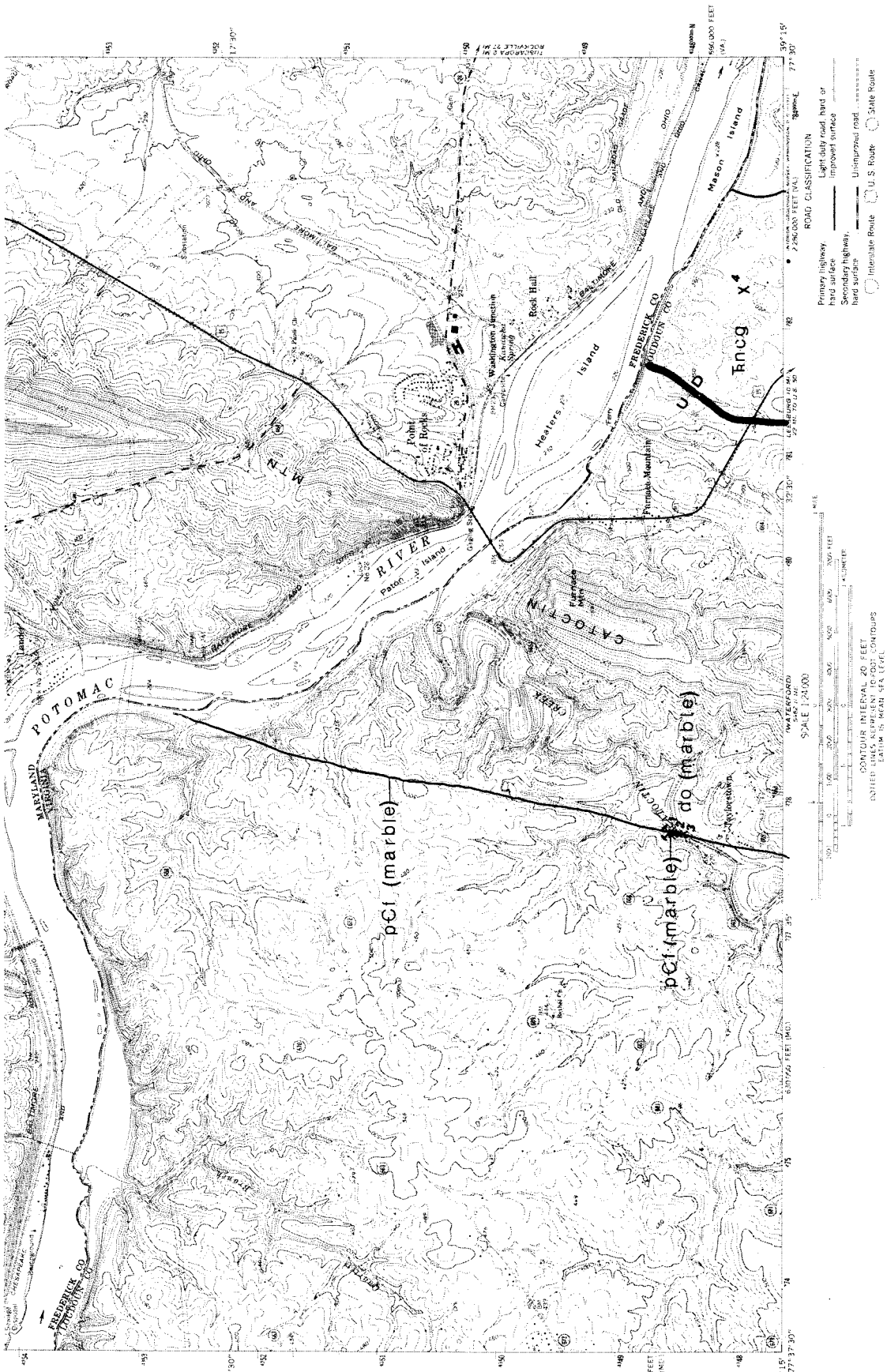


Figure 39. Southern half of Point of Rocks quadrangle (221D) showing carbonate-rock sample locations.

221D

221D

Table 44. Chemical analyses of carbonate-rock samples, Point of Rocks quadrangle (221D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
221D-1	Point of Rocks	Loudoun	2	Fauquier	Precambrian	Marble	54.03	42.52	2.52	.39	.53	.00	.00	.02	.00	.00	R-20092
221D-2	Point of Rocks	Loudoun	4	Fauquier	Precambrian	Marble	53.18	44.79	1.41	.34	.19	.00	.03	.01	.06	.00	R-20093
221D-3	Point of Rocks	Loudoun	2	Fauquier	Precambrian	Marble	50.66	42.67	4.66	.99	.91	.00	.03	.06	.00	.00	R-20094
221D-4	Point of Rocks	Loudoun	4	Newark	Triassic	Dolostone Conglom-erate	54.98	37.56	4.70	.97	1.04	.22	.44	.08	.01	.00	R-20095

Table 45. Reflectance analyses of carbonate-rock samples with brightness of 70 percent or higher, Point of Rocks quadrangle (221D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
221D-1	Point of Rocks	Loudoun	2	Fauquier	Precambrian	Marble	86.7	0.1	86.2	54.03	42.52	R-20092
221D-2	Point of Rocks	Loudoun	4	Fauquier	Precambrian	Marble	86.1	2.6	75.7	53.18	44.79	R-20093
221D-3	Point of Rocks	Loudoun	2	Fauquier	Precambrian	Marble	81.4	5.6	59.2	50.66	42.67	R-20094

Table 46 - Chlorine analyses of carbonate-rock samples, Point of Rocks quadrangle (221D), Loudoun County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
221D-2	Point of Rocks	Loudoun	4	Fauquier	Precambrian	Marble	.0063	(63)	53.18	44.79	R-20093
221D-4	Point of Rocks	Loudoun	4	Newark	Triassic	Dolostone Conglomerate	.029	(290)	54.98	37.36	R-20095

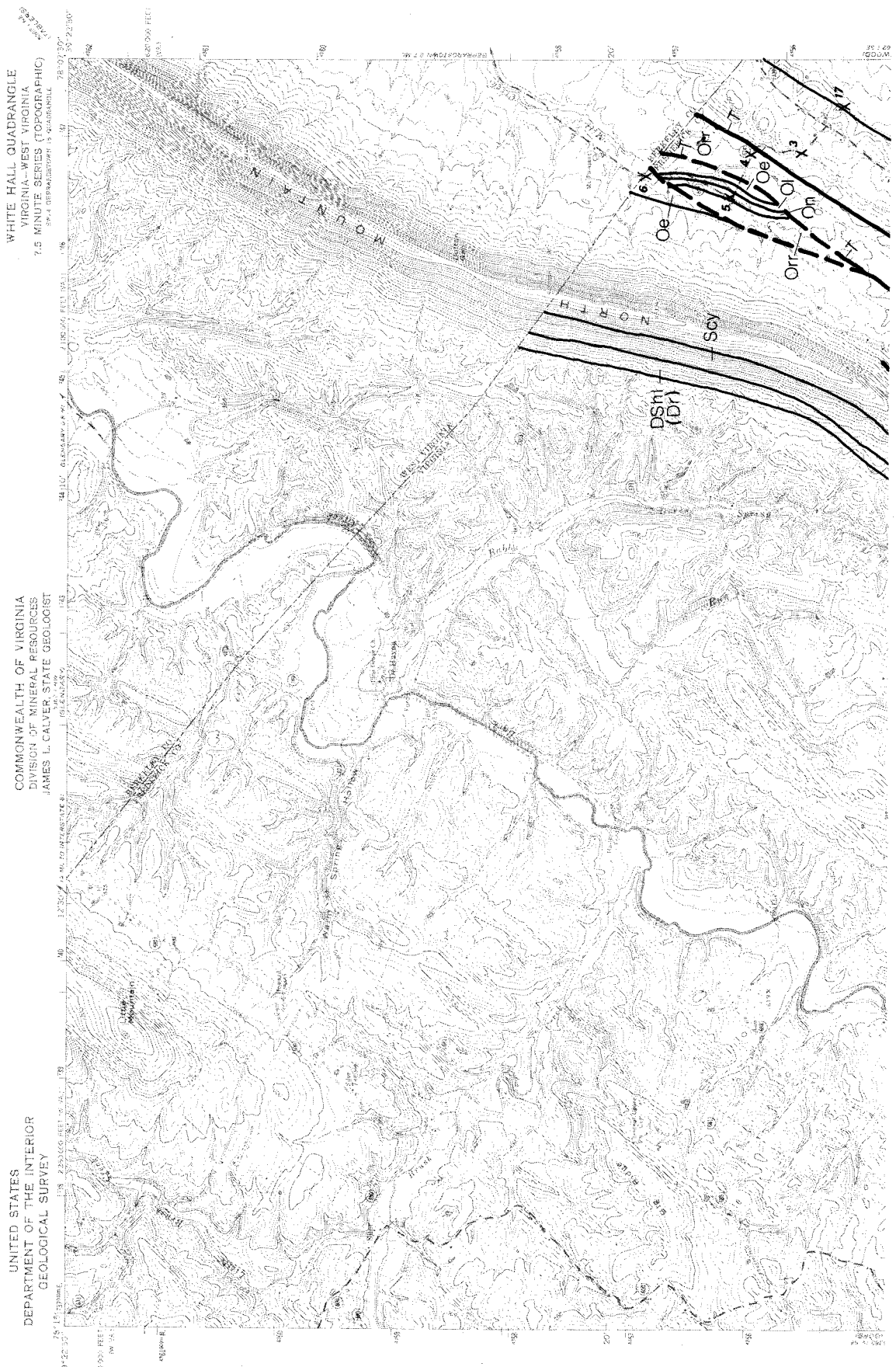


Figure 40. Northern half of White Hall quadrangle (223C) showing carbonate-rock sample locations.

223C

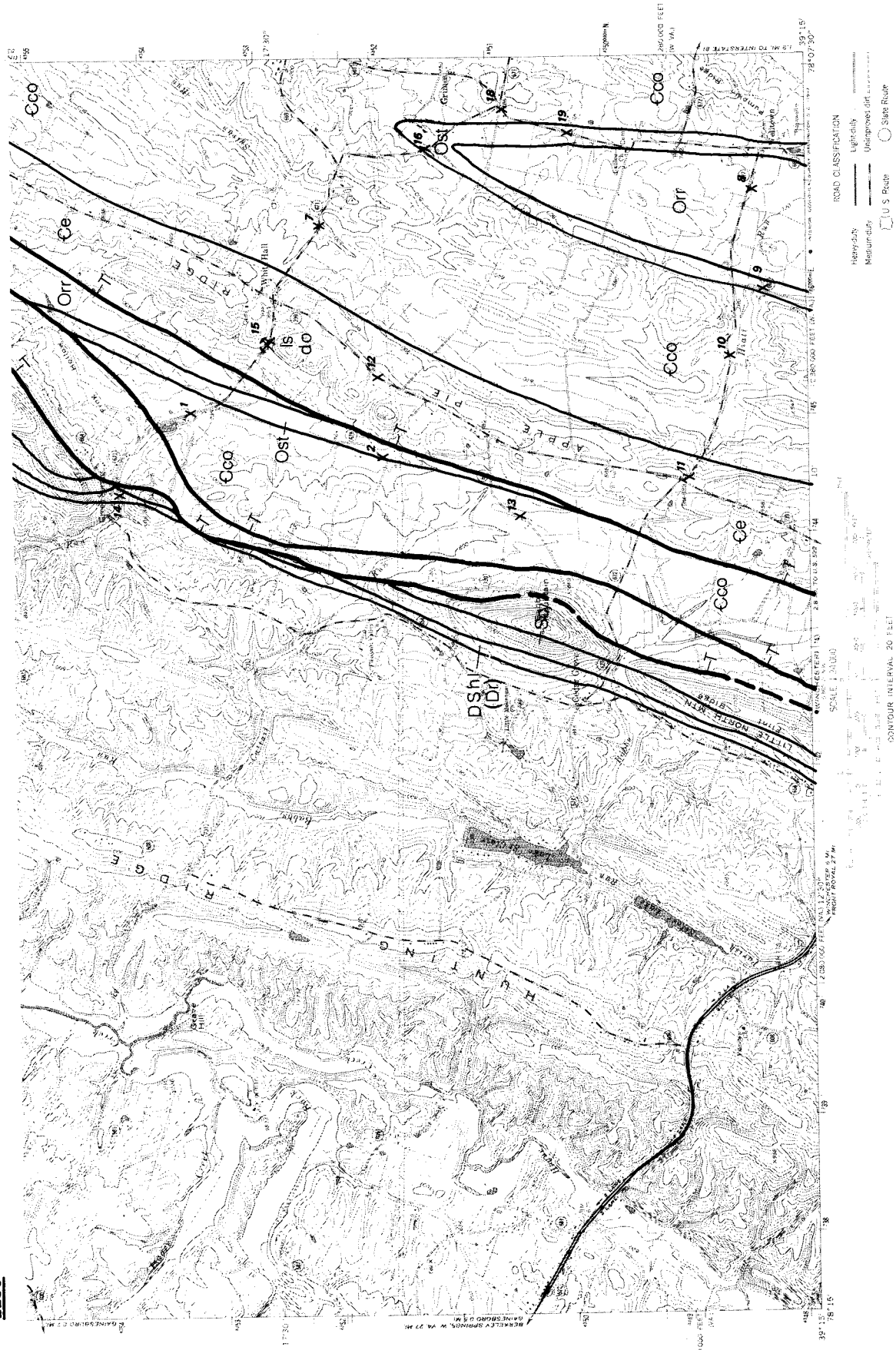


Figure 41. Southern half of White Hall quadrangle (223C) showing carbonate-rock sample locations.

Table 47. Chemical analyses of carbonate-rock samples, White Hall quadrangle (223C), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
223C-1	White Hall	Frederick	10	Conococheague	Cambrian	Dolostone	49.77	41.92	5.82	.77	.87	.77	.02	.04	.00	.02	R-18694
223C-2	White Hall	Frederick	4	Stonehenge	Ordovician	Limestone	87.98	1.96	6.76	.63	1.42	1.12	.00	.07	.03	.04	R-18695
223C-3	White Hall	Frederick	3	Elbrook	Cambrian	Dolostone	40.55	33.20	18.61	2.38	2.91	1.97	.06	.22	.04	.05	R-18789
223C-4	White Hall	Frederick	1	Rockdale Run	Ordovician	Dolostone	51.42	42.23	4.33	.86	.55	.48	.10	.03	.00	.00	R-18782
223C-5	White Hall	Frederick	4	New Market	Ordovician	Limestone	95.39	2.76	1.19	.10	.25	.15	.09	.01	.03	.04	R-18779
223C-6	White Hall	Frederick	4	Edinburg	Ordovician	Limestone	87.37	5.17	5.50	.37	1.05	.35	.06	.04	.03	.04	R-18777
223C-7	White Hall	Frederick	2	Conococheague	Cambrian	Dolostone	53.11	32.76	9.00	1.84	1.70	1.42	.04	.10	.00	.02	R-18778
223C-8	White Hall	Frederick	1	Rockdale Run	Ordovician	Limestone	95.79	1.66	1.88	.11	.25	.20	.04	.01	.02	.04	R-18785
223C-9	White Hall	Frederick	6	Stonehenge	Ordovician	Limestone	79.16	3.16	11.70	1.02	2.62	1.94	.12	.13	.00	.14	R-18784
223C-10	White Hall	Frederick	8	Conococheague	Cambrian	Magnesian Limestone	70.46	11.07	12.62	1.36	2.46	1.58	.14	.15	.06	.10	R-18783
223C-11	White Hall	Frederick	3	Elbrook	Cambrian	Magnesian Limestone	80.21	12.48	5.68	.61	.41	.39	.07	.02	.05	.09	R-18790
223C-12	White Hall	Frederick	2	Elbrook	Cambrian	Limestone	91.22	4.47	3.66	.20	.23	.11	.03	.01	.02	.05	R-18787
223C-13	White Hall	Frederick	1	Conococheague	Cambrian	Limestone	93.15	.95	4.20	.30	.66	.50	.18	.03	.02	.02	R-18788
223C-14	White Hall	Frederick	3	(Undifferentiated)	Devonian-Silurian	Limestone	87.86	6.41	3.94	.50	.91	.30	.00	.04	.00	.05	R-18780
223C-15	White Hall	Frederick	5	Elbrook	Cambrian	Magnesian Limestone	83.89	11.65	2.59	.52	.68	.59	.00	.04	.01	.03	R-18786
223C-16	White Hall	Frederick	1	Stonehenge	Ordovician	Limestone	59.94	4.46	22.43	2.94	6.11	3.57	.04	.25	.06	.16	R-20096
223C-17	White Hall	Frederick	2	Conococheague	Cambrian	Limestone	89.90	.00	6.42	.59	1.54	1.35	.01	.08	.02	.08	R-18781
223C-18	White Hall	Frederick	2	Conococheague	Cambrian	Limestone	82.12	7.28	7.86	.55	1.14	.71	.17	.05	.03	.09	R-19056
223C-19	White Hall	Frederick	5	Stonehenge	Ordovician	Limestone	95.46	.95	2.82	.22	.29	.21	.04	.02	.00	.01	R-20097

Table 48. Chlorine analyses of carbonate-rock samples, White Hall quadrangle (223C), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
223C-2	White Hall	Frederick	4	Stonehenge	Ordovician	Limestone	.0061	(61)	87.98	1.96	R-18695
223C-5	White Hall	Frederick	4	New Market	Ordovician	Limestone	.0072	(72)	95.39	2.76	R-18779
223C-6	White Hall	Frederick	4	Edinburg	Ordovician	Limestone	.0076	(76)	87.37	5.17	R-18777
223C-19	White Hall	Frederick	5	Stonehenge	Ordovician	Limestone	.0063	(63)	95.46	.95	R-20097

Table 49. Semiquantitative trace-element analyses of carbonate-rock samples, White Hall quadrangle (223C), Frederick County.

Map-Sample No.	-	White Hall-223C-6		White Hall-223C-19	
Rock Type	-	Limestone		Limestone	
Formation (Group, deposit)	-	Edinburg		Stonehenge	
Age	-	Ordovician		Ordovician	
	**Detection Limits				
Elements	Percent (ppm)				***Trace Element Percent (Parts per million)
Ag	.0005 (5)	< .002	(20)	< .0005	(5)
Al	.001 (10)	.7	(7,000)	.2	(2,000)
As	.009 (90)	< .009	(90)	< .009	(90)
*Au	.002 (20)	< .002	(20)	< .002	(20)
*B	.003 (30)	< .003	(30)	< .003	(30)
Ba	.002 (20)	.01	(100)	< .002	(20)
Be	.0001 (1)	< .0001	(1)	< .0001	(1)
Bi	.01 (100)	< .01	(100)	< .01	(100)
Ca	.05 (500)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005 (5)	< .0005	(5)	< .0005	(5)
*Co	.001 (10)	< .001	(10)	< .001	(10)
Cr	.0003 (3)	< .0003	(3)	< .0003	(3)
Cu	.0006 (6)	< .0006	(6)	< .0006	(6)
Fe	.0006 (6)	.3	(3,000)	.1	(1,000)
*Ga	.0002 (2)	< .0002	(2)	< .0002	(2)
*La	.01 (100)	< .01	(100)	< .01	(100)
Li	.002 (20)	< .002	(20)	< .002	(20)
Mg	.0001 (1)	2.	(20,000)	2.	(20,000)
Mn	.0008 (8)	.02	(200)	.004	(40)
*Mo	.0001 (1)	< .0001	(1)	< .0001	(1)
*Na	.3 (3,000)	< .3	(3,000)	< .3	(3,000)
No	.007 (70)	< .007	(70)	< .007	(70)
Ni	.0002 (2)	< .0002	(2)	< .0002	(2)
P	.7 (7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002 (20)	< .002	(20)	< .002	(20)
*Pd	.0001 (1)	< .0001	(1)	< .0001	(1)
Pt	.0006 (6)	< .0006	(6)	< .0006	(6)
*Sb	.06 (600)	< .06	(600)	< .06	(600)
*Sc	.0004 (4)	< .0004	(4)	< .0004	(4)
Si	.0006 (6)	3.	(30,000)	1.	(10,000)
Sn	.0006 (6)	< .0006	(6)	< .0006	(6)
Sr	.0001 (1)	.05	(500)	.02	(200)
*Ta	.02 (200)	< .02	(200)	< .02	(200)
*Te	.04 (400)	< .04	(400)	< .04	(400)
Ti	.03 (300)	< .03	(300)	< .03	(300)
*V	.005 (50)	< .005	(50)	< .005	(50)
*Y	.001 (10)	< .001	(10)	< .001	(10)
Zn	.0001 (1)	< .0001	(1)	< .0001	(1)
*Zr	.003 (30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

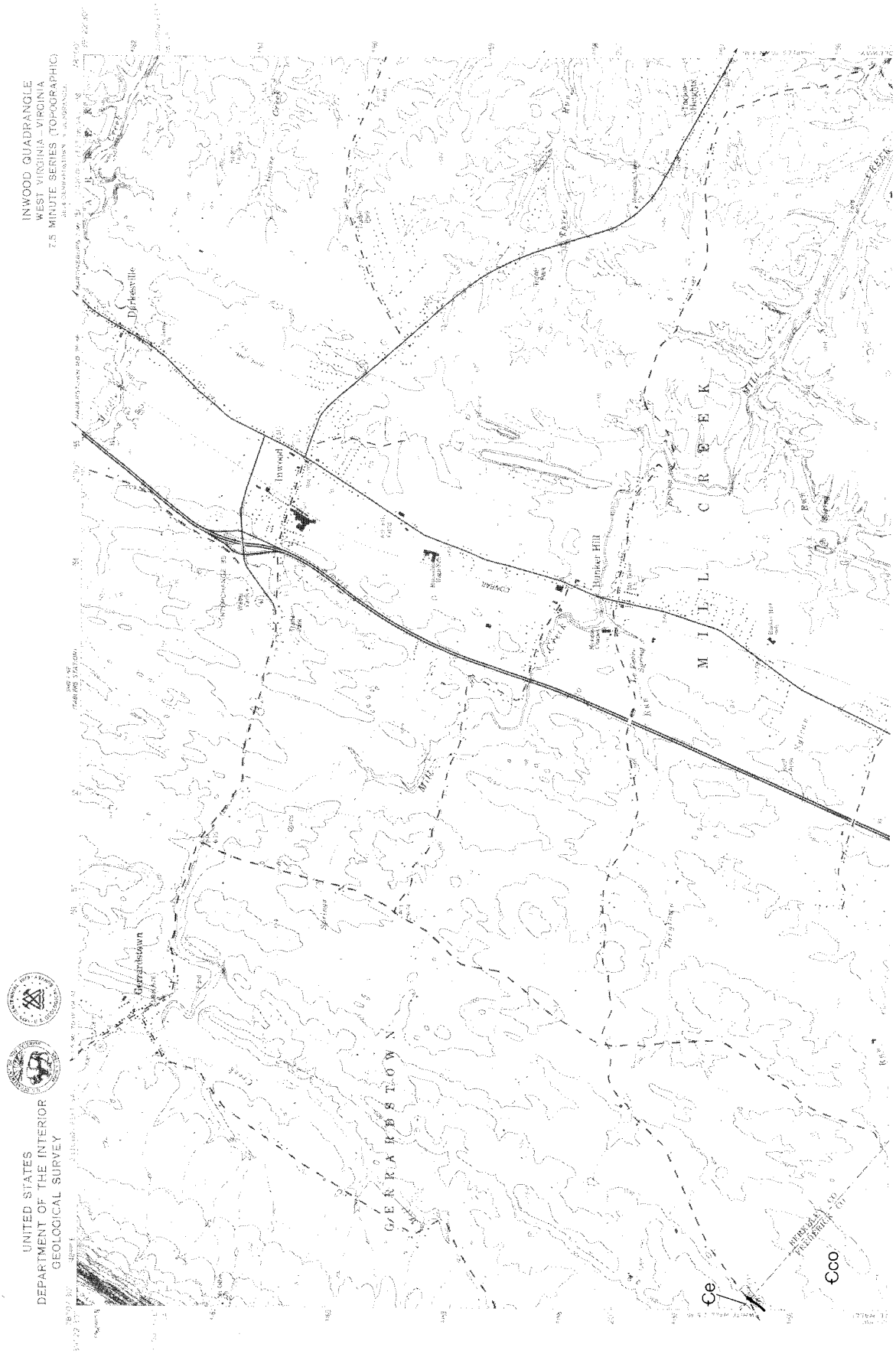


Figure 42. Northern half of Inwood quadrangle (223D) showing carbonate-rock location (no samples collected).

223D

Figure 43. Southern half of Inwood quadrangle (223D) showing carbonate-rock sample locations.

Table 50. Chemical analyses of carbonate-rock samples, Inwood quadrangle (223D), Frederick and Clarke counties.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCo_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
223D-1	Inwood	Frederick	5	Conococheague	Cambrian	Limestone	91.01	2.49	4.52	.40	.73	.67	.00	.03	.05	.11	R-18798
223D-2	Inwood	Frederick	1	Rockdale Run	Ordovician	Dolostone	52.07	35.93	8.49	1.52	1.25	.61	.00	.06	.01	.06	R-18791
223D-3	Inwood	Frederick	4	New Market	Ordovician	Magnesian Limestone	83.05	12.29	2.96	.34	.73	.37	.08	.04	.06	.08	R-18801
223D-4	Inwood	Frederick	1	Edinburg	Ordovician	Limestone	94.91	.28	3.50	.28	.59	.17	.18	.02	.02	.05	R-18792
223D-5	Inwood	Frederick	4	Lincolnshire	Ordovician	Limestone	99.35	.17	.26	.05	.10	.03	.00	.01	.04	.01	R-18797
223D-6	Inwood	Frederick	4	Rockdale Run	Ordovician	Dolostone	50.92	41.58	5.65	.51	.70	.54	.04	.03	.02	.01	R-18795
223D-7	Inwood	Frederick	3	Conococheague	Cambrian	Limestone	74.61	9.88	11.05	.93	1.80	1.39	.08	.10	.08	.08	R-18799
223D-8	Inwood	Clarke	2	Pinesburg Station	Ordovician	Dolostone	59.88	34.63	3.01	.77	1.07	.47	.08	.06	.00	.02	R-19041
223D-9	Inwood	Clarke	2	New Market	Ordovician	Limestone	97.86	1.36	.40	.06	.14	.06	.06	.01	.05	.01	R-19042
223D-10	Inwood	Clarke	2	Edinburg	Ordovician	Limestone	93.50	1.48	3.75	.31	.55	.11	.17	.02	.03	.07	R-19043
223D-11	Inwood	Frederick	3	Stonehenge	Ordovician	Limestone	85.98	2.92	7.64	.57	1.47	1.20	.00	.07	.07	.07	R-18793
223D-12	Inwood	Frederick	2	Stonehenge	Ordovician	Limestone	93.08	3.57	2.40	.23	.33	.30	.00	.02	.02	.04	R-18802
223D-13	Inwood	Frederick	1	Rockdale Run	Ordovician	Limestone	94.10	.00	4.00	.33	.83	.67	.00	.03	.00	.03	R-18800
223D-14	Inwood	Frederick	4	Conococheague	Cambrian	Limestone	80.92	1.22	16.32	.48	.56	.42	.02	.03	.01	.02	R-20098
223D-15	Inwood	Frederick	2	Stonehenge	Ordovician	Limestone	91.61	2.77	4.57	.20	.46	.32	.00	.02	.00	.05	R-18803
223D-16	Inwood	Frederick	3	Rockdale Run	Ordovician	Magnesian Limestone	86.80	10.85	1.69	.18	.29	.18	.00	.01	.00	.00	R-18796
223D-17	Inwood	Frederick	2	Edinburg	Ordovician	Limestone	96.38	.00	2.81	.21	.41	.13	.00	.02	.04	.01	R-18804
223D-18	Inwood	Frederick	3	Rockdale Run	Ordovician	Dolostone	55.58	37.71	5.00	.56	.73	.36	.00	.03	.00	.01	R-19057
223D-19	Inwood	Frederick	12	New Market	Ordovician	Limestone	93.69	4.49	1.12	.14	.33	.17	.03	.02	.01	.01	R-20099
223D-20	Inwood	Frederick	1	Lincolnshire	Ordovician	Limestone	91.03	.00	6.43	.56	1.38	.47	.00	.06	.05	.02	R-18794
223D-21	Inwood	Frederick	1	Edinburg	Ordovician	Limestone	91.01	.00	8.05	.26	.37	.09	.15	.02	.03	.01	R-19058
223D-22	Inwood	Frederick	3	Deposit	Quaternary	Marl	97.54	.00	1.56	.26	.41	.08	.00	.03	.06	.05	R-19059

Table 51. Reflectance analyses of carbonate-rock sample with brightness of 70 percent or higher, Inwood quadrangle (223D), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
223D-14	Inwood	Frederick	4	Conococheague	Cambrian	Limestone	82.8	4.1	66.4	80.92	1.22	R-20098

Table 52. Chlorine analyses of carbonate-rock samples, Inwood quadrangle (223D), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
223D-3	Inwood	Frederick	4	New Market	Ordovician	Magnesian Limestone	.0062	(62)	83.05	12.29	R-18801
223D-19	Inwood	Frederick	12	New Market	Ordovician	Limestone	.0056	(56)	93.69	4.49	R-20099

Table 53. Semiquantitative trace-element analyses of carbonate-rock samples, Inwood quadrangle (223D), Frederick County.

Map-Sample No.	-	Inwood - 223D-19
Rock Type	-	Limestone
Formation (Group, deposit)	-	New Market
Age	-	Ordovician

Elements	**Detection Limits Percent	(ppm)	***Trace Element Percent	(Parts per million)
Ag	.0005	(5)	< .001	(10)
Al	.001	(10)	.2	(2,000)
As	.009	(90)	< .009	(90)
*Au	.002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)
Fe	.0006	(6)	.05	(500)
*Ga	.0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)
Mg	.0001	(1)	4.	(40,000)
Mn	.0008	(8)	< .0008	(8)
*Mo	.0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)
No	.007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)
Si	.0006	(6)	.3	(3,000)
Sn	.0006	(6)	< .0006	(6)
Sr	.0001	(1)	.006	(60)
*Ta	.02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)
Zn	.0001	(1)	< .0001	(1)
*Zr	.003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

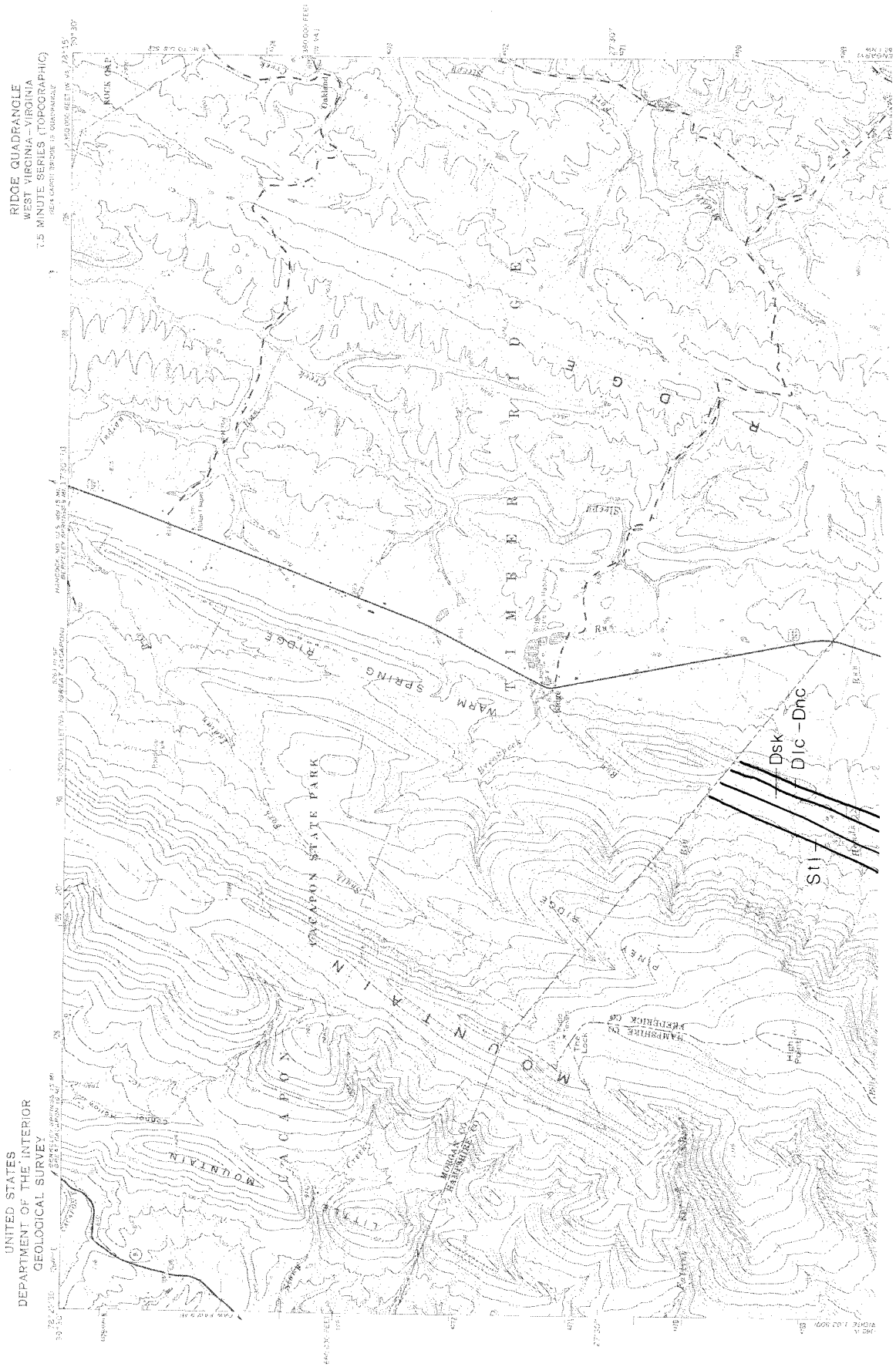


Figure 44. Northern half of Ridge quadrangle (224A) showing carbonate-rock location (no samples collected).

224A

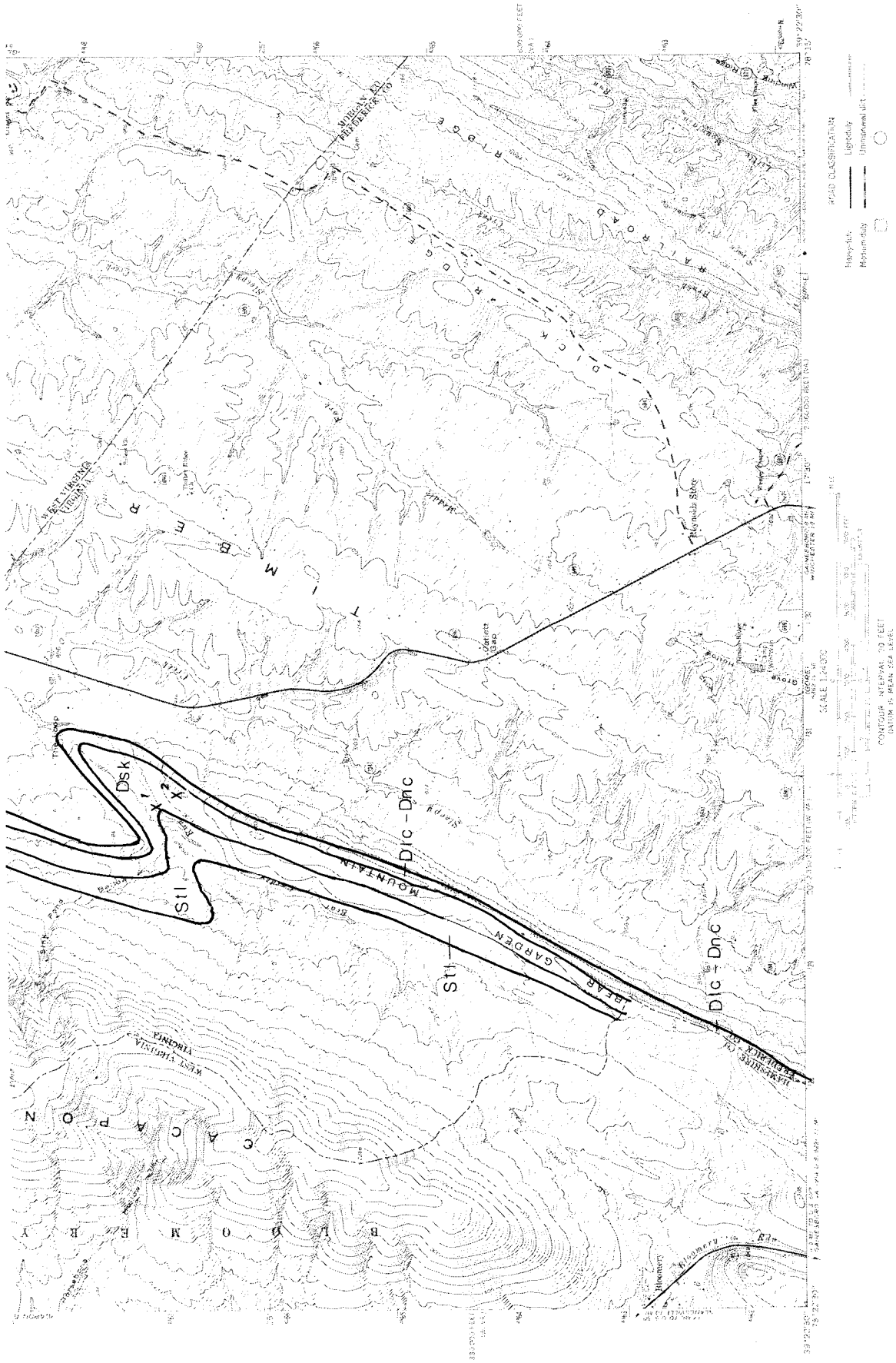


Figure 45. Southern half of Ridge quadrangle (224A) showing carbonate-rock sample locations.

Table 54. Chemical analyses of carbonate-rock samples, Ridge quadrangle (224A), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
224A-1	Ridge	Frederick	2	Keyser	Silurian	Limestone	88.29	2.49	6.96	.64	1.00	.32	.13	.07	.07	.03	R-18693
224A-2	Ridge	Frederick	1	Licking Creek	Devonian	Limestone	80.81	5.05	10.05	1.09	2.09	.68	.02	.10	.06	.04	R-18692

Table 55. Chlorine analyses of carbonate-rock samples, Ridge quadrangle (224A), Frederick County.

Map and Sample Number	Map Na (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
224A-1	Ridge	Frederick	2	Keyser	Silurian	Limestone	.015	(150)	88.29	2.49	R-18693
224A-2	Ridge	Frederick	1	Licking Creek	Devonian	Limestone	.017	(170)	80.81	5.05	R-18692

224A

Table 56. Semiquantitative trace-element analyses of carbonate-rock samples, Ridge quadrangle (224A), Frederick County.

Map-Sample No.	-	Ridge - 224A-1		Ridge - 224A-2	
Rock Type	-	Limestone		Limestone	
Formation (Group, deposit)	-	Keyser		Licking Creek	
Age	-	Silurian		Devonian	
	**Detection Limits				
Elements	Percent (ppm)				***Trace Element Percent (Parts per million)
Ag	.0005 (5)	< .004	(40)	< .003	(30)
Al	.001 (10)	.6	(6,000)	.9	(9,000)
As	.009 (90)	< .009	(90)	< .009	(90)
*Au	.002 (20)	< .002	(20)	< .002	(20)
*B	.003 (30)	< .003	(30)	< .004	(40)
Ba	.002 (20)	< .002	(20)	< .002	(20)
Be	.0001 (1)	< .0001	(1)	< .0001	(1)
Bi	.01 (100)	< .01	(100)	< .01	(100)
Ca	.05 (500)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005 (5)	< .0005	(5)	< .0005	(5)
*Co	.001 (10)	< .001	(10)	< .001	(10)
Cr	.0003 (3)	< .0003	(3)	< .0003	(3)
Cu	.0006 (6)	< .0006	(6)	< .0006	(6)
Fe	.0006 (6)	.6	(6,000)	1.	(10,000)
*Ga	.0002 (2)	< .0002	(2)	< .0002	(2)
*La	.01 (100)	< .01	(100)	< .01	(100)
Li	.002 (20)	< .002	(20)	< .002	(20)
Mg	.0001 (1)	2.	(20,000)	2.	(20,000)
Mn	.0008 (8)	.1	(1,000)	.04	(400)
*Mo	.0001 (1)	< .0001	(1)	< .0001	(1)
*Na	.3 (3,000)	< .3	(3,000)	< .3	(3,000)
No	.007 (70)	< .007	(70)	< .007	(70)
Ni	.0002 (2)	< .0003	(3)	< .0002	(2)
P	.7 (7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002 (20)	< .002	(20)	< .002	(20)
*Pd	.0001 (1)	< .0001	(1)	< .0001	(1)
Pt	.0006 (6)	< .0006	(6)	< .0006	(6)
*Sb	.06 (600)	< .06	(600)	< .06	(600)
*Sc	.0004 (4)	< .0004	(4)	< .0004	(4)
Si	.0006 (6)	3.	(30,000)	5.	(50,000)
Sn	.0006 (6)	< .0006	(6)	< .0006	(6)
Sr	.0001 (1)	.02	(200)	.01	(100)
*Ta	.02 (200)	< .02	(200)	< .02	(200)
*Te	.04 (400)	< .04	(400)	< .04	(400)
Ti	.03 (300)	< .03	(300)	< .03	(300)
*V	.005 (50)	< .005	(50)	< .005	(50)
*Y	.001 (10)	< .001	(10)	< .001	(10)
Zn	.0001 (1)	< .0007	(7)	< .0002	(2)
*Zr	.003 (30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

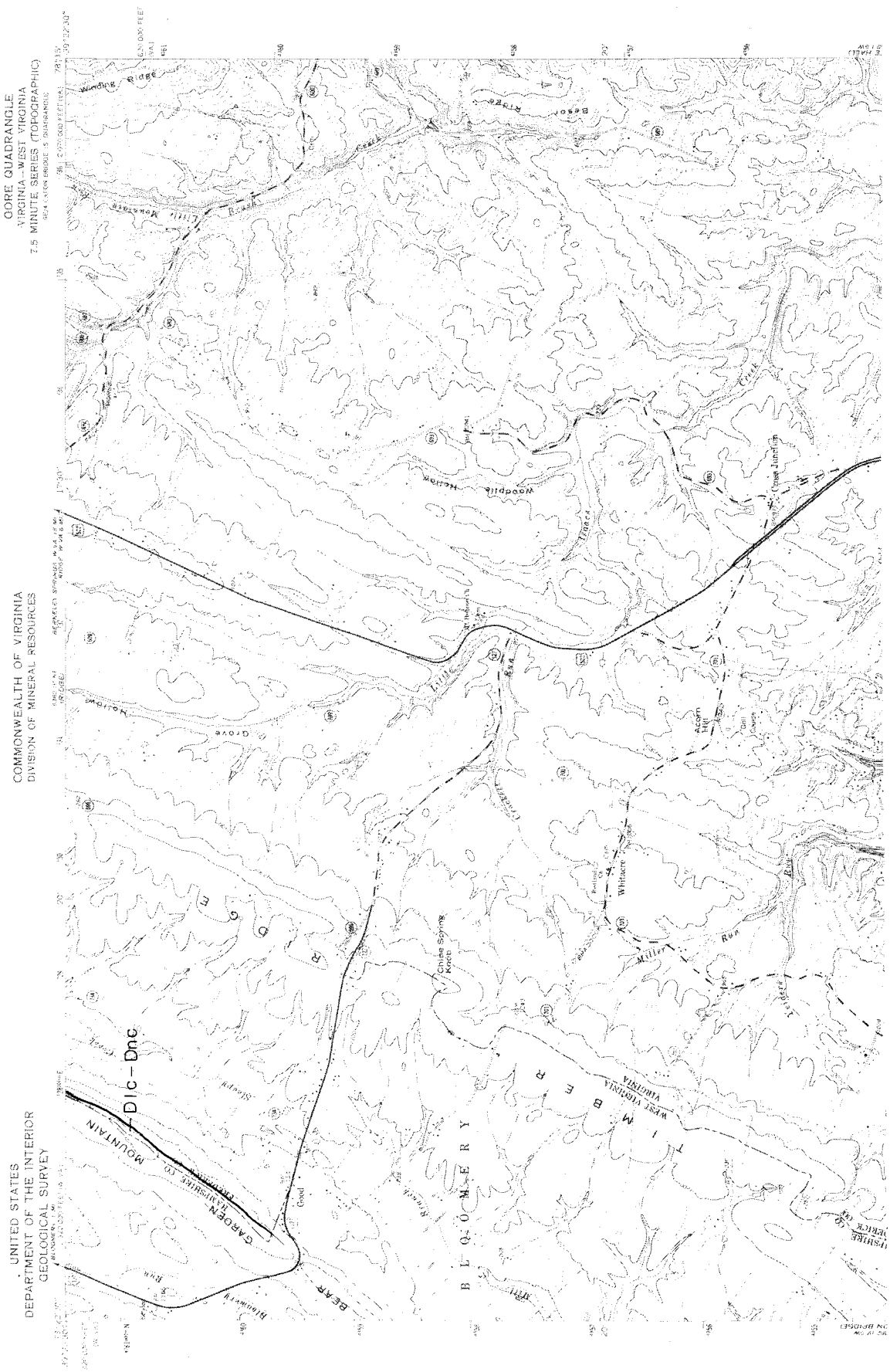


Figure 46. Northern half of Gore quadrangle (224D) showing carbonate-rock location (no samples collected).

224D

Figure 47. Southern half of Gore quadrangle (224D) showing carbonate-rock sample locations.

Table 57. Chemical analyses of carbonate-rock samples, Gore quadrangle (224D), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chemical Analyses (weight percent) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	K_2O	Na_2O	TiO_2	P_2O_5	S	Repository Number
224D-1	Gore	Frederick	35	Ridgley	Devonian	Limestone	91.07	.45	7.12	.55	.20	.05	.40	.01	.14	.01	R-18676
224D-2	Gore	Frederick	2	Tonoloway	Silurian	Limestone	77.32	7.40	11.15	.87	2.14	.71	.16	.13	.03	.08	R-18677
224D-3	Gore	Frederick	3	Keyser	Silurian	Limestone	85.82	3.03	8.02	.82	1.47	.49	.21	.07	.03	.04	R-18678
224D-4	Gore	Frederick	5	Licking Creek	Devonian	Limestone	95.91	1.12	2.34	.24	.14	.03	.03	.01	.11	.04	R-18679
224D-5	Gore	Frederick	5	Tonoloway	Silurian	Magnesian Limestone	26.84	22.61	32.36	6.65	8.11	1.91	.76	.61	.06	.19	R-18681
224D-6	Gore	Frederick	10	Tonoloway	Silurian	Limestone	86.99	7.31	3.70	.55	.85	.32	.04	.05	.04	.15	R-18680
224D-7	Gore	Frederick	6	Keyser	Silurian	Limestone	88.48	2.22	6.45	.68	1.41	.49	.10	.08	.00	.09	R-18675

Table 58. Reflectance analyses of carbonate-rock sample with brightness of 70 percent or higher, Gore quadrangle (224D), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Brightness (Percent)	Tint (Percent)	Whiteness (Percent)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
224D-4	Gore	Frederick	5	Licking Creek	Devonian	Limestone	77.8	1.9	70.2	95.91	1.12	R-18679

Table 59. Chlorine analyses of crbonate-rock samples, Gore quadrangle (224D), Frederick County.

Map and Sample Number	Map Name (7.5' Quad.)	County	Thickness Sampled (ft.)	Formation, Group, or Deposit	Age	Rock Type	Chlorine content Percent	(ppm)	$CaCO_3$ (Percent)	$MgCO_3$ (Percent)	Repository Number
224D-3	Gore	Frederick	3	Keyser	Silurian	Limestone	.018	(180)	85.82	3.03	R-18678
224D-4	Gore	Frederick	5	Licking Creek	Devonian	Limestone	.027	(270)	95.91	1.12	R-18679
224D-6	Gore	Frederick	10	Tonoloway	Silurian	Limestone	.024	(240)	86.99	7.31	R-18680

224D

Table 60. Semiquantitative trace-element analyses of carbonate-rock samples, Ridge quadrangle (224D), Frederick County.

Map-Sample No.	-		Gore - 224D-3		Gore - 224D-4		Gore - 224D-6	
Rock Type	-		Limestone		Limestone		Limestone	
Formation (Group, deposit)	-		Keyser		Licking Creek		Tonoloway	
Age	-		Silurian		Devonian		Silurian	
**Detection Limits								
Elements	Percent	(ppm)	***Trace Element Percent (Parts per million)					
Ag	.0005	(5)	< .003	(30)	< .002	(20)	< .002	(20)
Al	.001	(10)	.6	(6,000)	.07	(700)	.3	(3,000)
As	.009	(90)	< .009	(90)	< .009	(90)	< .004	(90)
*Au	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*B	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)
Ba	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Be	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Bi	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Ca	.05	(500)	>10.	(100,000)	>10.	(100,000)	>10.	(100,000)
*Cd	.0005	(5)	< .0005	(5)	< .0005	(5)	< .0005	(5)
*Co	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Cr	.0003	(3)	< .0003	(3)	< .0003	(3)	< .0003	(3)
Cu	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Fe	.0006	(6)	.6	(6,000)	.05	(500)	.4	(4,000)
*Ga	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
*La	.01	(100)	< .01	(100)	< .01	(100)	< .01	(100)
Li	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
Mg	.0001	(1)	2.	(20,000)	.6	(6,000)	>10.	(100,000)
Mn	.0008	(8)	.05	(500)	.02	(200)	.03	(300)
*Mo	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
*Na	.3	(3,000)	< .3	(3,000)	< .3	(3,000)	< .3	(3,000)
No	.007	(70)	< .007	(70)	< .007	(70)	< .007	(70)
Ni	.0002	(2)	< .0002	(2)	< .0002	(2)	< .0002	(2)
P	.7	(7,000)	< .7	(7,000)	< .7	(7,000)	< .7	(7,000)
Pb	.002	(20)	< .002	(20)	< .002	(20)	< .002	(20)
*Pd	.0001	(1)	< .0001	(1)	< .0001	(1)	< .0001	(1)
Pt	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
*Sb	.06	(600)	< .06	(600)	< .06	(600)	< .06	(600)
*Sc	.0004	(4)	< .0004	(4)	< .0004	(4)	< .0004	(4)
Si	.0006	(6)	3.	(30,000)	.2	(2,000)	1.	(10,000)
Sn	.0006	(6)	< .0006	(6)	< .0006	(6)	< .0006	(6)
Sr	.0001	(1)	.03	(300)	.01	(100)	.03	(300)
*Ta	.02	(200)	< .02	(200)	< .02	(200)	< .02	(200)
*Te	.04	(400)	< .04	(400)	< .04	(400)	< .04	(400)
Ti	.03	(300)	< .03	(300)	< .03	(300)	< .03	(300)
*V	.005	(50)	< .005	(50)	< .005	(50)	< .005	(50)
*Y	.001	(10)	< .001	(10)	< .001	(10)	< .001	(10)
Zn	.0001	(1)	< .0003	(3)	< .0001	(1)	.001	(10)
*Zr	.003	(30)	< .003	(30)	< .003	(30)	< .003	(30)

*Not detected in any of the 30 samples. **Detection limit may be higher for certain samples. ***Analyses by U.S. Bureau of Mines, Reno, Nevada.

APPENDIX I - Chemical analyses, Clarke County carbonate rocks.

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
	About 200 yds. north Road 668 and 100 yds. northwest of Wadesville	85	Lenoir	limestone	97.01	1.29	0.40	0.08	0.88
	About 1,000 ft. south of State Hwy. 274 and 1 1/2 miles southwest of Wadesville	39	Mosheim	limestone	96.78	1.12	0.28	0.08	0.90
		45		limestone	98.15	0.92	0.16	0.08	0.78
								R_2O_3	
	Along Road 646 about 1 1/2 miles northwest of White Post	40	Beekmantown	limestone	90.06	8.77	1.49	0.57	
		20		limestone	98.77	1.04	0.94	0.54	
		40		magnesium limestone	80.83	14.89	2.31	1.00	
		20		magnesium limestone	67.28	29.97	2.63	1.26	
		20		limestone	90.67	7.69	1.82	1.10	
		40		limestone	97.43	3.29	0.94	0.51	
	About 2,000 ft. north Hwy. 277 0.75 mile northwest White Post	100		limestone	92.17	2.08	4.52	0.12	0.86
	Along Road 639 about 3 1/2 miles north of Berryville	300		limestone	92.10	3.60	5.32	0.32	0.55
		150		limestone	90.63	3.30	4.37	0.95	0.87
		150		limestone	85.09	4.37	8.55	0.56	0.75
	About 1,000 ft. south of Hwy. 12 and 1 mile southwest of Boyce	125	Chepultepec	limestone	89.77	3.53	6.67	0.41	0.94
		125		limestone	93.43	2.97	4.94	0.54	0.29
	1/4 mile northwest of the Shenandoah River, 1 1/2 miles northeast of the Castleman Ferry Bridge	40	Tomstown	dolomite	54.82	43.74	0.64	0.52	0.28
		80		dolomite	54.02	42.51	1.54	0.44	0.36
		150		dolomite	54.22	42.53	1.58	0.68	0.64
	About 0.3 mile north of Hwy. 7 and 3.5 miles southeast of Berryville	96		dolomite	57.02	42.45	0.12	0.32	0.08
	In north bluff of Shenandoah River about 1.5 miles west of Shepherd Ford	242		dolomite	54.82	42.24	1.50	0.44	0.60
		200		dolomite	54.92	42.44	0.96	0.56	0.64
		149		dolomite	54.63	41.52	2.20	0.44	0.78
		128		dolomite	54.72	42.00	2.04	0.36	0.70
		312		dolomite	55.62	40.95	1.87	0.36	1.04
4	Along Shenandoah River	unknown	Tomstown (Shady)	dolomite	-	42.00	1 to 3	-	-
12	North quarry wall, Stuart M. Perry Inc., Berryville	8	Shady	dolomite	54.44	44.05	1.97	0.27	0.10

APPENDIX II - Chemical analyses, Frederick County carbonate rocks.

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
	Near Va.-W.VA. line 0.5 mile east of Rest	80		limestone	98.32	0.80	0.10	0.08	0.34
		30		limestone	97.72	1.05	0.06	0.04	0.62
	Along Ross Run, 0.4 mile southeast of Clearbrook	130		limestone	98.02	0.97	0.04	0.04	0.52
	About 100 yds. northeast of previous location	100		limestone	98.06	1.53	0.50	0.12	0.16
		22		limestone	93.22	4.27	1.89	0.17	0.35
	About 0.9 mile northeast of Stephenson	88		limestone	97.44	1.24	0.22	0.08	0.82
	About 1 mile east Hwy. 11 and 0.5 mile northeast of Winchester	73	Chepultepec	limestone	96.09	2.33	0.40	0.12	0.72
	Along U.S. Hwy. 11 at Vaucluse	80		limestone	97.52	0.92	0.18	0.08	0.44
1, 2, and 3	Along Road 627 about 1.5 miles northwest of Middletown	100		limestone	98.02	1.26	0.14	0.08	0.34
	M. J. Grove Lime Co. quarry 1.5 miles northwest of Middletown	100		limestone	97.72	0.94	0.08	0.12	0.48
									R_2O_3
	Along Road 652, 0.5 mile southeast of Kernstown	82		limestone	95.33	2.53	0.46		1.47
	Along the southwest slope of Star Fort Hill, 0.5 mile north of Winchester	35±		limestone	92.84	1.92	4.57		0.76
		35±		limestone	86.38	6.60	6.64		0.91
		35±		limestone	86.86	3.68	5.55		2.54
		35±		limestone	85.75	5.39	5.15		1.87
		35±		limestone	90.57	3.57	4.31		1.87
		35±		limestone	87.04	2.34	5.59		2.60
		35±		limestone	94.32	2.87	4.85		0.59
		35±		limestone	93.80	1.48	3.91		0.69
		50±	Conococheague (upper)	limestone	80.97	7.69	8.67		2.77
		50±		limestone	89.43	4.85	5.98		0.69
		50±		limestone	79.47	8.24	7.23		3.46
	One mile southwest of junction of State Roads 631 and 625, 2.5 miles east of Marlboro	35±	Chepultepec	limestone	88.62	5.01	6.36		0.96
		35±		limestone	83.86	3.97	8.69		2.27
		35±		limestone	90.54	8.47	2.65		0.91
		35±		limestone	88.93	5.77	6.96		1.38
		35±		limestone	84.59	5.12	6.78		1.24
		35±		limestone	91.72	3.59	3.83		0.90
		35±		limestone	89.90	3.66	4.85		1.04
		35±		limestone	91.45	3.05	4.31		0.49
	Along U.S. Hwy. 11, 0.5 mile southwest of Winchester	100	Chepultepec (lower)	limestone	90.24	1.41	8.04		1.47
		50	Conococheague (upper)	limestone	72.76	2.00	22.30		2.35
	Along State Road 652, 0.5 mile southwest of Kernstown	268	Edinburg	limestone	87.70	2.75	6.92		2.84
		94	Lincolnshire (exclusive of chert)	limestone	95.77	2.29	1.09		0.98

APPENDIX II - (cont'd).

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
								R_2O_3	
1, 2, and 3	North of U.S. Highway 50 at southwest end of Hayfield Ridge, 1 mile northwest of Hayfield	50	Tonoloway (lower)	limestone	55.99	1.75	16.86	24.51	
		50		limestone	65.17	1.72	20.65	11.14	
		50		magnesium limestone	54.07	11.89	31.48	4.84	
		50		limestone	85.74	3.54	8.53	1.89	
		50		magnesium limestone	67.29	13.61	12.49	6.22	
	Near Road 669, 0.75 mile southeast of Rest	391	Edinburg	limestone	90.89	2.58	5.18	0.34	1.26
	Stuart M. Perry Co. quarry south Hwy. 50, 2.5 miles west of Winchester	200	Conococheague (near middle)	magnesium limestone	68.36	16.10	14.10	1.30	1.40
	Along State Road 624 near Cedar Creek	100	Beekmantown (upper)	dolomite	51.62	40.91	5.88	0.49	0.56
	About 0.5 mile southwest of the intersection of Hwys. 50 and 522, 0.5 mile south of Winchester	350±	Pinesburg Station	dolomite	53.23	41.14	5.30	0.54	0.58
		350±		dolomite	54.58	40.59	5.71	0.44	0.63
		350±		dolomite	55.41	38.42	5.01	0.50	0.86
								R_2O_3	
	M. J. Grove Lime Co. quarry about 1.5 miles west of Middletown	(Avg. analyses of large tonnage from quarry)	Beekmantown (upper)	dolomite	55.72	42.48	1.08	1.04	

APPENDIX II - (cont'd.)

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5	S	MnO	K_2O	CO_2	H_2O	Insols.
5	Near Winchester(?)	(unknown)	(deposit)	limestone marl	Lime 52.62	0.43	-	-	-	0.06	-	-	0.58	-	-	2.61
		(unknown)	(deposit)	limestone marl	Lime 52.19	0.44	-	-	-	0.36	-	-	0.23	-	-	3.65
6	About 1 mile north of Winchester along Red Bud Run	(various thicknesses)	(deposit)	limestone marl	+90.00	-	-	-	-	-	-	-	-	-	-	-
8	3 miles S.W. Ridge W.Va.	(unknown)	Keyser	limestone	86.91	1.92	7.99	0.75	1.40	0.06	0.05	0.01	-	38.58	-	-

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	Insols.
10	1 1/2 miles west of Hayfield on U.S. Rt. 50 N. latitude 39°14'55" and E. longitude 78°17'15"	3.00	Keyser	limestone	85.5	7.6	6.9
		24.50	Tonoloway	magnesium limestone	63.0	12.1	24.8
				magnesium limestone	49.2	27.8	22.7
				limestone	86.5	5.7	7.5
				magnesium limestone	62.5	20.4	16.8
				magnesium limestone	66.6	14.9	18.0
				magnesium limestone	59.3	16.8	23.5

APPENDIX II - (cont'd.)

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %) $CaCO_3$	$MgCO_3$	Insols.
				magnesium limestone	65.2	16.6	17.6
				limestone	62.5	9.2	27.5
		18.00		magnesium limestone	28.8	23.2	48.3
				magnesium limestone	78.8	10.5	8.8
				magnesium limestone	74.1	12.3	19.6
10	1 1/2 miles west of Hayfield on U.S. Rt. 50 N. latitude 39° 14'55" and E. longitude 78° 17'15" (samples from either Rt. 50 roadcut or the Stodler or Rosenberger quarries)	28.25	Tonoloway	magnesium limestone	71.2	14.9	16.9
				magnesium limestone	79.7	13.4	8.3
				magnesium limestone	62.5	21.0	10.8
		2.00		magnesium limestone	35.1	23.1	40.5
		0.75		magnesium limestone	66.1	10.1	27.3
				magnesium limestone	70.2	10.2	18.8
		45.00		magnesium limestone	71.8	10.0	18.2
		12.00		limestone	76.3	7.8	17.3
				limestone	65.7	9.2	27.0
		77.50		limestone	67.9	6.3	24.0
				limestone	83.0	8.3	9.0
				limestone	73.7	6.3	19.9
				limestone	64.1	5.9	28.8
		3.00		magnesium limestone	32.4	20.6	46.6
	(samples from either Rt. 50 roadcut or the Stodler or Rosenberger quarries)			magnesium limestone	66.1	18.4	15.1
				limestone	72.5	7.1	20.0
				limestone	73.3	9.6	16.7
				limestone	79.9	5.0	14.2
		0.50		limestone	79.4	9.6	12.0
				magnesium limestone	55.5	21.9	20.2
				limestone	84.0	9.2	7.5
				magnesium limestone	61.4	22.2	14.3
	1 1/2 miles west of Hayfield on U.S. Rt. 50 N. latitude 39° 14'55" and E. longtitude 78° 17'15" (samples from either Rt. 50 roadcut or the Stodler or Rosenberger quarries) (continued)	13.75		dolomite	52.9	34.2	12.4
				magnesium limestone	67.5	17.1	19.2
10		6.50		magnesium limestone	59.6	18.1	21.0
		6.50	Tonoloway	dolomite	15.7	36.8	49.5
		8.50		magnesium limestone	68.8	13.8	17.4
				magnesium limestone	54.3	14.9	32.5
		7.00		magnesium limestone	76.0	13.8	14.2
				limestone	63.2	9.2	24.8
		21.25		limestone	63.2	7.0	29.2

APPENDIX II - (cont'd.)

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %)											
					$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3	P_2O_5	S	MnO	K_2O	CO_2	H_2O	Insols.
11	On turnpike near and west of Winchester	(unknown)	Formation II (Middle Cambrian)	magnesium limestone	80.60	14.48	2.68	1.68	-	-	-	-	-	-	0.56	-
	West of Winchester and from northwest turnpike	(unknown)		limestone	88.60	9.60	1.30	0.12	-	-	-	-	-	-	0.44	-
	Mile west of Winchester and from northwest turnpike	(unknown)		magnesium limestone	57.24	28.80	11.68	1.56	-	-	-	-	-	-	0.72	-

APPENDIX III - Chemical analyses, Loudoun County carbonate rocks.

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %)							
					$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O	Insols.	CO_2	H_2O
7	Luckett quarry 0.5 mile northeast Rt. 734 and 2 miles northwest of Stoke	30	Everona	marble	60.3	26.7	-	-		11.9	-	-
	Weathered quarry 0.75 mile northeast Rt. 734 and 2.60 miles northwest of Stoke	95		marble	56.8	40.2	-	-		3.0	-	-
	Loudoun Marble Co. quarry on Goose Creek and Rt. 733, 3.5 miles northwest of Stoke	60		marble	56.2	41.0	-	-		2.8	-	-
7	Goose Creek Lime Co. quarry 0.5 mile north of Loudoun Marble Co. quarry, Rt. 733	60	Everona	marble	65.3	26.4	-	-		7.4	-	-
	Shumate quarry northwest of junction Rts. 704 and 622 3.25 mile SW Paeonian Springs	25		marble	56.6	40.2	-	-		3.2	-	-
	Marshall quarry 0.5 mile southwest of Taylorstown and 250 yds. east Rt. 665	16		marble	57.4	40.3	-	-		3.2	-	-
	Taylor quarry, 20 yds. west of Catoctin Creek, 450 yds. northeast Rt. 669	14		marble	57.2	42.4	-	-		1.4	-	-
9	Leesburg Limestone quarry, 0.35 mile southeast of Rts. 7 and 15 junction	(unknown)	Triassic Border Conglomerate	limestone conglomerate	37.75	19.43	13.55	6.97		-	21.17	1.08
				limestone conglomerate	65.00	20.00	10.00	5.00		-	-	-
13	Henry Fairfax's place Loudoun Co.	(unknown)	Loudoun marbles	marble	79.00	17.01	-	0.60		2.12	-	-

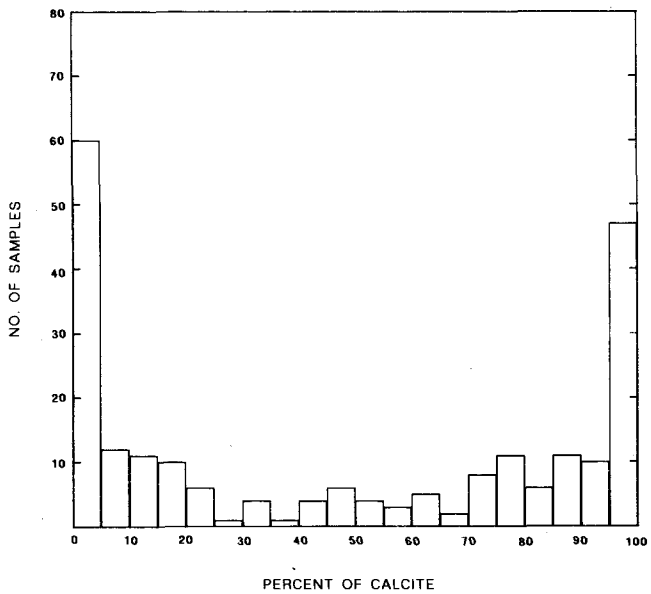
APPENDIX IV - Chemical analyses, Shenandoah County carbonate rocks.

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %)				
					$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
	Along Rt. 629 about 2 miles northeast of Strasburg	160±	Mosheim	limestone	98.25	0.80	0.10	0.04	0.42
2	About 200 yds. southwest of Road 629 and 2 miles northeast of Strasburg	100	Beekmantown	dolomite	54.79	41.55	3.43	0.46	0.64
		100		dolomite	53.99	38.20	4.12	0.43	0.52
		100		dolomite	56.40	36.46	5.91	0.55	1.07
	Standard Lime and Stone Co. quarry about 1 mile north of Strasburg	100±	Mosheim	limestone	98.15	0.95	0.14	0.08	0.52

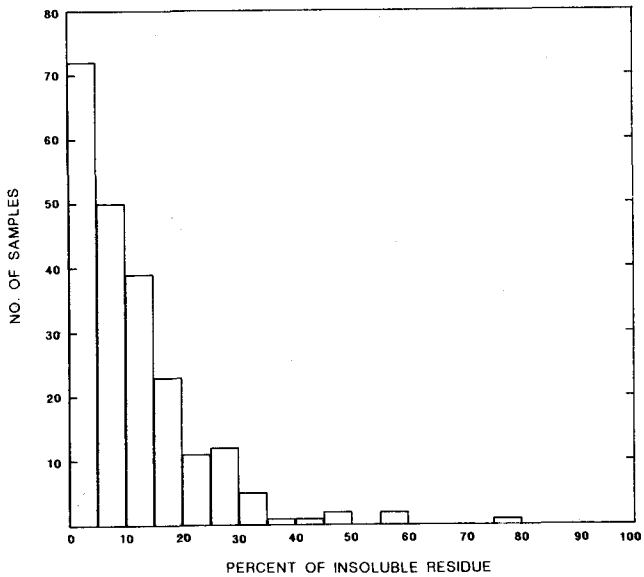
APPENDIX V - Chemical analyses, Warren County carbonate rocks.

Number of Appendix Reference	Sample Location	Thickness Sampled (ft.)	Formation	Rock Type	Chemical Composition (weight %)				
					$CaCO_3$	$MgCO_3$	SiO_2	Fe_2O_3	Al_2O_3
2	About 100 yds. east of Hwy. 522 and 1 1/2 miles northeast of Nineveh	55	Mosheim	limestone	95.89	2.97	0.20	0.08	0.80
	About 100 yds. east of Zion Church and 0.3 mile northeast of Nineveh	100±		limestone	95.76	2.79	0.44	0.04	0.58
								R_2O_3	
	Along Hwy. 522 and about 1 mile southwest of Nineveh	100	Athens	limestone	88.77	1.65	6.51	3.02	
		30	Lenoir	limestone	94.20	2.17	2.53	0.41	
		60	Mosheim	limestone	95.04	3.16	1.03	0.29	

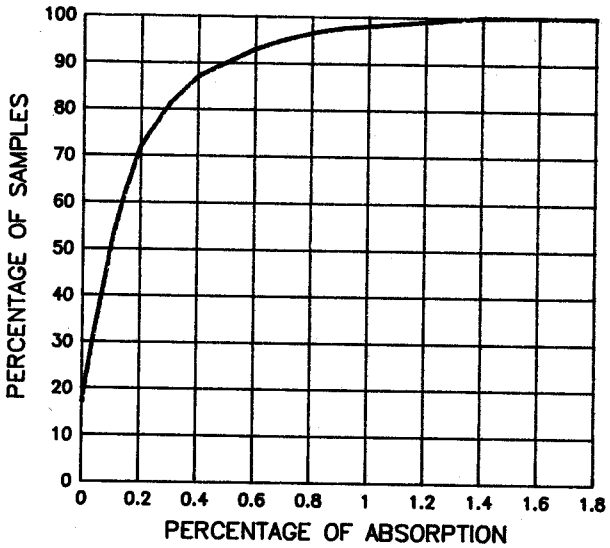
APPENDIX VI - Percentage of calcite in 224 carbonate samples from 42 active quarries and mines in Virginia (Sherwood and Newlon, 1964).



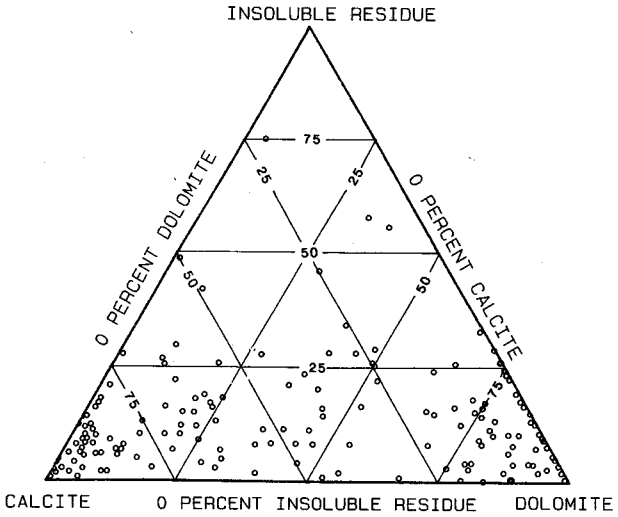
APPENDIX VII - Number of samples plotted versus percent insoluble residue for each sample - 224 carbonate samples from 42 active Virginia quarries and mines (Sherwood and Newlon, 1964).



APPENDIX VIII - Percentage of samples plotted versus percentage of absorption for 224 carbonate samples collected from 42 Virginia quarries and mines (Sherwood and Newlon, 1964).



APPENDIX IX - Ternary plot of insoluble material in 224 carbonate samples from 42 Virginia quarries and mines (Sherwood and Newlon, 1964).



APPENDIX X

REFERENCES (For Appendices I-IX)

1. Butts, Charles, and Edmundson, R. S., 1966, Geology and mineral resources of Frederick County: Virginia Division of Mineral Resources Bulletin 80, 142 p.

2. Edmundson, R. S., 1945, Industrial limestones and dolomites in Virginia: Northern and central parts of Shenandoah Valley: Virginia Geological Survey Bulletin 65, 195 p.

3. Edmundson, R. S., and Nunan, W. E., 1973, Geology of the Berryville, Stephenson, and Boyce quadrangles, Virginia: Virginia Division of Mineral Resources Report of Investigations 34, 112 p.

4. Edmundson, R. S., and Young, R. S., 1955, The Antietam-Beekmantown section in Shenandoah Valley, Virginia: Appalachian Geological Society Guidebook, joint field conference, Harrisonburg area, Virginia, p. 17-21.

5. Ellett, W. B., and Eskridge, A. T., 1897, Virginia marls: Virginia Agricultural Experiment Station Bulletin 78, v. 6, n. 7, p. 66-70.

6. Hubbard, D. A., Jr., Giannini, W. F., and Lorah, M. M., 1985, Travertine-marl deposits of the Valley and Ridge Province of Virginia - a preliminary report: Virginia Division of Mineral Resources, Virginia Minerals v. 31, n. 1, p. 1-8.

7. Mack, Tinsley, 1964, Everona formation in the northern piedmont, Virginia: Virginia Division of Mineral Resources, Virginia Minerals v. 10, n. 4, p. 1-4.

8. McCue, J. B., Lucke, J. B., and Woodward, H. P., 1939, Limestones of West Virginia: West Virginia Geological Survey v. 12, 560 p.

9. Roberts, J. K., 1928, The geology of the Virginia Triassic: Virginia Geological Survey Bulletin 29, 205 p.

10. Rodgers, H. W., Jr., 1965, Celestite from the Tonoloway Formation (upper Silurian) at Hayfield, Frederick County, Virginia [M.S. thesis]: University of Virginia, Charlottesville, 97 p.

11. Rogers, W. B., 1884, A reprint of annual reports and other papers on the geology of the Virginias, New York, D. Appleton and Company, 832 p.

12. Sherwood, W. C., and Newlon, H., Jr., 1964, Statewide survey for reactive carbonate aggregates, Virginia: Virginia Council of Highway Investigation and Research, 18 p.

13. Sweet, P. C., and Giannini, W. F., 1985, Refractory grade dolomite in Virginia: Virginia Division of Mineral Resources, Virginia Minerals v. 31, n. 1, p. 13-14.

14. Watson, T. L., 1907, Mineral resources of Virginia: Virginia - Jamestown Exposition Commission, Lynchburg, J. P. Bell Company, 618 p.