IRON ORE INVESTIGATIONS
BLAND, GILES AND TAZEWELL
COUNTIES

PART I

1. Location map-Bluefield NJ 17-8 AMS Series V501 (in pocket)

2. Cooper(1957)-Report of investigations of iron-bearing sandstones in the Nye Cove area, Tazewell and Bland counties.

3. Moon(1962)-BLM permit area-core logs.

4. Cooper(1962)-Logs.

5. Cooper(1962)-Summary report on first stage of prospecting for iron ore in Jefferson National Forest, Giles County.

6. Cooper(1962)-Recommendations for development of a substitute water supply for the town of Narrows, Virginia.

7. Cooper(1962)-Core log descriptions and analyses on Big Ridge cores.

PART II

8. Moon(1963)-Reconnaissance of Clinton ferruginous sandstones in parts of western Virginia.

9. Moon(1963)-Reconnaissance geology of the Chestnut Ridge area, Tazewell County.

10. Moon(1963)-Reconnaissance geology of the Big Ridge area, Bland and Tazewell counties.

11. Moon(1964)-Reconnaissance geology of the Dry Fork area, Bland County.

12. Moon(1964)-Brief notes on the geology of the Mercy Branch-Flat Top Mountain area, Giles County.

1956 1957
Beneficiation Tests
VPI.

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REPORT OF INVESTIGATIONS OF IRON-BEARING SANDSTONES IN THE NYE COVE AREA, TAZEWELL AND BLAND COUNTIES, VIRGINIA

Introduction

In August, 1956, the writer offered to conduct investigations relating to the possibilities for concentrating iron minerals occurring in the Silurian sandstones in the Big Ridge--Nye Cove are of Tazewell and Bland counties, Virginia. The objective of the project as then conceived was to determine whether it would be possible to produce a merchantable concentrate of hematite which could be considered acceptable to the steel industry.

Because of the seemingly tenuous prospects of reaching a favorable conclusion to such a speculative investigation, I consented to take on this investigation only with certain reservations, namely, (1) that I would accept no consultive fee or reimbursement for mileage expenses connected with visits to the property; (2) that Mr. E. L. Keesling of Bramwell, West Virginia, would purchase for the investigations certain equipment and photographs needed; and (3) that he would employ one of the graduate students in the Department of Geological Sciences to make a detailed area geologic study of the area concerned and to conduct such laboratory investigations of the material as might be feasible within the obvious limitations of a Master's thesis project.

Accordingly, Mr. Keesling employed Mr. G. K. Williams to make these studies and to work in close cooperation with me in the general investigation of this project. Limitations of time and facilities necessitate our concluding the investigation with the submission of this report. The Department of Geological Sciences acknowledges the donation of two items of equipment valued at approximately $3,150.00, which played a major part in the laboratory investigations conducted.

In submitting this report, I am suggesting that no information on this study be released to the press. Continued systematic study of this project in all of its ramifications must be carried out before the material can be said to constitute a source of recoverable and merchantable concentrated. Public notoriety generally inflated the significance of scientific discoveries beyond what is reasonable and valid conclusion. It also serves to make more difficult the systematic investigation of natural resources, because it gives property owners and others a desire to speculate in land and mineral holdings and to inflate the true value of the resources concerned. The interests of the parties to be served by investigations which have been carried on under my direction will not be served by premature publicity . It is my suggestion that you use the information herein presented as factual data to interest a steel company or an iron ore company in the possible further exploration and development of the material as a source of merchantable ore.

Nature and Distribution of the Iron

Deposits

The iron occurs in the form of finely crystalline hematite which fills the interstices between grains of quartz sand. The rock is a familiar type to any geologist who has worked in the Appalachian region. The iron-bearing sandstones appear quite hard and are very resistant to weathering. The heamtite forms a good bond, but the rock crushes with surprising ease. The percentage of iron oxide (Fe_2O_3) occurring in the raw stone will average about 24 per cent.

The iron-bearing sandstones have a maximum thickness of about 45 feet, and over considerable more that 1 square mile of the upland centering on Big Ridge, the average thickness as determined by core drilling is about 35 feet. The distribution of the red sandstones that contain the iron is shown in a general way on the geologic map accompanying "The Geology and Mineral Resources of the Burkes Garden Quadrangle," published as Virginia Geological Survey Bulletin 60. The areas determined by Williams to show exposures of iron-bearing sandstone in place are more specifically and accurately delineated on the accompanying geologic map prepared by Williams. I believe that it can be assumed that the red iron-bearing sandstones crop out in areas whose total acreage is estimated to be in excess of 1,800 acres. In such areas of outcrop, the ferruginous sandstones are present without any ? rocks. Most of the out crop areas are topographically situated so as to be ideally suitable for wholesale stripping and quarrying. The hard appearance of the sandstone as seen on the surface belies a fundamentally friable condition of the buried rock. Evidently the surface rock has been case-hardened. Suffice it to say that the general coherence of the sandstone as revealed in cores and diggings made on Big Ridge indicated that the rock could be quarried with minimum blasting.

On Big Ridge and the spurs leading off into Ny Cove to the west and into Laurel Creek on the east, the red sandstones dip at relatively low angles and can be considered virtually flat-lying. Such areas constitute approximately one-half of the acreage directly underlain by the red dandstones of Silurian age. The outcrop areas of the same beds in the western part of NyeCove and on East River Mountain have dips up to 30 degrees, but in nearly every outcrop area of the iron-bearing sandstone the beds dip so nearly parallel to the surface slope that extensive stripping of the sandstone without removal of any cover of younger rock would be possible.

Tonnage Reserves of Iron-Bearing Sandstone

Although the total outcrop area of the iron-bearing sandstones is far in excess of 1,000 acres, indeed, almost twice this figure, let us assume computation of the tonnage of this raw material which is available without mining or removal of any overlying rock on the basis of 1,000 acres. The formula to be used in the computation will be:

43,560 (square foot age/acre) x 1,000 (acres) x 35 (average thickness in feet) x 190 (weight lbs./cu. ft.) ÷ 2,200 (lbs. in a long ton of ore) = long tons of iron-bearing sandstone

Solution of this formula indicates occurrence of 131,670,000 long tons of raw iron-bearing sandstone per 1,000 acres, I believe that in the Nye Cove-Big Ridge area as mapped by Williams approximatedly 250.000.000 tons of sandstone are readily available for direct quarrying.. Anyone who takes the trouble to survey even in a cursory way the terrain and geologic structure of the Ny Cove-Big Ridge-Chestnut Ridge area covered by the geologic map prepared by Williams will readily appreciate that the tonnage figures are conservative.

Possibilities For Recovery of Hematite Ore From The Ferruginous Sandstone

Core-drilling done in 1956 provided a basis for determining the average thickness of the ore bed. When it became apparent that the tonnage was so large, and the material available so directly for open pitting, I concluded that it was worthwhile to explore whether the hematite could be concentrated by economically feasible milling methods to produce a merchantable concentrate.

Polished surfaces of representative samples of iron-bearing sandstone were prepared and examined under an ore microscope. The hematite is in exceedingly fine plate-like and acicular crystals and is relatively magnetic even without roasting. When the bond of hematite is broken and the rock is crushed, much of the hematite is exceedingly fine. The fine dust of hematite adheres to freed grains of quartz because of an electrostatic charge; consequently any dry separation has only limited success. Some of the hematite, as pointed out by Williams, includes small grains of angular quartz which is not freed except by exceedingly prolonged crushing. Nevertheless, a surprisingly large quantity of the iron oxide cement is freed in relatively granular condition sufficiently coarse to be amenable to dry magnetic treatment.

In our laboratory experimentation, we recognized early that it would be highly desirable to find a way to break the electostatic bond causing the small particles of free hematite to adhere to the quartz particles. High-tension electrostatic separation proved futile. Ultrasonic insonation of water-and dispersant-suspended slurries of the finely ground raw material, experimented on by Williams, indicated that the quartz grains could be scrubbed relatively clean of iron oxides, but the ultrasonic treatments applied by Williams did not produce a suspensoid of hematite which could be recovered by simple filtration. We have not been able to carry forward all the ultrasonic experiments that need to be conducted to determine whether high-frequency insonation can be commercially employed to aid in the recovery of the hematite from crushed iron-bearing sandstone. Our results are qualitatively interesting but by no means conclusive of anything.

Upon the conclusion of Williams thesis project, we have continued the experimental work on magnetic concentration of the hematite with results that I believe are sufficiently encouraging to indicate that merchantable concentrates of hematite can be produced from the iron-bearing sandstones. The work on magnetic separation was carried on by Mr. Mark Fara, assistant professor of geology, under my direction. Chemical analysis of the results of various tests were performed by Dr. J. W. Murray, professor of chemistry at VPI.

Two problems arise in preparation of the raw material for beneficiation tests. The only method of primary crushing at our disposal was a Denver jaw crusher. Fine grinding was accomplished not very satisfactorily with a laboratory-type ball mill. One major problem is the over-production of fines in these particular processes of comminution. The other problem related to inability to control the atmospheric dispersion of some of the iron and quartz. Milling in closed air circuits would eliminate this problem, and obviously with better crushing and grinding equipment, we would have been able to control the production of fines from which we have been unable to recover the iron.

In order to determine the degree of fineness at which maximum liberation of the hematite was achieved, a series of test were run, which showed that the maximum liberation of hematite was achieved in the ranges of -60 to -200 mesh (Tyler Screen Scale). All material was crushed so as to pass through the 140-mesh screen, because we found that coarser grinding allowed too many particles representing locked aggregated of hematite and small angular quartz grains and that finer grinding only served to proliferate the fines.

In our experiments, we found that crushing the material so that all of it passed 140 mesh resulted in only about 10 per cent of locked hematite-quartz aggregates surviving. Even grinding the sandstone to pass 140 mesh created what we consider excessive fines. Part of the fines is produced by reason of the real inherent difference in hardness and toughness of hematite and quartz. Grinding the material so that all passes 140 mesh results in production of fines aggregating 15 per cent to 30 per cent of the total feed. Assuming that out of 500 grams of original feed averaging 20 per cent iron oxide, about 100 grams of fines were produced by crushing and grinding so that all the material would pass 140 mesh. No way has yet been found to produce and iron concentrate from the fines by any method of dry treatment; therefore, we feel that the only hope for recovery of the iron from the fines will be by wet magnetic methods.

A crushing and grinding system which provided a continuous feed and discharge would surely reduce the proliferation of excessive fines and still achieve maximum liberation of hematite from the quartz. Nevertheless, no known drymethod will be able to separate the fine hematite which carries over and adheres by electrostatic attraction to the relatively larger quartz grains. The fact that the charge is neutralized in water would suggest that separation of the quartz and the iron in several size ranges will be achieved only by some kind of wet separation. But no equipment was available for carrying on tests involving wet magnetic separation. There is some doubt whether the material is sufficiently magnetic to be amenable to wet magnetic separation; but tests indicate that the roasting of the fines greatly increases magnetic susceptibility and so markedly so that such roasting would no doubt prove very useful in wet magnetic separation. The true value of the material upon which experiments have been made can only be determined by wet magnetic separations.

Separations were attempted utilizing froth flotation, dry separations using high-tension electric, electrostatic, and ultrasonic methods. With the equipment available to us, dry magnetic separations have produced the best results. We have been able to produce concentrates containing as much as 83 per cent hematite, or 58 per cent metallic iron, but only at the expense of quantity recovered. Considering all our experiments, the best results have been achieved by the following procedures.

FLOW SHEET FOR MOST EFFECTIVE DRY MAGNETIC SEPARATION

Ferruginous Sandstone → Jaw Crusher → Roll Mill → Pebble Mill

↓

Milled material all
-140 mesh

↓

Washing with water
disposal of the
very fine
hematite

↓

Dry the washed residue

↓

Induced Roll Dry
magnetic separator

tails
cleaned
once

concentrate
cleaned
twice

Tails

Middling
Product

(to be returned
to grinding
circuit)

Concentrate

The ferruginous sandstone obtained from the outcrop was crushed in a jaw crusher, then reduced to -20 mesh in a roller mill. A 500-gram sample was split off the original sample and -140 mesh material removed by sieving. The balance of the sample was placed in a laboratory type of ball mill and reduced in stages so that all passed 140 mesh. After all the material was crushed to -140 size, the material was treated with a small quantity of Sparkleen (a commercial detergent) and washed two times. The ultra-fine particles were decanted off in the treatment with the detergent. The fine material was then dewatered, dried, weighed, and set aside for analysis. The courser material was dried, weighed, and then fed into a Carpco Induced Roll Dry Magnetic Separator. The induced roll was saturated (2.0 A.) for the initial separation which yielded two products: a rough concentrate and a first tailings. The first tails were re-run through the separator once, and two products obtained, one of which--the cleaned tails--was set aside, weighed, and preserved for chemical analysis. The rough concentrate of the first run and the relative concentrate from the cleaning of the first tails were placed in the feed hopper and re-run, and the magnetic fraction re-run twice [illegible] concentrate. The less magnetic fraction constitute the [illegible].

<u>Summary of [illegible] of [illegible] Iron Sandstone</u>

Weight, original sample..........................500 grams
Fe_2O_3 content of original sample................. 23.4 percent
Calculated Fe_2O_3 in original sample...............117 grams
Weight of [illegible] coarse material...............381.9 grams
Weight of recovered fine material...............115.6 grams
Loss of material in washing process............ 2.5 grams
Material lost in separation process............ 8.2 grams
Total material lost........................... 10.7 grams

Tabulated Results On Specimen No. 27

Sample Number	Sample Designation	Weight in grams	Per cent Fe_2O_3	Per cent of total sample	Percent of total Fe_2O_3	Weight of Fe_2O_3	Calculated weight Fe Grams
27-A	Tails	224.5	[illegible]2.5	44.9	4.73	5.6	3.92
27-B	Concentrate	58.5	78.6	11.7	3[illegible].2	45.[illegible]	3[illegible].[illegible]3
27-C	Middlings	90.7	17.9	18.1	13.8	16.2	11.34
27-D	Fines	115.6	32.3	23.1	31.9	37.3	26.11
	Lost material	10.7		2.1			

Certain observations made in this experiment and many others similar to it should be emphasized. The tails constituting nearly 45 per cent of the total are very low in iron. There is sufficient iron in the fines to warrant special treatment, possible wet magnetic separation, inasmuch as this fraction contains approximately one-third of the iron in the raw material. Most important of all is the information relating to the concentrate. This material has a metallic iron content of 55 per cent. It is indicated that the simple treatment described in Experiment 27 would permit a recovery of hematite concentrate averaging 55 per cent metallic iron in quantities of one ton of concentrate for every 8.55 tons of raw fee. This fact is sufficiently encouraging to suggest that by additional wet magnetic treatment of the fine material which contains about one-third of the total iron, it should be possible to increase the yield of concentrate to one ton for every 5 tons of raw feed. The surprising magnetic susceptibility of the hematite is noteworthy, and this property lends strong encouragement to the possibilities for wet magnetic separation for a part of the sample.

Crushing Characteristics

In order to determine the crushing characteristics and distribution of the hematite in different size fractions, a sieve analysis was made and iron oxide determinations made on each fraction. All material was ground to pass 50 mesh and fractions separated down to 270 mesh with all the extremely fine material caught in a pan. This work indicated more clearly than anything else the principal problem in recovery of the iron, namely, the large proportion of -270 mesh hematite particles produced by simple crushing. The ease with which the hematite is so finely reduced in size poses for us a problem which we are unable to solve with our limited laboratory equipment; however, our "problem" might actually be an advantage for a commercial laboratory which had a wet magnetic separator. One of the expensive items in possible processing of low-grade iron ores is that of fine comminution. In the case of the Silurian iron-bearing sandstones, a large proportion of fines are generated on primary crushing and grinding, which signifies a highly friable structure of the particles of hematite.

Distribution of Hematite in Various Size Fractions of a Sieved Sample of Raw Sandstone

Size range	Grams Retained	Per cent of total	Per cent of Fe_2O_3	Grams of Fe_2O_3	Per cent of Fe_2O_3 of total
-50 to 70	98	5.27	13.8	13.5	3.2
-70 to 80	358	19.07	14.8	52.9	12.6
-80 to 100	290.2	15.5	15.7	45.5	10.8
-100 to 120	293	15.6	19.7	57.7	13.7
-120 to 140	140.7	7.5	24.9	34.9	8.3
-140 to 180	100.3	5.34	26.9	26.2	6.2
-180 to 200	133.7	7.17	30.0	40.0	9.5
-200 to 270	125.0	6.67	35.4	44.2	10.5
-270 to (pan)	277.3	14.78	40.5	112.2	26.9
Total	1.816.2				

The above tabulated summary indicates that it is going to be absolutely necessary to recover the iron from the fines in order to obtain a sufficient quantity of hematite concentrate to be economical. In consideration of the relatively strong magnetic susceptibility of the hematite, even without roasting, it seems to me virtually a foregone conclusion that the hematite in the fine sizes can be successfully recovered from wet magnetic separation. Assuredly, however, the ultimate answer to the commercial feasibility of producing an ore concentrate from the sandstone will hinge upon the correctness of my surmise.

Chemical Composition of The Raw Material And

Selected Concentrates

Ingredient	Original Raw Material Used in Exp. 27	Selected Samples 5D	5 E	27 B	27 D
SiO_2	72.3	15.4	69.8	13.2	50.5
Fe_2O_3	22.4	75.6	25.8	77.8	32.7
Al_2O_3	2.84	5.3	4.0	4.7	5.6
TiO_2	0.13	——	——	——	——
MnO_2	0.14	0.019	0.013	0.034	0.027
CaO	0.10	——	——	——	——
MgO	——	——	——	——	——
P_2O_5	——	0.091	0.054	0.028	0.16 (?)
K_2O	0.29				
Ign. Loss (dry)	0.96				

Identification of selected samples: 5 E-raw material used in Exp. 5
27 B-concentrate by dry magnetic separation; recovery 1:8.5.
27 D- -270 fines from Exp. 27.

The quantity of hematite in the raw stone from sample to sample is fairly uniform, averaging 20 to 25 per cent hematite. The analyst was not satisified with the P_2O_5 determinations on the concentrates actually include more than P_2O_5, and he has indicated orally to me that the 0.16 figure particularly seems to be in error because of inclusion of some other minor element coming down with the phosphorus pentoxide.

Feasibility of Production of a Merchantable Concentrate From the Silurian Sandstones

Our experiments indicate that without recovery of iron from the fines a ton of 55 per cent iron concentrate can be produced from 8.5 tons of raw material. If the iron can be recovered from the fines, it should be possible to increase the recovery of hematite from about 40 per cent, which is the best we have been able to do, to perhaps 80 to 85 per cent. This would allow production of a grade of ore concentrate acceptable to steel mills and in recovery rates that an ore concentrate by combination of wet and dry magnetic methods at the rate of 1 ton for every 5 to 6 tons of raw material.

The favorable factors connected with the material are: (1) occurrence in large quantity; (2) relative uniformity of grade of material; (3) ready availability of material for open pitting; (4) relative ease with which material crushes and proliferation of fines even in short run crushing and grinding; (5) and the ready availability of relatively low-cost fuel such as needed in the treatment of the raw stone. The most favorable factor overriding all others is the fact that the material can be quarried directly at exceptionally low cost. The savings in quarrying and mining costs should offset grinding and crushing costs and lower the recovery cost accordingly.

I am not failiar with the procedures used in arriving at the costs for milling so lean a material into a good concentrate. The Bureau of Mines (Report of Investigations 4988, The Future of Birmingham Red Ore, Jefferson County, Alabama, published in July, 1953) lists 12 costs items used in attempting to establish the cost of concentrating ore occurring in the Birmingham district. If comparisons are not too tenuous, we can, I believe, arrive at an approximate cost of producing a long ton of hematite concentrate from the sandstones on Big Ridge, which are representative of the material we have been studying. Quarrying costs can be estimated at $0.20 per ton of raw material, as against $1.00 per ton of mined material in the Birmingham district. Flotation costs for the Alabama ores would be higher than magnetic--separation costs for the Big Ridge material. Crushing and grinding costs for the two should be comparable. It does not seem unreasonable to believe that considering the 12 costs items the Bureau of Mines took into consideration in estimating probable milling costs for Birmingham ores it should be possible to mill 5 tons of raw iron-bearing sandstone and concentrate a ton of hematite ore averaging 55 per cent Fe for a total cost of about $11.00.

Considering the tonnage available, the low cost of quarrying that would surely prevail, and all other favorable factors, I feel that the results we have obtained are very encouraging--so much so that I believe you will be able to interest a steel company in the material. Further tests need to be run, but we cannot make them. It would be better for a company to carry on the work.

I regret to say that we have gone as far as we can go with the investigation of this project. We do not consider the time and thought we have contributed to the investigation to be a loss, because I am now convinced that a way can be found to make the Big Ridge ferruginous sandstones a usable source of raw material for production of pig iron and steel.

In view of thelimitations of our time and laboratory resources, we must discontinue experimental work. Therefore, this report constitutes our final report on the investigations made. In return for these investigations, the Department of Geological Sciences accepts as donation to our laboratory equipment of a Carpco High Intensity separator and a Carpco Induced Roll Magnetic Separator.

If questions arise concerning this report, I shall be glad to give them consideration and reply as needed.

Respectfully submitted,

S/ Byron N. Cooper
August 27, 1957

HOLE NUMBER: T1-7A

Lessee or permittee: E. L. Keesling Exp.
Address: Bramwell, West Virginia
Driller: Vaughan Bowling, Cunningham Core Drilling & Grouting
Finished: 26 October 1961
State: Virginia
Method of drilling: Diamond core
Logged by: W. A. Moon
S79E 14NE off vertical

Depth in feet From	To	Thickness	Description
0'0"	10'0"	10'0"	Overburden (Clinton formation)
10'0"	10'8"	8"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous; contains quartz granules.
10'8"	17'9"	7'1"	Sandstone, maroon, fine to coarse grained, ferruginous; contains maroon shale partings parallel to the bedding planes.
17'9"	28'0"	10'3"	Sandstone, maroon, fine to medium grained ferruginous; contains maroon clay galls (incl. 4" core loss).
28'0"	28'4"	4"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings.
28'4"	28'10"	0'6"	Shale, drab maroon.
28'10"	31'2"	2'4"	Sandstone, maroon, fine grained, highly ferruginous.
31'2"	33'8"	2'6"	Sandstone, maroon, medium to coarse grained, highly ferruginous.
33'8"	34'4"	8"	Shale, rust brown, contains black shale partings broken.
34'4"	34'7"	3"	Shale, pale olive drab.
34'7"	36'7"	2'0"	Shale and interbedded sandstone; shale grayish green to olive drab. Sandstone, maroon, fine to medium grained.
36'7"	37'7"	1'0"	Shale, pale grayish green glauconitic.
37'7"	37'11"	4"	Sandstone, maroon, fine to medium grained; contains maroon shale partings.
37'11"	40'2"	2'3"	Shale, pale grayish green; contains intercalations of maroon, fine to medium grained sandstone; includes 1' core loss.
40'2"	43'5"	3'3"	Sandstone shaly, pale green, fine to coarse grained; contains irregular pale green sandy shale partings and interbeds.

Depth in feet From	To	Thickness	Description
43'5"	43'6"	1"	Shale, maroon.
43'6"	44'2"	8"	Sandstone, grayish green, fine grained; lower 3" contains black shale partings.
44'2"	44'8"	6"	Sandstone, gray, fine to coarse grained, conglomeratic contains black limestone granules and pebbles and irregular green shale partings.
44'8"	47'	2'4"	Sandstone, pale green, fine grained; contains irregular green shale partings.
47'0"	50'3"	3'3"	Sandstone, pale grayish green, fine grained, shaly; contains irregular green shale partings.
50'3"	50'11"	8"	Shale, green.
50'11"	51'4"	5"	Sandstone, pale grayish green, fine grained, shaly; contains irregular pale green shale partings.
51'4"	51'9"	5"	Shale, pale gray.
51'9"	55'7"	3'10"	Sandstone, pale grayish green, fine grained, shaly contains irregular pale green shale partings.
55'7"	55'8"	1"	Shale, black.
55'8"	56'0"	4"	Sandstone, pale gray, fine grained, quartzitic.
56'0"	56'1"	1"	Shale, grayish black.
56'1"	56'2"	1"	Sandstone, pale gray, fine grained, quartzitic.
56'2"	57'	10"	Sandstone, grayish green, medium to coarse grained; contains quartz granules and irregular greenish shale partings.
57'	57'5"	5"	Shale, pale grayish green, sandy.
57'5"	58'1"	8"	Shale grayish green; contains 1" maroon shale at 57'8".
58'1"	58'8"	7"	Shale dark gray.
58'8"	60'4"	1'8"	Sandstone, gray fine grained, quartzitic; contains black shale partings.
60'4"	61'2"	10"	Sandstone, gray slight grayish hue, fine grained quartzitic.
61'2"	63'	1'10"	Sandstone, rust brown to gray to pale olive drab, fine to medium grained; contains rust brown clay galls and greenish gray shale partings, vuggy.

Depth in feet			Description
From	To	Thickness	
63'	66'8"	3'8"	Sandstone, maroon, coarse grained, ferruginous, conglomeratic; contains quartz granules and clay galls.
66'8"	68'4"	1'8"	Sandstone, maroon, fine grained, ferruginous.
68'4"	69'4"	1'0"	Shale, grayish green; contains maroon sandstone intercalations.
69'4"	69'7"	3"	Sandstone, grayish maroon, fine grained; contains grayish green shale partings.
69'7"	70'	5"	Sandstone, pale grayish green, fine grained; contains green shale intercalations.
70'	72'7"	2'7"	Sandstone, maroon, fine grained, ferruginous.
72'7"	72'9"	2"	Shale, greenish gray.
72'9"	74'11"	2'2"	Sandstone, pale gray, fine grained; contains irregular greenish gray shale partings.
74'11"	75'8"	9"	Sandstone, maroon, fine grained, ferruginous; contains intercalations of greenish gray shale.
75'8"	77'2"	1'6"	Shale and interbedded sandstone, shale grayish green; sandstone, pale gray, fine grained.
77'2"	77'3"	1"	Sandstone, maroon, fine grained.
77'3"	81'5"	4'2"	Sandstone and interbedded shale, sandstone gray to grayish black, fine grained; shale grayish black to grayish green.
81'5"	86'4"	4'11"	Shale, dark grayish green, contains gray fine grained sandstone pebbles and galls.
86'4"	86'9"	5"	Sandstone, maroon, fine grained, ferruginous.
86'9"	87'1"	4"	Sandstone, gray, fine to coarse grained, conglomeratic; contains large brown clayey sandstone pebbles.
87'1"	87'8"	7"	Sandstone, pale gray, fine grained; contains black shale partings.
87'8"	88'	4"	Shale, black.
88'	88'7"	7"	Sandstone, gray, fine to coarse grained; congl. contains viens and stringers of pyrite.

Depth in feet			Description
From	To	Thickness	
88'7"	91'	2'5"	Sandstone, pale grayish green, fine grained.
91'	92'4"	1'4"	Sandstone, pale grayish green, fine grained, contains irregular vienlets of maroon sandstone. (Includes 4" core loss).
92'4"	92'7"	3"	Sandstone grayish maroon, fine grained.
92'7"	97'11"	5'4"	Sandstone, pale gray to grayish green, fine grained; contains irregular partings of black shale.
97'11"	99'11"	2'0"	Sandstone, pale gray to grayish green, fine grained.
99'11"	100'6"	7"	Quartzite, grayish white, fine grained.

Log of Split Core T1-7A

0	10'		Overburden useable Clinton
			Sample 1 (10' - 17'9")
10'	10'8"	8"	Sandstone, maroon, coarse grained conglomeratic; highly ferruginous contains quartz granules.
10'8"	17'9"	7'1"	Sandstone, maroon, fine to coarse grained, ferruginous; contains scattered maroon shale partings parallel to the bedding planes.
			Sample 2 (17'9" - 28')
17'9"	28'	10'3"	Sandstone, maroon, fine to medium grained, highly ferruginous contains maroon clay galls.
28'	28'10"	10"	Shale drab maroon to gray not sampled.
			Sample 3 (28'10" - 34')
28'10"	31'2"	2'4"	Sandstone, maroon, fine grained, highly ferruginous.
31'2"	34'	2'10"	Sandstone, maroon, medium to coarse grained, ferruginous.
			Sample 4 (63' - 68'4")
63'	66'8"	3'8"	Sandstone, maroon, coarse grained, ferruginous, conglomeratic, contains quartz granules and clay galls.
			Sample 5 (70' - 72'7")
70'	72'7"	2'7"	Sandstone, maroon, fine grained ferruginous.

HOLE NUMBER: T1-8A

Lessee or permittee: E. L. Keesling Exp.
Address: Bramwell, West Virginia
Driller: Vaughan Bowling, Cunningham Core Drilling & Grouting Co.
Commenced drilling: 9 October 1961 Finished: 18 Oct. 1961
Method of drilling: Diamond core NX
Logged by: W. A. Moon
S74E 13° N off vertical

Depth in feet			Description
From	To	Thickness	
		Clinton formation	
0'0"	8'6"	8'6"	Overburden
8'6"	16'0"	7'6"	Sandstone and interbedded shale: sandstone, grayish white, fine grained; shale, pale grayish green; contains rust brown partings (core loss 3'10").
16'0"	19'2"	3'2"	Shale, pale grayish green, contains rust brown partings (core loss 1').
19'2"	19'8"	0'6"	Shale, maroon, sandy.
19'8"	20'3"	0'7"	Sandstone, maroon, coarse grained, slightly ferruginous, vuggy; contains yellowish brown clay galls.
20'3"	23'8"	3'5"	Sandstone, maroon, fine grained, slightly ferruginous; contains abundant maroon and grayish green shale partings and interbeds.
23'8"	25'0"	1'4"	Sandstone, maroon, coarse grained, friable, ferruginous. Contains abundant maroon shale partings.
25'	27'1"	2'1"	Sandstone, maroon, fine grained, ferruginous; contains maroon shale partings in the lower 1'.
27'1"	27'11"	0'10"	Sandstone, maroon, coarse grained, highly ferruginous; contains widely scattered maroon shale partings.
27'11"	29'9"	1'10"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings and maroon clay galls.
29'9"	30'5"	0'8"	Sandstone, maroon, coarse grained, ferruginous; contains maroon shale partings.
30'5"	31'1"	8"	Sandstone, maroon, coarse grained; highly ferruginous.
31'1"	32'3"	1'2"	Shale, olive drab to pale grayish green.
32'3"	33'5"	1'2"	Sandstone, pale grayish maroon (incl. 6" core loss).
33'5"	33'6"	1"	Sandstone, olive drab, fine grained.

Depth in feet			Description
From	To	Thickness	
33'6"	34'8"	1'2"	Shale, pale grayish green to olive drab.
34'8"	36'2"	1'6"	Sandstone, maroon, fine grained, shaly; contains abundant maroon shale partings parallel to the bedding planes.
36'2"	37'0"	0'10"	Shale, maroon (incl. 8" core loss).
37'0"	37'5"	0'5"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings.
37'5"	37'9"	0'4"	Sandstone, maroon, fine grained; highly ferruginous.
37'9"	42'0"	4'3"	Sandstone, maroon, coarse grained, ferruginous conglomeratic; contains quartz granules and widely scattered maroon shale partings.
42'0"	42'3"	0'3"	Shale, olive drab.
42'3"	45'11"	3'8"	Shale, pale grayish green.
45'11"	46'1"	0'2"	Sandstone, maroon, medium grained.
46'1"	46'6"	0'5"	Shale and sandstone. Shale, pale grayish green. Sandstone, gray, fine grained, occurs as partings.
46'6"	47'6"	1'0"	Shale pale grayish green, contains several maroon sandstone partings.
47'6"	47'8"	2"	Sandstone, maroon, medium to coarse grained.
47'8"	48'0"	4"	Sandstone, grayish green, conglomeratic, coarse grained.
48'0"	48'2"	2"	Sandstone, pale maroon, coarse grained.
48'2"	50'6"	2'4"	Sandstone, grayish green, fine grained, shaly.
50'6"	51'5"	0'11"	Shale, grayish green.
51'5"	52'3"	0'10"	Sandstone and interbedded shale; rust brown to gray, crumbly.
52'3"	56'7"	4'4"	Sandstone, pale grayish green, fine grained; contains irregular greenish gray shale intercalations.
56'7"	56'10"	3"	Shale, pale green.
56'10"	62'10"	6'0"	Sandstone, pale grayish green, fine grained; contains irregular greenish gray shale intercalations (includes 5" core loss)

Depth in feet From	To	Thickness	Description
62'10"	63'2"	0'4"	Shale, pale maroon, sandy.
63'2"	63'9"	0'7"	Shale, pale green, sandy.
63'9"	64'10"	1'1"	Shale, pale maroon, sandy.
64'10"	65'7"	0'9"	Shale, pale grayish green, sandy.
65'7"	67'0"	1'5"	Shale, pale grayish green, sandy; contains gray sandstone intercalations.
67'0"	68'2"	1'2"	Shale, green.
68'2"	68'5"	0'3"	Sandstone, pale grayish green.
68'5"	69'3"	0'10"	Shale, grayish black.
69'3"	69'9"	0'6"	Sandstone, rust brown, fine grained.
69'9"	71'	1'3"	Sandstone, pale grayish green, fine grained.
71'0"	71'3"	3"	Shale, green.
71'3"	72'2"	0'11"	Sandstone, pale gray, fine grained, fractured.
72'2"	73'3"	1'1"	Sandstone, pale grayish green, fine grained.
73'3"	74'6"	1'3"	Shale, pale gray (includes 8" core loss).
74'6"	78'0"	3'6"	Sandstone, maroon, fine grained, ferruginous; contains maroon clay galls.
78'0"	78'9"	9"	Sandstone, maroon, fine grained; ferruginous badly broken. (Includes 4" core loss).
78'9"	79'9"	1'0"	Sandstone, maroon, fine grained, ferruginous; contains maroon shale partings and clay galls.
79'9"	79'11"	2"	Shale, pale olive green.
79'11"	81'0"	1'1"	Sandstone, maroon, fine grained, ferruginous; contains widely scattered maroon shale partings and clay galls.
81'0"	83'9"	2'9"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous; contains quartz granules and maroon shale partings.
83'10"	83'11"	0'1"	Sandstone, rust brown, fine grained, shaly.

Depth in feet From	To	Thickness	Description
83'11"	86'3"	2'4"	Shale, grayish green, contains gray fine grained sandstone partings.
86'3"	88'5"	2'2"	Sandstone, drab maroon, fine to coarse grained, contains maroon and grayish green shale partings.
88'5"	90'4"	1'11"	Shale, grayish green; contains intercalations of grayish green and maroon sandstone.
90'4"	90'9"	5"	Sandstone and shale; sandstone, maroon, fine grained; shale maroon.
90'9"	91'6"	0'9"	Sandstone gray, fine grained, contains grayish green shale partings.
91'6"	91'11"	0'5"	Shale, grayish green.
91'11"	92'	1"	Sandstone, maroon, coarse grained.
92'0"	97'7"	5'7"	Shale, grayish green; contains gray, fine grained sandstone intercalations.
97'7"	100'2"	2'7"	Sandstone, grayish white, fine grained; contains gray shale intercalations in lower foot.
100'2"	100'8"	0'6"	Sandstone, rust brown, fine grained, friable.
100'8"	101'8"	1'0"	Sandstone, gray, fine grained, contains dark gray to black shale partings.
101'8"	103'5"	1'9"	Sandstone, pale greenish gray, fine grained.
103'5"	105'10"	2'5"	Sandstone, gray, fine grained, contains dark gray to black shale partings.
105'10"	107'	1'2"	Sandstone, dark gray to black, fine grained, vuggy.
107'0"	108'	1'0"	Sandstone, pale greenish gray, fine grained.
108'0"	108'5"	0'5"	Shale, black, vuggy.
108'5"	111'7"	3'2"	Sandstone, light gray, fine grained, vuggy; contains rust brown stained vugs (incl. 1'3" core loss).
111'7"	112'0"	0'5"	Sandstone, pale grayish white, fine grained.
112'0"	112'1"	1"	Shale, green.
112'1"	112'11"	10"	Sandstone, pale grayish green, fine grained.

Depth in feet			Description
From	To	Thickness	
112'11"	113'4"	5"	Clay, gray.
113'4"	114'2"	10"	Sandstone, pale gray, fine grained, contains rust brown partings (incl. 7" core gain) quartzitic.
114'2"	114'6"	4"	Quartzite, pale grayish brown, fine grained; contains reddish brown shale partings, durable.

Bottom of hole.

Log of Split Core

Hole: T1-8A   Date: 21 October 1961

Depth in feet From	To	Thickness	Description
			Sample 1 (19'6" - 23')
19'6"	20'4"	10"	Sandstone, maroon, fine to medium grained, ferruginous.
20'4"	23'	2'8"	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings.
23'	23'6"	6"	Shale, pale maroon to brownish olive drab.
			Sample 2 (23'6" - 31'1")
23'6"	31'1"	6'7"	Sandstone, maroon, fine grained, ferruginous; contains abundant, maroon shale partings.
31'1"	32'3"	1'2"	Shale, olive drab to pale greenish gray.
32'3"	32'11"	0'8"	Sandstone, gray fine grained.
32'11"	33'6"	0'7"	Shale, pale brown to yellow brown (includes 6" core loss).
33'6"	34'8"	1'2"	Shale, pale olive drab.
			Sample 3 (34'8" - 42')
34'8"	37'3"	2'7"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous; contains abundant maroon shale partings.
37'3"	42'	4'9"	Sandstone, maroon, coarse grained, congl.; ferruginous (incl. 8" core loss).
42'0"	74'6"	32'6"	Shale, pale greenish gray, contains partings and interbeds of gray, fine grained sandstone. See core log.
			Sample 4 (74'6" - 83'10")
74'6"	79'9"	5'3"	Sandstone, maroon, fine grained, ferruginous.
79'9"	79'11"	2"	Shale, pale green.
79'11"	83'10"	3'11"	Sandstone, maroon, fine grained, ferruginous contains sporadic maroon shale partings.
83'10"	86'3"	3'1"	Shale, pale greenish gray, contains gray fine grained sandstone intercalations.

Depth in feet			Description
From	To	Thickness	
86'3"	88'1"	1'10"	Sandstone, grayish maroon, fine grained, contains gray to grayish maroon shale partings, last 2" coarse grained.

End of Split Core Log.

HOLE NUMBER: T2-18A

Hole alignment: N 52 E 15° SE off vertical
Date started: December 11, 1961
Date completed: December 13, 1961
Driller: M. C. Vaughan, Cunningham Core Drilling Co.

Depth in feet			Description
From	To	Thickness	
0	4'	4'	Overburden, Clinton SS not useable.
4'	4'2"	2"	Sandstone, grayish maroon to gray, quartzitic, slightly ferruginous, shaly, broken.
4'2"	4'5"	3"	Sandstone, brown, fine grained, quartzitic.
4'5"	6'	1'7"	Sandstone, grayish maroon, fine grained, slightly ferruginous, quartzitic. Includes [illegible] core loss.
6'	12'6"	6'6"	Sandstone, maroon, fine to medium grained, ferruginous, contains abundant maroon shale partings [illegible] the bedding planes and clay galls. Quartzitic.
12'6"	13'8"	1'2"	Sandstone, maroon, fine grained, highly ferruginous, contains maroon clay galls.
13'8"	14'	4"	Sandstone, drab brownish maroon, fine grained, [illegible], slightly ferruginous thin bedded.
14'	14'10"	10"	Sandstone, maroon, medium to coarse grained, ferruginous, contains brownish maroon clay galls.
14'10"	14'11"	1"	Shale, pale green to [illegible] brown.
14'11"	16'10"	1'11"	Sandstone, grayish maroon, fine grained, slightly ferruginous, contains abundant irregular [illegible] shale partings parallel to the bedding planes.
16'10"	17'3"	5"	Shale, pale greenish gray.
17'3"	19'7"	2'4"	Sandstone, maroon to grayish maroon, fine [illegible] grained, slightly ferruginous, contains [illegible] maroon shale partings parallel to the bedding planes.
19'7"	19'10"	3"	Shale, pale [illegible].
19'10"	21'	1'2"	Sandstone, [illegible], coarse grained, ferruginous, [illegible], contains [illegible] clay galls and quartz [illegible].
21'	39'1"	18'1"	Sandstone, grayish maroon to [illegible], medium grained, slightly ferruginous, [illegible] bedded; contains abundant maroon, [illegible] and gray shale partings parallel to the bedding planes.

Depth in feet			Description
From	To	Thickness	
39'1"	40'	11"	Sandstone, maroon to dark red, coarse grained, highly ferruginous, extremely friable, contains quartz granules.
40'	40'1"	1"	Shale, pale tan.
40'1"	41'	11"	Sandstone, maroon, fine grained, [illegible], includes 3" core gain.
41'	42'11"	1'11"	Shale, pale green, contains partings and [illegible] of pale rust brown sandy shale and sandstone.
42'11"	61'5"	19'6"	Shale, [illegible] greenish gray, glauconitic; contains fine, [illegible] partings and [illegible] parallel to the bedding planes. These lenses contain pale gray, fine grained quartzitic sandstone.
61'5"	61'8"	3"	Sandstone, pale gray, fine grained, quartzitic.
61'8"	62'9"	1'1"	Shale, pale greenish gray.
62'9"	64'	2'3"	Sandstone, pale gray, fine grained, includes [illegible] core loss.
64'	67'4"	3'4"	Shale, pale gray, micaceous.
67'4"	69'8"	2'4"	Shale, gray to grayish brown, contains [illegible] rust brown silt and sandy shale [illegible] bedding planes. Includes 10" core [illegible].
69'8"	69'10"	2"	Shale, pale grayish brown, extremely [illegible].
69'10"	70'	2"	Shale, rust brown, sandy, broken, contains [illegible] chips of maroon sandstone.
70'	70'4"	4"	Sandstone, dark grayish maroon, fine grained.
70'4"	74'	3'8"	Shale, maroon to pale grayish green, sandy, crumbly; includes [illegible]'1" core loss.
74'	74'8"	8"	Sandstone, maroon, fine grained, ferruginous, [illegible]. Note: [illegible] shale zone from 71' to [illegible].
74'8"	74'10"	2"	Shale, pale green to lavender, broken.
74'10"	74'11"	1"	Sandstone, pale gray, fine grained.
74'11"	[illegible]	1"	Shale, [illegible] maroon.
75'	[illegible]	5'5"	Sandstone, maroon, fine grained, [illegible], contains partings and interbeds of pale brown to gray shale. Interval includes 3'1" core loss.

Depth in feet			Description
From	To	Thickness	
80'5"	80'9"	4"	Shale, lavender, broken.
80'9"	81'5"	8"	Sandstone, grayish purple, fine grained, [illegible].
81'5"	81'7"	2"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules.
81'7"	82'	5"	Shale dark red to maroon, includes 2" core [illegible].
82'	86'10"	4'10"	Sandstone, maroon, fine to coarse grained, ferruginous, contains quartz granules and a shale [illegible] of rust brown and maroon shale, broken. Includes 2' core loss,
86'10"	88'6"	1'8"	Sandstone, maroon, fine grained, ferruginous, contains [illegible] maroon shale partings parallel to the bedding planes.
88'6"	89'6"	1'	Sandstone, maroon, medium to coarse grained, ferruginous, contains quartz granules.
89'6"	95'9"	6'3"	Sandstone, maroon, fine to coarse grained, ferruginous, contains maroon, green and [illegible] shale partings parallel to the bedding planes.
95'9"	95'11"	2"	Sandstone, rust brown, fine grained.
95'11"	97'	1'1"	Shale, rust brown, crumbly. Includes 1' core loss.
97'	102'	5'	Shale, tan to pale rust brown, contains partings of pale rust brown silt and pale green shale. Includes 1'2" core loss.

End of hole.

Log of Split Core T2-18A

Date Logged: December 20, 1961

Depth in feet			Description
From	To	Thickness	
			Sample 1 (4' - 9'3")
4'	9'3"	5'3"	Sandstone, drab grayish brown to [illegible] maroon, fine grained, slightly ferruginous, weathered; contains pale rust brown to [illegible] shale partings.
			Sample 2 (9'3" - 13'8")
9'3"	10'3"	1'	Sandstone, drab maroon, fine grained, ferruginous.
10'3"	12'8"	2'5"	Sandstone, drab pale grayish maroon, fine grained, contains maroon shale partings parallel to the bedding planes.
12'8"	13'8"	1'	Sandstone, maroon, fine grained, ferruginous.
			Sample 3 (13'8" - 21')
13'8"	14'10"	1'2"	Sandstone, drab grayish brown to brownish [illegible], fine to medium grained, slightly ferruginous.
14'10"	16'10"	2'	Sandstone, grayish maroon, fine grained, [illegible] ferruginous, contains abundant [illegible] maroon shale partings thin bedded.
16'10"	17'3"	5"	Shale, [illegible] gray.
17'3"	19'7"	2'4"	Sandstone, drab grayish maroon, fine to coarse grained, slightly ferruginous, contains abundant maroon shale partings parallel to the bedding planes.
19'7"	19'10"	3"	Shale, pale tan.
19'10"	21'	2"	Sandstone, maroon, coarse grained, ferruginous, contains maroon clay galls and quartz granules.
21'	23'5"	2'5"	[illegible] grayish maroon shale; not sampled too poor.
			Sample [illegible] (23'5" - 37')
23'5"	37'	13'7"	[illegible] grayish maroon to drab [illegible] medium grained, slightly ferruginous [illegible] bedding, contains abundant [illegible] and gray shale partings parallel [illegible] planes.

Depth in feet			Description
From	To	Thickness	
37'	38'	1'	Shale, drab maroon, contains partings of maroon, fine grained ferruginous sandstone (not sampled).
			Sample 5 (38' - 41')
38'	39'1"	1'1"	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings and interbeds parallel to the bedding planes.
39'1"	40'	11"	Sandstone, maroon to dark red, coarse grained, ferruginous, extremely friable, contains quartz granules.
40'	40'1"	1"	Shale pale tan.
40'1"	41'	11"	Sandstone, maroon, fine grained, highly ferruginous, includes 5" core gain.
			Sample 6 (74' - 79'10")
74'	74'8"	8"	Sandstone, maroon, fine grained, ferruginous, broken.
74'8"	74'10"	2"	Shale, pale green to lavender broken.
74'10"	74'11"	1"	Sandstone, drab gray, fine grained.
74'11"	75'	1"	Shale, drab maroon.
75'	79'10"	4'10"	Sandstone, maroon, fine grained, ferruginous, contains partings and interbeds of pale brown to gray shale. Interval includes 3'1" core loss.
			Sample 7 (81'5" - 88'6")
81'5"	81'7"	2"	Sandstone, maroon, coarse grained, [illegible], contains quartz granules.
81'7"	[illegible]	5"	Shale dark red to maroon. Includes [illegible] core loss.
82'	[illegible]	4'10"	Sandstone, maroon, fine to coarse grained, [illegible] contains quartz granules and sporadic [illegible] rust brown and maroon shale broken. Includes [illegible] loss.
86'10"	88'6"	1'8"	Sandstone, maroon, fine grained ferruginous, contains abundant maroon shale partings parallel to the [illegible] planes.

Depth in feet			Description
From	To	Thickness	
			Sample 8 (88'6" - 95'9")
88'6"	89'6"	1'	Sandstone, maroon, medium to coarse [illegible], ferruginous, contains quartz granules.
89'6"	95'9"	6'3"	Sandstone, maroon, fine to coarse grained, ferruginous, contains maroon and green [illegible] brown shale partings parallel to the bedding planes.

End of log.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: August 31, 1961, Thursday

Depth in feet		Description
From	To	
0	3.5	Overburden - loose weathered white sandstone and soil.
3.5	5.5	Sandstone, white; slightly friable.
5.5	10	Sandstone, white to gray white, medium to coarse grained, slightly fractured.
10	13.2	Sandstone, white to gray, fine to medium grained, quartzitic.
13.2	17.8	Sandstone, white to gray white, quartzitic, contains 3" redish brown to gray clay seam. The lower 1 1/2' is fractured and iron stained.
17.8	22.8	Sandstone, gray to grayish black, medium grained, slightly granuler.
22.8	23.0	Sandstone, gray to grayish white, medium grained.
23.0	23.4	Clay, gray to grayish maroon. Encountered extreme bit blockage.
23.4	24.0	Gray clay and shale.
24.0	27.7	Sandstone, pale yellowish-brown, fine grained extremely friable, crumbly. Incl.(core loss .9').
27.7	28	Sandstone, grayish to pale brown, fine grained, crumbly.
	28'	Total Footage Drilled for the Day.

T2-1A
PAGE 2

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550

Date: September 1, 1961, Firday

Depth in feet From	To	Description
28	33	Sandstone and interbedded clay. Snadstone pale brown, fine to medium grained, friable. Clay gray.
33	35.8	Shale, sandy and gray.
35.8	38	Shale, clayey gray. Ostracod zone at 37', Leperdita alta.
38	40	Shale, grey, sandy slightly congl.
40	41.6	Snadstone, gray fine grained.
41.6	43.6	Sandstone, fine to medium grained, greenish gray. Incl. 4" of brown sandstone.
43.6	46.2	Appeared to be 2' greenish grey shale overlying 8" of maroon shale. No core recovery.

-Clinton - Keefer Contact.-

46.2	46.8	Sandstone, maroon, medium to coarse grained ferruginous.
46.8	48'5 3/4"	Sandstone, maroon, fine to medium grained, ferruginous.
48'6 1/2"	52'1.2"	Sandstone, maroon, medium to coarse grained, ferruginous. Basal foot contains granule sized pebbles. Thin clay intercalations along bedding planes in lower 3'.
52'1.2"	53'9"	Sandstone, maroon, medium to coarse grained. Some scattered quartz granules and abundant greenish gray shale intercalations along bedding planes.
53'9"	54'7"	Shale, greenish gray clayey.
54'7"	55'4 1/2"	Sandstone, maroon coarse grained abundant greenish gray clay shale intercalations on bedding planes. 1/2" thick zone of granular gray shale at 54'11 1/2".
55'4 1/2"	56'4 1/2"	Sandstone, maroon medium to coarse grained. Numerous quartz granules and maroon shale intercalations along bedding planes.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550
Date: September 1, 1961, Friday

Depth in feet From	To	Description
56'4 1/2"	57'3 1/2"	Sandstone, maroon fine to medium grained, numerous quartz granules, marked absence of clay and shale parings.
57'3 1/2"	57'10 1/2"	Sandstone, drab greenish gray, fine grained.
57'10 1/2"	59'7 1/2"	Shale, greenish gray.
59'7 1/2"	60'3 1/2"	Sandstone, maroon medium to coarse grained.
60'3 1/2"	60'8 1/2"	Sandstone, maroon fine grained.
60'8 1/2"	60'11"	Sandstone, maroon coarse grained.
60'11"	61'2"	Sandstone, maroon fine to medium grained with intercelations of greenish gray shale parallel to bedding planes.
61'2"	61'8"	Sandstone, maroon, coarse grained congl. large quartz grains.
61'8"	62'3"	Sandstone, maroon, fine to medium grained, numerous quartz pebbles.
62'3"	62'6"	Sandstone, maroon, fine grained; contains yellow brown shale intercalations.
62'6"	62'9"	Sandstone, maroon, fine to medium grained.
62'9"	62'11"	Sandstone, maroon; contains yellow brown shale intercalations crumbly.
62'11"	64'9"	Sandstone, maroon, fine to medium grained.
64'9"	65'6"	Sandstone, maroon, coarse grained.
	37'4"	Total Footage Drilled for the Day.

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Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 4, 1961, Monday

Depth in feet From	To	Description
65'6"	67	Sandstone, maroon, medium to coarse grained, ferruginous, contains numerous quartz granules.
67	69	Sandstone, maroon, fine to medium grained, ferruginous, contains widely scattered quartz granules.
69	70'2.4"	Sandstone, maroon, coarse grained congl., contains abundant white quartz granules and clay galls.
70'2.4"	70'6.25"	Sandstone, maroon, fine grained, ferruginous.
70'6.25"	70'11.25"	Sandstone, maroon, fine to medium grained with maroon clay intercalations parallel to bedding planes.
70'11/25"	75'7.75"	Sandstone, maroon, medium to coarse grained numerous thin zones of quartz granules parallel to bedding planes.
75'7.57"	76'.25"	Sandstone, maroon, fine to medium grained, ferruginous.
67'.25"	76'.26"	Clay, maroon.
76'.26"	77'7.6"	Sandstone, maroon, fine to medium grained, contains widely scattered white quartz granules.
77'7.6"	77'8"	Shale, brown to maroon.
77'8"	77'9"	Shale, gray, contains intercalations of light gray clay parallel to bedding planes.
77'9"	77'10.5"	Sandstone, fine to medium grained, maroon, contains maroon shale intercalations.
77'10.5"	78'2.4"	Shale, grayish green with alternating zones of maroon shale.
78'2.4"	78'2.5"	Sandstone,, maroon, fine to medium grained.
78'2.5"	79'5.5"	Shale, pale yellow to drab.
79'5.5"	79'6"	Shale, drab maroon with maroon shale intercalations parallel to the bedding planes.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550
Date: September 4, Monday

Depth in feet From	To	Description
79'6"	79'10.7"	Shale, yellow with pale gray-yellow in last .5".
79'10.7"	79'10.9"	Shale, drab brown, sandy.
79'10.9"	79'10.11"	Shale, yellow.
79'10.11"	80'2.1"	Sandstone, white.
80'2.1"	80'4.1"	Sandstone, maroon, fine grained, contains maroon shale intercalations parallel to the bedding planes.
80'4.1"	80'9.6"	Shale, grayish green.
80'9.6"	81'7.2"	Sandstone, maroon, fine to coarse grained congl. numerous clay gall, and scattered granular pebbles.
81'7.2"	82'3.6"	Shale, grayish green, sandy, contains interbeds of grayish white sandstone.
82'3.6"	82'4.1"	Sandstone, maroon, fine grained, ferruginous.
82'4.1"	86'4.1"	Shale, pale greenish-gray, clayey, contains intercalations of sandy shale and gray to white sandstone parallel to bedding planes.
86'4.1"	86'5.1"	Shale, pale gray green sandy (fossil zone) incl. trilobites.
86'5.1"	94'2.1"	Shale, pale grayish green, contains intercalations and interbeds of grayish-green sandy shale and gray sandstone.
94'2.1"	94'3.6"	Fossil zone including trilobites and ostracods. Grayish green sandstone, fine to medium grained.
94'3.6"	95'6.6"	Shale, pale grayish green.
95'6.6"	96'6.6"	Core loss.
96'6.6"	100'10.6"	Shale, pale grayish green, drab; contains intercalations of sandy shale and scattered fossil layers less than 1/2" thick.
[illegible]	[illegible]	
100'10.6"	101'1.6"	Zone of abundant fossils.

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T2-1A
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Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date:September 4, 1961, Monday

Depth of feet		Description
From	To	
101'1.6"	101'5"	Shale, grayish green, contains pale grayish green drab sandstone.
101'5"	101'11"	Abundant fossil zone includes trilobites.
101'11"	102'3.6"	Shale, grayish green.
102'3.6"	104'8.6"	Shale, greenish gray contains interbeds of sandstone, gray white to greenish gray, fine to meium grained; and intercalations of greenish gray sandy shale;
104'8.6"	106'3.6"	Sandstone, gray to grayish black, fine grained, contains interbeds of greenish gray sandy shale.
	39'2.7"	Total Footage Drilled for the Day.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 5, 1961, Tuesday

Depth in feet From	To	Description
106'8.6"	106'9.6"	Shale, pale grayish green and maroon, contains grayish green sandstone and sandy shale intercalations parallel to bedding planes.
106'9.6"	106'11"	Sandstone, fein grained, grayish maroon.
106'11"	107'10.8"	Shale, pale grayish green to maroon.
107'10.8"	108'3.8"	Sandstone, maroon, coarse grained, ferruginous congl. contains large quartz granules.
108'3.8"	108'10.8"	Sandstone, maroon, fine to medium grained, contains maroon shale intercalations parallel to bedding planes.
108'10.8"	109'1"	Sandstone, pale grayish green.
109'1"	112'4"	Sandstone, maroon, fine to coarse grained; contains intercalations of maroon shale parallel to bedding planes.
112'4"	112'6.3"	Shale, maroon.
112'6.3"	112'9.8"	Sandstone, pale gray green and maroon, fine grained, shaly.
112'9.8"	113'3.8"	Sandstone, maroon, coarse grained; contains quartz granules.
113'3.8"	113'4.8"	Shale, maroon.
113'4.8"	113'5.1"	Sandstone, maroon, coarse grained.
113'5.1"	113'5.6"	Shale, maroon.
113'5.6"	113'7"	Sandstone, maroon, coarse grained.
113'7"	113'9"	Shale, maroon and green.
113'9"	115'2"	Sandstone, maroon, coarse grained, contains large quartz granules.
115'2"	115'4.75"	Shale, maroon.

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Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 5, 1961, Tuesday

Depth in feet		Description
From	To	
115'9.6"	115'11"	Sandstone, maroon coarse grained.
115'11"	115'11.5"	Shale, maroon
115'11.5"	118'4.75"	Sandstone, maroon, medium to coarse grained ferruginous, contains widely scattered maroon shale intercalations.
118'4.75"	118'7"	Shale, greenish gray.
118'7"	118'8.5"	Sandstone, pale greenish gray.
118'8.5"	119'4.5"	Sandstone, maroon, fine grained.
119'4.5"	120'4.5"	Sandstone, maroon, contains maroon shale interbeds.
120'4.5"	122'8.75"	Shale, maroon to grayish, contains interbedded maroon sandstone, fine grained.
122'8.75"	122'9"	Shale, green.
122'9"	122'9.25"	Sandstone, maroon, fine grained.
122'9.25"	123'1.25"	Shale, grayish green.
123'1.25"	123'3"	Sandstone, maroon; contains interbedded maroon shale.
123'3"	123'5.5"	Sandy shale, grayish green.
123'5.5"	123'7"	Sandstone, maroon, fine grained.
123'7"	123'9.5"	Shale, grayish green.
123'9.5"	124'3.5"	Sandstone, medium to coarse grained, maroon, contains quartz granules.
124'3.5"	124'4.25"	Shale, maroon.
124'4.25"	124'5.25"	Sandstone, maroon, coarse grained.
124'5.25"	125'6.75"	Sandstone, maroon, fine grained contains maroon shale intercalations parallel to the bedding planes.

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Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550

Date: September 5, 1961, Tuesday

Depth of feet From	To	Description
125'6.75"	125'8.75"	Sandstone, maroon, coarse grained.
125'8.75"	126'	Sandstone, maroon, fine grained.
126'	128'4.25"	Sandstone, maroon, fine to medium grained, contains maroon shale intercalations parallel to the bedding planes.
128'4.25"	128'4.50"	Shale, green.
128'4050"	135'2.25"	Sandstone, maroon, fine grained; contains maroon shale intercalations parallel to the bedding planes.
135'2.25"	135'8.75"	Sandstone, maroon, coarse grained; contains quartz granules.
135'8.75"	136'2.4"	Sandstone, maroon, fine grained.
	29'6.4"	Total Footage Drilled for the Day.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 6, 1961, Wednesday

Depth of feet		Description
From	To	
136'2.4"	139'1.4"	Sandstone, maroon, fine grained, ferruginous relatively free of shale intercalations. Few scattered clay galls.
139'1.4"	139'3.4"	Sandstone, maroon, fine gra ned, contains abundant maroon shale intercalations parallel to the bedding planes and two thin green shale seams.
139'3.4"	140'5.4"	Sandsto e, maroon, medium to coarse grained.
140'5.4"	145'4.15"	Shale, pale gray green; contains grayish green sandstone interbeds.
145'4.15"	145'6"	Sandstone, pale grayish green, conglomerate; contains rounded quartz pebbles 2mm in diameter and black limestone pebbles.
145'6"	145'11"	Sandstone, pale grayish green conglomerate contains rounded quartz pebbles 2mm in diameter and black limestone pebbles.
145'11"	147'2"	Shale, grayish green.
147'2"	148'4"	Sandstone, gray, fine grained.
148'4"	148'6"	Sandstone, gray congl. coarse grained contains black limestone pebbles up to 1/4" in diameter.
148'6"	148'10"	Sandstone, gray, fine grained.
148'10"	150'5.5"	Sandstone, brown and gray, fine grained; contains intercalations and interbeds of gray shale. Core shows plastic deformation.
150'5.5"	155'8.4"	Sandstone, pale grayish green to olive brown, fine grined, contains scattered pale brown sandstone interbeds in upper 2'.
155'8.4"	159'7.65"	Sandstone, pale grayish green to olive drab, fine grained, contains widely scattered greenish gray shale intercalations.
159'7.65"	159'11"	Shale, pale grayish green; contains maroon, fine grained sandstone in thin intercalations.
159'11"	161'2"	Sandstone, pale grayish green, fine grained.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 6, 1961, Wednesday

Depth in feet From	To	Description
161'2"	162'1"	Sandstone, pale grayish green, fine grained; contains scattered intercalations of sandstone, maroon, fine grained.
162'1"	163'1"	Sandstone, maroon, fine grained, shaly, contains maroon shale intercalations.
163'1"	162'2"'	Sandstone, fine to coarse grained, grayish green contains greenish grey shale intercalations. This includes .55' core gain.
166'2"	167'	Quartzite, gray, fine grained.
	30'9.6"	Total Footage Drilled for the Day.

Description 6f Drill Cores

Hole Number: T2-1A
Elevation: 3,550 Date: September 7, 1961, Thursday

Depth in feet From	To	Description
167'	168'6"	Quartzie, grayish white, fine grained, contains black and brown shale intercalations.
	1'8"	Total Footage for Day.

T2-2A
PAGE 1

Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450

Date: September 8, 1961, Friday

Depth in feet		Description
From	To	
0	3	Overburden, Keefer sandstone.
3	8.8	Shale and clay, poor core recovery.
-Clinton Sandstone-		
8.8	12.4	Sandstone, maroon, medium to coarse grained. Clinton
12.4	15.15	Sandstone, maroon, fine to medium grained.
15.15	15.20	Shale, grayish green.
15.20	16.80	Sandstone, maroon, medium to coarse grained. Contains quartz granules and scattered maroon clay galls.
16.80	17.15	Shale, grayish green to olive drab.
17.15	18.4	Sandstone, maroon, coarse grained.
	18.4	Total Footage Drilled for the Day.

T 2-2A
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Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450 Date: September 11, 1961, Monday

Depth in feet From	To	Description
18.4	19.5	Sandstone, maroon, medium to coarse grained; contains maroon shale parting.
19.5	21.80	Shale, gray and maroon, soft clayey; contains two zones of maroon sandstone, each 0.2' thick.
21'9.6"	22'5"	Sandstone, maroon, fine to coarse grained; contains clay galls and maroon shale parting. Iron content nil.
22'6"	24'5"	Sandstone, maroon, medium to coarse grained, ferruginous, conglomeratic, marked absence of shale partings.
24'5"	25'5.5"	Sandstone, maroon, medium to coarse grained, ferruginous, vuggy; contains large quartz granules.
25'5.5"	25'5.6"	Shale, green.
25'5.6"	26'3"	Sandstone, maroon, fine to medium grained.
26'3"	26'4"	Shale, maroon and grayish green.
25'4"	26'6"	Sandstone, maroon, fine to medium grained.
26'6"	26'7"	Shale, grayish green.
26'7"	27'5"	Sandstone, maroon, fine to medium grained; contains abundant maroon shale partings.
27'5"	29'	Sandstone, maroon, fine to medium grained, ferruginous.
29'	33'3"	Sandstone, maroon, fine grained, ferruginous, contains clay galls; fractured, fractures filled with brown mud, fractures occur in upper and lower 1 foot of interval.
33'3"	35'3"	Sandstone, maroon, contains maroon shale partings, fine grained.

T2-2A
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Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450 Date: September 11, 1961, Monday

Depth in feet From	To	Description
35'3"	35'5"	Shale, maroon and gray.
35'5"	37'1"	Sandstone, maroon, fine to medium grained, contains maroon shale partings.
37'1"	37'11"	Sandstone, maroon, medium to coarse grained, ferruginous, vuggy, conglomeratic.
37'11"	39'	Sandstone, maroon, fine to medium grained, contains maroon shale partings and a 1" intercalation of gray shale.
39'	39'8"	Shale, gray to pale olive drab.
39'8"	40'	Sandstone, maroon, fine grained ferruginous.
40'	40'1"	Shale, grey.
40'1"	40'2"	Sandstone, maroon, fine to medium grained.
40'2"	41'2"	Shale, pale grayish green, glauconitic.
41'2"	42'4.5"	Shale, pale rust brown to olive drab.
42'4.5"	42'6"	Sandstone, maroon, coarse grained conglomeratic; contains brown clay galls.
42'6"	45'	Sandstone, maroon, fine grained, ferruginous, contains clay galls. Ostracod zone at 42'9".
45'	47'1.5"	Sandstone, maroon, fine grained, badly fractured, contains maroon shale intercalations.
47'1.5"	47'3.5"	Shale, brown, fractured.
47'3.5"	47'4.5"	Shale, maroon.
47'4.5"	47'6"	Shale, gray.

Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450 Date: September 11, 1961, Monday

Depth in feet		Description
From	To	
47'6"	47'7"	Shale, rust brown.
48'7"	52'6"	Shale, pale grayish green glauconitic.
52'6"	57'6"	Shale, pale grayish green, glauconitic, contains intercalations of greenish grey fine grained sandstone. Fossil zones at 53'6" and, 56'4".
	41'2"	Total Footage Drilled for the Day.

Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450

Date: September 12, 1961, Tuesday

Depth in feet From	To	Description
57'6"	57'8"	Shale, gray, sandy, fossiliferous; contains trilobites.
57'8"	67'8"	Shale, pale grayish green, unctuous; contains pale grayish green fine grained sandstone intercalations.
67'8"	68'11"	Shale, grey, contains intercalations of pale gray sandstone; fossiliferous, includes trilobites and brachiopods.
68'11"	69'5"	Shale, rust brown, sandy, fractured; contains several gray shale partings.
69'5"	73'9"	Shale, gray, unctuous.
73'9"	74'3"	Sandstone, maroon, fine grained, contains rust brown shale partings in lower 2".
74'3"	74'11"	Shale, gray, contains rust brown partings.
74'11"	75'2"	Shale, maroon.
75'2"	75'11"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous.
75'11"	76'	Shale, gray and maroon.
76'	76'4"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous.
76'4"	81'2"	Sandstone, maroon, fine to medium grained, highly ferruginous, contains widely scattered maroon shale partings and clay galls.
81'2"	82'	Sandstone, maroon, fine grained ferruginous, contains maroon shale partings and olive drab shale partings and olive drab shale intercalations.
82'	84'	Shale, maroon and olive drab, contains interbeds of fine grained, maroon sandstone.
84'	84'2"	Sandstone, maroon, coarse grained, ferruginous.
84'2"	84'6"	Shale, maroon.

Description of Drill Cores

Hole Number: T2-1A
Elevation: 3,450

Date: September 12, 1961, Tuesday

Depth in feet From	To	Description
84'6"	85'8"	Sandstone, maroon, coarse grained, ferruginous.
85'8"	86'8"	Sandstone, maroon, fine to medium grained, ferruginous.
86'8"		Green shale parting.
86'8"	88'6"	Sandstone, maroon, fine to medium grained, highly ferruginous.
88'6"		Green shale parting.
88'6"	88'7"	Sandstone, maroon, fine to medium grained.
88'7"		Green shale parting.
88'7"	89'5"	Sandstone, maroon, fine to medium grained, ferruginous.
89'5"	90'1.5"	Sandstone, maroon, coarse grained ferruginous, conglomeratic; contains quartz granules.
90'1.5"	92'9"	Sandstone, maroon, fine grained, contains abundant maroon shale intercalations.
92'9"	96'9"	Shale, maroon and greyish green, contains interbeds of maroon, fine grained sandstone, containing maroon shale partings.
96'9"	98'4.5"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous; contains quartz granules.
98'4.5"	98'9"	Shale, maroon and gray.
98'9"	99'2"	Sandstone, maroon, fine grained, contains maroon shale intercalations.
99'2"	101'6"	Shale, pale grayish green, glauconitic (incl. 1'3" core loss).

44' Total Footage Drilled for the Day.

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Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450 Date: September 13, 1961, Wednesday

Depth in feet		Description
From	To	
101'6"	103'5"	Shale, maroon and green.
103'5"	103'8"	Sandstone, maroon, fine grained.
103'8"	104'3"	Sandstone, pale grayish green, fine grained.
104'3"	105'8"	Shale, maroon and green.
105'8"	106'	Sandstone, maroon, fine to medium grained, slightly ferruginous.
106'	107'2"	Shale, grayish green (includes 8" core loss)
107'2"	107'4.5"	Sandstone, gray and brown, fractured.
107'4.5"	111'6"	Sandstone, gray to grayish black, slight maroon hue, fine grained.
111'6"	116'3"	Shale, gray, unctuous, contains gray fine grained sandstone interbeds.
116'3"	117'8.5"	Shale, dark grayish green, contains sandstone interbeds.
117'8.5"	119'7.5"	Sandstone, pale gray to grayish green, contains irregular brown silt and sand intercalations and green shale partings.
119'7.5"	126'5"	Sandstone, gray to grayish green, contains irregular green shale partings and clay galls.
126'5"	129'1"	Sandstone, gray, fine grained, contains sporadic maroon sandstone partings.
129'1"	130'1"	Sandstone, maroon, fine grained shaly; contains green and maroon shale partings.
130'1"	130'11"	Shale, maroon, sandy.
130'11"	132'5"	Shale, gray, sandy.
132'5"	133'2"	Sandstone, grayish green, fine to medium grained, contains green shale partings.
133'2"	134'	Shale, pale green.

Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450

Date: September 13, 1961, Wednesday

Depth in feet From	To	Description
134'	137'3"	Sandstone, pale grayish white, fine grained, quartzitic, contains grayish black shale partings.
137'3"	138'4"	Shale, grayish black, sandy.
138'4"	139'7"	Sandstone, gray, fine grained, quartzitic, contains blakc shale partings.
139'7"	139'11"	Shale, black.
139'11"	141'11"	Shale, gray, sandy.

-Shut down for day at 140'7"±

	39'1"	Total Footage Drilled for the Day.

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Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450 Date: September 14, 1961, Thursday

Depth in feet		Description
From	To	
141'11"	143'1"	Sandstone, pale gray, fine grained, contains gray shale parting.
143'1"	143'7"	Sandstone, gray, fine grained; contains large ellipsoidal clay pellets and balls.
143'7"	144'8"	Sandstone, gray to pale greenish gray, contains sporadic black to gray shale partings.
144'8"	146'5"	Sandstone, grayish maroon, fine grained.
146'5"	148'4"	Sandstone, maroon, fine grained, slightly ferruginous.
148'4"	152'	Shale, grayish green, unctuous.
152'	152'8"	Sandstone, maroon, fine grained.
152'8"	153'11"	Sandstone, gray, fine grained; contains gray shale intercalations.
153'11"	154'3"	Shale, gray, sandy.
154'3"	154'11"	Sandstone, gray, coarse grained, conglomerate; contains abundant black and gray clay pellets, quartz granules and fossils.
	14'9"	Total Footage Drilled for the Day.

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Description of Drill Cores

Hole Number: T2-2A
Elevation: 3,450

Date: September 15, 1961, Friday

Depth in feet From	To	Description
155'4"	157'6"	Shale, grayish black, contains gray fine grained sandstone intercalations parallel to bedding planes.
157'6"	158'2"	Sandstone, pale grayish white, fine grained, quartzitic.
158'2"	165'6"	Shale, grayish black, contains gray fine grained sandstone. intercalations.
165'6"	167'3"	Shale, grayish black.
167'3"	169'5"	Sandstone, gray to grayish green, fine grained.
169'5"	170'1.5"	Sandstone, gray, shaly.
170'1.5"	175'5"	Shale, gray to black, sandy; contains gray sandstone intercalations.
175'5"	175'8"	Conglomerate, gray, fine grained; contains gray sandstone and quartz pebbles set in a gray sandstone and shale matrix.
175'8"	178'9"	Sandstone, gray, fine grained, contains black and gray shale intercalations; core mottled with irregular brown sandstone intercalations.
178'9"	179'1"	Sandstone, grayish black, fine grained, vuggy; contains irregular intercalations of gray sandstone.
179'	181'4"	Sandstone, gray, fine grained, quartzitic.
181'4"	181'6"	Shale, gray.
181'6"	181'11"	Sandstone, grayish white, fine grained, quartzitic. Hard and durable.
	26'7"	Total Footage Drilled for the Day.

HOLE NUMBER: T2-19A

Drill alignment: N 55 E 15° SE off vertical
Date started: Wednesday, December 6, 1961
Date completed: Thursday, December 7, 1961
Driller: M. C. Vaughan, Cunningham Core Drilling Co.

Depth in feet			Description
From	To	Thickness	
0	2'	2'	Overburden, workable Clinton.
2'	4'3"	2'3"	Sandstone, maroon, fine grained, ferruginous includes
4'3"	6'5"	2'2"	Sandstone, maroon, fine to medium grained, ferruginous, includes 11" core loss.
6'5"	9'	2'7"	Sandstone, maroon, fine grained, [illegible], contains sporadic partings of maroon [illegible].
9'	10'9"	1'9"	Sandstone, maroon, fine to coarse [illegible] ferruginous contains quartz granules.
10'9"	13'6"	2'9"	Sandstone, maroon, fine to coarse grained, ferruginous contains abundant maroon shale [illegible]-ings parallel to the bedding planes.
13'6"	13'10"	4"	Sandstone, maroon, fine grained, ferruginous.
13'10"	16'10"	3'	Shale, maroon, includes 2'1" core loss.
16'10"	17'	2"	Sandstone, maroon, fine grained, ferruginous.
17'	18'8"	1'8"	Sandstone, maroon, coarse grained, ferruginous, conglomeratic; contains vugs, clay [illegible] and quartz granules.
18'8"	19'4"	8"	Shale, maroon, contains interbedded [illegible] grained ferruginous sandstone partings.
19'4"	19'10"	6"	Sandstone, maroon, coarse grained, ferruginous contains vugs and quartz granules.
19'10"	19'11"	1"	Shale, maroon.
19'11"	20'1"	2"	Sandstone, gray to pale rust brown, fine [illegible].
20'1"	20'9"	8"	Shale, pale grayish maroon, contains paper thin partings of yellowish to rust brown sandy [illegible].
20'9"	20'10"	1"	Sandstone, maroon, fine grained, ferruginous.
20'10"	23'5"	2'7"	Shale, pale gray, contains sporadic paper thin partings of rust brown sandy shale parallel to the bedding planes.

Depth in feet			Description
From	To	Thickness	
23'5"	23'6"	1"	Shale, maroon.
23'6"	23'8"	2"	Shale, gray.
23'8"	24'2"	6"	Sandstone, maroon, coarse grained, [illegible].
24'2"	24'4"	2"	Shale, lavender to grayish maroon.
24'4"	24'5"	1"	Sandstone, maroon, fine grained, [illegible].
24'5"	27'	2'7"	Shale, pale greenish gray, contains rust brown [illegible] thin shale partings parallel to the bedding [illegible] extremely unctuous.
27'	31'	4'	Shale, gray, [illegible] contains [illegible] partings parallel to the bedding [illegible]. Includes 2'8" core loss.
31'	31'7"	7"	Sandstone, pale olive drab, fine grained.
31'7"	36'	4'5"	Shale, pale maroon to lavender, [illegible] partings of fine grained pale grayish brown to rust brown sandy shale, parallel to the bedding planes.
36'	36'1"	1"	Shale, pale green, contains pebbles of grayish white fine grained sandstone.
36'1"	36'3"	2"	Shale, pale brown, unctuous.
36'3"	36'5"	2"	Sandstone, pale gray, fine grained quartzitic.
36'5"	39'6"	3'1"	Shale, pale brown, includes 2'11" core loss.
39'6"	40'3"	9"	Quartzite, grayish white, fine grained, thin bedded.
40'3"	41'	9"	Shale, pale gray.
41'	43'1"	2'1"	Quartzite, grayish white, fine grained, thin bedded.
43'1"	43'6"	5"	Shale, gray.
43'6"	44'4"	10"	Quartzite, grayish white, fine grained.
44'4"	44'7"	3"	Sandstone, grayish white quartzitic, contains [illegible] of green shale.
44'7"	45'	5"	Sandstone, rust brown, fine grained, shaly. Includes 2" core loss.

Depth in feet			Description
From	To	Thickness	
45'	46'8"	1'8"	Quartzite, grayish white, fine grained.
46'8"	47'3"	7"	Sandstone, conglomeratic, gray; contains [illegible] inch limestone pellets and clay pellets. Includes irregular lenses of gray quartzite [illegible].
47'3"	48'6"	1'3"	Sandstone, grayish green, fine grained, [illegible] with green glauconitic shale stringers, [illegible] pyrite crystals and pyritized fossils.
48'6"	50'8"	2'2"	Sandstone, grayish white to pale [illegible] green, quartzitic, contains green glauconitic shale partings parallel to the bedding planes.
50'8"	51'8"	1'	Quartzite, pale grayish white fine grained.
51'8"	57'8"	6'	Sandstone, grayish white to pale [illegible] green, contains minute irregular stringers [illegible] pyrite and pale irregular green shale partings.
57'8"	59'1"	1'5"	Sandstone, grayish maroon, fine grained.
59'1"	59'9"	8"	Shale green to greenish gray.
59'9"	60'	3"	Shale, pale yellowish brown, includes [illegible]" core loss.
60'	60'3"	3"	Sandstone, pale grayish white, fine grained quartzitic.
60'3"	64'	3'9"	Shale, pale [illegible] gray, contains interbeds and partings of rust brown manganese stained sandstone and sandy shale. Also contains lenses of grayish white fine grained quartzitic sandstone.
64'	65'	1'	Sandstone, pale grayish white fine grained quartzitic. Includes 7" core loss.

End of hole.

T2-19A Log of Split Core

Date logged: December 9, 1961

Depth in feet			Description
From	To	Thickness	
			Sample 1 (2' - 10'9")
2'	4'3"	2'3"	Sandstone, maroon, fine grained, ferruginous, includes 7" core loss.
4'3"	6'5"	2'2"	Sandstone, maroon, fine to medium grained, ferruginous, includes 11" core loss.
6'5"	9'	2'7"	Sandstone, maroon, fine grained, ferruginous, contains [illegible] partings of maroon [illegible].
9'	10'9"	1'9"	Sandstone, maroon, fine grained [illegible], ferruginous, [illegible] quartz granul[illegible]
			Sample 2 (10'9" - 13'10")
10'9"	13'10"	3'1"	Sandstone, maroon, fine to coarse grained, ferruginous, contains maroon [illegible] parallel to the [illegible] planes.
			Sample 3 (17' - 19'10")
17'	19'	2'	Sandstone, maroon, coarse grained, [illegible], conglomeratic, contains vugs, clay [illegible] and quartz granules.
19'	19'4"	4"	Shale, maroon, contains maroon sandstone, coarse grained ferruginous intercalations.
19'4"	19'10"	6"	Sandstone, maroon, coarse grained, ferruginous, contains vugs and quartz granules.

End of log.

HOLE NUMBER: T3-9A

Hole alignment N68E 15° NW
Date started: November 16, 1961
Date completed: December 4, 1961
Driller: Vaughan Bowling, Cunningham Core Drilling and Grouting

Depth in feet			Description
From	To	Thickness	
0	7'	7'	Overburden, white sandstone float and Clinton float.
7'	7'8"	8"	Shale, pale grayish white, fractured and broken.
7'8"	8'1"	5"	Sandstone, grayish maroon to gray, fine grained, slightly ferruginous.
8'1"	8'6"	5"	Sandstone, rust to reddish brown, fine grained, broken.
8'6"	12'	3'6"	Sandstone, pale grayish white to tan, fine grained, contains interbeds of pale gray to pale tan shale, includes 2" core loss.
12'	13'11"	1'11"	Sandstone, pale gray to white, fine grained, quartzitic, contains rust brown manganese stained partings and fractures. Includes 1'1" core loss.
13'11"	24'	10'1"	Sandstone, rust brown to tan, fine grained, contains partings and interbeds of chocolate brown shale; badly fractured and broken. Includes 7' core loss.
24'	25'3"	1'3"	Shale, pale grayish white to pale tan, unctuous.
25'3"	30'4"	5'1"	Sandstone, maroon, fine to coarse grained, ferruginous contains maroon clay galls, broken; includes 3' core loss.
		(Note fault zone 7' - 62')	
30'4"	30'6"	2"	Shale, pale tan, unctuous.
30'6"	38'7"	8'1"	Sandstone, maroon, fine to coarse grained, ferruginous contains maroon clay galls, broken. Includes 1'3" core loss.
38'7"	42'	3'5"	Shale, pale tan, includes 3'3" core loss.
42'	42'2"	2"	Shale, rust brown, sandy.
42'2"	42'4"	2"	Shale, pale gray.
42'4"	42'5"	1"	Sandstone, rust brown, fine grained.

Depth in feet			Description
From	To	Thickness	
42'5"	52'	9'7"	Shale, pale tan, broken and fractured; includes 8' core loss.
52'	62'	10'	Sandstone rust brown, fine grained, badly broken, includes 8'6" core loss.
62'	65'6"	3'6"	Shale, tan to pale rust brown, sandy, contains sporadic partings of greenish gray shale and a 1" bed of tan fine grained sandstone at 62'8".
65'6"	71'	5'6"	Shale, pale greenish gray, contains partings and lenses of gray fine grained quartzitic sandstone, includes 8" core loss.
71'	71'5"	5"	Sandstone, gray, fine grained, fossiliferous, contains ostracods and trilobites.
71'5"	72'3"	10"	Shale, pale greenish gray.
72'3"	72'6"	3"	Sandstone, gray, fine grained, fossiliferous, contains ostracods and brachiopods.
72'6"	75'2"	3'8"	Shale, pale greenish gray, contains sporadic lenses of gray fine grained quartzitic sandstone.
75'2"	77'	1'10"	Shale, gray, contains partings and interbeds of tan shale. Includes 1' core loss.
77'	87'3"	10'3"	Sandstone, maroon, fine grained, highly ferruginous complete absence of shale partings and clay galls.
87'3"	89'7"	2'4"	Sandstone, maroon, fine grained, ferruginous, contains partings of maroon shale parallel to the bedding planes.
89'7"	91'1"	1'6"	Sandstone, maroon, fine grained, ferruginous.
91'1"	91'4"	3"	Sandstone, maroon, fine grained, ferruginous, contains 50% maroon shale partings parallel to the bedding planes.
91'4"	91'9"	5"	Shale, maroon and pale gray, unctuous.
91'9"	92'8"	11"	Sandstone, maroon, coarse grained, ferruginous.
92'8"	93'4"	8"	Shale, grayish maroon, unctuous.
93'4"	94'7"	1'3"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and rust brown clay galls.

Depth in feet			Description
From	To	Thickness	
94'7"	95'1"	6"	Sandstone, maroon, coarse grained, ferruginous contains abundant maroon shale interbeds parallel to the bedding planes.
95'1"	95'5"	4"	Sandstone, maroon, coarse grained, ferruginous.
95'5"	95'9"	4"	Sandstone, maroon, coarse grained, ferruginous contains abundant maroon shale partings.
95'9"	97'	1'3"	Clay, gray, unctuous, includes 6" core loss.

Hole shut down.

T3-9A Log of Split Core

Date logged: December 9, 1961

Depth in feet From	To	Thickness	Description
			Sample 1 (25'3" - 38'3")
25'3"	30'4"	5'1"	Sandstone, maroon, fine to coarse grained, ferruginous, contains maroon clay galls, broken. Includes 3' core loss.
30'4"	30'6"	2"	Shale, pale tan unctuous.
30'6"	38'7"	8'1"	Sandstone, maroon, fine to coarse grained ferruginous, contains maroon clay galls, includes 1'3" core loss.
			Sample 2 (77' - 91'1")
77'	87'3"	10'3"	Sandstone, maroon, fine grained, ferruginous, contains sporadic paper thin wavelite partings at 86'.
87'3"	89'5"	2'2"	Sandstone, maroon, fine grained, ferruginous, contains scattered maroon shale partings parallel to the bedding planes.
89'5"	91'1"	1'8"	Sandstone, maroon, fine grained, ferruginous.
			Sample 3 (91'1" - 92'8")
91'1"	91'4"	3"	Sandstone, maroon, fine grained, ferruginous contains 50% maroon shale partings parallel to the bedding planes.
91'4"	91'9"	5"	Shale, maroon and pale gray unctuous.
91'9"	92'8"	11"	Sandstone, fine to coarse grained, ferruginous.
			Sample 4 (93'6" - 95'5")
93'6"	94'7"	1'1"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and rust brown clay galls.
94'7"	95'1"	6"	Sandstone, maroon, coarse grained, ferruginous, contains abundant maroon shale partings parallel to the bedding planes.

HOLE NUMBER: T4-3A

Depth in feet From	To	Thickness	Description
0	4'	4'	Overburden
4'	9'	5'	Sandstone, maroon, coarse grained, conglomeratic, ferruginous; contains quartz granules and contained vugs; weathered and broken. Includes 8" core loss.
9'	10'2"	1'2"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous, contains maroon shale partings parallel to the bedding planes.
10'2"	18'8"	8'6"	Sandstone, maroon, fine to coarse grained ferruginous, badly weathered and broken. Contains scattered maroon shale partings parallel to the bedding planes. Includes 1'5" core loss.
18'8"	24'10"	6'2"	Sandstone, maroon, coarse grained, conglomeratic ferruginous; contains quartz granules, clay galls and contained vugs, weathered and broken; contains maroon shale partings parallel to the bedding planes.
24'10"	26'	1'2"	Shale maroon, weathered, includes 1'1" core loss.
26'	28'10"	2'10"	Sandstone, maroon, fine grained to medium grained, ferruginous; contains abundant maroon shale partings and maroon clay galls; broken and weathered.
28'10"	32'6"	3'8"	Sandstone, maroon, coarse grained, ferruginous conglomeratic, contains quartz granules and vugs weathered.
32'6"	32'10"	4"	Sandstone, maroon, fine grained, ferruginous contains maroon shale partings, broken.
32'10"	33'3"	5"	Shale, maroon, broken.
33'3"	33'5"	2"	Shale, pale yellowish brown.
33'5"	36'	7"	Shale pale gray to pale grayish green, unctuous, weathered.
36'	36'6"	6"	Shale, yellowish brown to maroon.
36'6"	46'7"	10'1"	Shale, pale olive drab to pale grayish green, contains partings and lenses of yellowish brown shale, unctuous, includes 2'6" core loss.
46'7"	49'7"	3'	Shale, pale grayish green to pale grayish lavender, contains scattered partings of yellowish brown shale, unctuous.

Depth in Feet			Description
From	To	Thickness	
49'7"	49'11"	4"	Sandstone, yellowish brown fine grained.
49'11"	52'	2'1"	Shale, pale grayish green, contains lenses and partings of yellowish brown shale, includes 5" core gain.
52'	53'9"	1'9"	Shale, pale olive drab.
53'9"	54'4"	7"	Shale, pale olive drab, sandy.
54'4"	54'6"	2"	Sandstone, pale gray, shaly, fine grained.
54'6"	54'10"	4"	Shale, pale olive drab.
54'10"	56'1"	1'3"	Sandstone, gray, fine grained, includes 4" core loss.
56'1"	56'4"	3"	Shale, pale greenish gray to olive drab.
56'4"	56'7"	3"	Sandstone, maroon, fine grained.
56'7"	57'6"	11"	Shale, pale olive drab to yellowish orange.
57'6"	58'3"	9"	Sandstone, grayish maroon, fine grained.
58'3"	58'9"	6"	Shale, pale grayish green to pale olive drab.
58'9"	59'	3"	Sandstone, grayish maroon, fine grained.
59'	59'3"	3"	Shale, pale gray.
59'3"	59'6"	3"	Shale, maroon, contains partings of maroon, fine grained sandstone.
59'6"	60'	6"	Shale, grayish green to maroon.
60'	60'4"	4"	Sandstone, pale gray, fine grained.
60'4"	62'	1'8"	Shale and intercalated sandstone; shale, maroon; sandstone maroon, fine grained, includes 1' core loss.
62'	70'	8'	Sandstone, maroon, fine to medium grained, contains abundant partings of maroon shale parallel to the bedding planes.
70'	70'2"	2"	Sandstone, pale gray, fine grained.
70'2"	70'7"	5"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings.

Depth in feet From	To	Thickness	Description
70'7"	70'10"	3"	Sandstone, grayish maroon, fine grained.
70'10"	72'11"	2'1"	Sandstone, maroon, fine grained, ferruginous.
72'11"	77'	4'1"	Shale, maroon, contains scattered interbeds and partings of maroon, fine to medium grained ferruginous sandstone (includes 1'6" core loss).
77'	82'10"	5'10"	Shale, pale greenish gray, contains interbeds intercalations and irregular lenses of gray fine grained quartzitic sandstone.
82'10"	83'5"	7"	Sandstone, grayish green, fine grained quartzite.
83'5"	86'3"	2'10"	Shale, pale greenish gray, contains interbeds and irregular lenses of gray, fine grained quartzitic sandstone.
86'3"	87'	9"	Sandstone, gray to pale grayish white, fine grained, quartzitic, contains irregular partings of grayish black, shale parallel to the bedding planes. Includes 4" core gain.
87'	87'3"	3"	Shale, grayish black.
87'3"	88'	9"	Sandstone, gray to olive gray, fine grained.
88'	88'4"	4"	Shale, gray, contains rust yellow partings.
88'4"	93'3"	4'11"	Sandstone, gray, fine grained, quartzitic, includes 3" core loss.

Bottom of hole.

Log of Split Core — Date: Wednesday, November 8, 1961

Depth in feet From	To	Description
0	4'	Overburden
Sample 1 (4' - 7'9")		
4'	7'9"	Sandstone, maroon to grayish maroon, coarse grained, conglomeratic, contains clay galls and quartz granules, slightly ferruginous, weathered and broken.
7'9"	9'	Shale, pale drab maroon, weathered contains interbeds of maroon coarse grained sandstone, weathered and broken; includes 8" core loss.
Sample 2 (9' - 18'6")(Note: This not so good but sampled anyhow)		
9'	18'6"	Sandstone, drab grayish maroon, fine grained to medium grained, slightly ferruginous, contains abundant maroon shale partings and interbeds parallel to the bedding planes; contains maroon clay galls; badly broken and weathered. Includes 1'5" core loss.
Sample 3 (18'6" - 24'9") (Note: This not good either but sampled)		
18'6"	24'9"	Sandstone, drab maroon, coarse grained, slightly ferruginous; conglomeratic, contains quartz granules and contained vugs; weathered and broken, contains scattered maroon shale partings.
24'9"	26'	Shale, maroon, weathered; includes 1'1" core loss.
26'	28'10"	Sandstone and shale, sandstone maroon, fine to medium grained slightly ferruginous; contains abundant maroon shale partings and maroon clay galls.
Sample 4 (28'10" - 32'6")		
28'10"	32'6"	Sandstone, maroon, coarse grained, slightly ferruginous, conglomeratic; contains quartz granules and contained vugs; weathered and friable.
32'6"	32'10"	Sandstone, maroon, fine grained, broken. Contains abundant maroon shale partings.
32'10"	62'	See log.

Depth in feet		Description
From	To	
Sample 5 (62' - 68'5")		
62'	68'5"	Sandstone, maroon, fine to medium grained, ferruginous, contains partings of maroon shale parallel to the bedding planes.
68'5"	70'	Shale, maroon, contains abundant intercalations and interbeds of maroon fine grained, slightly ferruginous sandstone.
70'	70'2"	Sandstone, pale gray, fine grained.
70'2"	70'7"	Sandstone, maroon, fine grained slightly ferruginous contains maroon shale partings.
70'7"	70'10"	Sandstone, grayish maroon, fine grained.
Sample 6 (70'10" - 72'11")		
70'10"	72'11"	Sandstone, pale grayish maroon to maroon, fine grained, ferruginous.
72'11"	93'3"	See log.

End of Sampling

HOLE NUMBER: T4-16A

Drill alignment: Vertical
Date started:
Date completed:

Driller: Vaughan Bowling, Cunningham Core Drilling and Grouting Co.

Depth in Feet			Description
From	To	Thickness	
0	3'	3'	Overburden.
3'	11'6"	8'6"	Sandstone, maroon, coarse grained, ferruginous; contains quartz granules, maroon clay galls and sporadic rust brown clay galls; also includes contained vugs, weathered and broken. Includes 2'6" core loss, probably maroon shale.
11'6"	17'5"	5'11"	Sandstone, maroon, fine to medium grained, ferruginous; contains maroon clay galls and maroon shale partings; broken, includes 1'6" core loss, probably maroon shale.
17'5"	17'11"	6"	Sandstone, dark maroon, coarse grained, slightly ferruginous; contains maroon clay galls; rock broken.
17'11"	18'	1"	Sandstone, pale tan to rust brown, fine grained.
18'	22'10"	4'10"	Shale, pale grayish green to pale yellowish tan, unctuous; includes 3'9" core loss.
22'10"	24'2"	1'4"	Shale, pale yellowish tan to pinkish tan, unctuous.
24'2"	24'10"	8"	Shale, pale yellowish tan; contains interbeds of pale gray sandy shale.
24'10"	25'4"	6"	Sandstone, pale gray to mottled rust brown, fine grained, shaly and platy.
25'4"	25'10"	6"	Shale, pale gray to pale lavender; contains sporadic rust brown partings of shaly sandstone parallel to the bedding planes.
25'10"	26'3"	5"	Sandstone, pale gray to pale rust brown, fine grained.
26'3"	28'6"	2'3"	Shale, pale grayish purple to pale olive drab, contains rust brown shale partings parallel to the bedding planes.
28'6"	30'11"	2'5"	Shale, pale grayish green, contains sporadic rust brown paper thin shale partings parallel to the bedding planes; contains gray fine grained sandstone interbeds and intercalations. These sandstone interbeds contain ostracod remains Zygosella sp and Mostigobolbina sp.

Depth in feet			Description
From	To	Thickness	
30'11"	31'2"	3"	Shale, pale rust brown to grayish green.
31'2"	31'4"	2"	Sandstone, gray, medium to coarse grained quartzitic.
31'4"	31'8"	4"	Shale, greenish gray to pale olive drab; contains scattered brachiopod fragments.
31'8"	31'10"	2"	Sandstone, pale grayish maroon, fine grained.
31'10"	32'	2"	Shale, pale gray includes 4" core gain.
32'	32'9"	9"	Shale, pale gray.
32'9"	33'5"	8"	Sandstone, pale grayish maroon, fine grained, platy.
33'5"	34'11"	1'6"	Shale, pale gray to tan, unctuous, contains rust brown sandy shale partings parallel to the bedding planes.
34'11"	35'5"	6"	Shale tan to sienna.
35'5"	35'6"	1"	Shale, bright maroon.
35'6"	36'	6"	Shale and sandstone, shale chocolate to rust brown and black, contains irregular manganese partings; sandstone, pale gray, fine grained.
36'	36'5"	5"	Sandstone, grayish maroon, fine to coarse grained, ferruginous, contains maroon galls and scattered quartz granules, vuggy.
36'5"	36'10"	5"	Shale, pale pea green to greenish gray.
36'10"	37'1"	3"	Sandstone, grayish maroon, includes 3" core gain, fine grained, slightly ferruginous.
37'1"	37'3"	2"	Shale, pale brown.
37'3"	37'8"	5"	Shale, pale brown, contains interbeds of maroon, fine grained ferruginous sandstone.
37'8"	38'2"	6"	Shale, pale grayish green.
38'2"	38'5"	3"	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings.
38'5"	38'8"	3"	Shale, pale gray to pale lavender.
38'8"	38'10"	2"	Sandstone, gray to rust brown, fine grained.

Depth in feet			Description
From	To	Thickness	
38'10"	40'6"	1'8"	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings parallel to the bedding planes; contains sporadic encrustations of wavelite.
40'6"	41'	6"	Sandstone, maroon, fine grained, ferruginous, contains clay galls and quartz granules.
41'	46'	5'	Sandstone, maroon, fine to medium grained, ferruginous, contains abundant maroon shale partings and intercalations parallel to the bedding planes. Includes 2' core loss.
46'	52'	6'	Sandstone, maroon, medium to coarse grained, ferruginous, contains quartz granules; contains abundant maroon shale partings parallel to the bedding planes. Includes 1'6" core loss.
52'	52'5"	5"	Shale, maroon to pale olive drab.
52'5"	52'7"	2"	Sandstone, pale grayish maroon, fine grained.
52'7"	53'5"	10"	Sandstone, maroon, fine grained, ferruginous, contains sporadic quartz granules.
53'5"	53'10"	5"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and abundant maroon shale partings up to 1/4 inch in thickness.
53'10"	54'1"	3"	Shale, drab maroon.
54'1"	54'3"	2"	Sandstone, maroon, fine grained ferruginous.
54'3"	54'10"	7"	Shale, drab maroon, contains partings of maroon fine to coarse grained ferruginous sandstone.
54'10"	55'2"	4"	Sandstone, maroon, coarse grained, ferruginous.
55'2"	56'	10"	Shale, drab maroon, contains partings of fine to coarse grained maroon ferruginous sandstone.
56'	57'	1'	Shale, pale brown to pale grayish maroon, includes 4" core loss.
57'	57'4"	4"	Sandstone, gray to grayish maroon, fine grained, contains rust brown shaly sandstone partings.
57'4"	59'	1'8"	Shale, pale gray, contains 2" of grayish maroon, fine grained sandstone; includes 1' core loss.

Depth in feet			Description
From	To	Thickness	
59'	60'1"	1'1"	Shale, gray to tan, contains abundant rust brown, fine grained sandstone interbeds averaging 1/2 inch in thickness and rust brown shaly sandstone partings parallel to the bedding planes.
60'1"	60'10"	9"	Shale, pale tan to brownish gray, contains two maroon shale partings parallel to the bedding planes.
60'10"	61'3"	5"	Shale, grayish green.
61'3"	61'5"	2"	Shale, tan.
61'5"	61'10"	5"	Shale, grayish green.
61'10"	62'1"	3"	Sandstone gray to grayish green, fine grained quartzitic.
62'1"	62'6"	5"	Shale, maroon to grayish green.
62'6"	63'	6"	Sandstone, gray to grayish green, fine grained, quartzitic, platy. 3 inches left in hole.

End of hole.

Log of Split Core T4-16A

Date Logged: November 18, 1961

Depth in feet From	To	Thickness	Description
			Sample 1 (3' - 11'6")
3'	11'6"	8'6"	Sandstone, maroon, fine to coarse grained, ferruginous, contains quartz granules, maroon caly galls and sporadic yellowish brown to rust brown clay galls. Also contains vugs and yellowish brown shale partings. Includes 2'6" core loss probably maroon shale.
			Sample 2 (11'6" - 17'11")
11'6"	17'5"	5'11"	Sandstone, maroon, fine to medium grained, ferruginous, contains maroon clay galls and maroon shale partings, broken includes 1'6" core loss.
17'5"	17'11"	6"	Sandstone, dark maroon, coarse grained, ferruginous, contains maroon clay galls, broken.
			Sample 3 (36' - 37'1")
36'	36'5"	5"	Sandstone, maroon, fine to coarse grained, ferruginous, contains scattered quartz granules, vuggy.
36'5"	36'10"	5"	Shale, pale pea green to greenish gray.
36'10"	37'1"	3"	Sandstone, grayish maroon, fine grained, slightly ferruginous; includes 3" core gain.
			Sample 4 (40'6" - 46')
40'6"	41'	6"	Sandstone, maroon, fine grained, ferruginous, contains clay galls and quartz granules.
41'	46'	5'	Sandstone, maroon, fine to medium grained, ferruginous, contains abundant maroon shale partings and intercalations parallel to the bedding planes. Includes 2' core loss. Contains wavelite seam at 42'10". Shale comprises about 35%.
			Sample 5 (46' - 52')
46'	52'	6'	Sandstone, maroon, medium to coarse grained, ferruginous, contains quartz granules and abundant maroon shale partings parallel to the bedding planes. Includes 1'6" core loss. Also contains sporadic wavelite encrustations at 51'.
52'	52'5"	5"	Shale, maroon to pale olive drab.
52'5"	52'7"	2"	Sandstone, pale grayish maroon, fine grained.

Log of Split Core T4-16A

Date Logged: November 18. 1961

Depth in feet			Description
From	To	Thickness	
			Sample 1 (3' - 11'6")
3'	11'6"	8'6"	Sandstone, maroon, fine to coarse grained, ferruginous, contains quartz granules, maroon caly galls and sporadic yellowish brown to rust brown clay galls. Also contains vugs and yellowish brown shale partings. Includes 2'6" core loss probably maroon shale.
			Sample 2 (11'6" - 17'11")
11'6"	17'5"	5'11"	Sandstone, maroon, fine to medium grained, ferruginous, contains maroon clay galls and maroon shale partings, broken includes 1'6" core loss.
17'5"	17'11"	6"	Sandstone, dark maroon, coarse grained, ferruginous, contains maroon clay galls, broken.
			Sample 3 (36' - 37'1")
36'	36'5"	5"	Sandstone, maroon, fine to coarse grained, ferruginous, contains scattered quartz granules, vuggy.
36'5"	36'10"	5"	Shale, pale pea green to greenish gray.
36'10"	37'1"	3"	Sandstone, grayish maroon, fine grained, slightly ferruginous; includes 3" core gain.
			Sample 4 (40'6" - 46')
40'6"	41'	6"	Sandstone, maroon, fine grained, ferruginous, contains clay galls and quartz granules.
41'	46'	5'	Sandstone, maroon, fine to medium grained, ferruginous, contains abundant maroon shale partings and intercalations parallel to the bedding planes. Includes 2' core loss. Contains wavelite seam at 42'10". Shale comprises about 35%.
			Sample 5 (46' - 52')
46'	52'	6'	Sandstone, maroon, medium to coarse grained, ferruginous, contains quartz granules and abundant maroon shale partings parallel to the bedding planes. Includes 1'6" core loss. Also contains sporadic wavelite encrustations at 51'.
52'	52'5"	5"	Shale, maroon to pale olive drab.
52'5"	52'7"	2"	Sandstone, pale grayish maroon, fine grained.

Depth in feet From	To	Thickness	Description
			Sample 6 (52'7" - 55'2")
52'7"	53'5"	10"	Sandstone, maroon, fine grained, ferruginous, contains sporadic quartz granules.
53'5"	53'10"	5"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and abundant maroon shale partings up to 1/4" in thickness.
53'10"	54'1"	3"	Shale, drab maroon.
54'1"	54'3"	2"	Sandstone, maroon, fine grained, ferruginous.
54'3"	54'10"	7"	Shale, drab maroon, contains partings of maroon fine to coarse grained ferruginous sandstone.
54'10"	55'2"	4"	Sandstone, maroon, coarse grained, ferruginous.

End of Sampling.

HOLE NUMBER: T4A-21A

Date Started: December 18, 1961
Date Completed: January 19, 1962
Driller: M. C. Vaughan, Cunningham Core Drilling & Grouting Co.
Hole alignment: Vertical

Depth in feet			Description
From	To	Thickness	
0	4'7"	4'7"	Overburden (workable Clinton).
4'7"	6'	1'5"	Sandstone, maroon, coarse grained, ferruginous, broken includes 7" core loss.
6'	6'4"	4"	Shale, pale green.
6'4"	7'2"	10"	Sandstone, maroon, fine to medium grained, thin bedded, broken, ferruginous; contains partings of maroon shale.
7'2"	8'6"	1'4"	Shale, maroon, unctuous, contains several 1" [illegible] of ferruginous sandstone.
8'6"	10'7"	2'1"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules. Interval includes 1'8" core loss.
10'7"	23'4"	12'9"	Sandstone, maroon, fine to coarse grained, ferruginous, broken. Includes 3'11" core loss.
23'4"	23'8"	4"	Shale, maroon to pale greenish yellow.
23'8"	24'	4"	Sandstone, pale grayish brown to tan, fine grained.
24'	25'5"	1'5"	Sandstone, maroon, fine grained, ferruginous. Includes 6" core loss.
25'5"	26'	7"	Shale, maroon, contains fragments of maroon, fine grained, ferruginous sandstone. Includes 6" core loss.
26'	26'1"	1"	Sandstone, maroon, fine grained, ferruginous.
26'1"	26'2"	1"	Shale, maroon.
26'2"	26'8"	6"	Shale, pale gray to pale grayish green, unctuous.
26'8"	28'	1'4"	Sandstone, maroon, fine grained, ferruginous, [illegible] 7" core loss.
28'	29'6"	1'6"	Shale, pale greenish gray, contains several partings of pale maroon shale.

Depth in Feet			Description
From	To	Interval	
29'6"	3[illegible]' [illegible]"	[illegible]"	Shale, [illegible] greenish gray, contains several [illegible]s [illegible] of [illegible] gray fine grained sandstone [illegible] partings of maroon and rust brown shale [illegible]. Includes [illegible]" core loss.
33'11"	34'3"	4"	Shale, pale rust brown to tan. Includes [illegible] of rust brown fine grained sandstone.
34'3"	[illegible]'	[illegible]'[illegible]"	Shale, pale grayish tan to pale greenish gray. Includes [illegible]'[illegible]" core loss.
[illegible]'	[illegible]'[illegible]"	[illegible]'[illegible]"	Shale, [illegible] brown.
[illegible]'[illegible]"	[illegible]'	[illegible]'3"	Shale, pale gray to grayish maroon, [illegible]. Interval includes [illegible]" core loss.
[illegible]'	[illegible]'	[illegible]'	[illegible]stone [illegible] maroon, fine grained ferruginous [illegible] maroon shale partings parallel to the bedding planes.
[illegible]'	[illegible]'[illegible]"	[illegible]"	Shale, pale gray [illegible] green.
56'[illegible]"	[illegible]'[illegible]"	[illegible]"	Sandstone, [illegible] grayish maroon, fine grained.
56'[illegible]"	[illegible]	[illegible]	Sandstone, [illegible] maroon, fine grained, ferruginous.
[illegible]	[illegible]	[illegible]"	Sandstone, [illegible] maroon, fine grained, ferruginous, [illegible] abundant maroon shale partings parallel to the bedding planes.
[illegible]'[illegible]"	5[illegible]'[illegible]"	[illegible]"	Shale, pale maroon.
5[illegible]'10"	[illegible]	[illegible]"	[illegible], [illegible] maroon, fine grained, slightly [illegible]; contains partings of maroon shale parallel to the bedding planes.
58'[illegible]"	[illegible]	[illegible]	Shale, [illegible] rust brown.
[illegible]	[illegible]	[illegible]	Shale, pale maroon.
[illegible]	[illegible]	[illegible]"	Shale, maroon; contains lenses and partings of fine grained ferruginous maroon sandstone.
[illegible]'5"	[illegible]'3"	[illegible]	Sandstone, [illegible] maroon, fine to coarse grained [illegible]; contains abundant (40%) maroon shale [illegible] parallel to the bedding planes.
[illegible]'[illegible]"	[illegible]'	[illegible]"	Shale, [illegible] maroon, sandy.

Depth in feet From	To	Thickness	Description
29'6"	33'11"	4'5"	Shale, pale greenish gray, contains several lenses and interbeds of pale gray fine grained sandstone and includes partings of maroon and rust brown shale at 31'6". Includes 7" core loss.
33'11"	34'3"	4"	Shale, pale rust brown to tan. Includes interbeds of rust brown fine grained sandstone.
34'3"	43'	8'9"	Shale, pale grayish tan to pale greenish gray. Includes 7'3" core loss.
43'	46'4"	3'4"	Shale, rust brown.
46'4"	53'	6'8"	Shale, pale gray to grayish maroon, unctuous. Interval includes 5'2" core loss.
53'	56'	3'	Sandstone drab maroon, fine grained ferruginous contains maroon shale partings parallel to the bedding planes.
56'	56'3"	3"	Shale, pale grayish green.
56'3"	56'8"	5"	Sandstone, drab grayish maroon, fine grained.
56'8"	57'3"	7"	Sandstone, drab maroon, fine grained, ferruginous.
57'3"	57'7"	4"	Sandstone, drab maroon, fine grained, ferruginous, contains abundant maroon shale partings parallel to the bedding planes.
57'7"	57'10"	3"	Shale, pale maroon.
57'10"	58'7"	9"	Sandstone, drab maroon, fine grained, slightly ferruginous; contains partings of maroon shale parallel to the bedding planes.
58'7"	59'2"	7"	Shale, pale rust brown.
59'2"	59'6"	4"	Shale, pale maroon.
59'6"	60'5"	11"	Shale, maroon; contains lenses and partings of fine grained ferruginous maroon sandstone.
60'5"	62'8"	2'3"	Sandstone, drab maroon, fine to coarse grained ferruginous; contains abundant (40%) maroon shale partings and lenses parallel to the bedding planes.
62'8"	63'	4"	Shale, gray and maroon, sandy.

Depth in feet			Description
From	To	Thickness	
63'	64'2"	1'2"	Sandstone, drab grayish maroon, slightly ferruginous, quartzitic. Interval includes 6" core loss.
64'2"	64'4"	2"	Shale, maroon to brown.
64'4"	66'2"	1'10"	Sandstone, drab grayish maroon, fine to medium grained, ferruginous; contains abundant maroon shale partings, broken, includes 3" core loss.
66'2"	67'8"	1'6"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and vugs.
67'8"	68'6"	10"	Shale, drab maroon, contains interbeds of fine grained maroon ferruginous sandstone, broken and crumbly. Includes 6" core loss.
68'6"	69'10"	1'4"	Sandstone, maroon, coarse grained, ferruginous; contains maroon and rust brown clay balls and quartz granules.
69'10"	76'	6'2"	Shale, drab maroon, contains sporadic lenses of fine to medium grained ferruginous sandstone broken and crumbly. Includes 3'3" core loss.
76'	76'5"	5"	Sandstone, drab maroon, fine grained, slightly ferruginous, broken.
76'5"	81'	4'7"	Shale, pale rust brown to pale tan to grayish green; contains lenses and partings of pale rust brown fine grained quartzitic sandstone. Includes 2'3" core loss.

End of Hole.

Log of Split Core

Depth in feet			Description
From	To	Thickness	
			Sample 1 (4'7" - 7'2")
4'7"	6'1"	1'6"	Sandstone, maroon, fine to coarse grained, ferruginous, broken, weathered, includes [illegible] core loss.
6'1"	6'4"	3"	Shale, pale green, not sampled.
6'4"	6'7"	3"	Sandstone, maroon, fine to medium grained, ferruginous.
6'7"	7'2"	7"	Sandstone, maroon, fine grained, ferruginous, thin bedded, broken; contains abundant maroon and rust brown shale partings parallel to the bedding planes.
			Sample 2 (7'2" - 8'6")
7'2"	8'6"	1'4"	Shale, maroon, contains interbeds and [illegible] of maroon, fine to coarse grained ferruginous [illegible], broken.
			Sample 3 (8'6" - 23')
8'6"	10'7"	2'1"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules. Interval includes 1'8" core loss.
10'7"	23'4"	12'9"	Sandstone, maroon, fine to coarse grained, ferruginous, broken, includes 3'11" core loss.
			Sample 4 (24' - 28') (Note: Shale not sampled.)
24'	25'5"	1'5"	Sandstone, maroon, fine grained, ferruginous. Includes 6" core loss.
25'5"	26'	7"	Shale, maroon, contains fragments of maroon fine grained ferruginous sandstone. Includes 6" core loss.
26'	26'1"	1"	Sandstone, maroon, fine grained, ferruginous.
26'1"	26'2"	1"	Shale, maroon.
26'2"	26'8"	6"	Shale, pale gray to pale grayish green, [illegible].
26'8"	28'	1'4"	Sandstone, maroon, fine grained, ferruginous, includes 7" core loss.

28' - 53' See log.

Depth in feet			Description
From	To	Thickness	
			Sample 5 (53' - 56')
53'	56'	3'	Sandstone, maroon, fine grained, ferruginous, contains sporadic partings of maroon shale.
56'	56'3"	3"	Shale, pale tan to greenish gray, not sampled.
56'3"	56'8"	5"	Sandstone, drab grayish tan, fine grained quartzitic.
			Sample 6 (56'8" - 58'7")
56'8"	57'3"	7"	Sandstone, drab maroon, fine grained, ferruginous.
57'3"	57'7"	4"	Sandstone, drab maroon, fine grained, ferruginous, contains abundant maroon shale partings parallel to the bedding planes.
57'7"	57'10"	3"	Shale, pale maroon, not sampled.
57'10"	58'7"	9"	Sandstone, drab maroon, fine grained, slightly ferruginous, contains partings of maroon shale parallel to the bedding planes.
			58'7" - 60'5" See log not sampled.
			Sample 7 (60'5" - 64'2") Note shale units not sampled
60'5"	62'8"	2'3"	Sandstone, drab maroon, fine to coarse grained, ferruginous, contains abundant (40%) maroon shale partings and lenses parallel to the bedding planes.
62'8"	63'	4"	Shale, gray and maroon, sandy, not sampled.
63'	64'2"	1'2"	Sandstone, drab grayish maroon, slightly ferruginous, quartzitic, interval includes 6" core loss.
64'2"	64'4"	2"	Shale, maroon to brown, not sampled.
			Sample 8 (64'4" - 66'2")
64'4"	66'2"	1'10"	Sandstone, drab grayish maroon, fine to medium grained, ferruginous, contains maroon shale partings, broken, includes 3" core loss.
			Sample 9 (66'2" - 69'10")
66'2"	67'8"	1'6"	Sandstone, maroon, coarse grained, ferruginous, quartz granules and vugs.

Depth in feet			Description
From	To	Thickness	
67'8"	68'6"	10"	Shale drab maroon, contains interbeds of fine grained maroon sandstone ferruginous, broken and crumbly. Includes 6" core loss.
68'6"	69'10"	2'4"	Sandstone, maroon, coarse grained, ferruginous, contains maroon and rust brown clay galls and quartz granules.

End of Sampling.

Description of Drill Cores

Hole Number: T5-10A
Drill Alignment: N. 55 E. - 15 S. E.
Elevation: 3,425 Date: September 18, 1961, Monday

Depth in feet From	To	Description
0	5'6"	Overburden
5'6"	7'9"	Sandstone, maroon, fine to medium grained, slightly ferruginous. (Core loss 7")
7'9"	10'	Shale and interbedded maroon sandstone; shale, yellowish brown weathered, contains partings of maroon sandstone, vuggy. (Core loss 1'1")
10'	15'8"	Sandstone, maroon, medium to coarse grained, weathered, friable, ferruginous. (Core loss 1'2")
15'8"	20'8"	Sandstone, maroon, fine to medium grained; contains maroon clay interbeds. (Core loss 3'8")
	20'8"	Total Footage Drilled for the Day.

Description of Drill Cores

Hole Number: T5-10A
Drill Alignment: N. 55 E. - 15 S. E.
Elevation: 3,425 Date: September 19, 1961, Tuesday

Depth in feet From	To	Description
20'8"	27'	Sandstone, maroon, fine to medium grained, weathered and fractured, contains maroon clay interbeds. (Core loss 3'10")
27'	31'	Sandstone, maroon, fine to medium grained, weathered and broken, contains brown shale interbeds. (3'3" Core loss)
31'	37'6"	Sandstone, maroon, fine to medium grained, contains section of maroon and pale green shale. (Core loss 4'4")

Description of Drill Cores

Hole Number: T5-10A
Drill Alignment: N. 55 E. - 15 S. E.
Elevation: 3,425 Date: September 19, 1961, Tuesday

Depth in feet From	To	Description
37'6"	42'4"	Shale, pale green, clayey and unctuous. (Core loss 2'11")
42'4"	42'9"	Sandstone, maroon, fine grained, non ferruginous.
42'9"	42'11"	Shale, gray, clayey.
42'11"	43'10"	Shale, maroon, to pale purple, clayey.
43'10"	44'4"	Shale, pale grayish green.
44'4"	44'11"	Sandstone, maroon, fine grained.
44'11"	45'	Shale, grayish green.
45'	47'	Shale, pale grayish maroon, unctuous plactic. (10" Core loss)
47'	52'	Shale, maroon, contains maroon sandstone, interbeds and several gray shale clay seams. (Core loss 3'1")
52'	54'7"	Shale, gray, contains rust brown shale partings and pale yellow shale partings. (Core loss 7")
54'7"	59'	Sandstone, gray, fine grained quartzitic. (Core loss 3'4")
	38'4"	Total Footage Drilled for the Day.

T5-10A Log of Split Core

Date Logged: November 18, 1961

Depth in feet From	To	Thickness	Description
			Sample 1 (6' - 15')
6'	7'10"	1'10"	Sandstone, maroon, fine to coarse grained, contains quartz granules, ferruginous, includes 7" core loss.
7'10"	10'	2'2"	Sandstone, grayish maroon, contains rust brown shale partings and irregular manganese partings, slightly ferruginous. Includes 1'1" core loss, broken.
10'	15'	5'	Sandstone, maroon, coarse grained, ferruginous contains quartz granules and rust brown shale partings that are also filled with botryoidal manganese, broken.
			Sample 2 (37' - 37'7")
37'	37'7"	7"	Sandstone, maroon, fine to coarse grained ferruginous.

Description of Drill Cores

Hole Number: T5-13A

Elevation: 3450 Date: September 20, 1961, Monday

Depth in feet		Description
From	To	
0	5'	Overburden
5'	5'10"	Sandstone, maroon, coarse grained, ferruginous; fractured.
5'10"	8'6"	Sandstone, maroon, fine grained, ferruginous; fractured.
8'6"	13'8"	Sandstone, fine grained, maroon, ferruginous; fractured; contains rust brown, weathered clay and shale seams.
	13'8"	Total Footage Drilled for the Day.

Hole Number: T5-13A

Elevation: 3450 Date: September 21, 1961, Tuesday

Depth in feet		Description
From	To	
13'8"	14'5"	Sandstone, maroon, fine grained, ferruginous.
14'5"	16'6"	Sandstone, maroon, coarse grained, ferruginous; contains quartz granules, clay galls and rust brown weathered shale partings.
16'6"	17'4"	Same as above, badly fractured.
17'4"	18'8"	Shale, rust brown; weathered and fractured, contains maroon sandstone intercalations. (Core loss 9")
18'8"	22'7"	Shale, maroon; conatins maroon sandstone intercalations.
22'7"	23'11"	Sandstone, maroon, fine grained; badly fractured.
23'11"	24'3"	Sandstone, maroon, coarse grained, ferruginous.
24'3"	25'2"	Shale, maroon. (Core loss 10")

T5-13A

Description of Drill Cores

Hole Number: T5-13A

Elevation: 3450 Date: September 21, 1961, Tuesday

Depth in feet From	To	Description
25'2"	25'6"	Sandstone, maroon, fine grained.
25'6"	26'8"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous, vuggy; contains clay galls and quartz granules.
26'8"	32'	Sandstone, maroon, fine to coarse grained; contains maroon shale partings. (Core loss 4'6")
32'	38'3"	Shale, gray, contains rust brown partings.
38'3"	38'6"	Sandstone, pale grayish grown, fine grained, contains rust brown partings.
38'6"	38'8.5"	Sandstone, pale gray to grayish maroon.
38'8.5"	40'4"	Shale, maroon to purple, contains rust borwn partings.
40'4"	42'1"	Shale, gray unctuous. (Core loss 1')
42'1"	43'1"	Sandstone, maroon, fine grained.
43'1"	43'2"	Sandstone, maroon, coarse grained, vuggy.
43'2"	49'1"	Shale, gray, unctuous. (4'10" Core Loss)
49'1"	50'2"	Shale, ocher, fractured.
50'2"	51'6"	Sandstone, grayish brown, fine grained, contains ocher shale partings; highly fractured.
51'6"	52'8"	Sandstone, pale grey to pale grayish-tan, fine grained.
52'8"	54'9"	Sandstone, pale gray to pale brown, sandy.
54'9"	57'	Sandstone, pale grayish green, shaly; contains rust brown partings.
57'	61'	Sandstone, pale grayish green, fine grained; contains rust brown shale partings; rust brown mottlings possibly caused by weathering of pyrite crystals. Last 2 feet contains sporadic plant fossils.

	47'4"	Total Footage Drilled for the Day.

Description of Drill Cores

Hole Number: T5-13A

Elevation: 3450 | Date: September 22, 1961, Friday

Depth in feet From	To	Description
61'	62'	Sandstone, grayish brown, fine grained.
62'	62'1"	Sandstone, maroon, fine grained.
62'1"	65'1"	Shale, maroon. (Core loss 3', all lost)
65'1"	65'6"	Sandstone, light brown, fine grained.
65'6"	66'	Sandstone, gray contains rust brown shale partings.
66'	67'	Sandstone, maroon, contains maroon shale partings and grayish green clay galls.
67'	67'5"	Sandstone, grayish maroon, fine grained.
67'5"	71'5"	Shale, greenish gray; contains rust brown clay partings and grey, fine grained sandstone intercalations.
71'5"	71'10"	Sandstone, grey, fine grained.
71'10"	77'6"	Shale, gray to pale grayish green; contains light brown fine grained sandstone intercalations and rust brown shale partings. (Core loss 4')
77'6"	78'	Sandstone, light brown, fine grained; contains shale partings and rust brown.
78'	79'9"	Sandstone, pale grey, fine grained, quartzite; contains rust brown clay partings.
79'9"	80'4"	Sandstone, pale gray white to brown, fine grained.
80'4"	88'	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings and interbeds; badly broken. (Core loss 1'5")
	27'	Total Footage Drilled for the Day.

T5-13A
0-657

Description of Drill Cores

Hole Number: T5-13A

Elevation: 3450 Date: September 25, 1961, Monday

Depth in feet From	To	Description
88'	92'	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings and interbeds badly broken. (Core loss 1'6")
92'	94'	Sandstone, maroon, fine grained, ferruginous, contains widely scattered clay galls and maroon shale partings.
94'	97'4"	Sandstone, brown to pale gray, fine to medium grained, broken and weathered; contains maroon shale intercalations and yellow brown clay galls. (Core loss 9")
97'4"	98'9"	Sandstone, maroon, fine to medium grained, quartzitic; contains rust brown shale partings broken and weathered.
98'9"	99'10"	Sandstone, maroon, coarse grained, conglomeratic; contains abundant quartz granules. (lost 1' ferruginous)
99'10"	100'9"	Sandstone, maroon, fine grained, contains gray shale partings.
100'9"	101'6"	Shale, gray. (Core loss 8")
101'6"	103'10"	Sandstone, gray, fine grained.
103'10"	107'	Intercalated sandstone and shale; sandstone gray to grayish white, fine grained; shale, black.
	19'	Total Footage Drilled for the Day.

HOLE NUMBER: T5-14A

Lessee or permittee: E. L. Koehling Exp
Address: Bramwell, West Virginia
Driller: Norman Bowling Cunningham Core
Drilling Co.
Commenced drilling: September 28, 1961
Finished: October 13, 1961
Method of drilling: Diamond core
Logged by: W. A. Moon
State: Virginia

Depth in feet			Description
From	To	Thickness	
0	22'6"	22'6"	Overburden (Keefer sandstone)
22'6"	25'5"	2'11"	Sandstone, brown to grayish white, mottled, fine to medium grained; friable. Includes 1'6" core loss.
25'5"	29'2"	3'9"	Sandstone, gray to grayish white, fine to coarse grained, conglomeratic, flecked with maroon and rust brown splotches.
29'2"	29'11"	9"	Sandstone, fine grained, rust brown, crumbly.
29'11"	31'11"	2'0"	Sandstone, grayish white, fine to coarse grained contains reddish brown streaks and flecks. Quartzitic.
31'11"	35'	3'1"	Sandstone, white, fine to medium grained, quartzitic.
35'0"	35'3"	3"	Clay, gray.
35'3"	36'9"	1'6"	Sandstone, white, fine to medium grained, quartzitic.
36'9"	36'11"	2"	Clay, gray.
36'11"	38'0"	1'1"	Sandstone, white, fine grained; quartzitic.
38'0"	38'7"	0'7"	Clay gray. Includes 4" core loss.
38'7"	39'2"	0'7"	Sandstone, white, fine to medium grained.
39'2"	39'3"	0'1"	Clay, gray.
39'3"	41'11"	2'8"	Sandstone, white, fine grained, quartzitic. Includes 7" core loss.
41'11"	42'11"	1'0"	Sandstone, white, coarse grained; quartzitic.
42'11"	43'7"	0'8"	Sandstone, white, fine grained, quartzitic.

Depth in feet			Description
From	To	Thickness	
43'7"	44'10"	1'3"	Sandstone, white to grayish white, fine grained, quartzitic.
44'10"	45'1"	3"	Sandstone, gray to grayish black, medium to coarse grained.
45'1"	46'7"	1'6"	Sandstone, gray to grayish black, friable .
46'7"	48'5"	1'10"	Sandstone, grayish black, fine grained, clayey.
48'5"	48'10"	0'5"	Clay, black, sandy.
48'10"	49'1"	0'3"	Clay, grayish maroon.
49'1"	49'2"	0'1"	Sandstone, white to gray, fine grained.
49'2"	49'3"	0'1"	Clay, maroon.
49'3"	49'6"	0'3"	Sandstone, grayish white, fine grained.
49'6"	49'11"	5"	Sandstone, white, fine grained, quartzitic.
49'11"	50'0"	1"	Sandstone, rust brown, fine grained.
50'0"	51'3"	1'3"	Sandstone, white to grayish red, fine grained; quartzitic. Includes 5" core loss.
51'3"	55'11"	4'8"	Sandstone, grayish white to pale grayish brown, fine to medium grained; quartzitic.
55'11"	56'4"	0'5"	Sandstone, gray to grayish brown, fine grained.
56'4"	60'7"	4'3"	Sandstone, grayish white to grayish pink, fine grained; quartzitic. Lower 2 inches fractured.
60'7"	62'4"	1'9"	Sandstone, pale gray to grayish pink, fine grained; quartzitic.
62'4"	63'5"	1'1"	Sandstone, gray, fine grained, quartzitic.
63'5"	65'6"	2'1"	Sandstone, gray, medium to coarse grained, quartzitic.
65'6"	66'2"	0'8"	Sandstone, gray, fine grained, quartzitic; contains [illegible]
66'2"	66'7"	0'5"	Sandstone, grayish pink, fine grained, [illegible]
66'7"	[illegible]	2'5"	Shale, maroon and pale gray, [illegible]. Includes 1'7" core loss.

Depth in feet			Description
From	To	Thickness	
69'0"	70'4"	1'4"	Sandstone, rust brown, fine grained.
70'4"	76'0"	5'8"	Sandstone, yellowish brown, fine to medium grained, friable; contains gray clay partings and [illegible], includes 5' core loss.
76'6"	82'3"	5'9"	Sandstone, pale grayish white, fine [illegible], contains pale green and maroon shale [illegible]. ([illegible] loss 4'1")
82'3"	82'6"	0'3"	Sandstone, brown, fine grained, shaly.
82'6"	86'6"	4'0"	Shale, light brown to pale green, weathered. (Core loss 2'1")
86'6"	88'3"	1'9"	Sandstone, brown to grayish green, fine to medium grained; shaly, fractured.
88'3"	91'6"	3'3"	Shale, rust brown to grayish green. (Includes 2'1" core loss)
91'6"	94'9"	3'3"	Shale, greenish gray; contains grey fine grained sandstone intercalations.
94'9"	97'3"	2'6"	Shale, greenish gray, contains [illegible] intercalations, fine to medium grained. (Includes 1' core loss)
97'3"	97'6"	0'3"	Clinton formation, sandstone, maroon, [illegible], slightly ferruginous.
97'6"	98'2"	0'8"	Sandstone, maroon, fine to medium grained [illegible] rust brown shale interbeds.
98'2"	99'8"	1'6"	Sandstone, maroon, fine grained, slightly ferruginous.
99'8"	100'9"	1'1"	Sandstone, maroon, medium to coarse grained, [illegible]-ginous.
100'9"	106'3"	5'6"	Sandstone, maroon, fine grained, sli[illegible]-ous, contains abundant maroon shale [illegible].
106'3"	106'6"	0'3"	Sandstone, maroon, fine grained, [illegible]
106'6"	108'3"	1'9"	Sandstone, maroon, coarse grained, [illegible]-ous; contains scattered quartz [illegible].
108'3"	118'6"	10'3"	Sandstone, fine to medium grained, [illegible] ferruginous.

Depth in feet From	To	Thickness	Description
118'6"	121'1"	2'7"	Sandstone, maroon, coarse grained, [illegible] ferruginous.
121'1"	126'6"	5'5"	Sandstone, maroon, fine to [illegible], ferruginous.
126'6"	127'6"	1'0"	Sandstone, maroon, coarse grained, [illegible]; contains quartz granules, highly [illegible].
127'6"	129'2"	1'8"	Shale, pale brown to olive drab.
129'2"	134'7"	5'5"	Shale, pale grayish green, [illegible]; contains a 2" bed of grayish fine grained [illegible] at [illegible].
134'7"	134'8"	0'1"	Sandstone, grayish green, fine [illegible].
134'8"	138'5"	3'9"	Shale, pale grayish green, unctuous; contains sporadic plant fossils.
138'5"	146'2"	7'9"	Shale, pale grayish green, unctuous; contains scattered intercalations of pale grayish green fine grained sandstone.
146'2"	146'9"	7"	Sandstone, pale grayish green, fine grained.
146'9"	147'1"	4"	Shale, grayish green.
147'1"	147'6"	5"	Sandstone, pale gray, fine grained.
147'6"	151'7"	4'1"	Shale, pale grayish green, unctuous.
151'7"	152'8"	1'1"	Sandstone, pale grayish maroon, fine [illegible]. Includes 3" core loss.
152'8"	153'3"	0'7"	Sandstone, pale grayish maroon, fine grained; fossiliferous; contains brachiopods.
153'3"	153'9"	0'6"	Shale, pale grayish brown. (Includes 4" core loss)
153'9"	154'9"	1'0"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous.
154'9"	157'8"	2'11"	Sandstone, maroon, fine grained, ferruginous, contains abundant maroon shale partings.
157'8"	158'6"	0'10"	Shale, drab brown, sandy.
158'6"	160'0"	1'6"	Shale, pale grayish green, sandy.

Depth in feet			Description
From	To	Thickness	
160'0"	160'2"	2"	Shale, olive drab.
160'2"	160'9"	7"	Sandstone, pale maroon, fine to coarse grained, slightly ferruginous.
160'9"	161'0"	3"	Shale, maroon.
161'0"	161'4"	4"	Sandstone, pale maroon, coarse grained, slightly ferruginous.
161'4"	162'10"	1'6"	Shale, pale grayish green; contains several intercalations of maroon sandstone.
162'10"	164'2"	1'4"	Shale, pale olive drab to rust brown.
164'2"	164'7"	5"	Sandstone, maroon, fine to medium grained, ferruginous; contains maroon clay galls.
164'7"	169'10"	5'3"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings parallel to the bedding planes.
169'10"	170'1"	0'3"	Shale, grayish green to maroon; contains gray sandstone intercalations.
170'1"	170'6"	0'5"	Sandstone, maroon, fine grained, ferruginous; contains maroon shale partings parallel to the bedding planes.
170'6"	170'10"	0'4"	Shale, grayish green.
170'10"	171'11"	1'1"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings.
171'11"	172'2"	0'3"	Shale, drab maroon.
172'2"	172'8"	0'6"	Sandstone, maroon, coarse grained, [illegible] ferruginous.
172'8"	172'8.5"	0'0.5"	Clay, gray.
172'8.5"	174'1"	1'4.5"	Sandstone, maroon, coarse grained; [illegible], highly ferruginous; contains quartz granules.
174'1"	174'7"	0'6"	Sandstone, maroon, coarse grained, ferruginous; contains maroon shale partings.
174'7"	175'2"	0'7"	Sandstone, maroon, coarse grained; [illegible] ferruginous; contains quartz granules.

Depth in feet			Description
From	To	Thickness	
175'2"	175'9"	0'7"	Shale, grayish green; contains intercalations of maroon sandstone.
175'9"	177'1"	1'4"	Shale, grayish green, unctuous; includes 5" core loss.
177'1"	177'2"	0'1"	Sandstone, maroon, fine grained.
177'2"	177'5"	3"	Clay, gray.
177'5"	184'0"	6'7"	Shale, greenish gray; contains pale gray fine grained sandstone intercalations. Includes 5" core loss.
184'	184'6"	0'6"	Sandstone, pale gray, fine grained.
184'6"	184'11"	0'5"	Sandstone, pale grayish maroon, fine grained.
184'11"	185'8"	0'9"	Sandstone, pale grayish white, fine grained; contains gray shale partings.
185'8"	187'2"	1'6"	Sandstone, pale grayish maroon, fine grained.
187'2"	188'3"	1'1"	Sandstone, pale grayish maroon, fine to medium grained; contains pale green shale partings.
188'3"	188'9"	6"	Sandstone, pale gray to pale grayish green, fine grained; contains black shale partings.
188'9"	189'4"	0'7"	Sandstone, gray to grayish green, coarse grained; conglomeratic; contains shale partings.
189'4"	192'6"	3'2"	Shale, black; contains irregular gray fine grained sandstone intercalations.
192'6"	193'1"	0'7"	Sandstone, gray, coarse grained; contains black limestone pebbles and granules.
193'1"	194'9"	1'8"	Sandstone, gray, fine grained; flecked with black specks, possibly phosphatic fossil remains.
194'9"	196'7"	1'10"	Sandstone, pale greenish gray, fine grained; contains irregular pale green shale partings.

Bottom of hole

LOG OF SPLIT CORE

Date: Saturday, October 21, 1961
Hole: T5-14A (Box 4 of 10)

Depth in feet			Description
From	To	Thickness	
97'6"	98'2"	8"	Sandstone and interbedded shale; sandstone rust brown; contains rust brown shale partings. Sample 1 (98'2" - 101'8")
98'2"	101'8"	3'6"	Sandstone, drab maroon, fine grained slightly ferruginous.
101'8"	106'7"	4'9"	Sandstone, drab grayish maroon, fine grained, contains gray shale partings.
106'7"	107'	0'5"	Sandstone, drab maroon, coarse grained, conglomeratic, contains rust brown clay galls.
107'	127'5"	20'5"	Sample 2 (107' - 127'5") Sandstone, maroon, fine grained, ferruginous, marked absence of maroon shale partings.
127'5"	151'9"	24'4"	Shale greenish gray and gray fine grained sandstone, check core log.
151'9"	153'3"	1'6"	Sandstone, grayish maroon, fine grained.
153'3"	153'9"	6"	Shale, pale grayish tan, includes [illegible]
153'9"	154'9"	1'0"	Sample 3 (153'9" - 157'7") Sandstone, maroon, coarse grained, [illegible], conglomeratic, contains large quartz granules.
154'9"	157'7"	2'10"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings.
157'7"	164'2"	6'7"	Shale green and interbedded grayish green sandstone. See core log.
164'2"	165'7"	1'5"	Sample 4 (164'2" - 169'7") Sandstone, maroon, fine to medium grained, ferruginous.
165'7"	169'7"	2'0"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings.
169'7"	170'1"	6"	Shale, maroon to pale grayish green.
170'1"	171'0"	0'11"	Sandstone, gray to grayish maroon, fine grained.

Depth in feet			Description
From	To	Thickness	
			Sample 5 (171'0" - 175'3")
171'	172'	1'0"	Sandstone, maroon, fine grained, ferruginous; contains abundant maroon shale partings.
172'	172'2"	0'2"	Shale, pale brown.
172'2"	174'1"	3'11"	Sandstone, maroon, coarse grained, conglomeratic highly ferruginous.
174'1"	174'7"	6"	Shale, drab maroon.
174'7"	175'3"	8"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous.

End of Log

Hole [illegible] Log of Split Core

Date: November 8, 1961

Depth in feet		Description
From	To	
0	4'	Overburden
		Sample 1 (4' to 14')
4'	14'	Sandstone, pale drab maroon to grayish maroon, fine to medium grained, ferruginous; contains yellowish brown clay galls and scattered quartz granules, weathered and broken. Includes 5' core loss probably shale.
		Sample 2 (14' - 16'5")
14'	15'	Sandstone, maroon to grayish maroon, coarse grained, conglomeratic, martitic, slightly ferruginous; contains quartz granules and clay galls, weathered and broken.
15'	15'5"	Shale, pale [illegible] brown to maroon.
15'5"	16'5"	Sandstone, drab maroon to grayish maroon, fine grained, slightly ferruginous, weathered and broken.
16'5"	16'7"	Shale, pale brown to pink.
16'7"	22'	Core loss.
22'	49'8"	[illegible]. Greenish gray shale, includes interbeds and partings of greenish gray to white fine grained sandstone.
		Sample 3 (49'8" - [illegible])
49'8"	50'2"	Sandstone, maroon, fine to coarse grained, ferruginous.
50'2"	51'1"	Sandstone, maroon, fine to medium grained, ferruginous contains no quartz granules.
51'1"	51'2"	Shale, maroon.
51'2"	51'6"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings.
51'6"	53'7"	Sandstone, maroon, fine grained, ferruginous, contains sporadic phosphatic fossils.
53'7"	[illegible]	Sandstone, maroon, fine grained, contains maroon shale partings.

Depth in feet From	To	Description
53'8"	55'5"	Sandstone, maroon, coarse grained, conglomeratic highly ferruginous, contains quartz granules and clay galls.
55'5"	56'	Shale, maroon, contains 4" core loss.
56'	56'5"	Sandstone, maroon, coarse grained, conglomeratic ferruginous, contains quartz granules and clay galls, fossiliferous, contains unidentifiable ostracods.
56'5"	56'9"	Sandstone, maroon, coarse grained shaly, contains rust brown and maroon shale partings.
56'9"	57'6"	Shale, pale green to olive drab.
		Sample 4 (57'6" - 59'5")
57'6"	59'5"	Sandstone, maroon, fine to coarse grained, conglomeratic, ferruginous, contains scattered quartz granules and unidentifiable fossils.
59'5"	60'4"	Sandstone, drab brownish maroon, fine grained, contains abundant maroon and drab brown shale partings.
60'4"	61'	Shale, pale maroon, includes 6" core loss.
61'	61'3"	Sandstone, grayish maroon, fine grained.
61'3"	62'	Sandstone drab maroon, fine grained, contains abundant maroon shale interbeds and partings parallel to bedding planes.
62'	62'4"	Shale, pale brown.
		Sample 5 (62'4" - 65'10")
62'4"	65'10"	Sandstone, maroon, coarse grained, conglomeratic ferruginous, contains quartz granules and sporadic white phosphatic fossils.
65'10"	66'1"	Shale, pale brown.
66'1"	69'3"	Shale, grayish maroon, contains interbeds of grayish maroon, fine grained sandstone. Includes 11" core loss.
69'3"	70'2"	Shale, pale grayish green.
70'2"	70'8"	Sandstone, maroon, fine to coarse grained, contains interbeds of maroon shale.

Depth in feet From	To	Description
70'8"	72'1"	Shale, pale grayish green.
72'1"	73'3"	Shale, pale olive drab to pale brown.
		Sample 6 (73'3" - 77'9")
73'3"	77'6"	Sandstone, maroon, coarse grained, conglomeratic highly ferruginous, contains quartz granules and white phosphatic unidentifiable brachiopod remains.
77'6"	83'7"	See log.
		Sample 7 (83'7" - 83'10")
83'7"	83'10"	Sandstone, maroon, coarse grained highly ferruginous oalitic.
83'10"	125'11"	See log.
		Sample 8 (125'11" - 127'7")
125'11"	126'2"	Sandstone, maroon, fine grained ferruginous.
126'2"	127'3"	Shale, greenish gray.
126'3"	127'7"	Sandstone, maroon, fine grained, ferruginous.
127'7"	155'5"	See log.

HOLE NUMBER: T6-12A

Depth in feet From	To	Thickness	Description
			Clinton formation
0	4'	4'	Overburden, contains loose weathered blocks of ferruginous sandstone.
4'	13'	9'	Sandstone, maroon, medium to coarse grained, conglomeratic, ferruginous; broken and weathered, includes 5' core loss.
15'	15'6"	6"	Shale, maroon.
15'6"	16'5"	11"	Sandstone, maroon, coarse grained, ferruginous conglomeratic; badly broken.
16'5"	23'	6'7"	Shale, maroon, includes 6'6" core loss.
23'	23'5"	5"	Sandstone, pale grayish maroon, fine grained.
23'5"	23'10"	5"	Sandstone, pale yellowish brown to tan, fine grained.
23'10"	31'	7'2"	Shale, pale greenish gray to pale greenish yellow, weathered; includes 5' core loss.
31'	36'4"	5'4"	Shale, pale greenish gray to pale olive drab to pale brown; contains rust brown paper thin shale partings parallel to the bedding planes. Contains widely scattered intercalations of pale gray fine grained sandstone, includes 9" core loss.
36'4"	41'4"	5'	Shale, gray, unctuous; contains gray fine grained shaly sandstone partings.
41'4"	43'	1'8"	Shale, rust brown to grayish green, contains rust brown sandstone partings.
43'	44'4"	1'4"	Shale, pale grayish purple to grayish green.
44'4"	47'3"	2'11"	Shale, pale rust brown; contains partings of maroon and grayish green shale.
47'3"	47'6"	3"	Sandstone, maroon, fine grained, thin bedded, broken.
47'6"	47'8"	2"	Sandstone, gray to dull grayish maroon, fine grained.
47'8"	48'	4"	Sandstone, brown, fine grained platy.
48'	48'8"	8"	Sandstone, pale grayish maroon, fine grained.

Depth in feet From	To	Thickness	Description
48'8"	49'8"	1'	Shale, grayish green, includes 8" core loss.
49'8"	51'	1'4"	Sandstone, maroon, fine to coarse grained, ferruginous; contains quartz granules.
51'	51'2"	2"	Sandstone, maroon, fine to medium grained; contains maroon shale partings.
51'2"	52'10"	1'8"	Sandstone, maroon, fine grained, highly ferruginous.
52'10"	55'5"	2'7"	Sandstone, maroon, coarse grained, conglomeratic ferruginous; contains quartz granules, clay galls and very widely scattered maroon shale partings; conglomeratic.
55'5"	56'	7"	Shale, maroon; contains scattered maroon coarse grained ferruginous sandstone partings, includes 4" core loss.
56'	56'5"	5"	Sandstone, maroon, coarse grained, conglomeratic ferruginous.
56'5"	56'7"	2"	Sandstone, maroon, fine grained.
56'7"	57'6"	11"	Shale, pale grayish green to olive drab.
57'6"	59'1"	1'7"	Sandstone, maroon, coarse grained, conglomeratic ferruginous; contains quartz granules.
59'1"	60'2"	1'1"	Sandstone and interbedded shale; sandstone maroon, fine grained, slightly ferruginous; contains abundant maroon shale partings parallel to the bedding planes.
60'2"	61'	10"	Shale, maroon, includes 6" core loss.
61'	62'1"	1'1"	Sandstone and interbedded shale; sandstone maroon, fine grained, slightly ferruginous; contains abundant maroon shale partings and intercalations.
62'1"	62'5"	4"	Shale, maroon to olive drab.
62'5"	62'8"	3"	Sandstone, maroon, fine grained ferruginous.
62'8"	65'10"	3'2"	Sandstone, maroon, coarse grained; conglomeratic contains quartz granules, highly ferruginous.
65'10"	67'10"	2'	Sandstone, maroon, fine grained, slightly ferruginous, contains abundant maroon shale partings parallel to the bedding planes.

Depth in feet From	To	Thickness	Description
67'10"	69'	1'10"	Shale, maroon, includes 1' core loss.
69'	69'3"	3"	Sandstone, maroon, fine grained, contains abundant maroon shale partings.
69'3"	70'1"	10"	Shale, gray to maroon to olive drab.
70'1"	70'7"	6"	Sandstone, drab maroon, fine grained, shaly.
70'7"	71'8"	1"	Shale, gray to grayish green.
71'8"	73'2"	1'6"	Shale, pale olive drab to light brown to grayish maroon; contains interbeds of maroon fine grained sandstone.
73'2"	77'6"	4'4"	Sandstone, maroon, coarse grained, ferruginous contains quartz granules and contained vugs caused by leaching of clay galls, fossiliferous, contains brachiopods and ostracods, fossils are white possibly phosphatic.
77'6"	78'	6"	Shale, gray to grayish brown.
78'	79'3"	1'3"	Shale, gray to maroon.
79'3"	80'3"	1'	Sandstone, grayish purple, fine grained.
80'3"	81'	9"	Shale, gray to grayish green; contains partings of pale gray, fine grained sandstone.
81'	82'10"	1'10"	Shale, maroon, contains partings of grayish green shale and grayish fine grained sandstone.
82'10"	82'11"	1"	Sandstone, maroon, fine grained, ferruginous.
82'11"	83'7"	8"	Shale, gray to grayish maroon, sandy, contains gray fine grained sandstone intercalations.
83'7"	83'10"	3"	Sandstone, reddish maroon, oalitic ferruginous.
83'10"	84'2"	4"	Sandstone, gray, fine grained, quartzite.
84'2"	84'10"	8"	Shale, gray to grayish green; contains irregular partings of pale gray fine grained quartzite sandstone.
84'10"	86'	1'2"	Shale, gray to grayish brown, contains 2" interbeds of gray fine grained sandstone, includes 6" core loss.

Depth in feet From	To	Thickness	Description
86'	91'	5'	Sandstone, gray to grayish maroon, fine grained quartzitic.
91'	91'5"	5"	Sandstone, maroon, fine to medium grained, ferruginous.
91'5"	92'	7"	Shale, gray to grayish green, unctuous.
92'	93'	1'	Sandstone, pale gray, fine grained, quartzitic.
93'	94'3"	1'3"	Shale, gray to grayish black, contains pale gray fine grained partings of quartzite.
94'3"	98'9"	4'6"	Sandstone, grayish green, fine grained, quartzitic, contains pale green irregular shale partings.
98'9"	100'3"	1'6"	Sandstone, gray to pale grayish green, fine grained, quartzitic; contains irregular pale green shale partings.
100'3"	101'	9"	Sandstone, grayish green, fine grained.
101'	103'9"	2'9"	Sandstone, grayish green; contains maroon flecks fine grained; quartzitic.
103'9"	105'7"	1'10"	Sandstone, pale grayish green, fine grained, contains irregular pale green shale partings.
105'7"	105'10"	3"	Sandstone, maroon, fine grained.
105'10"	106'3"	5"	Sandstone, pale grayish green, fine grained.
106'3"	107'	9"	Sandstone, pale grayish maroon, fine grained.
107'	107'4"	4"	Shale, grayish green, unctuous.
107'4"	107'5"	1"	Quartzite, pale gray, fine grained.
107'5"	107'6"	1"	Shale, gray.
107'6"	108'	6"	Quartzite, pale gray, fine grained.
108'	109'1"	1'1"	Shale, grayish black, contains irregular interbeds of grayish white, fine grained quartzite.
109'1"	109'5"	4"	Quartzite, pale grayish white, fine grained.
109'5"	110'4"	11"	Quartzite, pale gray to grayish green, fine grained; contains gray and grayish green shale partings.

Depth in feet			Description
From	To	Thickness	
110'4"	110'9"	5"	Shale, pale green and maroon.
110'9"	110'10"	1"	Quartzite, pale gray, fine grained.
110'10"	110'11"	1"	Shale, pale green and maroon.
110'11"	112'10"	1'11"	Quartzite, pale gray, fine grained.
112'10"	119'7"	6'9"	Shale, grayish black to grayish green; contains irregular partings, intercalations and lenses of pale gray to grayish green fine grained quartzitic sandstone. Also contains widely scattered plant fossils.
119'7"	119'9.5"	2.5"	Sandstone, maroon, fine to medium grained; contains maroon shale partings.
119'9.5"	121'7"	1'9.5"	Shale, grayish black to dull grayish green; contains scattered irregular partings and lenses of pale gray fine grained quartzitic sandstone.
121'7"	123'7"	2'	Shale, greenish gray, contains interbeds and lenses of maroon, fine grained sandstone and gray fine grained sandstone.
123'7"	124'2"	7"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings.
124'2"	125'11"	1'9"	Shale, greenish gray; contains interbeds and lenses of maroon fine grained sandstone and gray, fine grained quartzitic sandstone.
125'11"	126'2"	3"	Sandstone, maroon, fine grained, ferruginous.
126'2"	126'3"	1"	Shale, greenish gray.
126'3"	127'7"	4"	Sandstone, maroon, fine grained, slightly ferruginous.
127'7"	128'4"	9"	Sandstone, maroon, fine grained, contains greenish gray to maroon shale partings.
128'4"	131'4"	3'	Shale, greenish gray to grayish black; contains intercalations and irregular lenses of pale gray to grayish green, fine grained quartzitic sandstone, includes 3" core gain.
131'4"	131'7"	3"	Sandstone, gray, fine grained, quartzitic.

Depth in feet From	To	Thickness	Description
131'7"	134'3"	2'8"	Shale, pale grayish black; contains thin lenses of pale gray quartzitic sandstone.
134'3"	134'4"	1"	Sandstone, maroon, fine to medium grained.
134'4"	137'6"	3'2"	Shale, gray to grayish black.
137'6"	137'7"	1"	Sandstone, gray, coarse grained, quartzitic.
137'7"	138'	5"	Shale, grayish black; contains a 1" interbed of gray, coarse grained sandstone.
138'	138'5"	5"	Sandstone, gray to grayish black, coarse grained, contains rounded quartz granules.
138'5"	139'6"	1'6"	Shale, grayish black, sandy.
139'6"	139'11"	5"	Sandstone, grayish white fine grained.
139'11"	140'2"	3"	Sandstone, grayish white, coarse grained conglomeratic, quartzitic; contains black limestone? granules.
140'2"	144'2"	2'	Sandstone gray to pale grayish green, fine grained quartzitic, contains scattered pyrite stringers. Last 12 inches contains irregular partings of pale green shale.
144'2"	149'9"	5'7"	Sandstone, pale gray to grayish black, fine to medium grained; contains irregular partings and interbeds of grayish black shale.
149'9"	150'11"	1'2"	Shale, black.
150'11"	152'8"	1'9"	Sandstone, pale grayish black to grayish brown mottled, contains irregular pyrite stringers and scattered pyritized fossils; quartzitic.
152'8"	155'5"	2'9"	Quartzite, pale grayish white, fine grained; contains nests and irregular stringers of pyrite and parting of pale green shale at 154'10". (4" core loss, left in hole)

Bottom of hole.

HOLE NUMBER: T6-15A

Drill alignment: Vertical
Date started: Tuesday, November 7, 1961
Date completed: Wednesday, November 15, 1961
Driller: M. C. Vaughan, Cunningham Core Drilling and Grouting Co.
Location Bearing N 55° W from T6-12A 460'

Depth in feet			Description
From	To	Thickness	
0'	4'	4'	Overburden
4'	7'10"	3'10"	Sandstone, grayish maroon, fine to medium grained, slightly ferruginous, weathered; contains yellowish brown clay galls and contained vugs. Includes 1'9" core loss.
7'10"	10'	2'2"	Sandstone, maroon, medium grained, contains sporadic quartz granules, ferruginous. Includes 7" core loss.
10'	15'5"	5'5"	Sandstone, maroon, fine grained, slightly ferruginous; broken and weathered; includes 4'7" core loss.
15'5"	18'	2'7"	Sandstone, maroon, coarse grained, quartzitic, slightly ferruginous, friable; contains abundant rounded quartz granules. Includes 6" core loss.
18'	18'4"	4"	Shale, grayish maroon.
18'4"	20'9"	2'5"	Sandstone, maroon, fine to coarse grained, ferruginous; contains abundant maroon shale partings parallel to the bedding planes. Includes 9" core loss.
20'9"	25'	4'3"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous, contains abundant rounded quartz granules and sporadic contained vugs. Includes 1' core loss.
25'	26'6"	1'6"	Shale, pale grayish green to maroon, contains scattered interbeds of maroon, fine grained sandstone in the lower 3 inches. Includes 6" core loss.
26'6"	26'10"	4"	Sandstone, pale grayish maroon, fine grained, slightly ferruginous.
26'10"	30'6"	3'8"	Sandstone, maroon, fine to coarse grained, ferruginous, broken; contains partings of maroon shale and maroon clay galls. Includes 1'9" core loss.
30'6"	31'4"	10"	Shale, pale olive drab to pale grayish tan.
31'4"	32'4"	1'	Sandstone, pale rust brown to grayish brown, fine grained; abundantly fossiliferous, includes ostracods: Mostigobolbina sp and Zygosella sp; crinoid stems all in excellent preservation.

Depth in feet			Description
From	To	Thickness	
32'4"	34'	1'8"	Shale, pale tan to grayish tan, includes 1'3" core loss.
34'	34'2"	2"	Sandstone, pale grayish brown to rust brown, fine grained.
34'2"	34'9"	7"	Shale, pale gray to pale grayish tan.
34'9"	35'1"	4"	Sandstone, pale grayish tan, fine grained.
35'1"	39'6"	4'5"	Shale, pale gray to pale grayish tan, includes 2' core loss.
39'6"	55'6"	16'	Shale, gray to grayish green, contains interbeds lenses and partings of gray fine grained sandstone and gray fine grained shaly sandstone.
55'6"	59'	3'6"	Shale, yellowish tan to pale brown.
59'	59'4"	4"	Shale, greenish gray.
59'4"	59'6"	2"	Sandstone, pale gray to pale grayish tan, fine grained.
59'6"	59'9"	3"	Shale, pale olive drab to pale gray.
59'9"	59'10"	1"	Sandstone, pale gray to pale grayish tan, fine grained.
59'10"	61'1"	1'3"	Shale, grayish maroon to pinkish maroon to olive drab; contains interbeds of grayish maroon fine grained sandstone.
61'1"	61'8"	7"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and clay galls, vuggy.
61'8"	61'11"	3"	Shale, olive drab to maroon.
61'11"	64'2"	2'3"	Sandstone, maroon, fine to medium grained, ferruginous, contains widely scattered maroon shale partings parallel to the bedding planes. Includes 4" core loss.
64'2"	66'2"	2'	Sandstone, maroon, coarse grained, highly ferruginous, conglomeratic; contains quartz granules, includes 2" core gain.
66'2"	66'4"	2"	Shale, yellowish tan.
66'4"	66'5"	1"	Shale, drab maroon.

Depth in feet			Description
From	To	Thickness	
66'5"	66'7"	2"	Sandstone, maroon, coarse grained, ferruginous.
66'7"	67'	5"	Shale, olive green to maroon, contains 1/4 inch parting of maroon fine grained ferruginous sandstone at 67'.
67'	67'2"	2"	Shale, maroon.
67'2"	67'6"	4"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules, conglomeratic.
67'6"	71'6"	4'	Shale, maroon, contains 1/4 inch to 1 inch thick interbeds of maroon fine grained ferruginous sandstones.
71'6"	75'3"	3'9"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous, contains large quartz granules rust brown clay pellets and contained vugs.
75'3"	76'6"	1'3"	Shale, maroon, contains 1" interbeds of grayish maroon fine grained sandstone.
76'6"	76'6.5"	0.5"	Shale, grayish green.
76'6.5"	76'10"	3.5"	Sandstone, drab maroon, fine grained, shaly, contains abundant maroon shale partings.
76'10"	77'2"	4"	Sandstone, drab maroon to grayish maroon, fine grained.
77'2"	77'3"	1"	Shale, pale greenish gray.
77'3"	77'9"	6"	Sandstone, maroon, fine grained, shaly, contains abundant maroon shale partings parallel to the bedding planes.
77'9"	78'10"	1'1"	Shale, olive drab to grayish maroon.
78'10"	79'	2"	Sandstone, maroon, fine grained, shaly, contains abundant partings of maroon shale.
79'	79'3"	3"	Shale greenish gray.
79'3"	79'9"	6"	Shale, maroon, contains partings of maroon fine grained sandstone parallel to the bedding planes.
79'9"	80'1"	4"	Shale, grayish green.
80'1"	80'9"	8"	Sandstone, maroon, fine grained, shaly, contains abundant maroon shale partings.

Depth in feet From	To	Thickness	Description
80'9"	82'9"	2'	Shale, greenish gray to maroon, contains 1/2 inch interbeds of maroon, fine grained ferruginous sandstone.
82'9"	85'	3'3"	Sandstone, maroon, fine grained, ferruginous, contains sporadic partings of maroon and pale green shale parallel to the bedding planes.
85'	86'10"	1'10"	Sandstone, maroon, fine to coarse grained, ferruginous, contains quartz granules, conglomeratic contains sporadic maroon and grayish green shale partings parallel to the bedding planes.
86'10"	87'5"	7"	Shale, yellowish tan to yellowish brown.
87'5"	89'10"	2'5"	Shale, greenish gray, contains sporadic lenses of greenish gray fine grained shaly quartzitic sandstone and sporadic maroon shale partings.
89'10"	92'10"	3'	Shale, pale greenish gray.
92'10"	93'	2"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous; contains quartz granules.
93'	93'5"	5"	Shale, greenish gray.
93'5"	93'6"	1"	Sandstone, grayish maroon, fine grained.
93'6"	94'6"	1'	Shale, greenish gray.
94'6"	95'	6"	Quartzite, greenish gray, fine grained, 5" left in hole.

End of hole.

Log of Split Core T6-15A

Date Logged: November 18, 1961

Depth in feet			Description
From	To	Thickness	
			Sample 1 (4' - 10')
4'	7'10"	3'10"	Sandstone, grayish maroon, fine to medium grained, ferruginous, weathered; contains yellowish brown clay galls and contained vugs. Includes 1'9" core loss.
7'10"	10'	2'2"	Sandstone, maroon, medium grained, contains sporadic quartz granules, ferruginous, includes 7" core loss.
10'	15'5"	5'5"	Not sampled. See log.
			Sample 2 (15'5" - 20'6")
15'5"	18'	2'7"	Sandstone, maroon, coarse grained, quartzitic ferruginous, friable, contains abundant rounded quartz grains, includes 1'6" core loss.
18'	18'4"	4"	Shale, grayish maroon.
18'	20'9"	2'9"	Sandstone, maroon, fine grained to coarse grained, ferruginous; contains roughly 40% maroon shale partings parallel to the bedding planes, includes 9" core loss.
			Sample 3 (20'9" - 25').
20'9"	25'	4'3"	Sandstone, maroon, coarse grained, conglomeratic, ferruginous, contains abundant rounded quartz granules and sporadic contained vugs. Includes 1' core loss probably maroon shale.
25'	26'6"	1'6"	Not sampled see log.
			Sample 4 (26'6" - 30')
26'6"	26'10"	4"	Sandstone, pale grayish maroon, fine grained, ferruginous.
26'10"	30'	3'2"	Sandstone, maroon, fine to coarse grained, ferruginous, broken, contains partings of maroon shale and maroon clay galls.
30'	61'1"	31'1"	See log.

Depth in feet			Description
From	To	Thickness	
			Sample 5 (61'1" - 66'2")
61'1"	61'8"	7"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and clay galls, vuggy.
61'8"	61'11"	3"	Shale, olive drab to maroon.
61'11"	64'2"	2'3"	Sandstone, maroon, fine to medium grained, ferruginous, contains widely scattered maroon shale partings parallel to the bedding planes. Includes 4" core loss.
64'2"	66'2"	2'	Sandstone, maroon, coarse grained, highly ferruginous, conglomeratic, contains quartz granules, includes 2" core gain.
66'2"	67'2"	1'	Shale, yellowish tan to olive green to maroon, contains 2" interbed of maroon coarse grained ferruginous sandstone at 66'5", not sampled see log.
			Sample 6 (67'2" - 67'6")
67'2"	67'6"	4"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules, conglomeratic.
67'6"	71'10"	4'4"	Shale, maroon, contains 1/4 inch to 1" interbeds of maroon, fine grained ferruginous sandstone, not sampled.
			Sample 7 (71'10" - 75'3")
71'10"	75'3"	3'5"	Sandstone, maroon, fine to coarse grained, highly ferruginous, conglomeratic, contains large quartz granules and contained vugs.
75'3"	80'1"	4'10"	Shale, greenish gray to olive drab contains interbeds and partings of maroon, fine grained shaly sandstone.
			Sample 8 (80'1" - 80'9")
80'1"	80'9"	8"	Sandstone, maroon, fine grained, shaly, contains abundant maroon shale partings.
			Sample 9 (82'9" - 86'7")
82'9"	85'4"	2'7"	Sandstone, maroon, fine grained, ferruginous, contains maroon and pale green shale partings parallel to the bedding planes.

Depth in feet			Description
From	To	Thickness	
85'4"	86'7"	1'3"	Sandstone, maroon, fine to coarse grained, ferruginous, contains maroon shale partings parallel to the bedding planes.
86'7"	93'10"	6'3"	Shale pale greenish gray contains lenses of greenish gray fine grained sandstone. See log for detailed description.
			Sample 10 (92'10" - 93')
92'10"	93'	2"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous, contains quartz granules.

End of Sampling on T6-15A.

HOLE NUMBER: T6-17A

Hole Alignment: Vertical
Date started: November 20, 1961
Date completed: November 30, 1961
Driller: M. C. Vaughan, Cunningham Core Drilling Co.

Depth in feet			Description
From	To	Thickness	
0	3'	3'	Overburden, workable Clinton.
3'	7'3"	4'3"	Sandstone, maroon, coarse grained, ferruginous, weathered, friable; contains quartz granules and vugs. Includes 1' core loss.
8'6"	12'5"	3'11"	Sandstone, drab maroon, fine grained, slightly ferruginous; contains sporadic partings of rust brown shale.
12'5"	16'	3'7"	Shale, drab maroon, contains interbeds of maroon fine grained ferruginous sandstone. Includes 2' core loss.
16'	17'8"	1'8"	Sandstone, drab maroon, fine grained.
17'8"	19'2"	1'10"	Sandstone, drab gray to drab maroon, fine grained.
19'2"	21'	1'10"	Shale, pale tan to grayish tan. Includes 1'6" core loss.
21'	21'6"	6"	Shale, pale greenish gray.
21'6"	21'7"	1"	Sandstone, pale grayish white, fine grained, fossiliferous; includes trilobites.
21'7"	25'2"	3'7"	Shale, tan to pale grayish brown; contains partings of rust brown sandy shale parallel to the bedding planes.
25'2"	26'4"	1'2"	Shale, tan.
26'4"	26'5"	1"	Sandstone, pale tan, fine grained, shaly.
26'5"	27'	1'7"	Shale, tan, unctuous.
27'	35'	8'	Shale, greenish gray, unctuous, includes 1'7" core loss.
35'	45'1"	10'1"	Shale, pale greenish gray, unctuous, contains sporadic partings and irregular lenses of pale gray, fine grained shaly quartzitic sandstone.
45'1"	48'	2'11"	Shale, pale brown to tan, contains pale tan fine grained sandstone partings and irregular lenses. Includes 8" core loss.

Depth in feet From	To	Thickness	Description
48'	49'3"	1'3"	Sandstone, maroon, fine to medium grained ferruginous, contains partings of maroon shale parallel to the bedding planes.
49'3"	52'10"	3'7"	Sandstone, maroon, fine to coarse grained, highly ferruginous, contains quartz granules and maroon clay galls.
52'10"	53'2"	4"	Shale, maroon.
53'2"	54'10"	1'8"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules and contained vugs.
54'10"	55'5"	7"	Sandstone, maroon, fine grained, ferruginous.
55'5"	60'	4'7"	Sandstone, maroon, fine to medium grained, contains abundant (40% - 50%) maroon shale and olive drab shale partings and lenses parallel to the bedding planes. Includes 3" core loss.
60'	64'5"	4'5"	Sandstone, maroon, coarse grained, conglomeratic, highly ferruginous, contains quartz granules and scattered white phosphatic fossils.
64'5"	70'3"	5'10"	Shale, maroon, broken, contains interbeds of maroon fine grained sandstone.
70'3"	71'1"	10"	Shale, pale greenish gray.
71'1"	71'4"	3"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings.
71'4"	71'10"	6"	Shale, greenish gray and maroon, contains 1" parting of maroon, fine grained, ferruginous sandstone at 71'6".
71'10"	72'	2"	Sandstone, maroon, fine grained ferruginous.
72'	72'5"	5"	Shale, olive drab.
72'5"	75'	2'7"	Sandstone, maroon, fine grained ferruginous.
75'	75'10"	10"	Sandstone, maroon, coarse grained, ferruginous, contains white phosphatic fossil fragments and quartz granules.
75'10"	78'	2'2"	Shale, pale greenish gray, contains lenses of fine grained gray quartzitic sandstone.

End of hole.

T6-17A Log of Split Core

Date logged: December 9, 1961

Depth in feet			Description
From	To	Thickness	
			Sample 1(3' - 7'3")
3'	7'3"	4'3"	Sandstone, maroon, coarse grained, ferruginous, weathered, contains quartz granules and vugs. Highly friable. Includes 1' core loss.
			Sample 2 (8'6" - 12'5")
8'6"	12'5"	3'11"	Sandstone, drab maroon, fine grained, ferruginous contains sporadic partings of rust brown shale.
			Sample 3 (48' - 49'5")
48'	49'5"	1'5"	Sandstone, maroon, fine grained, ferruginous, contains maroon shale partings parallel to the bedding planes.
			Sample 4 (49'5" - 55'4")
49'5"	50'6"	1'1"	Sandstone, maroon, fine grained, ferruginous.
50'6"	53'	2'6"	Sandstone, maroon, fine grained, ferruginous, contains widely sporadic maroon shale partings and wavelite encrustations.
53'	53'4"	4"	Shale, drab brownish maroon.
53'4"	54'10"	1'6"	Sandstone, maroon, coarse grained, ferruginous, contains quartz granules, contained vugs and white phosphatic fossil remains.
54'10"	55'4"	6"	Sandstone, maroon, fine grained, ferruginous.
			Sample 5 (60' - 64'5")
60'	64'5"	4'5"	Sandstone, maroon, fine to coarse grained, highly ferruginous; contains quartz granules and white phosphatic fossils.
			Sample 6 (72'5" - 75'10")
72'5"	74'8"	2'3"	Sandstone, maroon, fine grained, ferruginous, contains sporadic wavelite encrustations at 73'10".
74'8"	75'10"	1'2"	Sandstone, maroon, coarse grained, ferruginous, contains white phosphatic fossil shells and quartz granules.

HOLE NUMBER: T7-4A

Drill alignment N68E runners
15NW off vertical
Date started: Wednesday, Nov. 8, 1961
Date completed: Thursday, Nov. 9, 1961
Driller: Vaughan Bowling, Cunningham Core
Drilling and Grouting Co.

Depth in feet			Description
From	To	Thickness	
0'	11'	11'	Overburden, includes red soil and particles of clinton float.
11'	13'10"	2'10"	Shale, pale greenish gray, contains paper thin partings of pale yellow sandy shale.
13'10"	17'4"	3'6"	Shale, pale yellowish brown to pale tan; contains sporadic lenses of white fine to medium grained quartzitic sandstone. Includes 7" core loss.
17'4"	17'7"	3"	Shale, brown.
17'7"	19'0"	1'5"	Sandstone, grayish maroon, fine grained, slightly ferruginous, vuggy, fractured and broken. Includes 9" core loss.
19'0"	24'6"	5'6"	Sandstone, maroon, fine to coarse grained ferruginous, contains quartz granules and maroon clay galls; fractured, includes 1'6" core loss.
24'6"	24'9"	3"	Sandstone, rust brown, fine grained.
24'9"	25'	3"	Sandstone, pale grayish white to grayish maroon, fine grained.
25'	25'3"	3"	Conglomeratic sandstone, contains rounded quartz pebbles and granules set in a rust brown silty sandstone matrix.
25'3"	25'6"	3"	Sandstone, conglomeratic, contains rounded quartz pebbles and granules set in a matrix of pale gray to rust brown clayey silt.
25'6"	28'3"	2'9"	Quartzite, pale grayish white, fine grained, contains sporadic paper thin reddish brown irregular shale partings.
28'3"	28'7"	4"	Clay, gray.
28'7"	29'3"	8"	Quartzite, pale grayish white, fine grained, contains sporadic paper thin reddish brown irregular shale partings.

Depth in feet			Description
From	To	Thickness	
29'3"	29'9"	6"	Sandstone conglomeratic, rust brown, coarse grained; contains irregular angular fragments of grayish white fine grained quartzite.
29'9"	30'2"	5"	Quartzite, pale grayish white to drab maroon gray, fine grained; contains manganese stained shale partings.
30'2"	30'4"	2"	Shale, pale brown.
30'4"	30'8"	4"	Quartzite, gray to grayish white, fine grained contains intercalations of gray shale.
30'8"	31'8"	1'	Shale, gray.
31'8"	31'8.5"	0.5"	Quartzite, gray to grayish white, fine grained.
31'8.5"	32'3"	6.5"	Shale, gray.
32'3"	32'4.5"	1.5"	Quartzite, pale grayish white, fine grained.
32'4.5"	34'	1'5.5"	Shale, gray; includes 1'6" core loss. End of hole.

Log of Split Core

date logged Nov. 11, 1961

			Sample 1 (19' - 24'6")
19'	24'6"	5'6"	Sandstone, maroon, fine to coarse grained, ferruginous, contains quartz granules and maroon clay galls, fractured; includes 1'6" core loss.

Logs by Cooper after Moon

BYRON N. COOPER
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V. P. I. OFFICE
108 HOLDEN HALL
TELEPHONE
PRESCOTT 2-8261 EXT. 270

RESIDENCE
COUNTRY CLUB DRIVE
TELEPHONE
PRESCOTT 2-0736

GEOLOGICAL REPORT ON CORE HOLE T2-1A on PERMIT BLM- A- 050363

Feet From	Feet To	Formation	Description of Interval
0	46	Keefer quartzite:	Quartzite, white to gray, medium bedded.
46	46.7		Sandstone, reddish to brownish-gray; transitional.
		Rose Hill formation:	
46.7	57.3		Sandstone, reddish brown, ferruginous, friable, silty.
57.3	58.0		Sandstone, white, friable.
58.0	59.7		Shale, green, sandy, soft, unctuous.
59.7	61.8		Sandstone, reddish-brown, ferruginous, crumbly.
61.8	63.8		Sandstone, reddish-brown, very shaly, low in iron.
63.8	77.7		Sandstone, ferruginous, dark-maroon to purplish-black, contains numerous thin wisps of red and gray shale.
77.7	107.6		Shale, maroon-drab to greenish-gray with intercalations of maroon sandstone and white quartzite.
107.6	111.6		Sandstone, dark-red, ferruginous, coarse grained.
111.6	112.0		Shale, red, interbeds of greenish-gray sandstone.
112.0	114.7		Sandstone, dark-red, ferruginous, shaly.
114.7	118.7		Sandstone, dark-red, very coarse, few shale partings.
118.7	119.2		Sandstone-shale, greenish-gray parting.
119.2	119.8		Sandstone, ferruginous, medium grained, no shale.
119.8	124.1		Sandstone, medium to fine grained, ferruginous, very shaly, low iron content.
124.1	125.0		Sandstone, dark-red, highly ferruginous.
125.0	125.6		Shale with some thin hematitic sandstones; low in iron.
125.6	130.7		Sandstone, dark-red, hematitic, few shale partings.
130.7	135.3		Sandstone, dark-red, ferruginous, silty.
135.3	135.9		Sandstone, very ferruginous, coarse grained.
135.9	140.4		Sandstone, very hematitic, dark-red, coarse grained.
140.4	148.2		Shale, green, glauconitic.
148.2	162.2		Sandstone and shale, thin bedded, greenish-gray, few reddish blotches; few partings of granule conglomerate.
		Tuscarora formation	
162.2	168.6		Quartzite, white, very hard.

Chemical Analyses

From	To	Iron as Fe	Phosphorus as P
46.8	57.3	[illegible]%	0.17%
59.7	61.8	9.1	0.13
61.8	77.7	13.[illegible]	0.18
107.6	112.7	20.1	0.32
118.7	119.2	6.7 ✓	0.18
119.2	124.0	17.7	0.38
124.0	125.6	20.8	0.436
125.6	130.7	12.0	0.20
130.0	135.3	15.5	0.28
135.3	135.9	16.6	0.23
[illegible]	[illegible]	23.7 ✓	0.48

BYRON N. COOPER
GEOLOGIST
BOX 13
BLACKSBURG, VIRGINIA

V.P.I. OFFICE
108 HOLDEN HALL
TELEPHONE
PR[illegible] 2-6261 EXT. 279

RESIDENCE
[illegible] DRIVE
TELEPHONE
PR[illegible] 2-6736

GEOLOGICAL REPORT ON BORE HOLE T2-2A on Permit BIM-A-050368

Feet From	To	Formation	Description of Interval
0	3	Keefer sandstone (?)	chiefly overburden.
3	8.8	Keefer sandstone (?)	Sandstone, buff-gray, weathered;
		Rose Hill formation	
8.8	17.0		Sandstone, drak-maroon, reddish-brown, medium grained; low in iron.
17.0	17.4		Shale, gray, soapy when wet.
17.4	18.4		Sandstone, medium grained, ferruginous, reddish.
18.4	19.5		Sandstone, ferruginous, maroon-drab; minor core loss.
19.5	22.5		Shale, variegated, red and green; thin sandstone partings.
22.5	25.5		Sandstone, brown, low in iron; some natural voids.
25.5	27.0		Sandstone, ferruginous, shaly, low in iron.
27.0	32.3		Sandstone, reddish-brown, ferruginous, low in iron.
32.3	33.5		Shale and thin ferruginous sandstones.
33.5	37.9		Sandstone, ferruginous, fairly good.
37.9	42.5		Shale, green and buff; few partings of ferruginous sandstone.
42.5	47.6		Sandstone, ferruginous, fairly good iron content.
47.6	53.7		Shale and thin [illegible]stones.
53.7	71.2		Shale, gray.
71.2	75.2		Shale, var[illegible], gray and buff.
75.2	80.0		Sandstone, ferruginous, coarse, conglomeratic.
80.0	84.2		Shale and ferruginous sandstone partings.
84.2	86.9		Ferruginous [illegible], reddish-brown.
86.9	91.6		Sandstone, ferruginous, fair.
91.6	98.0		Shale, red and green.
98.0	99.8		Sandstone, very ferruginous, best material.
99.8	103.9		Greenish-gray shale.

Chemical analyses

From	To	Iron as Fe	Phosphorus as P
8.8	19.5	19.6%	not completed
19.5	32.3	13.5	"
75.2	80.0	25.0	"
84.2	86.9	21.9	"
98.0	99.8	32.4	"

Average
22.[illegible]

Total [illegible]

LOG OF CORE HOLE T4-3A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic description
0	0	4	0	4	0	Overburden.
						Clinton formation:
4	0	7	9	3	9	Sandstone, ferruginous, coarse grained.
7	9	9	[illegible]	1	3	Shale, pale drab, maroon.
9	0	18	6	9	6	Sandstone, maroon to gray, low in iron.
18	6	24	9	6	3	Sandstone, drab-maroon, low in iron.
24	9	26	0	1	3	Shale, maroon, weathered.
26	0	28	10	2	10	Sandstone shaly, slightly ferruginous.
28	10	32	6	3	8	Sandstone, ferruginous, coarse grained.
32	6	32	10	[illegible]	4	Sandstone, ferruginous, fine grained, broken.
32	10	62	0	29	2	Sandstone, shale, and clay, gray to brown.
62	0	68	5	6	5	Sandstone, ferruginous, fine to medium grained.
68	5	70	10	2	5	Shale and sandstone, gray to brown.
70	10	72	11	2	1	Sandstone, ferruginous, grayish maroon.
72	11	93	3	20	4	Shale, gray to greenish-gray, few thin brown sands.

Chemical Composition

						Fe: %	P: %
4	0	7	9	3	9	9.67	0.114
9	0	18	6	9	6	8.70	0.068
18	6	24	9	6	3	13.06	0.074
28	10	32	6	3	8	19.99	0.142
62	0	68	5	8	5	22.65	0.182
70	10	72	11	2	1	21.76	0.232

Prepared by, W. A. Moon and B. N. Cooper

LOG OF CORE HOLE T7-4A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	II	11	0	11	0	Overburden; red soil and ferruginous sandstone float.
11	0	17	7	6	7	Clinton (Rose Hill) formation: Shale, yellowish to brown, sandy, fossiliferous.
17	7	19	0	1	5	Sandstone, grayish brown, slightly ferruginous.
19	0	24	6	5	6	Sandstone, ferruginous, coarse grained.
24	6	28	3	3	9	Sandstone and conglomerate, gray to brown.
28	3	28	7		4	Clay, gray.
28	7	30	2	1	7	Sandstone and quartzite, gray to brown.
30	2	30	4		2	Shale, pale brown.
32	4	34	0	1	8	Quartzite, sandstone and shale, gray.

CHEMICAL ANALYSIS

						Fe	P
19	0	24	6	5	6	16.60	0.206

Log prepared by, William A. Moon

and B. N. Cooper

T-1

LOG OF CORE HOLE 7A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	0	10	0	10	0	Overburden (workable Clinton sandstone).
						Clinton formation:
10	0	17	9	7	9	Sandstone, ferruginous, coarse grained.
17	9	28	0	10	3	Sandstone, ferruginous, fine to medium grained.
28	0	28	10	0	10	Shale, maroon, gray.
28	10	34	0	5	2	Sandstone, ferruginous, coarse grained.
34	0	63	0	29	0	Shale, thin sandstone, gray to brownish-gray.
63	0	66	8	3	8	Sandstone, maroon, ferruginous.
66	8	68	4	1	8	Sandstone, maroon, coarse grained.
68	4	70	0	1	6	Shale, gray to red.
70	0	72	7	2	7	Sandstone, ferruginous, fine grained.
72	7	99	11	27	4	Shale and thin sandstone, gray.
						Tuscarora formation
99	11	100	6		7	Quartzite.

Chemical Composition

						Fe: %	P:%
10	0	17	9	7	9	23.18	0.0385
17	9	28	0	10	3	17.06	0.185

Prepared by W. A. Moon and B. N. Cooper

LOG OF CORE HOLE T1-8A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	0	8	6	8	6	Overburden
8	6	16	0	7	6	Clinton formation: Sandstone and interbedded shale, 3'10" core loss.
16	0	19	8	3	8	Shale, maroon to gray.
19	8	23	0	3	6	*Sandstone, ferruginous, fine grained. T1-8A-1-z1
23	0	23	6	0	6	Shale, maroon to brownish-gray.
23	6	31	1	6	7	*Sandstone, ferruginous, fine grained; contains numerous shale partings. T1-8A-2-z2.
31	1	34	8	3	7	Shale and intercalated sandstone, drab-gray.
34	8	42	0	7	4	*Sandstone, ferruginous, coarse grained; 8" core loss. T1-8A-3-z3.
42	0	74	6	32	6	Shale, gray; interbeds of gray sandstone.
74	6	83	10	9	4	*Sandstone, ferruginous, fine grained; includes 2" parting of shale. T1-8A-4-z4.
83	10	86	3	3	1	Shale, gray, sandy.
86	3	88	1	1	10	Sandstone, pale maroon, bottom 2" coarse grained.
88	1	97	7	9	6	Shale, greenish-gray, some intercalated sandstones.
97	7	113	4	15	9	Shale, gray, intercalated sandstones.
113	4	114	6	1	2	Tuscarora sandstone: Quartzite, gray, very hard.
		114	6			TOTAL DEPTH

Analyses (%)

Sample No.	Fe	P	Thickness of zone Ft.	In.
T1-8A-1-z1	19.64	.176	3	6
T1-8A-2-z2	16.10	.234	6	7
T1-8A-3-z3	22.86	.256	7	4
T1-8A-4-z4	15.29	.125	9	4

Byron N Cooper

Byron N Cooper, Supervisor of Prospecting
November 16, 1961

LOG OF CORE HOLE T3-9A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	0	7	0	7	0	Overburden.
						Clinton formation:
7	0	25	3	18	3	Sandstone and shale, greenish-gray to brown, soft and broken.
25	3	38	7	13	4	Sandstone, ferruginous, thin shale partings.
38	7	77	0	38	5	Shale and thin sandstones, gray to brown.
77	0	91	1	14	1	Sandstone, ferruginous, fine grained.
91	1	92	8	1	7	Sandstone, ferruginous, fine to coarse grained, includes 5 inch shale parting.
92	8	93	6	0	10	Shale, grey, sandy.
93	6	94	7	1	1	Sandstone, ferruginous, coarse grained.
94	7	95	1	0	6	Sandstone, ferruginous, coarse grained.

Chemical Composition

						Fe: %	P: %
25	3	38	7	13	4	19.96	0.155
77	0	91	1	14	1	23.73	0.267
91	1	92	8	1	7	20.78	0.254
94	7	95	1	0	6	25.16	0.391

Prepared by W. A. Moen and B. N. Cooper

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LOG OF CORE HOLE T5-10A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and description
0	0	5	6	5	6	Overburden.
						Clinton formation.
5	6	7	10	2	4	Sandstone, ferruginous, quartz granules.
7	10	15	0	7	2	Sandstone, ferruginous, coarse grained
15	0	20	5	5	5	Sandstone, much core loss, ferruginous.
20	5	37	10	17	5	Sandstone, ferruginous, much core loss, material recovered, sampled as is.
37	10	44	0	6	2	Shale, gray to brown.
44	0	54	0	10	0	Shale, sandy, soft and broken, poor core recovery.
54	0	59	0	5	0	Sandstone, brown to gray.

Chemical Composition

						%Fe	%P
5	6	15	0	9	6	28.85	0.293
20	5	37	10	17	5	17.51	0.095

Prepared by, ____________
B. N. Cooper

LOG OF CORE HOLE T6-12A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	0	4	0	4	0	Overburden.
4	0	14	0	10	0	Clinton formation: Sandstone, ferruginous, coarse grained.
14	0	16	5	2	5	Sandstone, ferruginous, coarse grained, includes 5inch shale parting.
16	5	16	7	0	2	Shale, gray
16	7	23	0	6	5	Core lost.
23	0	49	8	26	8	Shale, greenish-gray, soft, unctuous.
49	8	56	5	6	9	Sandstone, ferruginous, fine to coarse grained.
56	5	56	9	0	4	Sandstone, ferruginous, very shaly, low in iron.
56	9	57	6	0	9	Shale, green to olive-drab.
57	6	59	5	1	11	Sandstone, ferruginous, coarse grained.
59	5	62	4	2	11	Sandstone and shale, drab-gray to brown.
62	4	65	10	3	6	Sandstone, ferruginous, fine to coarse grained.
65	10	73	3	7	5	Shale and shaly sandstone, drab-gray to brown.
73	3	77	6	4	3	Sandstone, ferruginous, conglomeratic.
77	6	83	7	6	1	Shale, drab, thin ferruginous sandstone beds near base.
83	7	83	10	0	3	Sandstone, ferruginous, very coarse grained, oolitic.
83	10	125	11	42	11	Shale, thin sandstones and quartzites, including few thin plates of ferruginous sandstone; very low in iron.
125	11	127	7	1	8	Sandstone, ferruginous, fine grained, includes shale parting.
127	7	152	8	25	1	Shale, thin sandstones, and clay, soft.

Chemical composition

						Fe%	P%
4	0	14	0	10	0	12.57	0.079
14	0	16	5	2	5	16.60	0.133
49	8	56	5	6	9	24.02	0.323
57	6	59	5	1	11	20.63	0.120
62	4	65	10	3	6	27.40	0.321
73	3	77	6	4	3	28.53	0.461
83	7	83	10	0	3	28.88	0.842
125	11	127	72	1	8	10.80	0.124

Prepared by B. N. Cooper and W. A. Moo

LOG OF CORE HOLE T5-13A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic description
0	0	5	0	5	0	Overburden.
						Clinton (Rose Hill) formation.
5	0	13	8	8	8	Sandstone, ferruginous, fractured.
13	8	17	4	3	8	Sandstone, red, coarse to medium grained, fractur
17	4	22	7	5	3	Shale, brown to maroon, few sandstone interbeds.
22	7	24	3	1	8	Sandstone, ferruginous, maroon.
24	3	25	2	0	11	Shale, maroon, core loss 10 inches.
25	2	32	0	6	10	Sandstone, ferruginous, core loss 4'6".
32	0	38	3	6	3	Shale, gray, rusty partings.
38	3	38	8½	0	5½	Sandstone, gray to brown, low in iron.
38	8½	42	1	3	3½	Shale, maroon to gray, unctuous.
42	1	43	2	2	1	Sandstone, maroon, porous, vuggy.
43	2	50	2	7	0	Shale, core loss 4'10".
50	2	62	1	11	11	Sandstone, gray to brown, low in iron.
62	1	65	1	3	0	Shale, maroon, core loss 3'.
65	1	71	10	6	9	Sandstone, gray, low in iron.
71	10	77	6	5	10	Shale, brown to gray, thin sandstone interbeds.
77	6	80	4	2	10	Sandstone, gray to brown, low in iron.
80	4	94	0	13	9	Sandstone, ferruginous, fine to coarse grained, core broken. Core loss 2'11".
94	0	97	4	3	4	Sandstone, pale gray, fine grained, low in iron.
97	4	100	9	3	5	Sandstone, ferruginous, fine to coarse grained; core loss 1'9".
100	9	101	6	0	9	Shale, gray; core loss 8 inches.
101	6	103	10	2	4	Sandstone, gray, fine grained.
103	10	107	0	3	2	Sandstone and shale, white to black.
107	0					Bottom of hole

Chemical Composition

						Fe: %	P: %
5	0	11	0	6	0	24.48	0.108
13	6	16	11	3	5	28.69	0.193
23	2	26	9	3	7	24.48	0.201
83	0	94	1	11	1	18.96	0.129

(Because of high core loss sample analyses may not be representative of zones)

Prepared by ______________________
B. N. Cooper and W. A. Moon

LOG OF CORE HOLE T5-14A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and Lithologic character
0	0	22	6	22	6	Overburden
22	6	82	6	60	0	Keefer sandstone: Sandstone and quartzite, gray to brownish-gray; partings of greenish-gray shale.
82	6	97	6	15	0	Clinton formation: Shale and sandstone, greenish-gray to brownish-gray.
97	6	98	2	0	8	Sandstone and shale, medium-brown; low in iron.
98	2	101	8	3	6	*Sandstone, maroon-drab, fine grained. T5-14A-1-z1
101	8	107	0	5	4	Sandstone, drab-maroon, coarse to fine grained.
107	0	127	5	20	5	*Sandstone, maroon-drab, fine grained; no shaly partings. T5-14A-z2-z2
127	5	151	9	24	4	Shale, greenish-gray, some fine grained gray sandstone.
151	9	153	3	1	6	Sandstone, platy, pale-maroon, fine grained.
153	3	153	9	0	6	Shale, grayish-tan, includes 4" core loss.
153	9	154	9	1	0	*Sandstone, ferruginous, coarse grained. T5-14A-3-z3
154	9	157	7	2	10	*Sandstone, ferruginous, abundant shale.
157	7	164	2	6	7	Shale, greenish-gray; some interbedded sandstone.
164	2	169	7	3	5	*Sandstone, ferruginous; shaly partings. T5-14A-4-z4
169	7	170	1	0	6	Shale, maroon to pale green.
170	1	171	0	0	11	Sandstone, very pale maroon.
171	0	175	3	4	3	*Sandstone, ferruginous, shaly partings. T5-14A-5-z5
175	3	184	0	8	9	Shale and sandstone, greenish-gray, fairly soft.
184	0	189	4	5	4	Sandstone, grayish to greenish-gray.
189	4	192	6	3	2	Shale, black.
192	6	196	7	4	1	Sandstone, gray, flecked with black.
		196	7			Bottom of Hole

Sample No.	Analyses (%) Fe	P	Thickness of Zone Ft.	In.
T5-14A-1-z1	10.14	.146	3	6
T5-14A-2-z2	13.52	.166	20	5
T5-14A-3-z3	20.54	.354	3	10
T5-14A-4-z4	15.29	.125	3	5
T5-14A-5-z5	26.88	.644	4	3

Byron N. Cooper, Supervisor of Prospecting
November 16, 1961

LOG OF CORE HOLE T6-15A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic description
0	0	4	0	4	0	Overburden.
4	0	10	0	6	0	Clinton (Rose Hill) formation: Sandstone, ferruginous, coarse to medium grained.
10	0	15	5	5	5	Sandstone. slightly ferruginous, includes 4'7" core loss.
15	5	20	6	5	1	Sandstone, ferruginous, includes thin shale parting.
20	6	20	9		3	Shale, gray.
20	9	25	0	4	3	Sandstone, ferruginous, includes 1' core loss.
25	0	26	6	1	6	Shale, gray to maroon.
26	6	30	0	3	2	Sandstone, ferruginous, fine to coarse grained.
30	0	61	1	31	1	Shale and thin bedded sandstone, greenish-gray, soft, easily broken. Fossiliferous.
61	1	66	2	5	1	Sandstone, ferruginous, includes thin shale partings.
66	2	67	2	1	0	Shale, yellow to olive-drab.
67	2	67	6		4	Sandstone, ferruginous, coarse grained.
67	6	71	10	4	4	Shale, maroon.
71	10	75	3	3	5	Sandstone, highly ferruginous, fine to coarse grained.
75	3	80	1	4	10	Shale, grey to olive drab.
80	1	80	9	0	8	Sandstone, ferruginous, shaly.
80	9	82	9	2	0	Sandstone and shale, gray to maroon, low in iron.
82	9	86	7	3	10	Sandstone, ferruginous, mainly fine to medium grained.
86	7	92	10	6	3	Shale, gray to greenish-gray.
92	10	95	0	2	2	Sandstone and shale, gray.

						Fe (%)	P(%)
4	0	10	0	6	0	8.91	0.073
15	5	20	6	5	1	13.29	0.115
20	9	25	0	4	3	16.70	0.139
26	6	30	0	3	5	15.56	0.109
66	1	66	2	5	1	22.85	0.121
67	2	67	6		4	24.15	0.135
71	10	75	3	3	5	25.45	0.190
80	1	80	9	0	8	15.07	0.189

PREPARED BY William A. Moon and B. N. Cooper

LOG OF BORE HOLE T4-16A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and description.
0	0	3	0	3	0	Overburden.
						Clinton formation:
3	0	11	6	8	6	Sandstone, ferruginous, fine to coarse grained.
11	6	17	11	5	11	Sandstone, ferruginous, clay galls, 1'6" core loss.
17	11	36	0	18	1	Shale and sandstone, tin bedded, soft; fossiliferous.
36	0	37	1	1	1	Sandstone, ferruginous, low in iron.
37	1	40	6	3	5	Sandstone and shale, gray to red, low in iron.
40	6	46	0	5	6	Sandstone, ferruginous, fine to coarse grained.
46	0	52	0	6	0	Sandstone, ferruginous, wavellite incurstations at 51'.
52	0	52	7	0	7	Shale, gray.
52	7	55	2	2	7	Sandstone, ferruginous, coarse grained to medium grained.
55	2	63	0	7	10	Shale and thin sandstone, gray to brown.

Chemical Analysis

						% Fe	% P
3	0	11	6	8	6	17.34	0.163
11	6	17	11	5	11	18.64	0.146
36	0	37	1	1	1	13.62	0.132
40	6	46	0	5	6	16.37	0.209
46	0	52	0	6	0	20.10	0.331
52	7	55	2	2	7	17.67	0.215

Prepared by B. N. Cooper and W. A. Moon

LOG OF CORE HOLE Y6-17A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Description of Formation and Lithologic Character
0	0	3	0	3	0	Overburden
						Clinton (Rose hill formation).
3	0	7	3	4	3	Sandstone, ferruginous, medium to coarse grained.
7	3	8	6	1	3	Sandstone, brown, slightly ferruginous.
8	6	12	5	3	11	Sandstone, ferruginous, medium to coarse grained.
12	5	48	0	35	7	Shale and sandstone, gray to brown, soft, broken.
48	0	49	5	1	5	Sandstone, ferruginous, medium to fine grained.
49	5	55	4	5	11	Sandstone, ferruginous, coarse grained.
55	4	60	0	4	8	Sandstone, ferruginous, contains 40 to 50 per cent shale partings; low in iron.
60	0	64	5	4	5	Sandstone, ferruginous, coarse grained tofine grained.
64	5	78	0	13	7	Shale and thin sandstone, gray to brown, soft; ferruginous sandstone at 72'5" to 75'10".

Chemical Composition

From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	%Fe:	%P:
3	0	7	3	4	3	11.20	0.042
8	6	12	5	3	11	16.80	0.090
48	0	49	5	1	5	18.75	0.221
49	5	55	4	5	11	19.88	0.232
60	0	64	5	4	5	30.03	0.437
72	5	75	10	3	5	25.16	0.372

Prepared by W. A. Moon and B. N. Cooper

LOG OF CORE HOLE 18A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic description
0	0	4	0	4	0	Overburden.
4	0	9	3	5	3	Clinton (Rose Hill formation): Sandstone, ferruginous.
9	3	13	8	4	5	Sandstone, ferruginous, fine grained.
13	8	21	0	2	4	Sandstone, drab-gray, slightly ferruginous.
21	0	23	5	2	5	Sandstone, gray to maroon, too poor to sample.
23	5	37	0	13	7	Sandstone, grayish maroon, ferruginous, very shaly.
37	0	38	0	1	0	Shale, drab-maroon.
38	0	41	0	3	0	Sandstone, ferruginous, fine grained.
41	0	74	0	33	0	Shale, gray to brown, thin sandy beds included.
74	0	79	10	5	10	Sandstone, fine grained,ferruginous. shaly.
79	10	81	5	1	7	Shale and sandstone, gray to purplish-gray.
81	5	88	6	7	1	Sandstone , fine grained to coarse grained, ferruginous.
88	6	95	9	7	3	Sandstone, fine to coarse grained, ferruginous.
95	9	102	0	4	3	Shale.

ANALYSES

						Fe%	P%
4	0	9	3	5	3	10.47	0.118
9	3	13	8	4	5	10.98	0.108
13	8	21	0	7	4	8.55	0.136
23	5	37	0	13	7	8.23	0.140
38	0	41	0	3	0	15.98	0.118
74	0	79	10	5	10	15.98	0.122
81	5	88	6	7	1	15.01	0.128
88	6	95	9	7	3	16.30	0.110

Prepared by W. A. Moon and B. N. Cooper

LOG OF CORE HOLE T6-19A

Depths From Ft.	From In.	To Ft.	To In.	Thickness Ft.	Thickness In.	Formation and Lithologic character
0	0	2	0	2	0	Overburden
2	0	10	9	8	9	Clinton formation: Sandstone, ferruginous, coarse to medium grained.
10	9	13	10	3	1	Sandstone, ferruginous, fine to coarse grained.
13	10	17	0	3	2	Sandstone and shale, brown to red, low in iron.
17	0	19	10	2	10	Sandstone, ferruginous, medium to coarse grained.
19	10	65	0	45	2	Shale and sandstone, greenish-gray to brown, few hard layers are quartzitic; mostly soft rock.

From Ft.	From In.	To Ft.	To In.	Thickness Ft.	Thickness In.	Chemical Composition in %	
2	0	10	9	8	9	Fe:21.78%	P:0.085%
10	9	13	10	3	1	Fe:16.88%	P:0.179%
17	0	19	10	2	10	Fe:32.95	P:0.386%

Prepared by, W. A. Moon and B. N. Cooper

LOG OF HOLE T4-21A

Depths From Ft.	In.	To Ft.	In.	Thickness Ft.	In.	Formation and lithologic character
0	0	4	7	4	7	Overburden (workable ferruginous Clinton ss.)
4	7	7	2	2	7	Clinton (Rose Hill) formation: Sandstone, ferruginous, contains three inches of shale.
7	2	8	6	1	4	Shale, Maroon, unctuous.
8	6	10	7	2	1	Sandstone, ferruginous, coarse grained.
10	7	23	4	12	9	Sandstone, ferruginous, broken, much core loss.
23	4	24	0	0	8	Shale and sandstone, gray and brown.
24	0	25	5	1	5	Sandstone, ferruginous, fine grained.
25	5	26	0	0	7	Shale.
26	0	26	1	0	1	Sandstone, ferruginous, fine grained.
26	1	26	8	0	7	Shale, gray to maroon.
26	8	28	0	1	4	Sandstone, fine grained, ferruginous.
28	0	43	0	15	0	Shale and sandstone, gray to brown, soft.
43	0	46	4	3	4	Shale, rusty brown.
46	4	53	0	6	8	Shale, gray to maroon, unctuous.
53	0	56	0	3	0	Sandstone, drab-maroon, ferruginous.
56	0	56	3	0	3	Shale, greenish gray.
56	8	57	7	0	11	Sandstone, ferruginous, maroon shale partings abundant.
57	7	57	10	0	3	Shale, maroon.
57	10	58	7	0	9	Sandstone, maroon-drab, ferruginous, coarse grained, abundant shale partings.
58	7	60	5	1	10	Sandstone, ferruginous, shaly.
60	5	64	2	3	9	Sandstone, ferruginous, coarse-grained; shale partings.
64	2	64	4	0	2	Shale, maroon.
64	4	66	2	1	10	Sandstone, grayish maroon, shaly.
66	2	67	8	1	6	Sandstone, coarse grained, ferruginous.
67	8	68	6	0	10	Shale, drab-maroon, 6" core loss.
68	6	69	10	1	4	Sandstone, maroon, ferruginous clay galls.

ANALYSES

						Fe%	P%
4	7	7	2	2	7	15.66	0.106
7	2	8	6	1	4	15.17	0.114
8	6	23	0	14	6	18.40	0.070
24	0	28	0	4	0	14.85	0.072
53	0	56	0	3	0	21.79	0.132
56	8	58	7	1	11	19.69	0.260
60	5	64	2	3	9	15.17	0.068
64	4	66	2	1	10	18.89	0.060
66	2	69	10	3	8	21.95	0.058

Prepared by W. A. Moon
and B. N. Cooper

5

SUMMARY REPORT ON FIRST STAGE OF PROSPECTING FOR IRON ORE IN JEFFERSON NATIONAL FOREST, GILES COUNTY, VIRGINIA

This report summarizes the findings of prospecting and exploration of the Clinton iron-bearing sandstone occurring in seven prospecting-permit areas comprising some 12,000 acres in Jefferson National Forest, Giles County, Virginia, which were assigned to Minerals Development Corporation by the original permittee, E. L. Keesling. The report covers the results of surface geologic studies conducted by William A. Moon, geologist, who was principally responsible for conduct of field operations, also the results of preliminary core drilling by Cunningham Core Drilling and Grouting Corporation, and also some of the pertinent aspects of the laboratory and pilot-plant testing program conducted in the laboratories of Lurgi Gesellschaft für Chemie und Huttenwesen in Frankfurt am Main, West Germany. Chemical analyses of splits of the rock cores were prepared for analysis, utilizing crushing and fine-grinding equipment in the engineering laboratories at Virginia Polytechnic Institute, and these samples were largely analyzed for phosphorus and iron content by Lerch Brothers, Incorporated, Consulting Iron Ore Chemists, located at Hibbing, Minnesota. The German tests on the raw material were arranged for by Dravo Corporation, American sales representative for Lurgi.

Surface work was initiated on June 15, 1961, when Mr. William A. Moon was employed to handle field exploration. During the period June 15, 1961 through August 27, 1961, Mr. Moon undertook to map in detail the areal distribution of the Clinton iron formation in the seven permit areas. This work has necessarily continued up to the present time. The upper and lower contacts of the Clinton iron formation with the overlying and underlying rock formations, respectively, have been plotted on 1:24,000-scale air photos specially obtained for this purpose. Mr. Moon followed the drilling closely, logged and split the cores, and assisted in the preparation of samples for chemical analysis.

The original prospecting plan called for taking portions of the rock cores from the ore-bearing zones encountered in the drill holes and preparing from these samples a composite sample weighing several hundred pounds for testing in the Lurgi Works. Late during the progress of core drilling, it became known that Lurgi would require a much larger sample weighing approximately 8 tons. Consequently in order to prepare such a sample for shipment to Germany, it was necessary to obtain bulk surface samples from outcropping ore zones which could be identified from core-drilling done near those outcrops. The material shipped to Germany consisted of about 1,600 pounds of especially high-grade material from Pearis Mountain, and the rest (aggregating more than 7 tons) composed of equal quantities of material obtained from Sugar Run Mountain and from an area near Mercy Branch southwest of Angels Rest. The samples shipped to Germany compared favorably with the ore zones considered workable, as found in the core holes.

Mr. Mark Fara, Assistant Professor of Geology in the V. P. I. Department of Geological Sciences, went to Germany and observed the test procedures carried out by the Lurgi laboratory. Final results on the European tests have not been obtained, and it is not possible to make a specific evaluation of the outcome of these tests. Mr. Fara prepared a brief descriptive summary of the work performed in the Lurgi laboratory. That report was submitted to Mr. C. E. Pond, General Manager, on April 2, 1962.

As required by Federal regulations governing prospecting on United States property, quarterly reports on prospecting activity were prepared for the periods ending June 30, 1961; September 30, 1961; December 31, 1961; and March 31, 1962; copies of which are on file with the General Manager. These reports include detailed logs of core holes, chemical analyses, and a summary of footage drilled and money expended on each of the seven prospecting-permit areas. These reports are sent to D. C. Abernethy, Regional Mining Superviser, United States Geological Survey, Washington, D. C.

Surface Mapping Of Clinton Formation

Prospecting permits were necessarily obtained from the U. S. Forest Service on the basis of very little detailed geological work in the areas covered by the prospecting permits. Therefore, one of the principal phases of prospecting was to map in detail the iron-bearing formation to be core-drilled and tested. Air-photographic stereo coverage was obtained in March, 1961. Geologic mapping of the ore beds was done on this excellent photographic base in a preliminary way. If prospecting work should continue past Stage 1 of the prospecting plan, the air photographs will be used as the basis for a 1:1,000-scale topographic contour map covering the seven prospecting permits. The detailed geologic information already obtained in the course of Mr. Moon's field activities can be transferred to that new topographic base map as soon as it is made. For present purposes of reference, a 1:1,320-scale photo-enlargement of the standard Narrows topographic sheet (surveyed in 1932) has been used, a copy of which map accompanies this brief report. This map shows the areal distribution of the Clinton iron beds which are underlain by a resistant ridge-making orthoquartzite known as the Tuscarora Formation and overlain by an equally resistant but not quite so thick light-gray sandstone or orthoquartzite known as the Keefer Formation. The map also shows measured dip inclinations and strike bearings of outcropping ledges as observed from place to place; and the map records the locations of all "A" series drill holes as projected and drilled. Typical cross sections showing the topographic situation and geologic structure of the two principal zones of ferruginous sandstone in the Clinton Formation are shown on the accompanying base map.

The geologic map submitted with this summary does not embody all the detail that was obtained from field study and which will be incorporated in a more detailed geologic map based on the detailed topographic base map to be prepared if prospecting work continues past completion of Stage 1. The accompanying map is, however, wholly satisfactory for present purposes.

Core Drilling And Ore Sampling

Two series of columnar sections of drill holes accompanying this report show the thickness and quality of the ferruginous sandstones encountered in 17 drill holes representing an aggregate drilled footage of approximately 1,700 feet. Drilling was carried on in the area from late August until January (1962). Because of the exceedingly rough terrain and lack of adequate equipment, core drilling was exceedingly slow. Work that ordinarily would have required no more than 8 weeks actually required nearly six months.

Core drilling disclosed two zones of ferruginous sandstone which vary considerably in thickness and quality from place to place within the seven permit areas. Generally, one distinctively better zone of material ranging from 15 to 20 feet thick and averaging 20 per cent or more of iron was identified. In many places, this better zone is the lower one, but in some places, as shown in the series of columnar sections, the upper zone is better than the lower zone.

The better material ranges from 20 to 28 per cent metallic iron, and it is this better grade of material that is considered workable under present conditions. The thickness of workable material is only about one-third that anticipated. Thin intercalations of adulterating shale lower the iron content of the ore beds, but such shale is never seen admixed with ore beds cropping out at the surface. Some of the shale intercalations are relatively thick, so that mining of the ore will be somewhat more difficult than anticipated.

The two ore zones are separated by a prominent body of shale with some soft intercalated sandstone. Most of this intervening material is soft enough to present a minimum problem in quarrying and stripping operations. If reference is made to the columnar sections of the drill holes, it will be seen that where the lower zone of ferruginous sandstone is the better grade material, it would require stripping of all the top zone of ferruginous sandstone as well as the 45-foot zone of shale that overlies the lower zone. Core drilling shows that the Clinton Formation is well bedded, that the main iron-bearing zones persist in general throughout the area, but not without marked variations in local occurrence and grade.

These determinations make it hazardous to reason that material of the quality of that encountered in one of the drill holes persists very far from that particular place. When the prospecting plan was mapped out, it was hoped that the formation would exhibit consistency in thickness and grade so that the first group of core holes would show rather accurately the overall thickness and grade that could be expected. That hope was not realized. Portions of the area considered to be probably the best for future working were most disappointing. A few of the holes encountered very little good material. Despite the distressing variations observed, the core-hole data can be used to aid in estimating the thickness and grade in relatively localized portions of the total area covered by systematic study. Furthermore, core drilling has substantiated the fact that better material occurs within the permit areas than is known to occur in other Appalachian areas tributary to the Norfolk and Western Railway. Actually, the quality of the better material is only very slightly lower than was anticipated. The main disappointment disclosed from core drilling was the relative thinness of good material.

The results of core drilling confirm that the area investigated contains the best grade of Clinton ore known to occur in considerable quantity. The thinness of the better grade material encountered in the core holes simply necessitates scaling down rather drastically the tonnage estimates for recoverable, workable material. When the prospecting permits were applied for, it was anticipated that the reserves of usable material would be between 300 and 400 million tons. The actual reserves, based on the limited amount of drilling done, would be more properly estimated at about 120 million tons. Based upon an anticipated annual consumption of about 2 million tons of raw material to produce about 650,000 tons of commercial concentrate, it now appears safe to estimate there is sufficient material within the permit areas to last for about 60 years. Although this figure is considerably less than the 200 years supply expected to be found, it is still far more than adequate for the size of operation contemplated. Few metallic mineral deposits have a life expectancy of more than 75 years. Therefore, the test drilling data obtained, although somewhat disappointing, have disclosed sufficient material of the best-known grade of 20 per cent or better of metallic iron to be worth attempting to develop. along the lines envisioned earlier.

Based upon experience of the first stage of prospecting, at least 50 drill holes will be necessary to prove up an ore reserve of 40 million tons sufficient to supply a concentrating and beneficiation mill for 20 years. If prospecting continues past the first stage of the prospecting plan, $25,000 should be budgeted for proving a 20-year ore supply.

Table 1.- Summary of estimated reserves of material averaging 20% or better of iron in the Clinton (Rose Hill) formation, which can be quarried from permit areas in Jefferson National Forest, based upon all work done up to April 1, 1962.

Name of Area	BLM Permit Number	Size (In Feet) Length of Outcrop	Size (In Feet) Width of Outcrop	Thickness of Ore (Feet)	Per Cent Iron	Reserves In Millions Of Tons
Mercy Branch	A-051841	7,200	3,500	17	23-24	45
Pearis Mtn. (A)	A-050368 & A-o51841	20,000	750	15	22	25
Pearis Mtn. (B)	A-050368	6,500	1,500	25	20	25
Flattop Mtn.	A-o55777 A-051911 A-052619	3,500	1,000	30	18+	10
Nobusiness Creek	A-050369	5,000	500	30	21	7
Sugar Run Mtn.	A-050367	8,500	250	20	20	4

Note: "Pearis Mtn. (A)" lies northeast of Nobusiness-Mill creeks divide."Pearis Mtn. (B)" lies at the southwest end of Pearis Mountain.

As shown in Table 1, there are two relatively large bodies of ore of good grade: (1) the most important and the largest single deposit situated on the mountain slopes on either side of Mercy Branch of Mill Creek; and (2) a strip about 21,000 feet long along the outcrop of the upper zone of ferruginous sandstone on the segment of Pearis Mountain from the Mill Creek--Nobusiness Creek divide northeastward for a distance of nearly 5000 feet beyond the Appalachian Power Company's transmission lines. From these two sectors of the permit areas, it should be possible in the light of all that is now known to recover 65 to 75 million tons of raw material.

Core drilling and ore sampling indicate that these two deposits, whose estimated tonnage reserves of the material of the best grade constitute approximately 65 per cent of the total recoverable reserves now believed to be present, must be the two deposits selected for any contemplated development.

Mining Problems

Results of core drilling point up to conditions that will have principal influence in the success or failure of any mining enterprise that may be undertaken in the permit areas. The geologic and topographic situation of the large deposit tributary to Mercy Branch cannot be worked in the manner anticipated originally and which was discussed in considerable detail in various talks with the Forest Service officials, which led to granting of the permits. The plan originally envisioned consisted of quarrying out a long open cut which would be subsequently and progressively filled in and the surface rehabilitated by return of the tailings to the open cut. This system may be applicable to the

Pearis Mountain belt of outcrop, but definitely not to the one that is tributary to Mercy Branch. Large-scale stripping would have to be done in the latter, which would delay greatly any systematic restoration of the surface use of the land for forest. An average of 25 feet of covering material (overlying body of shale and in parts of the Mercy Branch deposit also the upper poor zone of ferruginous sandstone) would have to be stripped off before the lower better zone of ferruginous sandstone can be quarried out. Thus enormous stock piles of overburden would have to be created, which would later be redistributed over the surface after the good material had been mined. Problems created by this additional requirement of mining in the area containing the largest deposit can be overcome for an estimated $0.75 per ton of concentrate produced, but only provided that the Federal government allows mining in the Mercy Branch area.

When core drilling started, the best material in the permit areas was thought to be southwest of the Mill Creek divide, but with the first stage of core drilling having been completed, it is now quite apparent that the major portion of the reserves of the best material are in the watershed of Mill Creek. The recoverable reserves in the permit areas outside Mill Creek watershed simply are not sufficient to sustain an iron-ore processing and beneficiating industry. Therefore, it is absolutely essential that Mill Creek be considered the first and most important source of raw material for the industry contemplated.

In order to accomplish such an arrangement, it will be necessary to prevail upon the Town of Narrows to surrender its water rights in

Mill Creek. The only way permission was ever obtained to prospect in the Mill Creek watershed was to promise the Town that if prospecting was carried on in that area that it would in no way adversely affect the Town's water supply, or that if extensive prospecting or later mining were undertaken the permittees would develop for the Town of Narrows an adequate substitute water supply acceptable to the Town. This requirement can be worked out satisfactorily at an expense to the Corporation not in excess of $40,000. Work is already well under way in exploring adequate substitute water supplies for the Town of Narrows, but results and final recommendations are not yet available.

It would still remain to get the Forest Service to agree to a new and drastically different mining plan that would require wholesale stripping of an area of about 640 acres. This part of the problem of freeing the Mill Creek area for extensive quarrying will be much more difficult to accomplish. The only way this problem can be satisfactorily solved is to get the Forest Service to surrender its claim to the surface in the Mill Creek watershed in return for a comparable acreage of wooded land adjacent to some other part of the Jefferson National Forest. Such an arrangement would eliminate the intolerable attrition between the miner and the Forest Service during any attempted mining operations in the Mill Creek area. It would not and, of course, could not eliminate the Government's royalty on any iron recovered from the Mill Creek area.

The suggested methods for freeing the Mill Creek watershed are absolutely necessary, and their successful employment is a contingency upon which any future mining of iron ore in the permit areas will depend. Ways for surmounting this major problem to mining have already been submitted to the General Manager and will not be elaborated upon in this report.

Mining of the better material on Flattop Mountain will also entail a different system of recovery than contemplated, which will require wholesale stripping of considerable overlying soft rock, which will later be redistributed back over the quarried-out area. Quarrying in the Flattop Mountain area is not of immediate concern as a pressing problem. In the other areas of outcrop where mining could be undertaken, as enumerated in Table 1, the general method of restoring the surface and returning same to forest could be successfully carried out.

Beneficiation Tests

An essential part of the first stage of prospecting is to prove that a concentrate can be produced from the raw material, which would be acceptable to steel mills for blast furnace feed. The material shipped to Germany for testing in the Lurgi laboratory and pilot plant was to have been tested to yield a satisfactory answer to the question of successful beneficiation of the raw material into a merchantable concentrate. The Lurgi laboratory is recognized as the preeminent facility for such testing. Nothing comparable is available in the United States. A "statement of general objectives" was prepared prior to commencement of the Lurgi tests so that Mineral Development Corporation's interests would be fully protected by charting the Lurgi tests in directions that would yield a positive and specific answer to the question: "Can an iron concentrate of merchantable grade be processed at a reasonable cost and with a favorable percentage recovery of the iron from the raw material?".

As Prof. Fara has intimated in his memorandum of April 2, 1962, the Lurgi tests essentially confirmed our smaller scale studies and previous tentative conclusions, but there are still outstanding questions that must be solved, which will obligate Minerals Development Corporation for more unanticipated expense. First, the German laboratory does not have wet magnetic beneficiation equipment of the special type that would be required to obtain the best grade of final wet-magnetic concentrate from the roasted, magnetized preliminary concentrate. Accordingly, Lurgi has been requested to furnish through Dravo Corporation 1,000 pounds of roasted, magnetized material, which will be turned over to Minerals Development Corporation for transmittal to manufacturers of efficient wet-magnetic separators in the United States, who will make the final separation and recover a wet-magnetic concentrate. The 1,000-pound sample can be split into two samples and submitted to two different manufacturers. This will furnish the Corporation with an unequivocal answer to the preeminent question concerned in the first stage of prospecting. Assuming that this 1,000-pound sample is received within the next two weeks, it will be late May before the results will be available.

During the course of Lurgi testing a discrepancy was incurred in keeping a record of all the iron in the raw material. Lurgi's trained personnel have searched long and hard for a way to resolve and to account for a substantial amount of iron that was "lost" somewhere in the processing procedures. This "loss" is more a matter of bookkeeping than anything else. The discrepancy will eventually be resolved, but until this is accomplished, about 15 per cent of the iron in the raw material that was processed cannot be accounted for either in the tailings or in the concentrates in the various stages of testing.

Lurgi has requested that a 15-ton sample of material be shipped to Frankfurt for a complete rerun of all tests, which will be conducted at Lurgi's expense with Minerals Development Corporation underwriting only the cost of collecting the sample and shipping it to Frankfurt. Lump material could be sent, which would present a much smaller problem than shipping crushed ore as was done previously. It is not anticipated that Lurgi will release any information on the first round of tests until after the second sample has been processed. Therefore, Minerals Development Corporation has no choice but to cooperate with Lurgi in the proposed rerun of the raw material. Results of the Lurgi tests together with results of American tests of wet-beneficiation of the roasted, magnetized product Lurgi prepared from the first shipment of raw material must be in hand in order to determine whether it is advisable to proceed with subsequent stages of prospecting.

Summary

Work sofar completed has established that there is material of a grade appreciably better than that known in any other Appalachian deposit of the Clinton Formation in Virginia, which occurs within the permit areas in Jefferson National Forest in quantity sufficient to supply an iron-concentrate mill with raw material for 50 years or more. The major portion of the best reserves is situated in the Mill Creek watershed, and it is doubtful whether there are sufficient reserves outside this area to be worked exclusively. Therefore, the removal of restrictions that would hamper mining is imperative. If the permit areas can be freed of governmental control, save for payment of royalty on the minerals produced, it would be a great help to full utilization of the lands as a source of iron ore. The fact that the reserves are not nearly so large as originally anticipated makes mining in the Mill Creek watershed absolutely necessary in order to supply a mill with sufficient material to operate over a reasonable period.

The Lurgi tests will have to be repeated in order to determine what happened to the "missing" iron. The 15-ton sample requested should be collected as soon as possible and shipped to Frankfurt as requested. Most of the objectives of the Lurgi testing program on the Giles County ore were achieved with satisfactory results. The ore can be effectively reduced and magnetized in the Lurgi-patented reducing kiln. The roasted, reduced, magnetic product from this kiln was tested in a wet-magnetic separator not specially adapted for the Virginia material, and the best separation effected was just under 60 per cent Fe. A better concentrate can be produced in a separator designed to separate minus-325 mesh material, such as manufactured by Stearns or Dings here in the United States.

Dravo Corporation has requested Lurgi to ship a 1,000-pound sample of the kiln product produced in Germany, which can be sent to wet-magnetic separator manufacturers in the United States for trial separations and recovery of a high-grade iron concentrate that will, do doubt, average several per cent higher than the best of the German tests which were made using a separator designed to recover ferrosilicon alloy from a slurry rather than very finely ground magnetic iron oxide.

The delays attending a rerun of the Lurgi tests are regrettable, but these must be endured. The test program was sufficiently satisfactory to answer the major question of the amenability of the Virginia ore to reduction in the Lurgi kiln. This discovery is the last of the major contingencies to be removed in probing the possibility for producing a high-grade concentrate from the Clinton ore in Giles County.

If the 1,000-pound sample of roasted magnetic product is shipped to the United States promptly, the Corporation should have the results of wet-magnetic separation tests made on American separators within six weeks or less. As soon as these results are in hand, the Corporation will know whether it has a process that will work commercially. It appears very likely that a favorable result will be forthcoming, therefore it is recommended that consideration be given to authorizing the following work to be done between now and the time the results of the Lurgi tests are finally received:

(1) develop full information on all possible substitute water supplies for the Town of Narrows (continuing work already started);

(2) investigate possibilities for freeing the permit areas of government control of the surface by swapping acre for acre the forest land adjacent to government land for the permit areas, with due allowance for allowing the government to collect its royalty for minerals produced therefrom;

(3) preparation of a 15-ton sample of representative material for immediate shipment to Germany, involving a company expenditure of approximately $1,000; and

(4) contract with Abrams Aerial Surveys to make the topographic base map needed for further work, from photographs flown by that company in March, 1961.

Mr. Moon will continue his study of the Mercy Branch area where it is contemplated that mining should be undertaken first if undertaken at all within the permit areas. He will initiate a stream study to determine the nature and extent of natural transport of loose sediment, including red hematite, from the natural wooded slopes in the prospecting areas. The Forest Service is anxious to have this work start well before the onset of the usual decline in rainfall during the summer months.

The work consummated during the past 10 months has brightened considerably the prospects for establishing an iron ore industry based upon the deposits under lease.

Byron N. Cooper

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April 8, 1962

1962 cm (6)

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RECOMMENDATIONS FOR DEVELOPMENT OF A SUBSTITUTE WATER SUPPLY FOR THE TOWN OF NARROWS, VIRGINIA

Preliminary Statement

Preliminary drilling and chemical analysis of drill cores obtained from the Clinton ferruginous sandstone in Jefferson National Forest permit areas indicates that the bulk of the ore reserves of the highest quality sofar found is located in BLM Tract A-051841 in the valleys of Mercy Branch and Mill Creek between Wolf Creek Mountain and Pearis Mountain, south of Narrows, Virginia. That watershed serves as the water supply for the Town of Narrows, Virginia. The reservoir built by the Town consists of a small concrete dam that impounds a small quantity of surface water in Mill Creek downstream from the confluence with Mercy Branch. The dam is really little more than a weir that serves to conduct water into the intake pipe. The capacity of the reservoir is negligible.

Late in 1960, the writer conferred with the Narrows Town Council and secured from them a resolution endorsing the application of E. L. Keesling for a prospecting permit in a tract including the Town water reservoir. This endorsement was offered only after I had assured the Council that any extensive prospecting for or mining of iron minerals within the watershed of Mill Creek would be undertaken only after the Town had been furnished a substitute water supply acceptable to it in both quality and quantity, and only after the Town had released its water rights. I was authorized to make that guarantee by the permit applicant, E. L. Keesling, who was present at the Council meeting.

Knowingly or unknowingly, Minerals Development Corporation had to assume responsibility for that guarantee when E. L. Keesling assigned his permits to the Corporation. At the time the permits were acquired the possibility of ever mining ferruginous sandstone in the Mill Creek watershed was viewed as very remote, because all information then in hand seemed to indicate that the best deposits lay southwest of the divide between Nobusiness and Mill creeks. The first stage of prospecting has definitely established that the best ore is actually northeast of that watershed divide and that the greater tonnage of quarriable material is obtainable in that area. Therefore, the Mill Creek watershed has had to be considered the Corporations principal potential ore supply. Without access to the Mill Creek deposits, there is probably insufficient raw material to justify any attempt at commercial development of the sandstone deposits as a source of iron. Consequently, the finding of a substitute water supply for the Town of Narrows has become an inescapable requirement fulfillment of which is absolutely necessary to proceed past the first stage of prospecting. The Forest Service has already required the Corporation to spend about $800 repairing and reseeding the Mill Creek road by way of which two bulk samples of ferruginous sandstone were hauled out of BLM-A-051841 permit tract. On Monday or Tuesday of the present week, the Appalachian Power Company sent a heavy service truck down the same road during a rainy period and probably nullified most of the remedial work previously expended under Mr. W. A. Moon's direction. If the Corporation undertakes any prospecting connected with Stage Two of the official prospecting plan mutually approved by the permittee, it must have executed development of a satisfactory substitute water supply for the Town of Narrows and have secured a termination of the Town's water rights in the Mill Creek watershed. For these reasons, it is considered advisable to explore the possibilities for a substitute water supply and have in hand a plan for its exploration and development, which can be put into effect immediately if the management decides to continue with the prospecting plan through the second stage.

Present Water Supply Of Town Of Narrows

The present reservoir on Mill Creek is probably capable of supplying about 200,000 gallons per day. That amount probably suffices the Town's present needs. The valley of Mill Creek is so steep and narrow that it will not be feasible to construct a higher dam and attempt to impound any additional water. Therefore, any expansion of the Town's water supply must look to development of a supply in some other area. Reportedly the Town has made some use of a stand-by well, but no investigation of that reported well was made in order to avoid the risk of stirring up local apprehension about the field studies that have been conducted.

The quality of water supplied by the Mill Creek runoff (Tables 1, 2, and 16) is excellent. Dissolved solids average only about 50 ppm. The pH of the water is less than 7 and probably averages about 6. Ferrous iron seems to be absent. Despite the limited quantity that can be recovered from so small a reservoir or impoundment area, Narrows has a valuable source of water of a superior quality that is unexcelled in southwestern Virginia.

Possible Substitute Water Supplies

New River.- This large river offers abundance of surface water that could furnish Narrows with all the water the Town could ever need. As shown by Table 3, the quality of water is definitely inferior to that of Mill Creek, and the dissolved solids probably average about 140 ppm. New River water is, however, quite acceptable in quality, based on U. S. Public Health Service standards, but it would create considerable objection from the local populace who have become accustomed to soft water from Mill Creek. New River tends to carry large quantities of dissolved solids and also much suspended sediment, so much in fact that a three-stage filtration plant would probably be required to process the water. Such a plant can only operate efficiently at an uptake of about 500,000 gpd, which is more than the Town can be expected to use in the foreseeable future. In order to soften the water to a condition anywise comparable to the present supply would require very expensive treatment.

The cost of the expensive filtration plant that would be needed to prepare water directly from New River can be avoided if the river is utilized as recharge for a 300-foot well that could be drilled at some convenient place relatively close to the river. Clear water is being obtained from two wells of enormous yield at the Celco Fibers Division of Celanese Corporation near Bluff City, from fractured dolomites. One well yields 1,000 gpm and another 1,200 gpm, both on continuous pump with virtually no drawdown. Heavy chlorination of the well water is, however, required.

Evidently, the fractured dolomite occurs also in the vicinity of Narrows and can serve just as effectively as a natural filter bed in clarifying the recharge water from New River. If the Town would not object to water of the quality of that obtained from such a well, a substitute water supply could be developed from a well utilizing recharge from New River at minimum cost. Actually two wells would be required, and the total cost of constructing them and installing suitable turbine pumps should not exceed $8,000. At least an attempt should be made to induce the Town to settle for such a supply. The chief argument in favor of such a supply is that use of river water is inevitable if Narrows enjoys any considerable growth and industrial expansion. The excellent Mill Creek supply will not be able to serve a larger community.

Wolf Creek.- This major tributary of New River averages about 100 ppm of dissolved solids south of Rocky Gap, Bland County, above its confluence with Clear Fork which drains a large limestone valley (Table 4). As shown by Tables 5 to 9, inclusive, Wolf Creek offers water of a quality roughly comparable to New River. However, the turbidity of Wolf Creek is subject to extreme variance, which would tax any filtration plant designed to clear up water from that source. The dissolved solids average about 160 ppm, but there is considerable fluctuation with rate of discharge. The one detraction of Wolf Creek is the relatively high organic pollution of the runoff.

The creek conceivably could be utilized as recharge for a 300-foot water well drilled somewhere relatively close to the creek into fractured dolomite. In the Narrows district, the dolomite is rather extensively ground up into a fault gouge which would doubtless increase materially the bicarbonate and carbonate hardness of the well water compared to that of the creek water itself. This fault gouge is not present along New River, and for that reason well water of better quality can be expected from a well utilizing New River for recharge than one dependent upon Wolf Creek for its recharge.

Springs.- The valley of Wolf Creek is fed by a large number of natural springs, most of them draining off the northwest side of the valley across thick bodies of fault gouge composed of dolomite flour locally quarried for "magnesium marl". The expectable quality of spring water is attested by Table 10, which is so hard that it cannot be considered seriously with better quality waters available for utilization. Spring supplies are also subject to the vagaries of rainfall. Yields decrease markedly during drouths, and during excessively rainy seasons turbidity becomes a serious problem in water treatment. Springs should be ruled out as a satisfactory source of water.

Piney Creek.-From The Hopper northeast to New River, Piney Creek flows between Piney Ridge and the main East River Mountain. The creek essentially follows a high-angle fault zone cutting sandstones and shales of upper Ordovician to lower Devonian formations, only a few beds of which are appreciably calcareous. Essentially, Piney Creek Valley is a "freestone" watershed whose water is comparable to that of Mill Creek. However, the drainage area of Piney Creek is materially less than that of Mill Creek and Mercy Branch. The high elevation of the valley floor which is situated on a fault zone doubtless encourages subsurface percolation and underflow. Water of the quality of that shown in Tables 12 and 13 can probably be obtained from 300-foot wells so located as to intercept the fault zone. The absence of human habitation in the middle and upper reaches of Piney Creek watershed insures water of good purity. Considering the size of the drainage area and the possibilities for accentuating infiltration for recharge of wells located along Piney Creek as a consequence of heavy pumping, it should be possible to produce up to about 300,000 gpd of water of excellent chemical quality and biological purity, which would make a very satisfactory substitute for the Town's present supply.

The fault zone in the bottom of the valley precludes possibility for any effective surface impoundment of water, but the fault would actually benefit production of ground water that was recharged by surface flow. Two wells located somewhat more than 300 feet apart and in the general vicinity of the second power transmission-line crossing the valley could be constructed for about $8,000. A 7,000-foot pipeline would be required to connect that supply with present Town mains.

Water rights would have to be obtained from owners of the land involved. If possible, consideration should be given to outright purchase of the rough mountain land that lies within the drainage of Piney Creek.

Other sources.- A number of small surface streams occur in the deep, short valleys draining the mountainous slopes northwest of State Highway 61 in Wolf Creek Valley. The quality of water in the largest of these small streams is given in Table 14. The water is almost as good as Piney Creek water, but the former is too far away from Narrows to be given serious consideration even as an auxiliary source.

Recommendations

From field studies of terrain and from analyses of three rounds of water samples collected from 16 localities, it is clear that the best substitute source for a water supply for the Town of Narrows would be from wells situated in the valley of Piney Creek near the second or upper power transmission line.

The wells drilled in that locality should be constructed after an option has been obtained on water rights in the private land involved. The wells should be drilled to a depth of 300 feet with a diamater sufficient to carry a 10-inch casing. The wells should be cased at least 50 feet below stream level. Pumping tests should be conducted in the period July through mid-November and should be no less than 48 hours duration. The pumping of the wells should be conducted under conditions of a stabilized drawdown with the pump impellers set at about 250 feet. Careful records should be kept on the wells and subsequent pumping tests in order not to overevaluate the yields of the wells.

The first well should be drilled purely as an exploratory venture before any commitment has been made with the Town. The second well should not be drilled within 300 feet of the other well. One well will serve as a standby for the other. The well elevations of about 2,250 feet will insure gravity flow to virtually all parts of the Town of Narrows.

If the Piney Creek supply is utilized as recommended, a third well should be drilled along Wolf Creek to serve as a temporary auxiliary supply in case of extensive fire.

In reviewing the water analyses, maximum figures rather than minimum should be used in evaluating the various sources summarized in Tables 1-16.

Plate 1 shows the locations of 15 of the 16 localities where water was sampled in connection with preparation of this report. Samples were collected by W. A. Moon at the times indicated in Tables 1 to 16. Analyses were made in the laboratory of the Motive Power Department of the Norfolk and Western Railway Company.

Table 1 - Water quality data on Mill Creek above junction with Mercy Branch, Map Location 1, about 2.9 miles south of Narrows, Giles County, Virginia.

Sample Number		5 1/	5A 2/	5B 3/
pH @ 77° F.		5.50	5.99	7.00
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	6.8	3.4	3.4
Suspended matter	ppm.	8.5	0.4	0.4
Total dissolved solids	ppm.	46.2	51.3	44.5
Manganese	ppm.	0.00	0.00	0.0
Ferrous Iron	ppm.	0.1	0.00	0.0
Calcium Sulphate	ppm.	0.0	0.00	0.0
Calcium Bicarbonate	ppm.	1.4	0.80	0.0
Magnesium Sulphate	ppm.	0.0	0.00	0.0
Magnesium Carbonate	ppm.	0.7	0.7	1.2
Nitrates as $NaNO_3$	ppm.	1.9	0.30	9.0
Chlorides as NaCl	ppm.	5.1	6.9	5.1
Calcium Soap Hardness	ppm.	1.7	1.4	1.4
Calc. Total Alkalinity	ppm.	3.4	3.4	1.7

1/ Sample 5 taken 12:45 P.M., Mar. 26, 1962. Weather: partly cloudy.

2/ Sample 5A taken 8:30 A.M., May 1, 1962. Weather: partly cloudy, sunny, warm.

3/ Sample 5B taken 3:50 P. M., May 24, 1962. Weather: clear sunny, warm.

Table 2 - Water quality data on Mercy Branch, above Mill Creek, Location 2, about 2.8 miles south-southeast of Narrows, Giles County, Virginia.

Sample Number		6 1/	6A 2/	6B 3/
pH @ 77° F.		5.50	6.21	5.70
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	5.1	4.3	2.6
Suspended matter	ppm.	6.3	2.6	0.2
Total Dissolved Solids	ppm.	51.3	46.2	46.2
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	1.4	1.4	1.5
Magnesium Sulphate	ppm.	0.0	0.00	0.0
Magnesium Carbonate	ppm.	0.7	1.3	0.7
Nitrates as $NaNO_3$	ppm.	0.4	0.75	7.5
Chlorides as NaCl	ppm.	15.4	8.6	6.0
Calcium Soap Hardness	ppm.	1.7	2.9	1.7
Calc. Total Alkalinity	ppm.	5.1	3.1	1.7

1/ Sample 6 taken 1:20 P. M., March 26, 1962. Weather: partly cloudy, cool, windy.

2/ Sample 6A taken 8:55 A. M., May 1, 1962. Weather: partly cloudy, warm, sunny.

3/ Sample 6B taken 4:20 P. M., May 24, 1962. Weather: clear, warm, sunny.

Table 3 - Water quality data on New River, off west bank of New River, Location 3, about 1.5 miles north of Narrows, Giles County, Virginia.

Sample Number		13 1/	13A 2/	13B 3/
pH @ 77° F.		7.74	8.51	7.69
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	7.6	0.0	1.7
Suspended matter	ppm.	6.0	5.2	1.0
Total dissolved solids	ppm.	76.9	150.5	141.9
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	47.0	47.1	47.1
Magnesium Sulphate	ppm.	7.2	0.0	4.1
Magnesium Carbonate	ppm.	16.0	21.1	17.2
Nitrates as $NaNO_3$	ppm.	9.6	10.2	9.0
Chlorides as NaCl	ppm.	1.2	7.2	8.6
Calcium Soap Hardness	ppm.	54.0	54.4	53.0
Calcium Total Alkal.	ppm.	48.0	54.4	49.6

1/ Sample taken 11:15 A. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken 2:15 P. M., April 30, 1962. Weather: partly cloudy, warm, sunny.

3/ Sample taken 8:15 A. M., May 24, 1962. Weather: clear, calm, warm; water low.

Table 4 - Water quality data on Wolf Creek at point 1.8 miles south of Rocky Gap, Bland County, on U. S. Route 52. (Sample taken 50 feet above Tuscarora-Juniata contact.)

Sample Number		1 1/	1A 2/	1B 3/
pH @ 77° F.		7.21	7.78	7.79
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	3.4	6.0	0.9
Suspended matter	ppm.	9.5	2.6	2.6
Total dissolved solids	ppm.	104.4	124.8	119.7
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.10	0.0
Calcium sulphate	ppm.	0.0	0.00	0.0
Calcium Bicarbonate	ppm.	41.6	65.9	52.7
Magnesium Sulphate	ppm.	0.0	0.00	6.0
Magnesium Carbonate	ppm.	10.1	3.4	5.1
Nitrates as $NaNO_3$	ppm.	7.3	3.6	10.0
Chlorides as NaCl	ppm.	13.7	7.7	6.0
Calcium Soap Hardness	ppm.	37.7	44.8	43.6
Calc. Total Alkalinity	ppm.	39.4	45.0	38.6

1/ Sample taken 4:30 P. M., March 17, 1962. Weather: cloudy, windy, cool.

2/ Sample taken 8:30 A. M., April 30, 1962. Weather: cloudy, overcast, cool.

3/ Sample taken 2:10 P. M., May 24, 1962. Weather: warm, overcast, rain, showers.

Table 5 - Water quality data on Wolf Creek 4.1 miles southwest of Narrows at Junction of Roads 724 and 673, Giles County, Virginia. Map location 4.

Sample Number		9 1/	9A 2/	9B 3/
pH @ 77° F.		7.08	8.62	8.12
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	6.0	0.0	1.7
Suspended matter	ppm.	1.0	7.2	3.8
Total dissolved solids	ppm.	154.0	104.3	136.8
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.1	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	55.1	33.2	58.2
Magnesium Sulphate	ppm.	0.0	1.1	0.0
Magnesium Carbonate	ppm.	13.4	11.5	18.6
Nitrates as $NaNo_3$	ppm.	9.0	6.0	9.0
Chlorides as NaCl	ppm.	10.0	8.2	6.0
Calcium soap hardness	ppm.	50.0	35.1	58.1
Calcium Tot. Alkalinity	ppm.	50.0	34.2	59.8

1/ Sample taken at 9:15 A. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken at 9:15 A. M., April 30, 1962. Weather: cloudy, showers.

3/ Sample taken at 12:05 P. M., May 24, 1962. Weather: warm, sunny, clear.

Table 6 - Water quality data on Wolf Creek at stream-gaging station on south side of Wolf Creek 1.3 miles southwest of Narrows, Giles County, Virginia. Map location 5.

Sample Number		10 1/	10A 2/	10B 3/
pH @ 77° F.		7.20	7.89	7.91
Color		none	none	none
Turbidity		slight	slight	slight
Free carbon dioxide	ppm.	8.0	3.4	0.3
Suspended matter	ppm.	15.0	1.4	1.6
Total dissolved solids	ppm.	137.0	172.7	169.2
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.2	0.1	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	68.0	77.6	69.3
Magnesium Sulphate	ppm.	10.8	3.0	0.0
Magnesium Carbonate	ppm.	7.6	24.4	26.5
Nitrates as $NaNo_3$	ppm.	10.8	10.8	9.0
Chlorides as NaCl	ppm.	10.0	8.6	6.0
Calcium Soap Hardness	ppm.	60.0	79.5	74.4
Calc. Total Alkalinity	ppm.	51.0	77.0	75.2

1/ Sample taken at 9:30 A. M., March 27, 1962. Weather: warm, sunny, clear.
2/ Sample taken at 9:45 A. M., April 30, 1962. Weather: cloudy, showers.
3/ Sample taken at 12:10 P. M., May 24, 1962. Weather: warm, sunny, clear.

Table 7 - Water quality data on Wolf Creek, south bank across from playground about 300 feet above trash dump at Narrows town limits, Giles County, Virginia. Map location 6.

Sample Number		11 1/	11A 2/	11B 3/
pH @ 77° F.		7.92	8.40	7.89
Color		none	none	none
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	6.0	0.0	1.7
Suspended matter	ppm.	3.0	7.2	3.2
Total Dissolved Solids	ppm.	164.2	124.8	169.3
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	55.0	30.5	69.3
Magnesium Sulphate	ppm.	8.4	5.3	2.0
Magnesium Carbonate	ppm.	12.6	20.8	23.9
Nitrates as $NaNO_3$	ppm.	9.6	9.0	9.0
Chlorides as NaCl	ppm.	8.0	6.0	7.7
Calcium Soap Hardness	ppm.	56.0	47.5	71.8
Calc. Total Alkalinity	ppm.	49.0	43.1	70.1

1/ Sample taken at 10:10 A. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken at 10:00 A. M., April 30, 1962. Weather: cloudy, showers.

3/ Sample taken at 12:20 P. M., May 24, 1962. Weather: warm, sunny, clear.

Table 8 - Water quality data on Wolf Creek 2 miles southwest of Narrows, Giles County, Virginia. Map location 7.

Sample Number		12 1/	12A 2/	12B 3/
pH @ 77° F.		8.01	8.92	7.55
Color		none	none	brownish
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	4.8	0.0	0.5
Suspended Matter	ppm.	2.0	8.2	15.2
Total Dissolved Solids	ppm.	97.5	112.9	157.3
Manganes	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	48.6	19.4	66.4
Magnesium Sulphate	ppm.	3.1	2.0	0.0
Magnesium Carbonate	ppm.	17.1	20.5	12.9
Nitrates as $NaNO_3$	ppm.	9.0	7.2	9.0
Chlorides as NaCl	ppm.	9.0	6.8	6.8
Calcium Soap Hardness	ppm.	53.0	38.5	56.4
Calc. Total Alkalinity	ppm.	50.4	36.8	65.0

1/ Sample taken at 10:30 A. M., March 27, 1962. Weather: clear, sunny.
2/ Sample taken at 10:05 A. M., April 30, 1962. Weather: rain, steady.
3/ Sample taken at 10:20 A. M., May 24, 1962. Weather: cool, cloudy, showers.

Table 9 - Water quality data on Wolf Creek behind Narrows Hotel, 50 feet upstream from old sewage discharge pipe, Narrows, Giles County, Virginia. Map location 8.

Sample Number		14 1/	14A 2/	14B 3/
pH @ 77° F.		8.10	7.05	7.62
Color		none	none	brownish
Turbidity		slight	slight	med. amt.
Free Carbon Dioxide	ppm.	2.0	3.1	3.6
Suspended Matter	ppm.	4.0	4.4	43.2
Total Dissolved Solids	ppm.	106.0	172.7	169.3
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	53.5	76.1	74.8
Magnesium Sulphate	ppm.	6.0	0.0	0.0
Magnesium Carbonate	ppm.	13.4	23.7	23.9
Nitrates as $NaNO_3$	ppm.	9.0	7.2	8.0
Chlorides as NaCl	ppm.	12.0	7.7	6.8
Calcium Soap Hardness	ppm.	54.0	75.2	73.5
Calc. Total Alkalinity	ppm.	49.0	75.2	73.5

1/ Sample taken at 11:30 A. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken at 2:30 P. M., April 30, 1962. Weather: partly cloudy, warm, sunny.

3/ Sample taken at 10:05 A. M., May 24, 1962. Weather: cool, showers, low clouds.

Table 10 - Water quality data on spring water issuing from cavern in dolomite, located on gravel road 0.4 mile north of Shumate, Giles County, Virginia. Map location 9.

Sample Number		15 1/	15A 2/	15B 3/
pH @ 77° F.		7.18	7.06	7.31
Color		none	none	none
Turbidity		slight	slight	none
Free Carbon Dioxide	ppm.	15.0	10.3	12.3
Suspended Matter	ppm.	6.0	1.4	1.0
Total Dissolved Solids	ppm.	171.0	239.4	236.0
Manganese	ppm.	0.0	0.00	0.0
Ferrous Iron	ppm.	0.1	0.00	0.0
Calcium Sulphate	ppm.	0.0	0.00	0.0
Calcium Bicarbonate	ppm.	119.9	146.8	133.4
Magnesium Sulphate	ppm.	0.0	0.0	2.0
Magnesium Carbonate	ppm.	32.8	37.4	35.9
Nitrates as $NaNO_3$	ppm.	1.2	7.2	9.0
Chlorides as NaCl	ppm.	10.0	9.4	9.4
Calcium Soap Hardness	ppm.	102.0	131.7	126.5
Total Alkalinity, Calc.	ppm.	113.0	135.1	124.8

1/ Sample taken at 1:00 P. M., March 27, 1962. Weather: clear, warm, sunny.
2/ Sample taken at 3:05 P. M., April 30, 1962. Weather: cloudy, high, overcast.
3/ Sample taken at 10:55 A. M., May 24, 1962. Weather: cool, cloudy, showers.

Table 11 - Water quality data on stream on Thomas Blankenship property, 1.1 miles west of Narrows, Giles County, Virginia. Map location 10.

Sample Number		16 1/	16A 2/	16B 3/
pH @ 77° F.		6.72	7.08	6.34
Color		none	none	brownish
Turbidity		slight	slight	med. amt.
Free Carbon Dioxide	ppm.	2.0	2.1	0.5
Suspended Matter	ppm.	1.0	7.8	17.8
Total dissolved solids	ppm.	70.0	83.8	71.8
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	0.0	3.4	8.3
Magnesium Sulphate	ppm.	0.0	0.0	0.0
Magnesium Carbonate	ppm.	3.7	2.5	0.0
Nitrates as $NaNO_3$	ppm.	0.6	0.6	9.0
Chlorides as NaCl	ppm.	12.0	7.2	6.0
Calcium Soap Hardness	ppm.	4.4	4.8	2.6
Calc. Total Alkalinity	ppm.	4.4	5.1	4.3

1/ Sample taken at 1:50 P. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken at 3:40 P. M., April 30, 1962. Weather: high overcast, cloudy.

3/ Sample taken at 10:35 A. M., May 24, 1962. Weather: cool, cloudy, showers.

Table 12 - Water quality data on Piney Creek beneath upper power transmission line crossing, 2 miles west-northwest of Narrows, Giles County, Virginia. Map location 11.

Sample Number		2 1/	2A 2/	2B 3/
pH @ 77° F.		6.60	8.79	6.78
Color		none	none	none
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	1.7	0.0	4.3
Suspended Matter	ppm.	13.9	6.6	0.4
Total Dissolved Solids	ppm.	35.9	70.1	54.7
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	5.5	5.3	4.2
Magnesium Sulphate	ppm.	0.0	0.0	0.0
Magnesium Carbonate	ppm.	1.4	3.0	2.1
Nitrates as $NaNO_3$	ppm.	0.9	1.2	11.0
Chlorides as NaCl	ppm.	12.0	7.4	6.9
Calcium Soap Hardness	ppm.	5.1	6.9	5.1
Calc. Total Alkalinity	ppm.	8.5	7.2	5.1

1/ Sample taken at 9:00 A. M., March 26, 1962. Weather: cool, cloudy, overcast.

2/ Sample taken at 2:35 P. M., April 30, 1962. Weather: cloudy, sunny, warm.

3/ Sample taken at 8:45 P. M., May 24, 1962. Weather: cool, cloudy, overcast.

Table 13 - Water quality data on Piney Creek, 2.25 miles upstream from second power transmission line, 3 miles west northwest of Narrows, Giles County, Virginia. Map location 12.

Sample Number		3 1/	3A 2/	3B 3/
pH @ 77° F.		5.81	6.00	5.6
Color		none	none	none
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	5.1	3.4	6.0
Suspended Matter	ppm.	14.1	2.5	0.7
Total Dissolved Solids	ppm.	44.5	59.9	51.3
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	1.4	0.0	1.5
Magnesium Sulphate	ppm.	0.0	0.0	0.0
Magnesium Carbonate	ppm.	0.7	1.4	1.4
Nitrates as $NaNO_3$	ppm.	0.7	0.6	9.0
Chlorides as NaCl	ppm.	12.0	7.7	6.9
Calcium Soap Hardness	ppm.	1.7	1.7	2.6
Calc. Total Alkalinity	ppm.	3.4	3.4	3.4

1/ Sample taken at 10:00 A. M., March 26, 1962. Weather: cloudy, cool.

2/ Sample taken at 1:40 P. M., April 30, 1962. Weather: warm, sunny.

3/ Sample taken at 9:20 A. M., May 24, 1962. Weather: cloudy, cool, showers.

Table 14 - Water quality data on stream .35 mile southeast of The Hopper, just below junction of two main branches, 4 miles west of Narrows, Giles County, Virginia. Map location 13.

Sample Number		7 1/	7A 2/	7B 3/
pH @ 77° F.		6.20	6.41	6.27
Color		none	none	none
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	3.4	4.3	4.8
Suspended Matter	ppm.	9.9	2.2	2.6
Total Dissolved Solids	ppm.	53.0	49.6	47.9
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	2.8	4.4	1.1
Magnesium Sulphate	ppm.	0.0	0.0	0.0
Magnesium Carbonate	ppm.	0.7	0.0	1.2
Nitrates as $NaNO_3$	ppm.	0.4	1.2	12.0
Chlorides as NaCl	ppm.	13.7	8.6	6.9
Calcium Soap Hardness	ppm.	2.6	2.1	2.1
Calc. Total Alkalinity	ppm.	6.8	3.6	5.1

1/ Sample taken at 4:20 P. M., March 26, 1962. Weather: partly cloudy.
2/ Sample taken at 10:25 A. M., May 1, 1962. Weather: warm and sunny.
3/ Sample taken at 11:20 A. M., May 24, 1962. Weather: warm and sunny.

Table 15 - Water quality data on creek draining valley south of The Hopper, about 400 feet north of State Highway 61, 4 miles west-southwest of Narrows, Giles County, Virginia. Map location 14.

Sample Number		8 1/	8A 2/	8B 3/
pH @ 77° F.		6.60	6.94	7.03
Color		none	none	reddish
Turbidity		slight	slight	29 ppm.
Free Carbon Dioxide	ppm.	3.4	3.4	4.8
Suspended Matter	ppm.	6.7	3.2	29.4
Total Dissolved Solids	ppm.	58.2	65.0	66.7
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.1	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	5.5	8.6	12.5
Magnesium Sulphate	ppm.	0.0	0.0	3.2
Magnesium Carbonate	ppm.	1.4	2.0	1.4
Nitrates as $NaNO_3$	ppm.	0.5	1.2	9.0
Chlorides as NaCl	ppm.	6.8	8.6	6.0
Calcium Soap Hardness	ppm.	5.1	7.7	12.1
Calc. Total Alkalinity	ppm.	6.8	8.9	9.4

1/ Sample taken at 9:00 A. M., March 27, 1962. Weather: clear, warm, sunny.

2/ Sample taken at 4:20 P. M., April 30, 1962. Weather: high overcast.

3/ Sample taken at 11:45 A. M., May 24, 1962. Weather: warm, sunny.

Table 16 - Water quality data on Narrows reservoir, 2 miles south of Narrows, Giles County, Virginia. Map location 15.

Sample Number		4 1/	4A 2/	4B 3/
pH @ 77° F.		6.20	5.99	7.02
Color		none	none	none
Turbidity		slight	slight	slight
Free Carbon Dioxide	ppm.	5.1	3.4	3.1
Suspended Matter	ppm.	14.0	0.4	0.6
Total Dissolved Solids	ppm.	46.2	51.3	49.6
Manganese	ppm.	0.0	0.0	0.0
Ferrous Iron	ppm.	0.0	0.0	0.0
Calcium Sulphate	ppm.	0.0	0.0	0.0
Calcium Bicarbonate	ppm.	2.8	0.8	1.9
Magnesium Sulphate	ppm.	0.0	0.0	0.0
Magnesium Carbonate	ppm.	1.4	0.7	1.8
Nitrates as $NaNO_3$	ppm.	0.7	0.3	8.0
Chlorides as NaCl	ppm.	10.3	6.9	5.6
Calcium Soap Hardness	ppm.	3.4	1.4	3.4
Calc. Total Alkalinity	ppm.	5.1	3.4	4.3

1/ Sample taken at 11:30 A. M., March 26, 1962. Weather: cloudy, cool.

2/ Sample taken at 9:30 A. M., May 1, 1962. Weather: warm, sunny.

3/ Sample taken at 5:05 P. M., May 24, 1962. Weather: warm, sunny, clear.

The future of the Clinton iron project depends heavily on the successful completion of an understanding with the Town of Narrows whereby the Town relinquishes its water right in Mill Creek and accepts a reasonable substitute water supply. These necessary attainments will require skillful negotiation, and the full responsibility for that phase of the project should be assumed by some person in the Norfolk and Western Railway Company. It will not be possible for me to participate in any of the negotiations with the Town, although I shall be glad to supply information if needed. After the clearance has been obtained to proceed with development of the auxiliary supply, I shall be glad to resume work on the water project, follow the progress of the wells, and evaluate the results of the drilling and subsequent pumping tests.

July 3, 1962

Submitted in triplicate

Prepared by,

Byron N. Cooper

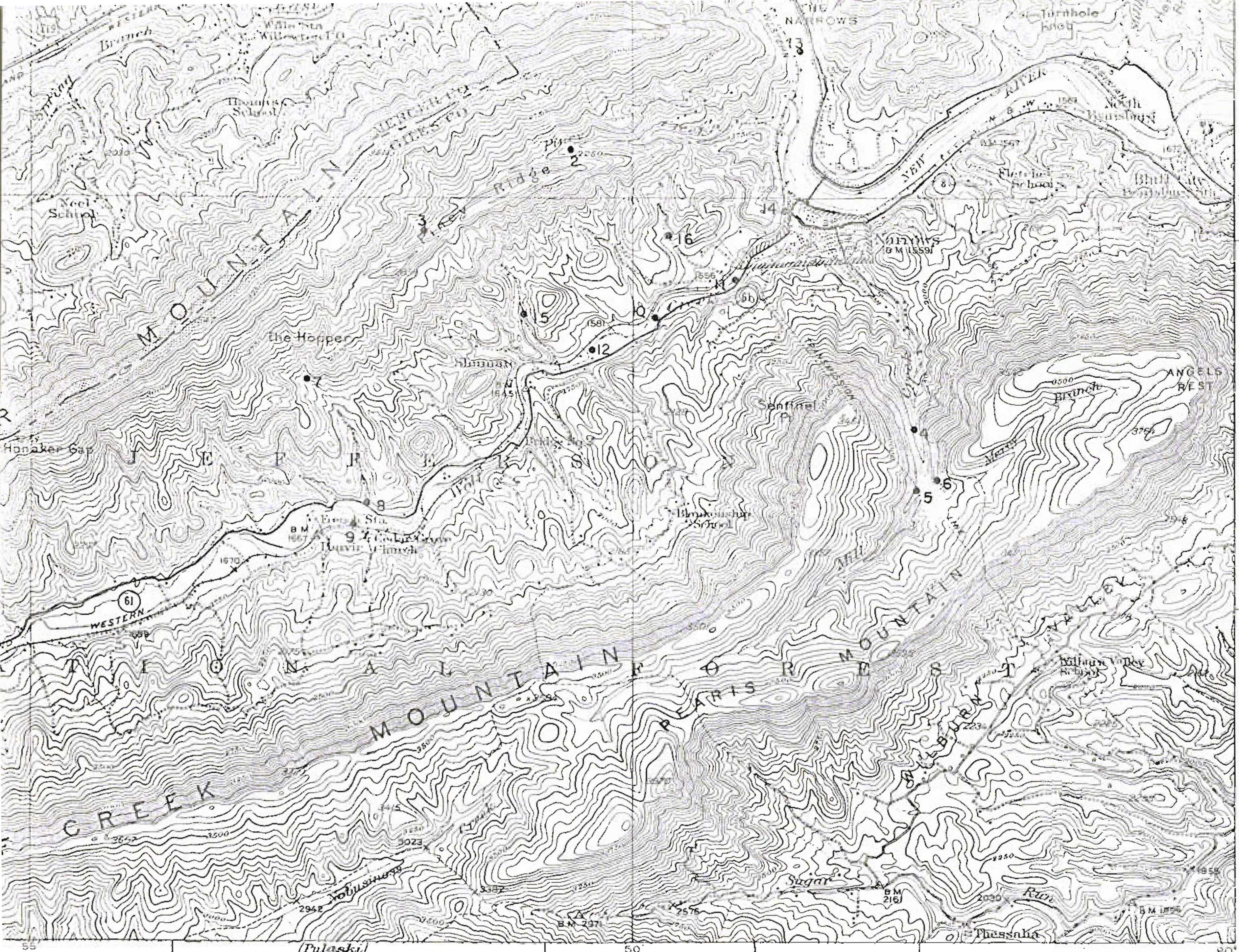

PLATE I

Scale $\frac{1}{62500}$

0 1 2 3 4 Miles

1000 500 0 1000 2000 3000 4000 5000 6000 7000 Yards

1000 0 5000 10000 15000 20000 Feet

1 .5 0 1 2 3 4 5 Kilometers

Polyconic projection. North American datum
5000 yard grid based upon U.S. zone system B

NARROWS, W.VA.-VA.

• Location of Station 2-16

Station 1 is at Rock Gap in Bland Cou

1962 (7)

CORE LOG DESCRIPTIONS AND ANALYSES ON BIG RIDGE CORES

Hole #3

From	To	Thickness Sample	Description
0	18'3"	18'3"	*Sandstone, drab-maroon, friable. Core loss 8'.
18'3"	18'4"	1"	Shale, greenish-gray, excluded from sample.
18'4"	25'	6'8"	*Sandstone, slightly ferruginous; core loss 2'.
25'	42'	17'	*Sandstone, highly ferruginous, coarse to fine grained; quartz granules, phosphatic fossils.
42'	45'	3'	Shale, not sampled.
	45'		Total Depth.

Analyses (%)

From	To	Thickness	Iron as Fe	Phosphorus as P
0	25'	24'11"	16.60	0.146
25	42	17'	20.63	0.135

Approximately 42 feet average 182% Fe.

****

Hole #4

From	To	Thickness Sample	Description
0	10'	10'	*Sandstone, drab grayish-maroon, ferruginous; core loss 4'.
10'	17'	7'	Sandstone, grayish-maroon, broken, low in iron; notsampled==; core loss 3'.
17'	22'6"	5'6"	*Sandstone, maroon, quartzitic, sporadic shale partings; core loss about 1!6".
22'6"	32'	9'6"	*Sandstone, highly ferruginous, about 3' core loss.
32'	36'	4'	Shale, not sampled; soft, unctuous.

(Analyses) %

From	To	Thickness	Iron as Fe	Phosphorus as P
0	10'	10'	17.89	0.250
17'	22'6"	5'6"	16.76	0.173
22'6"	32'	9'6"	24.02	0.122

Approximately 25 feet averaging 19.90% Fe.

****

Cy to NPC 4/3/63

Cy to Hanna Mining Co. 3/.../63 – (5 P...)

Hole #8

From	To	Thickness Sample	Description
0	15'	15'	No core recovered
15'	19'	4'	*Sandstone, ferruginous, maroon-drab, sporadic shale partings; somewhat weathered, friable.
19'	23'	8'	*Sandstone, same as above; core loss 3 feet.
23'	32'	9'	*Sandstone, same as above; 7 feet core loss.
	32		Total Depth
			(Analyses %)
			Iron as Fe Phosphorus as P
15'	32'	17'	17.73 0.103
			Approximately 17 feet averaging 17.73% Fe.

****

Hole #

From	To	Thickness Sample	Description
0	2'		*Sandstone, drab-grayish-maroon; fine grained; core loss 1'.
2'	14'		Shale, pale grayish-tan
14'	23'		*Sandstone, drab-maroon, fine grained, shaly; core loss 2'.
23'	50'		Shale and sandstone, not sampled.
	50'		Total Depth.
			(Analyses %)
			Iron as Fe Phosphorus as P
0	2'	2'	10.88 0.119
2'	14'	12'	14.91 0.171
12'			14 feet of material too low to be workable.

****

Hole # 11

From	To	Thickness Sample	Description
0	12'-	12'	Overburden; no core recovered.
12'	30'	18'	*Sandstone, drab-maroon, medium grained, ferruginous. Clay galls and parting; possibly 8' core loss.
30'	59'	29'	Shale, not sampled; soft, plastic.
59'	75'	16'	*Sandstone, grayish-maroon, clay partings, fine grained.
75'	97'	22'	*Sandstone, coarse grained, ferruginous; thin shale partings excluded from sample.
	97'		Total Depth.
			(Analyses %)
			Iron as Fe / Phosphorus as P
12'	30'	18'	18.38 / 0.0.107
59'	97'	38'	19.34 / 0.159
			Approximately 50 feet average 19.13% Fe.

****

Hole #12

0	10'	10'	No core recovered.
10'	27'	17'	*Sandstone, grayish-brown, coarse grained; slightly ferruginous; many clay galls; core loss about 8 feet.
27'	45'	18'	*no core in box; used at VPI for experiments.
	45'		Total Depth.
			(Analyses %)
			Iron as Fe / Phosphorus as P
10'	27'	17'	21.76 / 0.184

****

Hole #13

From	To	Thickness Sample	Description
0	7'	7'	Sandstone, drab-brown, fine grained.
7'	12'6"	5'6"	*Sandstone, drab grayish-maroon, shale partings.
12'5"	13'6"	1'	Shale, buff-brown, not included in sample.
13'5"	20'6"	7'	*Sandstone, drab-grayish-maroon, fine grained; shaly.
20'5"	29'6"	9'	Sandstone, gray to pale maroon, not sampled because very low in iron.
29'5"	30'6"	1'	Sandstone, dark-maroon, fine grained, slightly ferruginous; shale parallel to bedding.
30'5"	34'	3'5"	*Sandstone, maroon, fine grained, shaly.
34'	98'	64'	Sandstone and shale; bottom part is Tuscarora sandstone.
	98'	Total Depth.	

(Analyses %)

From	To	Thickness Sample	Iron as Fe	Phosphorus as P	
7'	20'6"	12'6"	14.99	0.0.164	Too poor
30'6"	34'	3'6"	16.12	0.219	to sample

****

Hole # 21

From	To	Thickness Sample	Description
0	7'	7'	Overburden.
7'	14'	7	*Sandstone, maroon, fine to medium grained.
14'	15'	1'	* Sandstone, fine to medium grained, ferruginous.
15'	25'	10'	*Sandstone, maroon, coarse grained, ferruginous; core loss 10'.
25'	35'	10'	*Sandstone, maroon, coarse grained, core loss 7 feet.
35'	40'	5'	Shale and sandstone, not sampled.
	40'		Total Depth.

(Analyses %)

From	To	Thickness Sample	Iron as Fe	Phosphorus as P
7'	25'	18'	17.73	0.116
25'	35'	10'	24.50	0.126

Approximately 28 feet average 20.15% Fe.

****

Cores Stored In Narrows
Power House

Core logs prepared by William A. Moon
April-May, 1962

Summary On Big Ridge
Cores

The Big Ridge cores were partially consumed in Mr. Fara's 1957-1958 tests on beneficiation of Clinton iron ores. Much of the good material was used up. However, some holes were preserved completely, and those holes were largely the basis for the splitting and sampling of core for chemical analysis.

The Big Ridge property contains up to 45 feet of ferruginous sandstone with very few shale breaks, and none of much consequence. The iron content varies somewhat, but does not exceed 20% at best for the ore beds as a whole. The general run of material, comprising about 80 per cent of the deposit, will average 16 to 18 per cent metallic iron. The deposit is fairly large, but the recoverable tonnage is probably not over 100 million tons. The grade of the material is substantially lower than can be considered workable at the present. The deposit is however one of the best in southwest Virginia and further experimentation may yet prove that such material can be concentrated and sold at a profit.

The phosphorus content of the material does not vary with the iron content, as does the material in Jefferson National Forest. Some material with higher iron is lower in phosphorus than some material with lower iron. This is somewhat puzzling.

A full record of the contents of each core box reposes in the geological files of Minerals Development Corporation. If the deposit were to be worked over and tested thoroughly, it should be core-drilled again and the cores analyzed as done on the Forest tracts in Giles County

B. N. Cooper
Blacksburg, Virginia

September 8, 1962

FROM
G. K. WILLIAMS
M.S. THESIS, V.P.I - 1958
"IRON ORE INVESTIGATIONS
BLAND, GILES, AND TAZEWELL
COUNTIES"

Description of Drill Cores

Hole Number: 1
Elevation: 4,000 Depth of Hole: 60 feet

Depth in feet		Description
From	To	
0	10	Sandstone, white, fine grained with brown iron-stained bonds.
10	12	Sandstone, fine grained, ferruginous.
12	17	Sandstone, coarse grained, ferruginous, fractured.
17	21	Sandstone, coarse grained, ferruginous, friable.
21	27.5	Sandstone, coarse grained, ferruginous.
27.5	33	Sandstone, coarse grained, ferruginous, soft, friable, contains clay balls.
33	33.5	Shale and clay, variegated pink and olive-drab.
33.5	37	Sandstone, coarse grained, ferruginous, with friable clay parting at 35 feet.
37	37.5	Shale, white to buff, present as parting.
37.5	43.5	Sandstone, medium grained, ferruginous, soft and friable.

...ber: 1 (conti...ed)
...ion: 4,000 Depth of hole: 60 feet

... in feet		Description
...om	To	
43.5	48	Sandstone, medium grained, rich in hematite.
48	51	Sandstone, medium grained, red to maroon, highly ferruginous.
51	59	Shale, variegated pink, gray, and green, plastic.
59	60	Shale, gray to white clay shale, contains little silica.

[illegible]ber: 2
[illegible]on: 4,050 Depth of Hole: 65 feet

[illegible] in feet		Description
[illegible]	To	
0	3	Sandstone, coarse grained, ferruginous.
3	4	Sandstone, very coarse grained, ferruginous.
4	5.3	Sandstone, medium grained, ferruginous, friable.
5.3	10.3	Sandstone, maroon, ferruginous, friable.
10.3	13	Sandstone, fine grained ferruginous.
13	15	Sandstone, fine grained, highly ferruginous.
15	17	Sandstone, medium grained, highly ferruginous.
17	18.5	Sandstone, coarse grained, highly ferruginous.
18.5	22	Sandstone, fine grained, ferruginous.
22	26	Sandstone, dark-red, coarse grained, ferruginous.
26	30	Sandstone, ferruginous, soft, friable, crumbly.
30	39	Clay shale, variegated pink and green.
[illegible]	43	Clay shale, gray with green hue, plastic.

[illegible] 2 (continu[illegible])

[illegible] 4,050 — Depth of hole: 65 feet

[illegible] feet		Description
[illegible]	To	
4[illegible]	44.5	Clay shale, gray to white.
44.5	44.5	Sandstone, buff, stained with manganese.
44.5	56	Clay shale, gray.
56	65	Clay shale, gray with bluish tint.

[illegible]er: 3
[illegible]: 4,075 | Depth of Hole: 45 Feet

[illegible] in feet		Description
[illegible]om	To	
0	5.5	Sandstone, dark-red, fine grained, ferruginous.
5.5	8	Sandstone, dark-red, coarse grained, ferruginous, contains clay balls.
8	12	Sandstone, red, coarse grained, ferruginous, friable.
12	20.3	Sandstone, dark-maroon, fine grained, ferruginous, gray plastic clay parting at 18.3 feet.
20.3	25	Sandstone, red, coarse grained, ferruginous, friable.
25	26	Sandstone, dark-red, coarse grained, ferruginous.
26	28	Sandstone, red to purple, fine grained, ferruginous.
28	42	Sandstone, red, coarse grained, ferruginous with clay balls.
42	45	Shale, variegated pink to white and gray.

...umber: 4
...ation: 3,850 Depth of Hole: 36 Feet

...th in feet		Description
...om	To	
0	10	Sandstone, red, coarse grained, ferruginous with shale partins.
10	12	Sandstone, red, coarse grained, ferruginous.
12	16	Sandstone, maroon, fine grained, ferruginous.
16	23.5	Sandstone, red, medium grained, ferruginous with shale partings.
23.5	32	Sandstone, maroon, coarse grained, highly ferruginous.
32	36	Clay, variegated, plastic.

[illegible]er: 5
[illegible] 3,800 — Depth of Hole: 71 Feet

[illegible] in feet		Description
[illegible]	To	
0	17	Sandstone, pink to white, coarse grained.
17	25	Sandstone and siltstone, ocher-colored, soft.
25	35	Sandstone, coarse grained, ferruginous.
35	39	Sandstone, maroon, fine grained, ferruginous.
39	47	Sandstone, red, coarse grained, ferruginous.
47	52	Sandstone, red, coarse grained, ferruginous with clay partings.
52	65	Sandstone, red, coarse grained, ferruginous, friable.
65	71	Clay shale, brown to white.

[illegible] 6
[illegible] 3,900 — Depth of Hole: 76 Feet

[illegible] Feet		Description
[illegible]	To	
[illegible]	13	Sandstone, buff to white, friable.
13	15	Sandstone, white with oxidized fractures.
15	21	Sandstone, white to gray, quartzitic.
21	28	Sandstone, white, conglomeratic.
28	33	Sandstone, red, ocher-colored.
33	54	Sandstone, red medium to coarse grained, ferruginous, hard, dip of 10° to 12°.
54	65	Sandstone, red to maroon, medium grained, ferruginous.
65	72	Sandstone, red, ferruginous, friable.
72	76	Shale, variegated pink, gray, white.

Hole Number: 9
Elevation: 3,950 Depth of Hole: 37 Feet

Depth in feet		Description
From	To	
0	32	Sandstone, red, ferruginous, solid looking, driller records 25' core loss.
32	37	Shale, variegated pink, gray, green, white.

Hole Number:
Elevation: 4,000 Depth of Hole: 50 Feet

Depth in Feet		Description
From	To	
0	2	Sandstone, red to maroon, ferruginous.
2	14	Shale, buff.
14	15	Sandstone, purplish to gray, ferruginous.
15	19	Sandstone, red, fine grained, ferruginous.
19	22	Sandstone, reddish-gray, medium grained, ferruginous.
22	29	Shale, buff.
29	33	Sandstone, white, iron-stained.
33	35	Shale, gray to tan, slick.
35	38	Sandstone, red, coarse grained, ferruginous, friable.
38	50	Sandstone, gray mottled. (Clinch).

Hole Number:
Elevation: 3,950 Depth of Hole: 41 Feet

Depth in feet		Description
From	To	
0	2.5	Sandstone, coarse grained, highly ferruginous, friable.
2.5	11	Sandstone, gray to purple, fine grained, ferruginous, hard.
11	28	Shale, buff, slick.
28	36	Sandstone, gray - buff, soft, broken.
36	41	Clay shale, gray, slick.

Hole Number 11
Elevation: 4,300 Depth of hole: 97 feet

Depth in feet		Description
From	To	
0	28.5	Sandstone, red to maroon, medium to coarse grained, ferruginous, steeply dipping.
28.5	29	Clay, variegated pink, green, and buff.
29	30	Sandstone, medium grained, ferruginous.
30	32.4	Shale, red, masses of limonite and manganese present.
32.4	59	Clay, variegated, green-gray to pink, crumbly.
59	61.5	Sandstone, dark-red to maroon, medium grained, top of interval low in hematite but becomes highly ferruginous downward.
61.5	66.4	Sandstone, red to red-gray, medium to coarse grained, ferruginous.
66.4	75	Sandstone, medium grained, ferruginous with numerous white plastic shale partings.

Hole Number: (continued)
Elevation: 4,000 Depth of hole: 97 feet

Depth in feet		Description
From	To	
75	86	Sandstone, red to gray, medium to coarse grained, ferruginous, contains white plastic clay partings at 76.4, 77.5 and 82.75 feet.
86	97	Sandstone, red to maroon, fine to medium grained, highly ferruginous, friable.

4.

Hole Number:
Elevation: 3,000 Depth of Hole: 45 feet

Depth in feet		Description
From	To	
0	11.5	Sandstone, coarse grained, ferruginous.
11.5	18	Sandstone, red to gray, medium grained, ferruginous.
18	22	Sandstone, red to gray, medium grained, semi-hard, ferruginous, slightly friable.
22	26	Sandstone, gray to red, medium grained, ferruginous, hard, vertical plastic clay-shale parting at 23.5.
26	45	Sandstone, red to gray, medium grained, ferruginous, highly friable, blocky.

Number: 13

Elevation: 3,950 — Depth of Hole: 98 feet

Depth in feet		Description
From	To	
0	7	Sandstone, brown, crumbly.
7	12.5	Sandstone, red, medium to fine grained, ferruginous.
12.5	13.5	Shale, buff.
13.5	20	Sandstone, red, fine grained, low in hematite.
20	27.5	Sandstone, gray to purplish, low in hematite.
27.5	28.5	Sandstone, light gray, hard.
28.5	34	Sandstone, red, medium grained, ferruginous, hard to crumbly.
34	42	Sandstone, brown, fine grained, oxidized.
42	47	Shale, gray, silty.
47	52	Sandstone, gray, silty. (Clinch).
52	72	Sandstone, light-gray, limonite-stained.
72	98	Sandstone, white with minor iron stains.

Hole Number: [illegible]
Elevation: 3,100 Depth of hole: 45 feet

Depth in feet		Description
From	To	
0	12	Sandstone, blocky, intercalated with manganese and limonite, highly fractured (keefer).
12	26.5	Sandstone, white with iron stains, not highly fractured.
26.5	28	Clay, white, plastic.
28	33	Sandstone, brown, iron-stained, medium grained, ferruginous, low in hematite.
33	34	Sandstone, red, fine grained, ferruginous, friable. (Clinton).
34	40	Clay, variegated pink, gray, white, plastic.
40	40.5	Sandstone, yellowish-buff, friable, no hematite present.
40.5	45	Clay, white, plastic.

Holes 16 through 21 were drilled in Clinch sandstone and the descriptions of their cores have been omitted from the text.


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8
9
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RECONNAISSANCE OF CLINTON FERRUGINOUS
SANDSTONES IN PARTS OF WESTERN VIRGINIA

(A summary report of investigation of the deposits of Clinton ferruginous sandstone occurring in the Appalachian Valley of Western Virginia, between James River and Tazewell County.)

Prepared by W. A. Moon
and B. N. Cooper

RECONNAISSANCE OF CLINTON FERRUGINOUS SANDSTONES IN PARTS OF WESTERN VIRGINIA

Mr. W. A. Moon, geologist for Minerals Development Corporation, completed the preliminary study of the geology of the permit areas in Jefferson National Forest, Giles County, Virginia, in July, 1962. During the subsequent seven months up to the time of writing of this report, Mr. Moon has undertaken a number of different geological studies designed to increase our knowledge of the geology of Giles County and of the geographic occurrence, geologic structure, and general character of the Clinton ferruginous sandstones in a large area of western Virginia.

During the course of his studies of the Clinton beds, a number of areas were discovered, which appear to have considerable promise as additional sources of ferruginous sandstone of the general type occurring in Jefferson National Forest permit areas situated between Wolf Creek Mountain and Pearis and Flattop mountains southwest of Pearisburg, Virginia. In the course of this rather extensive reconnaissance examination of the Clinton ferruginous sandstones, 76 samples of ferruginous sandstone were collected. These were processed in the laboratories of the VPI Department of Geological Sciences at Blacksburg and cuts were prepared for analysis by Lerch Brothers, Iron Ore Chemists, Hibbing, Minnesota. All pertinent data on these samples are summarized in Table 1. Details concerning the stratigraphy of the Clinton Formation in several localities are given in Geologic Sections 1 through 14, which follow Table 1.

Table 1.-Analyses of samples of Clinton ferruginous sandstones in western Virginia. (Analyses by Lerch Brothers, Iron Ore Chemists, Hibbing, Minnesota.)

Sample Number	Mountain On Which Deposit Occurs	Reference Map	Dip Of Ore Beds	Thickness Of Ore Beds (Feet)	Length Of Outcrop Belt Pertinent To Sample (Feet)	Width Of Outcrop Belt (Feet)	Chemical Analysis (%) Fe	P	Number	Units
1	Spruce Run	A	30°se	20	4,000	200	22.34	.219	1	7
2	Spruce Run	A	30°se	14	4,000	200	24.92	.240	1	5-6
3	Spruce Run	A	30°se	30	4,000	200	22.50	.171	7	7
*4	Spruce Run	A	26°se	15	4,000	300	24.92	.151		
5	Spruce Run	A	26°se	15	4,000	200	24.43	.132	**	
6	Spruce Run	A	45°se	18	5,000	200	21.06	.465	2	2
7	Spruce Run	A	45°se	22	5,000	200	13.02	.114	2	7
8	Spruce Run	A	40°se	10	2,500	200	23.47	.270	3	3
9	Spruce Run	A	42°se	14	5,000	200	23.31	.405	5	12-15
10	Spruce Run	A	42°se	9	5,000	200	20.90	.276	5	11
11	Spruce Run	A	42°se	10	5,000	200	16.07	.279	5	13-17
12	Rich	B-C	30°se	22	80,000	250	15.27	.261	6	12
13	Rich	B-C	30°se	3	80,000	10	13.98	.234	6	15
14	Rich	C	47°se	15	80.000	250	15.59	.138	***	
15	Garden	C	30°nw	21	25,000	200	17.20	.318	7	1-5
16	Garden	C	30°nw	4	25,000	10	11.06	.171	7	7
17	Round	B	8°se	21	1,300	1,300	13.00	.126	****	
18	Round	B	flat	7	1,300	1,300	22.49	.363	****	
19	Walker	B	26°se	8	80,000	500	24.37	.204	*****	
20	Walker	B	25°se	5	80,000	500	25.17	.360	*****	
21	Walker	B	25°se	7	80,000	500	21.64	.252	*****	
22	Walker	B	35°se	10	80,000	700	24.05	.492	*****	
23	Walker	D-B	15°se	10	80,000	350	21.32	.345	*****	
24	Walker Mountain	B	19°se	10	20,000	300	19.08	.303	*****	
25	Walker	B	20°se	10	20,000	300	22.92	.627	*****	
26	Chestnut Ridge	C	60°se	13	20,000	200	18.11	.087	******	
27	Chestnut Ridge	C	30°se	6	20,000	200	17.31	.177	*******	
28	Chestnut Ridge	C	30°se	14	20,000	200	22.12	.213	********	
29	Chestnut Ridge	C	30°se	15	20,000	200	19.72	.471	********	
30	Garden	C	5°se	15	2,000	1,200	16.83	.132		

* Sample from nose of Spruce Run Syncline
** Samples 1-5, inclusive, taken from same 4,000-foot strike length.
*** Section appears faulted; no good exposures; best exposed ledges sampled.
**** For details of geology see H. S. Ladd's 1944 report on Round Mtn. Manganese
***** Sampled localities on Walker Mountain devoid of bedrock exposures
****** Samples from along new road to fire tower.
******* Material sampled is loose shingle on old log trail
********From near junction of roads on Oneida Branch and Chestnut Ridge

Table 1, continued

31	Garden	C	5°se	15	2,000	1,200	18.45	.234		
32	Deskin	E	10°se	6	75	100	12.50	.248		
33	Paint Lick	E	90°	20	50	150	13.95	.119		
34	Morris Knob	E	10°se	13	300	1,500	16.35	.145		
35	Peters Mountain	F	28°se	21	10,000	150	14.75	.155	9	4,6
36	Peters	F	35°se	5	10,000	200	15.55	.149		
37	Peters	A	38°se	13	4,000	70	16.19	.155	*	
38	Flat Ridge	A	45°se	15	10,000	125	15.23	.077	**	
39	Flat Ridge	A	40°se	17	10,000	125	18.27	.062	**	
40	Peters	A	22°se	7	10,000	3,000	20.68	.224	***	
41	Peters	A	flat	13	10,000	3,000	16.83	.191	****	
42	Peters	A	low	5	10,000	3,000	17.95	.155	*****	
43	Peters	A	30°se	4	25,000	300	17.35	.161		
44	Peters	A	17°se	15	15,000	250	17.63	.155	******	
45	Peters	A	17°se	15	15,000	250	16.35	.140	******	
46	Peters	A	20°se	11	10,000	1,200	13.47	.146	10	2
47	Peters	A	20°se	11	10,000	1,200	14.75	.143	10	2 *******
48	Peters	A	30°se	9	20,000	300	14.91	.102		
49	Peters	A	0-30°se	15	20,000	300	16.19	.191		
50	Pork	A-G	17°se	10	7,500	2,000	20.76	.218	********	
51	Fork	A-G	17°se	20	7,500	2,000	16.67	.131	*********	
52	Potts	A	14°se	6	5,000	1,500	19.56	.218	**********	
53	Potts	A	14°se	6	5,000	1,500	19.88	.221	**********	
54	Potts	G	45°se	18	50,000	200	19.72	.149	11	2-10
55	Potts	G	45°se	34	50,000	300	17.31	0.112	11	12
56	Sinking Creek	G	35°se	4	75.000	200	17.47	.149	******	
57	Sinking Creek	G	35°se	9	75,000	200	15.47	.095		
58	Sinking Creek	G	30°se	9	75,000	200	21.16	.149	*******	
59	Sinking Creek	G	30°se	20	75,000	300	22.44	.512	******	
60	Sinking Creek	G	45°se	11	75,000	300	21.16	.329	******	
61	Johns Creek	G	10°se	15	6,500	2,600	21.08	.131	12	4
62	Kelly Knob	G	flat	4-5	6,500	2,600	17.15	.170		
63	Johns Creek	G	50°se	19	30,000	150	21.32	.218	13	13
64	Johns Creek	G	50°se	9	30,000	150	15.07	.173	13	4
65	Potts	H	23°se	5	35,000	200	19.56	.254		
66	Bald	H	25°se	10	60,000	250	17.31	.167	******	
67	Bald	H	38°se	5	35,000	1,000	19.08	.236		
68	Rich Patch	I	65°se	10	60,000	250	18.11	.260	14	14-15
69	Rich Patch	I	65°se	31	60,000	250	16.03	.278		
70	Potts	H	33°se	2.5	7,500	2,600	18.11	.194		
71	Potts	H	33°se	3	7,500	2,600	18.92	.332	******	
72	Potts	H	20°se	10	7,500	2,600	18.43	.137	******	
73	Bald	H	so°se	10	7,500	2,600	15.87	.146		
74	Little	I	125°se	13	10,000	500	15.39	.095		
75	Potts	H	55°nw	7	50,000	100	16.67	.128		
76	Doe	A	10°ne	10	9,000	1,000				

* Nearly all material from West Virginia side of state line.

** Beds locally faulted, dip variable, sampled across outcrop.

*** Sample taken from near ridge crest

**** Sample taken from ledge 3 feet below base of Sample 41

***** Float material sampled across strike

******Float material sampled across strike

******* dips variable; poorly exposed

********along old log skid trail

*********float blocks sampled across strike

**********JUST NORTH OF STONY CREEK FIRE TOWER

Geologic Section 1. Pearisburg Quadrangle. Spruce Run Mtn.
Located just north of junction of field
and Road 606.

Rose Hill formation (136 feet)

Upper limit not seen, measurement taken on dip slope.	Thickness Feet
7. Float only, float includes both fine and coarse grained ferruginous sandstone slabs.............	68
6. Sandstone, maroon, fine grained, ferruginous; contains maroon clay galls......................	5
5. Sandstone, maroon, medium grained, ferruginous..	9
4. Covered interval................................	12
3. Sandstone, maroon, fine to medium grained, ferruginous; probably includes 10 feet of shale..	28
2. Sandstone, maroon, coarse grained, ferruginous; may not be in place............................	2
1. Covered interval, probably shale................	12

Tuscarora sandstone

Geologic Section 2. Pearisburg Quadrangle, Spruce Run Mountain
Located near rail fence and just northeast of three large oaks that stand alone on the ridge crest.

Rose Hill formation (124 feet)	Thickness Feet	
4. Mostly covered, scattered outcrops of fine grained ferruginous sandstone and shaly sandstone appear on dip slope..	22	U SS (some included [illegible] ?)
3. Covered interval....................................	42	M sh
2. Sandstone, maroon, medium to coarse grained, ferruginous	18	L SS
1. Covered interval....................................	42	L sh

Tuscarora sandstone

Geologic Section 3. Pearisburg Quadrangle, Spruce Run Mountain
Located approximately 0.5 miles southwest
of Section 1.

	Thickness Feet
Rose Hill formation (164 feet)	
6. Sandstone and shale, mostly covered, sandstone, maroon, shaly, slightly ferruginous.................	26
5. Covered interval....................................	24
4. Sandstone, maroon, fine grained, very shaly, slightly ferruginous....................................	12
3. Sandstone, maroon, coarse grained, ferruginous, includes 14 feet of covered interval................	24
2. Sandstone, maroon, fine grained, thin bedded, slightly ferruginous, shaly..................................	38
1. Covered interval, probably shale.....................	40
Tuscarora sandstone	

Geologic Section 4. Pearisburg Quadrangle. Located northwest of old house near the southwest end of Spruce Run Mountain.

Rose Hill formation (121 feet)	Thickness Feet
10. Sandstone, maroon, fine grained, ferruginous, iron content low;	27
9. Covered interval, probably shale	46
8. Sandstone, maroon, fine grained, ferruginous	8
7. Covered interval	10
6. Sandstone, maroon, fine grained, ferruginous, slabby, contains maroon clay partings parallel to the bedding planes	8
5. Covered interval	12
4. Sandstone, maroon, coarse grained, ferruginous	2
3. Covered interval	7
2. Sandstone, maroon, fine to coarse grained, quartzose, ferruginous	9
1. Covered interval	28

Tuscarora sandstone

Geologic Section 5. Pearisburg Quadrangle, Spruce Run Mountain

	Thickness Feet
Keefer sandstone	
Rose Hill formation (145 feet)	
18. Covered interval	19
17. Sandstone, maroon, coarse grained, slightly ferruginous, conglomeratic; contains quartz pebbles	4
16. Covered interval	11
15. Sandstone, maroon, medium grained, ferruginous, thin-bedded, platy; contains clay galls and quartz granules	4
14. Covered interval	2
13. Sandstone, maroon, fine grained, slightly ferruginous	2.5
12. Covered interval	13
11. Sandstone, maroon, fine grained, thin-bedded, platy and shaly; contains maroon clay galls and maroon shale partings, ferruginous	9
10. Covered interval	4.5
9. Sandstone, maroon, fine grained, ferruginous; contains maroon clay galls	2
8. Covered interval	2
7. Sandstone, maroon, fine grained, ferruginous, shaly	2.5
6. Sandstone, maroon, fine grained, ferruginous; contains maroon clay galls	1
5. Covered interval	1.5
4. Sandstone, maroon, fine grained, ferruginous	1
3. Covered interval	3
2. Sandstone, maroon, coarse grained, ferruginous, thin to medium bedded; contains quartz granules	8
1. Covered interval; probably shale and quartzose sandstone	55

Tuscarora sandstone

Geologic Section 6. Bland Quadrangle. Located south of Rocky Gap. Section taken along the northeast side of Route 52.

Keefer sandstone	Thickness
Rose Hill formation (167 feet)	Feet
16. Covered interval	29
15. Sandstone, maroon, fine grained, thin-bedded, slightly shaly, ferruginous	3
14. Covered interval	5.5
13. Shale, drab	2
12. Sandstone, maroon, fine to coarse grained, thin to medium bedded; contains maroon clay galls, ferruginous	22
11. Sandstone, drab grayish-maroon, fine grained	1
10. Covered interval	3
9. Sandstone, drab grayish-maroon, fine grained	0.5
8. Shale, drab-gray to grayish-brown; contains interbeds of fine-grained brown and gray sandstone	27
7. Sandstone, drab grayish-maroon	3
6. Covered interval	17.5
5. Sandstone, drab grayish-maroon, fine-grained,	3
4. Covered interval	9
3. Shale and sandstone, drab brownish-gray, fine-grained, quartzose	2
2. Sandstone float; maroon, fine to coarse-grained ferruginous slabs	9
1. Covered interval	22

Tuscarora sandstone

Geologic Section 7. Burkes Garden Quadrangle. Located in Mill Gap. Section measured along the southwest bank of the creek thru the gap.

Keefer sandstone
Rose Hill formation (42.5 feet) section incomplete

		Thickness Feet
8.	Shale and sandstone, pale-tan and brown to olive, fine grained	15
7.	Sandstone, drab grayish-maroon and pale-gray, thin-bedded; some units slightly ferruginous to ferruginous	4
6.	Shale, sandy	2
5.	Sandstone, maroon, fine-grained, thin-bedded, ferruginous	3.5
4.	Sandstone, maroon, coarse-grained, conglomeratic, ferruginous	2
3.	Sandstone, maroon, fine-grained, ferruginous, thin to medium-bedded	5.5
2.	Sandstone, maroon, coarse-grained, contains fine-grained interbeds, ferruginous; contains maroon clay galls	7
1.	Sandstone, maroon, fine-grained, contains maroon clay galls	3.5

Section not measured to the Tuscarora sandstone.

Geologic Section C. Pounding Mill Quadrangle. Located on the southeast side of Paint Lick Mountain just south of sample 33. (SEE MAP)

Keefer sandstone

Rose Hill formation (173 feet)

		Thickness feet
8.	Covered interval, probably shale	12
7.	Sandstone, maroon, fine-grained, ferruginous, thin bedded; contains sporadic maroon clay galls	56
6.	Covered interval, mostly shale	78
5.	Sandstone, maroon, fine-grained, slightly ferruginous, thin-bedded...........................	2
4.	Sandstone, light-brown, fine-grained, quartzitic ..	3
3.	Covered interval	24
2.	Sandstone, drab grayish-maroon, fine grained	6
1.	Sandstone and shale, mostly covered	12

Tuscarora sandstone

Geologic Section 9. Narrows Quadrangle. Located on top of Peters Mountain near the corner of the Va.- West Va. state line near Narrows.

	Thickness feet
Keefer sandstone	
Rose Hill formation (191 feet)	
7. Covered interval	40
6. Sandstone, maroon, fine to medium-grained, ferruginous, thin-bedded; contains maroon shale partings	14
5. Covered interval, probably shale	107
4. Sandstone, maroon, fine-grained, thin-bedded, ferruginous; contains maroon shale partings parallel to the bedding planes	7
3. Covered interval	4
2. Sandstone, drab-maroon, fine-grained, slightly ferruginous; contains maroon shale partings and abundant maroon clay galls	2
1. Covered interval	17
Tuscarora sandstone	

Geologic Section 10. Pearisburg Quadrangle. Located on the crest of Peters Mountain about 300 yards southwest of the barb wire fence around the field.

Rose Hill formation (51 feet) section not complete	Thickness feet
3. Mostly covered, probably shale	18
2. Sandstone, maroon, fine-grained to coarse-grained thin bedded, ferruginous	11
1. Covered interval	22

Tuscarora sandstone

Geologic Section 11. Waiteville Quadrangle.
Located on the south slope of Johns Creek Mountain along the road from Level Green to Maggie

Keefer sandstone
Rose Hill formation (178 feet)

	Thickness Feet
16. Shale, pale grayish-green and rust-brown.........	30
15. Shale, pale grayish-green to rust-brown; contains interbeds of rust-brown sandstone...............	18.5
14. Sandstone, drab grayish-maroon to pale grayish-white, fine-grained............................	5
13. Shale, rust-brown, sandy........................	8
12. Sandstone, drab-maroon, fine to medium-grained, ferruginous, thin-bedded, shaly; contains lenses and partings of rust-brown and maroon shale.......	34
11. Shale, pale grayish-green; contains interbeds of rust-brown, pale-gray and drab-maroon sandstone..	39
10. Sandstone, maroon, coarse-grained, ferruginous....	2
9. Shale, rust-brown................................	4.6
8. Sandstone, drab-maroon, fine-grained; contains abundant maroon shale partings, ferruginous.......	4.6
7. Sandstone, drab-maroon, fine-grained, ferruginous..	11.5
6. Shale, rust-brown to drab-maroon; contains lenses and partings of drab-maroon ferruginous sandstone..	5.8
5. Sandstone, maroon, coarse-grained, ferruginous, quartzose......................................	2.3
4. Shale, rust-brown to pale grayish-green............	3.5
3. Shale, rust-brown to grayish-green; contains intercalations of drab-maroon fine-grained ferruginous sandstone...........................	3.5
2. Sandstone, drab-maroon, coarse-grained, quartzose, ferruginous.....................................	3.5
1. Shale, rust-brown................................	3.5

Tuscarora sandstone

Geologic Section 12. Waiteville Quadrangle. Located 0.5 miles southwest of the abandoned Lookout Tower on Johns Creek Mountain. Partial section only.

Rose Hill formation (81 feet)	Thickness feet
4. Sandstone, maroon, fine to coarse-grained, ferruginous, contains maroon clay galls and quartz grains	15
3. Covered interval	33
2. Sandstone, maroon, fine-grained, ferruginous, thin-bedded; may not be in place	2
1. Covered interval	28

Tuscarora sandstone

Geologic Section 13. Waiteville Quadrangle. Located on Johns Creek road just north of the Craig Co. - Giles Co. line on the north slope of Johns Creek Mountain.

	Thickness feet
Keefer sandstone	
Rose Hill formation (211 feet)	
19. Shale and sandstone; shale, pale grayish-green, weathers pale rust-brown; contains interbeds of pale grayish-green to pale gray, fine-grained sandstone. Thin-bedded	21
18. Sandstone, maroon, coarse-grained, quartzose; slightly ferruginous. Not sampled	3.2
17. Sandstone and shale; sandstone, drab grayish-maroon, shaly, thin-bedded; shale, pale rust-brown to pale grayish-green	21
16. Mostly covered; shale exposed in drainage ditch, pale grayish-green, weathers pale rust-brown	28
15. Sandstone, drab-maroon, fine to coarse-grained; contains maroon clay galls, ferruginous	15
14. Covered interval	2
13. Sandstone, maroon, fine to coarse-grained, ferruginous, thin to medium-bedded but appears massive along the road; contains phosphatic fossil shells and quartz granules	19
12. Sandstone, pale-tan to white, coarse-grained, conglomeratic; contains quartz granules, thick bedded	2.5
11. Shale and sandstone, shale, pale grayish-green to pale rust-brown. Sandstone, rust-brown to drab-maroon, thin-bedded	8
10. Shale and sandstone; shale, pale grayish-green to pale rust-brown; sandstone, rust-brown to drab-maroon, thin-bedded	9.5
9. Sandstone, pale grayish-green to pale brownish-white thin to medium-bedded; contains partings of pale grayish-green shale	7
8. Sandstone, drab grayish-maroon, slightly shaly; contains interbeds of maroon sandy shale, the sandstone is fine-grained and thin to medium-bedded	12

These data together with other data obtained in 1958-1959 indicate that quarriable tonnages of Clinton ferruginous sandstone comparable in quality to the Clinton ferruginous sandstones prospected in the seven permit areas southwest of Narrows, Virginia, occur in a number of places as shown in Table 2.

Table 2.- Summary of estimated quarriable reserves of Clinton ferruginous sandstone.

Location Of Area	Pertinent Details
1. Butt Mountain Area, west of Cascades, near Lookoff Rock, 4 miles northeast of Kimballton, Giles County, Virginia. Pearisburg Quadrangle.	Thickness of workable beds: 25 feet Estimated per cent of Fe: 20-21 per cent Area of outcrop: 1,000 acres Estimated quarriable tonnage:86 million tons
2. Doe Mountain, northeast of Pacers Gap, near Mountain Lake Golf Course, 10 miles from Pembroke, Giles County, Virginia. Pearisburg Quadrangle.	Thickness of workable beds: 20 feet Estimated per cent of iron: 20-21 per cent Area of outcrop: 700 acres Estimated quarriable tonnage: 51 million tons
3. Walker Mountain, northeast of U. S. Routes 21-52, about 10 miles northwest of Wytheville, Wythe County, Virginia. Bland and Pulaski Quadrangles.	Thickness of workable beds: 10 feet Estimated per cent of Fe: 22.5 per cent Area of outcrop: 500 to 700 feet wide, 80,000 feet long Estimated quarriable tonnage: 55 million tons
4. Sinking Creek Mountain, southeast of Newport, Giles County, Virginia. Waiteville Quadrangle.	Thickness of workable beds: 8-10 feet. Estimated per cent of Fe: 22 per cent Area of outcrop: 200 feet wide, 75,000 feet long Estimated Quarriable tonnage: 30 million tons
5. Fork Mountain, Pearisburg and Waiteville quadrangles, Giles County, Virginia	Thickness of workable beds: 15 feet Estimated per cent of Fe: 20 per cent Area of outcrop: 2,000 feet wide, 7,500 feet long

6. Spruce Run Mountain, between Newport and New River, Giles County, Virginia. Pearisburg Quadrangle.	Thickness of workable beds: 15 feet Estimated per cent of Fe: 23 per cent Area of outcrop: 25,000 feet long, 200 feet wide Estimated quarriable tonnage: 12 million tons
7. Johns Creek Mountain and Salt Pond Mountain, near Mountain Lake. Pearisburg Quadrangle.	Thickness of workable beds: 15 feet Estimated per cent of Fe: 21 per cent Area of outcrop: 5,000 feet long, 1,200 feet wide Estimated quarriable tonnage: 11 million tons
8. Kelly Knob Area, Waiteville and Pearisburg quadrangles, Giles and Craig counties, Virginia.	Thickness of workable beds: 10 feet Estimated per cent of Fe: 21 per cent Area of outcrop: 385 acres Estimated quarriable reserves: 16.5 million tons
9. Chestnut Ridge, Nye Cove, Burkes Garden Quadrangle, Tazewell County, Virginia.	Thickness of workable beds: 15 feet Estimated per cent of Fe: 21 per cent Area of outcrop: 350 acres Estimated quarriable reserves: 23 million tons

In a report submitted in 1957 to the Norfolk and Western Railway Company by B. N. Cooper, three areas of occurrence of Clinton ferruginous sandstone were pointed out: (1) the area between Pearis, Wolf Creek, and Flattop mountains, Giles County; (2) the Big Ridge area, Bland and Tazewell counties; and (3) the Butt Mountain-Mountain Lake area, Giles County. The first two named areas are under control of Minerals Development Corporation. Copies of the 1957 Cooper report modified in form by the Norfolk and Western Railway Company were circulated by the Industrial and Agricultural Department Manager among interested persons. One of these copies apparently fell into the hands of Mr. T. C. Spangler of Narrows, who utilized the information and leased the Butt Mountain properties owned by James Laing of Pearisburg, Virginia. Preliminary examination of the Butt Mountain deposit indicated it was of enormous size but probably of inferior quality. Before we were able to make a detailed investigation and obtain Company authorization to have chemical analyses made on samples of Butt Mountain ferruginous sandstones, we were denied access to the Laing property by its owner.

The Butt Mountain area, especially west of the Cascades on Little Stony Creek, very probably contains 20 feet or more of material that will average 20 to 21 per cent metallic iron. Possibly lesser thick-esses of the best beds might even average 24 per cent iron, but actually none of the material in that area, which was examined by the writer before being denied further access to the property, is of the quality that characterizes the Mercy Branch--Mill Creek deposits. The total size of the Butt Mountain area from which ferruginous sandstones could be quarried exceeds 1,000 acres. Despite all the observed indications that the deposit on Butt Mountain is probably not more than 20 to 21 per cent metallic iron, this deposit is certainly the most important deposit of ferruginous sandstone in the entire southwestern Virginia area. The total tonnage reserves of ferruginous sandstone southwest of the Mountain Lake Road (County Highway 600) approach 1 billion tons. Possibly 135 to 250 million tons of ferruginous sandstone in the Butt Mountain-Mountain Lake area may average slightly above 20 per cent metallic iron.

With the exception of the Spruce Run Mountain and Chestnut Ridge areas tabulated in Table 2, virtually all of the deposits and reserves enumerated lie within the bounds of a national forest.

Detailed studies should be made of all the specific deposits enumerated in this report.

The specific data recorded on pages 2-20 were obtained by Mr. W. A. Moon, geologist for Minerals Development Corporation; the rest of the report is by the undersigned.

February 24, 1963

B. N. Cooper

Respectfully submitted,

William A. Moon
B. N. Cooper

1963

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PT. I

INDEX

INTRODUCTION

Purpose of Investigation

The primary purpose of this survey was to estimate the approximate tonnage of crude ferruginous sandstone available from the Rose Hill formation in the Chestnut Ridge area. The extent of the Rose Hill formation was also outlined.

The investigation included:

(1) preparation of a reconnaissance geologic map and structure sections,

(2) The detailed measuring of three geologic sections of the Rose Hill formation.

Method of Investigation

The investigation was conducted with the use of Dept. of Agriculture Soil Conservation aerial photos made in 1953. (Scale 1" = 1,000'). United State Geological Survey topographic maps were also used. Field work commenced August 6, 1963 and terminated August 27, 1963. Dense vegetation and heavy forest cover hampered the investigation and all formation contacts are approximately located only. Distances were approximated through the use of aerial photos and by the Brunton compass and pace method whenever possible.

Location of the Area

The Chestnut Ridge area is located in the eastern corner of Tazewell County, Virginia. The area surveyed is bounded on the north by the crest of East River Mountain, on the south by the crest of Buckhorn Mountain and the eastern boundary is County Road 662. The western boundary is an arbitrary northwest trending line from the 3823 foot bench mark on Buckhorn Mountain to the 4254 foot bench mark just northeast of Chimney Rock.

The area is accessible from Bluefield, West Virginia, via State Route 85 southwest to Double Gates thence southeast on County Road 662 over East River Mountain. County Road 662 also connects with State Route 61 which runs southwest from Rocky Gap to Tazewell. Route 61 lies just south of Buckhorn Mountain. From County Road 662 the area is accessible by two Forest Service Roads. The First road parallels Cove Creek and the second (recently constructed) extends southwest from County Road 662 along the southern flank of East River Mountain to triangulation point 4326 where a state forest lookout tower has recently been installed. Another road which closely follows the west bank of Oneida Branch connects the fire tower road with the Cove Creek Road. This road is called the Oneida Branch road. A logging road also extends from the headwaters of Oneida Branch out along the crest of Chestnut Ridge for approximately 0.4 miles. Various other timber trails have recently been opened up for the purpose of selective logging. These are mostly accessible only by foot. The area southwest of the fire tower is accessible only by foot.

STRATIGRAPHY

Seven marine sedimentary rock formations are exposed in the Chestnut Ridge area. They range in geologic age from Upper Ordovician to Devonian and include in ascending geologic sequence;

The Juniata formation (thickness $\pm$ 415 feet), Tuscarora sandstone ($\pm$ 130 feet), Rose Hill formation ($\pm$ 165 feet), Keefer sandstone and Tonoloway limestones ($\pm$ 90 feet), Rocky Gap sandstone ($\pm$ 60 feet), Huntersville Chert ($\pm$ 60 feet) and Devonian shales. Of these only the Rose Hill formation was studied in detail. These and other formations have adequately been described by Williams (1957) and Cooper (1943) (See references).

The Rose Hill Formation

Distribution: The Rose Hill formation extends along the southeastern flank of East River Mountain forming flatirons that dip from 50 to 24 degrees to the southeast. Both the upper and lower zones of ferruginous sandstone are present along this belt. On Chestnut Ridge the entire ridge is capped by the Rose Hill formation which forms a gentle anticline that plunges to the east.

Three other belts of ferruginous sandstone occur in the area. The first parallels the north bank of Cove Creek from Oneida Branch to the headwaters of Cove Creek and the second belt parallels the northern flank of Buckhorn Mountain. This latter belt is generally encountered about one-half way up the mountain slope. Both of these belts are complexly folded and locally dip from 45 degrees to vertical. Therefore they were not considered to be of economic value at present. The third belt occurs in the trough of a tightly folded syncline that lies on the northwestern flank of East River Mountain. This belt extends from the fire tower to the southwest. Steep dips characterise this area and the belt is cut transversely by deep erosional draws. Most of the Rose Hill formation is obscured by either "Keefer" or Tuscarora colluvium. This belt is not considered to be of economic importance.

Mapping Unit

The Rose Hill formation includes as a field mapping unit all the shales and sandstones from the top of the last massive white quartzite ledge of the underlying Tuscarora sandstone to the basal massive white quartzite ledge of the overlying "Keefer" sandstone.

Lithology

The Rose Hill formation is composed chiefly of pale grayish green shales containing lenses, interbeds and partings of greenish-gray, fine-grained quartzose sandstone. These two rock types weather pale rust-brown to tan and compose approximately 75 percent of the formation. The remaining 25 percent is composed of drab-maroon fine to coarse grained ferruginous sandstone. The sandstone is thin to medium bedded often weathering to a slabby rubble. Maroon clay galls, irregular maroon shale partings and phosphatic fossil fragments occur sporadically within the iron ore bearing beds. The iron units occur at two distinct horizons within the Rose Hill formation. The first ore zone occurs from 20' to 25' below the base of the Keefer - Rose Hill contact and the lower ore zone occurs roughly 25' above the top of the Tuscarora sandstone. The two ore zones are seperated by an intermediate zone or middle zone of from 45 - 70' of shale and interbedded sandstone. Hematite fills the interstices of the quartzose sandstone in the iron bearing beds and the content of Fe varies probably from 5 to 24 percent with the average running close to 17 - 20 percent. (See Geologic Sections 1, 2 and 3 for a more detailed description of the lithology.)

Thickness and Extent

The geologic sections indicate an ore thickness ranging from 16 feet (incomplete) to a maximum of 31 feet for the upper zone. The lower ore zone, exposed for measuring only along Road 662, contained 16.5 feet of ore in a total interval (including shale breaks) of 27 feet. Complete sections of the Rose Hill formation are extremely scarce. The crest of Chestnut Ridge is upheld by the upper ferruginous unit and outcrops of this sandstone (prob.. 18 - 20% Fe) occur along the southern slope of this ridge from 0 - 5 feet below the ridge crest. The observed thickness varies from a maximum of 15 - 18 feet near the northwestern end of the ridge and tapers gently to four feet on the eastern nose of the ridge. The average observed thickness is estimated to be 10 feet. However the topographic features, bench - like appearance of Chestnut Ridge, and Geologic Sections 1, 2 and 3 indicate that a possible average thickness of 20 feet may be proved by drilling. The width of outcrop appears to vary from 150 to 400 feet and the length of outcrop is about 1.15 miles. The lower ferruginous sandstone was not seen exposed on Chestnut Ridge. Partial outcrops of the lower zone occur on the north flank of East River Mountain along the fire tower road about 550 yards northeast of the tower. Also partial exposures are seen along the Oneida Branch Road. These exposures show interbedded ferruginous sandstone and shale averaging 2 to 3 feet in thickness.

The belt extending along the southern flank of East River Mountain shows flatiron outcrops of upper ferruginous sandstone ranging from 2 to 6 feet in exposed thickness. The average thickness is taken to be 10 feet. The outcrop width is estimated to average 150 - 200 feet and the length of outcrop belt is extimated to be 12,000 feet. The lower ferruginous sandstone unit although exposed in this belt was not considered. The weight of a cubic foot of crude ore was taken to be 190 pounds.

Tonnage Estimates

Observed tonnage estimates for Chestnut Ridge are estimated to be 1.5 million tons and for the southern flank of East River Mountain to be 1.7 million tons. These figures are based on actual surface outcrop and represent ~~[illegible]~~ a minimum available tonnage. Since it is believed that the thickness of the upper ferruginous sandstone is closer to an average of 20 feet this could increase the probable tonnage figures to 3.5 million tons for Chestnut Ridge and the East River Mountain belt to 2.5 million tons. If the overlying shale upper shale can be stripped off the width of the outcrop belt on Chestnut Ridge could be increased to roughly 500 feet and it is possible that the thickness of the upper ore zone could reach 30 feet (see Geologic Section 2.) This would increase the potential of Chestnut Ridge alone to 7 million tons of crude ore.

Summary

Based on surface observations alone it is estimated that Chestnut Ridge has a minimum of 1.5 million tons of crude ore and the East River Mountain belt 1.7 million tons. However it is believed that the ore thickness on Chestnut Ridge runs closer to 20 feet therefore the estimates could be 3.5 million tons and 2.5

million tons respectively. If surface stripping of the upper shale can be carried out on Chestnut Ridge and the ore thickness reaches a maximum of 30 feet (indicated by Geologic Section 2) then the tonnage estimate could conceivably approach 12 million tons.

Recommendations

1. That the area be leased to support Big Ridge.
2. That the area be reexamined in the fall or winter (when all the leaves and vegetation is gone) and tape measurements be made of the width and length of outcrop.

GEOLOGIC SECTIONS

Geologic Section 1. - Rose Hill formation exposed along County Road 662 approximately 250' southeast of the junction of County Road 662 and the crest of East River Mountain.

	Thickness Feet
Keefer sandstone	
Rose Hill formation (± 194.40 feet)	
23. Shale, pale grayish green to pale rust brown: section partly covered............	25.4'
22. Shale, pale grayish maroon.................	1.5'
21. Shale, pale grayish green to rust orange, weathers rust brown; contains interbeds of drab maroon to grayish maroon fine grained slightly ferruginous sandstone. Shale comprises 60% of section...................	7.5'
20. Sandstone, drab maroon, fine grained, ferruginous, contains abundant maroon shale partings and interbeds parallel to the bedding planes. Shale appears to comprise 35% of section. Last 15 inches is massive bed of drab maroon fine grained ferruginous sandstone................................	5'

		Thickness Feet
19.	Sandstone, drab maroon to grayish maroon, fine grained, ferruginous siliceous, contains interbeds and partings of pale grayish green, rust brown, and maroon shale..............	0.65'
18.	Shale, pale tan to rust brown..............	1.3'
17.	Sandstone, drab maroon, fine grained, ferruginous; contains interbeds and partings of pale grayish green, rust brown, and maroon shale parallel to the bedding planes; weathers rust brown on bedding surfaces..................................	4.5'
16.	Shale, pale grayish green, weathers rust brown....................................	1'
15.	Sandstone, drab maroon, fine grained, ferruginous; contains maroon clay galls....	3'
	<u>Note:</u> Localized folding and faulting occurs here and explains thickness of upper ferruginous sandstone and the thickness of shale in the middle zone.	
14.	Interval mostly covered; contains sporadic outcrops of pale gray to grayish green shale chips weathering pale rust brown; contains interbeds and lenses of pale rust brown to grayish green and graysih white fine grained quartzose sandstone...........	94.5'

		Thickness Feet
13.	Sandstone, drab grayish maroon, fine grained, ferruginous (12 - 14% Fe); contains 50% interbedded shale and drab brown sandstone..........................	3.5'
12.	Covered interval; mostly shale, contains several 1" beds of drab maroon fine grained ferruginous sandstone......................	1.0'
11.	Sandstone, drab maroon, fine grained, thin bedded, slightly ferruginous...............	0.6'
10.	Sandstone, drab maroon, medium to coarse grained ferruginous (± 20% Fe); contains quartz granules and phosphatic fossil fragments..................................	2.75'
9.	Shale, drab maroon, sandy.................	1.0'
8.	Sandstone, drab maroon, fine to medium grained ferruginous, thin bedded..........	2.25'
7.	Interval mostly covered, contains shale and sandstone, Shale pale grayish green to pale rust brown; sandstone interbeds are drab grayish maroon, fine grained and low in Fe. - 12%.............................	2125'
6.	Sandstone, drab maroon, fine grained, ferruginous shaly. Contains drab maroon shale partings............................	2.9'

		Thickness Feet
5.	Shale, drab brown..........................	1.0'
4.	Sandstone, drab maroon, fine to medium grained ferruginous; contains abundant clay galls and paper thin shale partings........	5.0'
3.	Clay shale, pale rust brown, unctuous......	3.5'
2.	Sandstone, drab maroon, fine to medium grained, ferruginous, thin to medium bedded	1.5'
1.	Mostly covered, shale, drab yellowish brown; contains interbeds of buff fine grained quartose sandstone................	25'

Tuscarora sandstone

Geologic Section 2. - Rose Hill formation along County Road 622 0.75 miles north of the junction of State Road 61 and County Road 622. Section through Buckhorn Mountain.

		Thickness Feet
Keefer sandstone		
Rose Hill formation (167 feet)		
13.	Covered interval..........................	8.5'
12.	Shale, pale grayish green, weathers pale rust brown; contains irregular lenses, partings, and interbeds of pale rust brown and grayish green fine grained quartzose sandstione................................	14.7'
11.	Sandstone, pale grayish green, fine grained, quartzose; grades directly into ferruginous sandstone..................................	1.3'
10.	Sandstone, drab maroon, fine grained, ferruginous; contains abundant clay galls..	1.0'
9.	Sandstone, drab maroon, fine grained, ferruginous, thin bedded, shaly; contains abundant shale partings parallel to the bedding planes and maroon clay galls. 25% shale......................................	3.7'

	Thickness Feet
8. Sandstone, drab maroon to rust brown, coarse grained, ferruginous; in lower 0.5 feet interstices are filled with rust red silt rather than Fe..............................	1.5'
7. Shale, pale grayish green, weathers pale rust brown................................	3.1'
6. Sandstone, drab maroon, fine grained, ferruginous, last 1.5' contains 20% shale..	3.7'
5. Sandstone, drab maroon, coarse grained, ferruginous, medium bedded.................	1.3'
4. Sandstone, drab maroon, fine grained, ferruginous, massive ledges (probably 18 to 20% Fe); contains sporadic maroon clay galls....................................	14.5'
3. Interval mostly covered; includes sporadic outcrops of pale grayish green shale that weathers pale rust brown. Also contains interbeds of grayish green fine grained quartzose sandstone.......................	50'
2. Interval covered, same as above. No lower ferruginous sandstone zone is exposed but a partial section is exposed in Cove Creek just southwest of the road.................	50'

	Thickness
	Feet
1. Covered interval..........................	14'

Tuscarora sandstone

Geologic Section 3. - Located in Cove Creek, approximately 1.7 miles southwest of the junction of the Cove Creek trail and Oneida Branch.

	Thickness Feet
Keefer Sandstone	
Rose Hill formation (36.6 feet incomplete)	
6. Covered interval (uppershale)...............	20'
5. Sandstone, drab maroon, very fine grained, ferruginous, quartzitic; forms massive ledge in creek..................................	4'
4. Sandstone, drab maroon, fine grained, ferruginous, thin bedded, platy; contains maroon shale partings parallel to the bedding planes..................................	1.5'
3. Sandstone, drab maroon, fine grained, ferruginous, thin bedded; contains abundant maroon clay galls..........................	2.6'
2. Covered interval, log jam, no outcrops; probably ferruginous sandstone..............	2'
1. Sandstone, maroon, fine to coarse grained, thin to medium bedded.......................	6.5'

End of section, rest of the Rose Hill formation and Tuscarora sandstone obscured by colluvium in creek.

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Cooper, B. N. (1944) Geology and Mineral Resources of the Burkes Garden Quadrangle, Va. Geol. Sur. Bull. 60 298 pp.

Williams, G. K. (1958) An Investigation of the Iron Deposits in the East River Mountain District. Un. Pub.. M. S. thesis, library Virginia Polytechnic Institute, Blacksburg, Virginia, 85 pp.

RECONNAISSANCE GEOLOGY

of the

BIG RIDGE AREA

Bland and Tazewell Counties, Virginia

with a supplement

on

The East River Mountain - Route 52 area

Bland County, Virginia

MINERAL DEVELOPMENT CORP.

By:

W. A. Moon, Jr.

Date submitted:

11 November 1963

INDEX

INTRODUCTION

Purpose of Investigation

The purposes of this reconnaissance were as follows:

1. To map and define the extent of the ferruginous sandstone beds of the Rose Hill formation in the Big Ridge area.
2. To make a generalized gross tonnage estimate of crude ore available from both the upper and lower ferrugineus sandstone zones.
3. To reconnaissance map the southern flank of East River Mountain from the eastern boundary of the Keesling property northeastward to U. S. Route 52.
4. To ascertain whether this area (outlined in no. 3) should be leased as a possible source of iron.

Method of Investigation

The investigation was conducted with the use of Dept. of Agriculture Soil Conservation aerial photos made in 1953 (Scale 1"= 1,000' and 1"= 1667'). United States Geologic Survey topographic maps of the Bland, Va.-West Va. and Burkes Garden, Va. 15 minute quodrangles were also used. A tape and compass map prepared by Dr. John Hagen (Hanna Mining Company) proved very useful.

Field work commenced Sept. 9, 1963 and terminated Nov. 4, 1963. A heavy secondary forest growth hampered the investigation until the leaves fell. Contacts were approximated through the use of aerial photos and sometimes by use of the Brunton compass and pace method. Topographic maps proved useful for elevations.

In the vicinity of Big Ridge all stations or observation points within the Rose Hill formation were marked by stacked stones with the number of the station recorded on the bottom surface of the top stone. This number was circled to prevent confusion with stations put out earlier by Hanna Mining.

Big Ridge Area

Location of the area

The Big Ridge area lies in the northwestern corner of Bland County, Va. and in the eastern corner of Tazewell County, Va. The area surveyed is bounded on the northwest by the crest of East River Mountain on the southwest by County Road 662, on the southeast by the crest of Buckhorn Mountain and on the northeast by the Appalachian power line. The area mapped encompasses roughly 9.75 square miles.

Accessibility of the area

The Big Ridge property is readily accessible from Bluefield, Va.-West Va. via State Route 85 southwest to Double Gates thence southeast on County Road 662 to the crest of East River Mountain. About 100 feet south of the crest of East River Mountain a Forest Fire road to the northeast extends along the southern crest of East River Mountain. The area (see Plate 1) is encircled with numerous forest access roads. Route 61 lying just south of and parallel to Buckhorn Mountain connects with County Road 622 and furnishes access to the area from Tazewell and Rocky Gap, Va. The interior of Big Ridge has an abundance of old log roads some of which are open and others that could easily be opened by the clearing of downed trees and brush. Jeeps and other 4-wheel drive vehicles can travel most of the area easily. Big Ridge is covered with secondary timber growth, scrub brush, briars and laurel thickets.

Previous work

Two better known earlier workers in this area were Campbell (1896) and Butts (1932). Campbell included Big Ridge in his Pocahontas folio which displayed the geology on a broad regional basis. Butts also briefly covered the regional geology of the area in his well known map of the geology of the Appalachian Valley of Virginia.

The first fairly detailed work on the area was Cooper's report in 1944 on the Burkes Garden Quadrangle. In 1956-1957 Williams (a Virginia Polytechnic Institute graduate student) briefly outlined the Rose Hill formation in the area. During this period 22 holes were core drilled in the area. Of these only 13 were positively located during the investigation by Hanna Mining Company. In July of 1963 Dr. John Hagan (Hanna Mining Company) conducted a brief compass and tape survey to outline the iron beds, locate drill holes, and survey roads. The partially completed geologic map also showed the locations of 12 chip samples and five bulk sample areas. A total of 54.23 short tons of ore was shipped to Hibbing, Minnesota for further testing.

Stratigraphy

Seven marine sedimentary rock formations occur in the Big Ridge area. They range in geologic age from Upper Ordovician to Devonian and include in ascending geologic order; the Juniata formation (thickness ±415 feet), Tuscarora sandstone (±130 feet), Rose Hill formation (±165 feet), Keefer sandstone and Tonoloway limestone (±90 feet), Rocky Gap sandstone (±60 feet), Huntersville chert (±60 feet) and Devonian shales. Of these only the Rose Hill formation was studied in detail. These formations have been adequately described by Cooper (1944) and Williams (1957). However since the formations that underlie and overlid the Rose Hill formation are so similar and have been confused frequently in previous work brief descriptions of them, the Tuscarora and "Keefer" sandstones, will be given below.

Tuscarora sandstone

The Tuscarora sandstone occurs along the crest of East River Mountain forming a prominent ridge. It is also exposed in the structural saddle across the Big Ridge anticline and it is predominently exposed on the southern flank of Big Ridge. Here the gentle southern dip of the beds and the influence of the thrusts that lie to the southeast have rendered this area a mass of loose blocks with only sporadic outcrops visible. Just west of the 4116 bench mark on the crest of Big Ridge the Tuscarora sandstone is exposed in two deep ravines that plunge to the southwest. Here the Tuscarora forms cliffs up to 12 feet high. Thier extent can readily be traced in the fall after the leaves fall. This formation also outcrops on the southern crest and flank of Buckhorn Mountain where it is overturned.

The Tuscarora sandstone is predominently a pale grayish-white to white medium to coarse-grained quartzose sandstone. The basal beds are generally conglomeratic, containing rounded quartz pebbles up to 1 inch in diameter. The rock can be classified as an orthoquartzite as the quartz grains have been cemented together by secondary silica. Interbedded with the sandstone beds are beds of olive drab shale. The Tuscarora is unfossiliferous except for supposed worm marking or borings called Arthophycus or Scolithus.

The Tuscarora bears a striking lithologic resemblance to the Keefer sandstone and there are only two positive ways that the two can be distinguished. These are:

1. Stratigraphic position
2. Presence of the fossil ostracod Leperditia in the Keefer sandstone.

Rose Hill formation

Distribution

The Rose Hill formation outcrops along the southern slope of East River Mountain except along the portion of East River Mountain just northeast of the junction of County Road 662 and the crest of East River Mountain. Here the formation is exposed along the northern crest of East River Mountain for approximately 1 mile. The Rose Hill is well exposed in the core of the Big Ridge anticline. This anticline is a large domal stucture that dominates the area. Partial exposures also occur sporadically on the crest and northern flank of Adz Ridge. Geologic Sections 1 and 2 taken along County Road 662 show good outcrops near the crest of East River Mountain and in the gap of Buckhorn Mountain respectively. Exposures of the interbedded shales and sandstones occur on the forest fire road that parallels Laurel Creek and the northeastern flank of Big Ridge. The upper ferruginous sandstone is well exposed in all of the bulk sample areas (See Plate 1) and around the southwestern fringe of the anticline. The lower ferruginous sandstone has excellent outcrops around the fringes of the two ravines in the western edge of the anticline. Partial exposures also occur north of the 4116 bench mark on the crest of Big Ridge. A belt of outcrop also occurs along the crest and southern flank of Buckhorn Mountain where the formation is overturned. This belt is badly faulted and crumpled being heavily influenced by the great Narrows thrust that lies along the southern slope of Buckhorn Mountain. The small area of ferruginous sandstone just north of the road and Laurel Creek (See Plate 1) may possibly have been deposited as colluvium. The relationships are obscure.

Lithology

The Rose Hill formation is composed chiefly of pale grayish-green shales containing lenses, interbeds, and partings of greenish-gray, fine-grained, quartzose sandstone. These two rock types weather pale-rust-brown to grayish-tan and in the Big Ridge area compose roughly 65 to 70% of the formation. The remainder of the formation is composed of drab maroon, fine to coarse-grained ferruginous sandstone. This sandstone is thin to medium bedded often weathering to a slabby rubble. Maroon clay galls, irregular maroon shale partings, and phosphatic fossil fragments occur sporadically within the iron bearing beds.

The iron units occur at two distinct horizons within the Rose Hill formation. The first or upper ferruginous sandstone occurs roughly from 0 to 25 feet below the base of the Keefer sandstone. The second ferruginous sandstone zone or lower zone occurs approximately 25 feet above the top of the underlying Tuscarora sandstone. These two ore zones are separated from each other by an intermediate zone of shale and quartzose sandstone referred to as the "middle zone" or middle shale. This middle shale appears to vary from 30 to 70 feet in thickness with the average thickness approaching 45 feet. The middle shale contains beds of fine grained quartzose sandstone that weather drab gray. In previous reports this zone was confused with the Clinch sandstone. Close examination by cracking these rocks show that they are pale tan to grayish-white thin-bedded, often laminated and contain characteristic Rose Hill fossils.

Hematite fills the interstices of the two iron ore zones mentioned and the content of iron from grab sample assays and bulk sampling averages approximately 19.50% Fe. (Hagen 1963) Geologic sections 1 and 2 give a more detailed description of the lithology.

Mapping Units

The Rose Hill formation includes as a field mapping unit all the shales and sandstones from the top of the last massive white quartzite ledge of the underlying Tuscarora sandstone to the basal massive white quartzite ledge of the overlying "Keefer" sandstone. On the crest of the Big Ridge anticline the Rose Hill formation was mapped in detail and the ferruginous sandstone units were delineated. In adjacent areas the formation was mapped as one unit either because the area was complexly faulted, or obscured or so small in outcrop width that it was felt that the extra time involved would not be justified at the present time.

"Keefer" sandstone

The Rose Hill formation in the Big Ridge area is overlain by a succession of drab-grayish-white coarse-grained conglomeratic quartzose sandstone beds that closedly resemble the Tuscarora sandstone. These beds however belong to the basal Keefer which grades upward into a thin bedded drab-gray to grayish-tan fine-grained sandstone that is predominently thin bedded. These beds often show traces of maganese mineralization. The presence of *Lperditia* and other fossils will aid in destinguishing these beds from the Tuscarora.

The overlying younger formations, the Tonoloway limestone, Rocky Gap sandstone, Huntersville chert and Devonian shales although mapped are not described here. Excellent rock descriptions are available in Cooper's Burkes Garden report (1944).

Structure

The dominant structure in this area is a broad domal anticline located through the center of Big Ridge and consequently named the Big Ridge anticline. This structure is bordered on the west by the Cove Creek syncline and on the east by the Laurel Creek syncline. Adz Ridge, a small anticline, extends westward from the southwest corner of the Big Ridge anticline. The southeastern flank of the Big Ridge anticline is bordered by a small tight syncline containing remnants of the Rose Hill formation. This area lies partially along the lower forest road. The small syncline also lies in fault contact with the northwestern limb of the overturned Buckhorn Mountain syncline. The trough of the Buckhorn Mountain syncline is beleived to be faulted and the southern overturned limb shows evidence of repeated faulting and bedding plane slippage. This limb forms the crest of Buckhorn Mountain. This structure is directly affected by the great Narrows thrust which lies just to the southeast.

Overburden

The upper shale that overlies the upper ferruginous sandstone is extremely difficult to delineate. It is nearly always obscured by Rose Hill ferruginous sandstone float. Probably the shale-ferruginous sandstone contact lies fairly close to the Keefer sandstone. Overburden from this zone should cover no more than 15% of the exposed area mapped as upper ferruginous sandstone. Thicknesses probably vary from 0 to 15 feet. Elsewhere in the area the upper ferruginous sandstone probably has overburden from 0 to 4 feet. The bulk of this overburden is ferruginous sandstone rubble.

Thicknesses and tonnage estimates

Upper ferruginous sandstone

In the areas on Big Ridge where the upper ferruginous sandstone is capped by the Keefer the ferruginous bed thickness appears to average 40-45 feet (Williams 1957). However drill cores have no record of core loss but core was lost and it was probably shale interbeds or partings. A recheck of the core boxes indicates that a 30 foot thickness is more in line. The measured sections (Geologic Sections 1 and 2) show thicknesses of ± 15 feet and 25 feet respectively. In areas of good exposures, surface observations, grab sample locations, and bulk sample areas indicated thicknesses varying from 2 to 26 feet.

The tendancy of the upper ferruginous sandstone to weather into a mass of rubble makes surface thickness determinations difficult. Drilling in the National Forest in Giles County and on Big Ridge has always shown greater thicknesses than those calculated from surface exposures.

Therefore the average thickness of the upper ferruginous sandstone is estimated to be 20 feet.

The exposed areas of upper ferruginous sandstone used in the tonnage calculations include: the two large areas in the vicinity of bulk sample areas 1, 2, and 3; the belt east of Big Ridge; the small circular deposit (± 5' thick) on the western tip of Big Ridge and part of the belt just north of Adz Ridge.

The total available tonnage is estimated to be 12.5 million tons. New drill holes 14 and 5 (Williams 1957) indicate a Keefer sandstone and shale thickness of 25 feet. This thickness naturally thins towards the ferruginous sandstone contact as indicated by drill hole 1 which showed 10 feet of Keefer sandstone. If this overlying Keefer sandstone could be stripped back to the vicinity of drill holes 14 and 5, then the tonnage estimate could be boosted 4 million tons to give a total figure of 16.5 million tons.

Lower ferruginous sandstone.

The broadest area of lower ferruginous sandstone is located on the crest of Big Ridge in the vicinity of triangulation point 4116. Here drill holes 9 and 10 indicate a thickness of 7 and 11 feet respectively. No surface thicknesses could be obtained in the immediate area but outcrops along the roads and paths around Big Ridge indicate thicknesses from 2 to 18 feet. Geologic section 1 indicates 18 feet of lower ferruginous sandstone contained in an interval of shale and ferruginous sandstone totaling 27 feet. The lower zone appears to average from 30 to 50% interbedded shale. The average thickness of the lower ferruginous sandstone around point 4116 is estimated to be 8 feet. The available tonnage is estimated roughly to be 2 million tons. Other areas were considered as too thin.

East River Mountain - Route 52 Area

Location and Accessibility

The East River Mountain area lies in the northwestern corner of Bland County, Va. and is bounded on the northwest by the crest of East River Mountain, on the southwest by the Appalachian Power line and the Big Ridge area. County road 613 lies along the southeastern boundary of the area and U. S. Route 52 marks the northeastern boundary. The area roughly encompasses 5 square miles and is accessible mainly by County Road 613. From this road a few seldom used timber roads extend half way up East River Mountain. Most of the area is accessible only by foot. As a result of repeated timber cuttings most of the area is a mass of secondary timber growth, scrub brush, briar patches and laurel thickets.

Previous work.

Although included in reports by Butts (1934) and Campbell (1894) the area has never been mapped in detail.

Mapping proceedure

The same general proceedure used on Big Ridge was also used in this area. Part of this area was mapped on a topographic map (Plate 2) and since the northeastern area has no available usuable topographic map, the geology was placed on aerial photos DTJ-10L-38 and DTJ-10L-60. The area was only briefly surveyed and the geology strictly of a reconnaissance nature.

Stratigraphy and exposures

The statements concerning the Big Ridge stratigraphy also apply here. The upper shale of the Rose Hill formation is nearly absent in this belt. At most only a few feet of shale is present between the top of the ferruginous sandstone and the "Keefer" sandstone.

Excellent exposures of the upper ferruginous sandstone occur along U. S. Route 52 and also on the ridges northwest of Camp Laurel (See Plate 2). Various blocks (float?) and areas of ferruginous sandstone occur down in the Devonian shales. These may be of float origin or possibly blocks caught in small thrusts. The relationships are obscure. Outcrops of upper ferruginous sandstone surround the "Keefer" sandstone outliers lying in the syncline along East River Mountain. The areas are small and the syncline breached by deep erosional draws. The lower ferruginous sandstone was not seen mainly because the up-hill fringes of the Rose Hill formation are engulfed along strike by great masses and "boulder trains" of Tuscarora colluvium.

Structure

The area is synclinal along East River Mountain forming the northwest limb of the Laurel Creek-Dry Fork syncline. Northwest of Camp Laurel a small syncline is developed in the Tuscarora, Rose Hill, and "Keefer" formations. This structure is bounded on the southeast by several thrusts. Continuations of these thrusts are visible along U. S. Route 52.

Thickness and Reserves

The same general formational thicknesses on Big Ridge apply here. Along U. S. Route 52 in the gap of Wolf Creek

Mountain 3.5 miles southeast of Laurel Creek the upper ferruginous sandstone is 22 feet thick. Along U. S. Route 52 about 0.6 miles south of the crest of East River Mountain outcrops of the upper ferruginous sandstone are exceldently displayed. These ledges are 10 feet thick (surface ovservations). Since the "Keefer" is eroded back from the flatiron this area could produce roughly 0.5 million ton of ore.

No other sizeable areas of readily available ferruginous sandstone were found in the area. Along East River Mountain the upper ferruginous sandstone is gennerally "tucked under" the overlying "Keefer" sandstone flatirons so closely that little or no outcrop width is present. Therefore it is suggested that no leasing action be taken on this are at the present time.

Summary

1. The iron reserves of the upper ferruginous sandstone on Big Ridge are estimated to be 12.5 million tons. This figure is based on an average ore thickness of 20 feet and a mineable area as outlined (use on map) on Plate 1. Stripping of a portion of the overlying "Keefer" sandstone and shale (probably not exceeding 25 feet in thickness) would increase these reserves to 16.5 million tons. This estimate is conservative.

The lower ferruginous sandstone is estimated to contain 2 million tons in the vicinity of triangulation point 4116. Other areas of lower ferruginous sandstone could possibly add another 0.5 million tons.

2. The East River Mountain - Route 52 area (Plate 2 and aerial photos) was reconnaissance mapped and only one locality, along U. S. Route 52 appeared suitable for mining. This area outlined on aerial photo DTJ-10L-58 shows at least 10 feet of upper ferruginous sandstone and could possibly produce 0.5 million tons of crude ore.

The remainder of this area contained no other large areas of ferruginous sandstone easily mineable on a quantity basis.

Recommendations

1. If further work is done on Big Ridge then the area should be plane table mapped in the spring, winter, or fall and the property boundaries surveyed. Future core drilling should be done so that maximum core recovery is achieved.

2. Except possibly for the small mineable area along U. S. Route 52 no further leasing action should be taken on the East River Mountain - Route 52 area at the present time.

GEOLOGIC SECTIONS

Geologic Section 1. - Rose Hill formation exposed along County Road 662 approximately 250' southeast of the junction of County Road 662 and the crest of East River Mountain.

	Thickness Feet
Keefer sandstone	
Rose Hill formation (±194.40 feet)	
23. Shale, pale grayish-green to pale rust brown; section partly covered................	25.4'
22. Shale, pale grayish-maroon....................	1.3'
21. Shale, pale grayish-green to rust orange, weathers rust brown; contains interbeds of drab maroon to grayish-maroon fine grained slightly ferruginous sandstone. Shale comprises 60% of section......................	7.5'
20. Sandstone, drab-maroon, fine grained, ferruginous, contains abundant maroon shale partings and interbeds parallel to the bedding planes. Shale appears to comprise 35% of section. Last 15 inches is massive bed of drab-maroon fine-grained ferruginous sandstone................................	5'

	Thickness Feet
19. Sandstone, drab maroon to grayish maroon, fine grained, ferruginous siliceous, contains interbeds and partings of pale grayish green, rust brown, and maroon shale..................	0.65'
18. Shale, pale tan to rust brown.................	1.5'
17. Sandstone, drab maroon, fine grained, ferruginous; contains interbeds and partings of pale grayish green, rust brown, and maroon shale parallel to the bedding planes; weathers rust brown on bedding surfaces.....................................	4.5'
16. Shale, pale grayish green, weathers rust brown.....................................	1'
15. Sandstone, drab maroon, fine grained, ferruginous; contains maroon clay galls.......	3'
14. Note: Localized folding and faulting occurs here and explains thickness of upper ferruginous sandstone and the thickness of shale in the middle zone.	
14. Interval mostly covered; contains sporadic outcrips of pale gray to grayish green shale chips weathering pale rust brown; contains interbeds and lenses of pale rust brown to grayish green and grayish white fine grained quartzose sandstone.............	94.5'

	Thickness Feet
13. Sandstone, drab grayish maroon, fine grained, ferruginous (12-14% Fe): contains 50% interbedded shale and drab brown sandstone................................	3.5'
12. Covered interval; mostly shale, contains several 1" beds of drab maroon fine grained ferruginous sandstone.........................	1.0'
11. Sandstone, drab maroon, fine grained, thin bedded, slightly ferruginous..................	0.6'
10. Sandstone, drab maroon, medium to coarse grained ferruginous (_20% Fe); contains quartz granules and phosphatic fossil fragments..	2.75'
9. Shale, drab maroon, sandy......................	1.0'
8. Sandstone, drab maroon, fine to medium grained ferruginous, thin bedded..............	2.25'
7. Interval mostly covered, contains shale and sandstone. Shale pale grayish green to pale rust brown; sandstone interbeds are drab grayish maroon, fine grained and low in Fe.-12%...................................	2.25'
6. Sandstone, drab maroon, fine grained, ferruginous shaly. Contains drab maroon shale partings.................................	2.9'

		Thickness Feet
5.	Shale, drab brown..............................	1.0'
4.	Sandstone, drab maroon, fine to medium grained ferruginous; contains abundant clay galls and paper thin shale partings............	5.0'
3.	Clay shale, pale rust brown, unctuous..........	3.5'
2.	Sandstone, drab maroon, fine to medium grained, ferruginous, thin to medium bedded...	1.5'
1.	Mostly covered, shale, drab yellowish brown; contains interbeds of buff fine grained quartose sandstone.....................	23'

Tuscarora sandstone

Geologic Section 2. - Rose Hill formation along County Road 622 0.75 miles north of the junction of State Road 61 and County Road 622. Section through Buckhorn Mountain.

		Thickness Feet
Keefer sandstone		
Rose Hill formation (167 feet)		
13.	Covered interval................................	8.5'
12.	Shale, pale grayish green, weathers pale rust brown; contains irregular lenses, partings, and interbeds of pale rust brown and grayish green fine grained quartzose sandstones....................................	14.7'
11.	Sandstone, pale grayish green, fine grained, quartzose; grades directly into ferruginous sandstone.....................................	1.3'
10.	Sandstone, drab maroon, fine grained, ferruginous; contains abundant clay galls.....	1.0'
9.	Sandstone, drab maroon, fine grained, ferruginous, thin bedded, shaly; contains abundant shale partings parallel to the bedding planes and maroon clay galls. 25% shale..	3.7'

	Thickness Feet
8. Sandstone, drab maroon to rust brown, coarse grained, ferruginous; in lower 0.5 feet interstices are filled with rust red silt rather than Fe..................................	1.3'
7. Shale, pale grayish green, weathers pale rust brown..	3.1'
6. Sandstone, drab maroon, fine grained, ferruginous, last 1.5' contains 20% shale.....	3.7'
5. Sandstone, drab maroon, coarse grained, ferruginous, medium bedded....................	1.3'
4. Sandstone, drab maroon, fine grained, ferruginous, massive ledges (probably 18 to 20% Fe); contains sporadic maroon clay galls..	14.5'
3. Interval mostly covered; includes sporadic outcrops of pale grayish green shale that weathers pale rust brown. Also contains interbeds of grayish green fine grained quartzose sandstone..........................	50'
2. Interval covered, same as above. No lower ferruginous sandstone zone is exposed but a partial section is exposed in Cove Creek just southwest of the road....................	50'
1. Covered interval............................	14'

Tuscarora sandstone

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RECONNAISSANCE GEOLOGY

of the

DRY FORK AREA

BLAND COUNTY, VIRGINIA

By:

W.A. Moon, Jr.

Date submitted:

25 February 1964

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Reconnaissance Geology of the Dry Fork Area

Introduction

Purposes of Investigation

1. To reconnaissance map and define the extent of the ferruginous sandstone beds of the Rose Hill formation in the Dry Fork area.

2. To make a generalized gross tonnage estimate of crude ore available from the Taylor Property in the Dry Fork area.

3. To ascertain whether this property should be leased for further development.

Method of Investigation

No recent topographic maps were available for the area so the mapping was done entirely with the use of Dept. of Agriculture Soil Conservation aerial photos made in 1953 (scale 1 inch = 1,000 feet). Field work commenced Dec. 16, 1963 and terminated 2 February 1964. Contacts were approximated on the photos using the Brunton-pace method. Twelve chip samples were taken from representative outcrops of ferruginous sandstone beds. These samples were sent to Lerch Bros., Hibbing, Minn. for analysis. The results are included in this report. An adjacent area, the Forest Products tract, (see tract map) was also very friefly studied.

Location of the area

The Dry Fork area lies in the northeastern corner of Bland County. The area is bounded on the northwest by the crest of East River Mountain, on the northeast by the convergence of these two ridges, on the southeast by Buckhorn Mountain and on the southwest by U. S. Route 52.

The Taylor property is confined primarly to the southern flank of East River Mountain and encompasses roughly 1846 acres. The southern boundary of this property is rather indefinite as nearly all the line trees have been cut. No actual boundaries or markers were found or located on the ground during the field work.

Accessibility of the area

The Dry Fork areais accessible from Bluefield, West Va. by U.S. Route 52 and County Road 613. The latter road runs thru the heart of the area and parallels Dry Fork. Numerous old logging roads and skid trails extend from County Road 613 up the southern slope of East River Mountain but the majority of these are either washed out or blocked by dense scrub brush and fallen trees. The head of Dry Fork is accessible only by jeep along several logging trails that parallel Dry Fork creek. The entire area is covered by secondary timber growth, scrub brush, briars, and laurel thickets.

Previous work

Cambell (1896) included the Dry Fork area in his Pocahontas folio which displays the geology on a broad regional basis. Butts (1932) also covers the regional geology on his map of the Geology of the Appalachian Valley of Virginia. Prior to this report the area has never been mapped in detail.

Stratigraphy

General statement

For brevity only the Rose Hill formation and its underlying (Tuscarora sandstone) and overlying ("Keefer" sandstone) formations were mapped in detail. The colluvium and alluvium that clogs the ravines in the area were also roughly outlined.

Tuscarora sandstone

The Tuscarora sandstone underlies the Rose Hill formation. It outcrops along the crest of East River Mountain where it forms a prominent ridge. The Tuscarora is also exposed on the crest of Buckhorn Mountain near the head of Dry Fork and in the vicinity of the U.S.G.S. bench mark.

The Tuscarora sandstone is predominently a pale-grayish-white to white, medium to coarse-grained quartzose sandstone. The basal beds are generally conglomeratic and contain rounded quartz pebbles. The rock is often classified as an orthoquartzite and contains interbeds and paper-thin partings of olive-drab shale. The Tuscarora contains the fossils(?) Arthophycus and Scolithus. These are considered to be worm trails and worm borings.

Rose Hill formation

The Rose Hill formation outcrops along the southern flank of East River Mountain throughout the Dry Fork area. It is particuliarly well exposed in the head of Dry Fork just southwest of Jesse's Knob (see photo 4). The formation also covers the area on the southern flank of Buckhorn Mountain just southwest of the intersection of Buckhorn Mountain and East River Mountain.

The Rose Hill formation is composed chiefly of pale greenish-gray shale which contains interbeds and lenses of pale greenish-gray fine to medium-grained quartzose sandstone. This rock type comprises roughly 75% of the formation. The remaining 25% is composed of drab-maroon, fine to medium-grained, thin to medium-bedded ferruginous sandstone. The rock is a quartzose sandstone that contains hematite which fills the interstices and cements the quartz grains together. This ferruginous sandstone generally occurs in two zones. The thickest zone known as the "upper ferruginous sandstone" lies about 6-10 feet below the "Keefer-Rose Hill contact and appears to range in thickness from 20 to 30 feet. The other ferruginous sandstone occurs about 12 feet above the base of the Tuscarora sandstone and appears to range in thickness from 5 to 12 feet. The two zones are separated from each other by a " middle zone" of shale and sandstone which appears to be 90-100 feet thick.

No complete measured sections could be made in the Dry Fork area but a hand-leveled generalized section is given below.

Geologic Section 1. Hand-leveled section taken in the vicinity of Jesse's Knob and sample locality DF-5.

"Keefer" sandstone

Rose Hill formation (± 167 feet)	Thickness feet
5. "Upper shale" pale greenish-gray, weathers pale tan.........	6-8
4. "Upper ferruginous sandstone", drab-maroon, fine to medium grained, thin to medium bedded, ferruginous; contains sporadic maroon shale partings and maroon clay galls, often displays prominent cross-bedding.........................	30
3. "Middle shale", mostly covered, shale, pale grayish-green, weathers pale tan, contains interbeds and lenses of pale grayish-green, fine to medium-grained quartzose sandstone...	100
2. "Lower ferruginous sandstone", interval covered, sandstone drab-maroon, fine to coarse grained, ferruginous, thin to medium bedded..	6-10
1. "Lower shale", pale grayish-green, weathers pale tan........	10-12

Tuscarora sandstone

Another section measured 3 miles south of Dry Fork thru the gap in Wolf Creek Mountain is given below.

Geologic section 2. Located south of Rocky Gap. Section taken along the northeast side of Route 52, gap cuts thru Wolf Creek Mountain. Dip averages 30°S.

"Keefer" sandstone

Rose Hill formation (167 feet)	Thickness feet
16. Covered interval..	29
15. Sandstone, maroon, fine grained, thin bedded, shaly, ferruginous; Fe 13.98, Phos. 0.234	3

Geologic section 2 (continued.)	Thickness feet
14. Covered interval..	5.5
13. Shale, drab..	2
"Upper ferruginous sandstone"	
12. Sandstone, maroon, fine to coarse grained, thin to medium bedded; contains maroon clay galls, ferruginous, Fe 15.27, Phos. 0.261..	22
11. Sandstone, drab grayish-maroon, fine grained..............	1
10. Covered interval..	3
9. Sandstone, drab grayish-maroon, fine grained...............	0.5
"Middle shale"	
8. Shale, drab- grey to grayish-brown; contains interbeds of fine grained brown and grey sandstone......................	27
7. Sandstone, drab grayish-maroon..........................	3
6. Covered interval..	17.5
5. Sandstone, drab grayish-maroon, fine grained..............	3
4. Covered interval..	18
3. Shale and sandstone, shale pale tan, sandstone, drab brownish gray, fine grained, quartzose............................	2
"Lower ferruginous sandstone ?"	
2. Covered interval, probably ferruginous sandstone; sandstone float, maroon, fine to coarse grained, ferruginous.........	9
" Lower shale"	
1. Covered interval..	22

Tuscarora sandstone

These two sections indicate a thickness of 165-170 feet for the Rose Hill formation. The "upper ferruginous sandstone in the Dry Fork area had observed outcrops that ranged from 12 to 20 feet in thickness(average). Since the "middle shale"- "upper ferruginous sandstone" contact was never exposed the "upper ferruginous sandstone" will probably average 20 feet or better. The thickness, however, needs to be proved by core drilling.

In the vicinity of DF-8 and DF-9 a massive ledge of "upper ferruginous sandstone" is exposed. The ledge ranges in thickness from 15 to 25 feet.

Twelve chip samples were taken from the area and the results are tabulated below.

Sample No.	Thickness	Zone	% Fe.	%Phos.
*DF-1	16 feet	ufs	20.95	.297
DF-2	10 feet	ufs	14.51	.108
DF-3	4 feet	lfs	17.09	.159
*DF-4	15 feet	ufs	19.83	.183
*DF-5	23 feet	ufs	14.35	.192
# DF-6	7 feet	ufs	16.93	.110
# DF-7	21 feet	ufs	14.99	.240
*DF-8	20 feet	ufs	15.80	.201
*DF-9	15 feet	ufs	16.12	.159
DF-10	8 feet	lfs	18.54	.093
DF-11	sampled across strike on dip slope	ufs	18.70	.174
*DF-12	18 feet	ufs	18.54	.165
		Weighted Av 157 feet	16.69	

Averages

Entire area

	Thickness	%Fe	%Phos.
UFS	16 feet	16.77	.197
LFS	6 feet	18.05	.115

Averages

Taylor property (areas outlined in red on photos)

	Thickness	%Fe	%Phos.
UFS	18 feet	17.33	.203
LFS	4-6 feet	17.00	.150

* Denotes samples used in making averages for Taylor property.

# Denotes samples taken on the Forest Products tract.

"Keefer" sandstone

The Rose Hill formation is conformably overlain by the "Keefer" sandstone. Good exposures occur along the southern flank of East River Mountain where the formation forms prominent flatirons. The "Keefer" is also partially exposed in the nose of the Dry Fork syncline just southwest of Jesse's Knob. Here the "Keefer" is estimated to be not more than 10-15 feet thick.

This Keefer formation is composed of drab grayish-white to white, fine to medium to coarse-grained sandstone. It contains interbeds of pale grayish-green to olive-drab shale. The formation grades upward into a pale grayish-white to tan, fine-grained, thin-bedded quartzose sandstone that frequently shows traces of manganese mineralization. The sandstone beds commonly contain the ostracod Leperdita tho none were found in the immediate area. The "Keefer" is estimated to be 75-100 feet thick in the Dry Fork area.

Alluvium and colluvium

The alluvial and colluvial deposits in the area were outlined on the aerial photos. Along East River Mountain and particularly in the southwestern corner of this mountain the bedrock geology is almost completely buried under masses of Tuscarora and Rose Hill "talus". This "talus" is composed chiefly of blocks, boulders, cobbles, and pebbles. Similar deposits clog all the draws extending down the southern slope of East River Mountain. In the headwaters of Dry Fork all of the area along the creek is obscured by alluvium and colluvium.

Structure

The dominent structure in Dry Fork is the Dry Fork syncline. This fold trends southwest to northeast and Jesse's Knob forms the nose of the syncline. The structural axis closely parallels Dry Fork creek.

The southern limb of this syncline is probably cut by two high angle thrusts (?). The thrust (?) relationships are obscured by alluvium and colluvium and outcrops are scarce. The Buckhorn Mountain area just south of the head of Dry Fork Creek is anticlinal. Although sporadic outcrops of Rose Hill ferruginous sandstone can be found along the crest and southern slope of Buckhorn Mountain(outside of the mapped area) the area is too badly faulted to serve as a source of iron ore. The structural complications and numerous low-angle thrusts along this mountain stem from the great Narrows thrust which trends along the southern base of Buckhorn Mountain. Minor thrusting also occurs in the post-Rose Hill formations along East River Mountain.

Tonnage Estimates

Only the areas outlined in red ink on the aerial photos were used in making the tonnage estimates. The other areas were either too small in surface area or else obscured by colluvium.

Two tracts of land were involved in the estimate. The first tract is the Dry Fork of Taylor property. The second tract is the Forest Products tract located on the southern slope of Buckhorn Mountain just south of Jesse's Knob. Tonnage estimates in the chart on the following page were calculated using different estimated thicknesses.

Tract	Ore zone	If estimated thickness is	Then probable tonnage is
Taylor tract	ufs	15 feet	11 million tons
Taylor tract	ufs	20 feet	15 million tons
Taylor tract	ufs	25 feet	18.5 million tons
Taylor tract	lfs	10 feet	1 million tons
Forest Products tract	ufs	15 feet	7 million tons
Forest Products tract	ufs	20 feet	9 million tons
Forest Products tract	ufs	25 feet	12 million tons

The above chart illustrates a probable ore estimate from 11 to 18 million tons of crude ore for the Taylor property and a probable ore estimate of from 7 to 12 million tons for the Forest Products tract.

Since the average overall thickness of the "upper ferruginous sandstone" is probably 20 feet, the estimate for the Taylor tract is roughly 14-16 million tons. The Forest Products tract probably contains 7-9 million tons. Core drilling is needed to prove the exact thicknesses of the ore zones.

Summary

The Taylor property in the Dry Fork area contains a probable ore reserve of 14-16 million tons of crude ore. This figure is based on an estimated thickness of "upper ferruginous sandstone" of 20 feet and a mineable area as outlined on the aerial photos. By leasing an adjacent property to the south (Forest Products tract) an additional 7 million tons might be obtained.

Twelve chip samples were taken in the area. The iron content of the "upper ferruginous sandstone" ranged from a low of 14.35% to a high of

20.95% while the phosphorus ranged from 0.108% to 0.297%. The average iron content of the "upper ferruginous sandstone for the mineable areas on the Taylor property was 17.33% while the average for the entire area mapped was 16.77%. The iron content in the area is variable.

Recommendations

1. If it is proven by Hanna Mining that ore averaging 17% Fe and running in areas as low as 14.35% Fe can be used then the area should be leased. If more chip samples were taken in the vicinity of DF-4 and DF-5 then the average of this one area might be raised to 17-18% Fe.

2. If leased the area should be plane-table mapped, core drilled, and sampled in detail.

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BRIEF NOTES ON THE RECONNAISSANCE GEOLOGY OF THE MERCY BRANCH---MILL CREEK AREA, GILES COUNTY, VIRGINIA

Purpose of Investigation

The purpose of this survey was to make a semi-detailed geologic map of the area leased in the Jefferson National Forest, Giles County, Va. An attempt was made to ascertain the extent and thickness of the two ferruginous sandstone units contained within the Rose Hill formation. Seven chip samples were taken in the Mercy Branch area and a chart showing tonnage estimates was prepared.

Method of Investigation

Aerial photos enlarged to a scale of 1 inch equals 1,000 feet were used for base maps. Brunton compass and pace and tape traverses were made across the outcrop belts and observation points (shown on the photos) were marked in the field by stacked stones bearing the observation point number. Field work commenced in April 1964 and terminated in June 1964.

Location of the area

The area is located in the northwestern portion of Giles County and lies within the synclinal area bounded by Wolf Creek Mountain on the northwest and Pearis Mountain, Sugar Run Mountain, and Brushy Mountain on the southeast.

Accessibility of the Area

The Mercy Branch--Flat Top Mountain area is accessible by County Road 665 up Wilburn Valley and County Road 663 along Sugar Run Creek. Numerous jeep roads extend from the National Forest Roads that give good access to the area. The region is covered by secondary timber growth, scrub brush, and laurel thickets.

Previous Work

An earlier worker in the area was Charles Butts who included the area in his

"Geologic Map of the Appalachian Valley of Virginia". A detailed geologic map of Giles County has been compiled by certain Virginia Polytechnic Institute graduate students and the author. The report is being prepared for publication by Dr. B.N. Cooper, Dept. Geologic Sciences, V.P.I., Blacksburg, Va.

In Sept. of 1961, Minerals Development Corp. initiated a core drilling project and mapping study of the area. By January of 1962 17 drill holes were completed. All penetrated the Rose Hill formation. In June of 1962 a generalized geologic map of the area was completed. Several bulk samples of ferruginous sandstone were taken and shipped to Germany for beneficiation tests. These sample areas are indicated on the aerial photos. Specific information regarding tonnages and test data is available from Minerals Development Corp.

samples in VDMR repository

Stratigraphy

In this report only three geologic formations are of importance. These are the "Keefer" sandstone, Rose Hill formation, and the Tuscarora sandstone. Only the Rose Hill formation is of economic interest. Since the formations have been adequately discussed in other reports they are only briefly discussed here.

"Keefer" sandstone

The "Keefer" sandstone overlies the Rose Hill formation and is composed of grayish-white orthoquartzites and pale greenish-gray shales that are roughly 200 feet thick. In Giles County the formation varies from 130 feet to 230 feet thick. The quartzite members are resistant to erosion and form prominent "flatirons" on dip slopes. The "Keefer" sandstone can be distinguished from the older Tuscarora sandstone only by stratigraphic position and the infrequent occurrance of the ostracode Leperdita in the "Keefer" sandstone.

Rose Hill formation

Underlying the "Keefer" sandstone is the Rose Hill formation which is composed of pale grayish-green shales, grayish-green fine to medium grained quartzose sandstones and drab-maroon, fine to coarse-grained ferruginous quartzose sandstone. The ferruginous sandstones comprise roughly 30% of the formation and are composed of sub-rounded quartz grains bonded together by hematite which fills the interstices. The formation is divided into five mapping units. These include in descending stratigraphic order: the "upper shale" composed of pale grayish-green shale; the "upper ferruginous sandstone" composed of drab maroon, fine to coarse grained, thin to medium bedded ferruginous sandstone; a "middleshale" zone composed of pale grayish-green shale containing intercalations, lenses and interbeds of pale grayish-green fine to medium grained quartzose sandstone; a "lower ferruginous sandstone" zone of drab-maroon, fine to coarse grained ferruginous sandstone. This zone contains several 2 to 3 feet thick shale units which comprise roughly 50% of the entire mapping unit. The "lower shale" is composed of pale grayish-green shale. In the Mercy Branch area this unit contains a thin bed of drab-maroon, fine grained, ferruginous sandstone from 2 to 3 feet thick. This unit was mapped separately as "llfs" where exposed.

The entire formation ranges from 117 to 160 feet in thickness but averages roughly 120 feet overall. The Tuscarora sandstone conformably underlies the Rose Hill formation.

Thickness ranges (approximate) are listed below.

Zone	Thickness Range (In feet)	Average(Approx.)	
us	3----------31	25 feet	
ufs	10----------38*	30 feet	upper iron ore zone
ms	21----------39	30 feet	Middle Shale
lfs	10----------33*	18 feet	lower iron ore zone
ls	16----------40	20 feet	Lower shale

* Average thicknesses of the ferruginous sandstone includes shale interbeds.

The above figures illustrate the wide variability of the five Rose Hill subdivisions. Further these units were extremely hard to define. It was extremely difficult to recognize, separate, and map. In previously mapped areas to the southwest on Big Ridge and Dry Fork the units are more clearly exposed and much better defined. Outcrops in the Mercy Branch-- Flat Top Mountain area were scarce and the variability of the mapping units along strike led to some stratigraphic confusion. The ferruginous sandstone units not only show a variability of thickness but they also vary in fe. content, and percentage of shale interbeds and partings. (See drill hole logs and analyses for a more complete description.) The seven chip samples listed below also emphasize this variability.

Sample No.	Zone	Thickness in feet	% Fe.	%Phos.
1	lfs	7	16.30	0.191
2	ufs	11	10.25	0.068
3	ufs	23	11.38	0.121
4	ufs	7	10.73	0.106
5	ufs	5	10.33	0.084
6	lfs	sampled across strike	23.89	0.127
7	lfs	2.5	15.33	0.099
Averages	ufs	11.5	10.90	0.102
	lfs	not calculated.		

Tuscarora sandstone

The Tuscarora sandstone underlies the Rose Hill formation and is composed chiefly of extremely durable quartzose sandstones and interbedded pale greenish-gray shales. This sandstone is a prominent ridge maker in the area and forms massime cliffs that are easily recognised on the aerial photographs. In Giles County the Tuscarora varies in thickness from 90 to 140 feet.

See next page for tonnage estimates.

TONNAGE CHART FOR AREAS IN THE JEFFERSON NATIONAL FOREST

Areas	Zone	Area in sq. ft. No shale stripping	Estimated thickness in feet 2#	Tonnage No stripping	Total area in sq. ft. Strip us	Total area in sq. ft. Strip us, ufs, & ms	Estimated thickness in feet 2#	Tonnage 3# with stripping
Mercy Branch	ufs	5,800,000	9	5,220,000	9,060,000	--------	15	13,590,000
	lfs	9,900,000	12	11,880,000	--------	24,870,000	15	37,300,000
Pearis Mtn.	ufs	5,900,000	20	10,800,000	9,700,000	----------	25	24,000,000
	lfs	5,400,000	10	5,400,000	---------	19,100,000	15	28,600,000
Sugar Run Mtn. 1#	ufs	3,270,000	18	5,800,000	3,800,000	----------	20	7,600,000
	lfs	750,000	6	450,000	---------	5,000,000	8	4,000,000
Flat Top Mtn.	ufs	4,340,000	15	6,500,000	5,480,000	----------	18	9,800,000
	lfs	2,300,000	10	2,300,000	---------	6,430,000	10	6,430,000
			Total	48,350,000			Total	131,320,000

1# The area on Sugar Run Mountain mapped as Srh (undifferentiated) was not included in the tonnage estimates. Neither was the ferruginous sandstone belt north of Mill Creek (along Wolf Creek Mountain). The belt just north of Flat Top Mountain was not included. (Area between Flat Top Mountain and No Business Creek).

2# Thicknesses are conservative and based on drill hole data and field observations of thinning a nd thickening both up dip and along strike. (No shale intervals are included).

3# Tonnage estimates are based on 1 cubic foot of ferruginous sandstone weighing 200 pounds.

Recommendations

1. That all information collected during the Minerals Development Corp. "iron ore" project in southwest Virginia be edited, condensed, and compiled into one complete report.

2. If further development work in the area is undertaken then the area should be plane table mapped and pattern core drilled.

W. A. Moon, Jr.

W. A. Moon, Jr.

Field Geologist

Minerals Development Corp.

16 June 1964.

FIELD NOTES, JEFFERSON NATIONAL FOREST (MERCY BRANCH, FLAT TOP MTN. AREA)

Numbers correspond to those on the 1,000 feet to 1 inch scale aerial photos.

1. Stk otcs. ss. drab-gray, to white; cr. gr. N64E dip 15S.

2. Up. fe. ss., drab mar. fn. gr., fe. thn. to med. bedded. exp. on road.

3. Up. fe. ss. 6' exp. drab. mar., exp. under power line. S33E dip 50SW.

4. Stk under power line. N5W dip 5SW.

5. Up. fe. ss. drab mar. mostly covered. N88E dip 11S.

6. Line of traverse from 6. S62E, no otcs. seen to creek.

7. Stk. exc. otcs. ss. gr. wh., cr. gr. N48E dip13S. 20 feet east reading is N58E dip 15N 5 feet exp. qtzose. ss.

8. St on trail S82E dip 6S.

9. Old prospect pits dug in area. Lower fe. ss. and sh., choc. br. rich in Mn. but unit is not over 1' thick. Area sporadically overlain by thin veneer of lfs.

10. St otcs. may not be in place N53E dip 5S.

11. St ledge. N51E dip10S.

12. St. N60E dip 5S.

13. St exp. in draw approx loc. N60W dip 8S.

14. St, N54E dip 7S.

15. Cross roads

16. " "

17. " "

18. " "

19. St otcs. N88W dip 7S

20. Cross roads and old sawmill turn around. Approx. loc.

21. Stk-us. contact.

22. Stk exp. in road. S38E dip 7SW may not be in place.

23. Oj, N54E dip 22N

24. St, N54E dip 18N.

25. St, N58E dip 15N

26. St caps ridge N54E dip 14N

27. Lfs. Look for small saddle behind lfs. This saddle mks. ms-lfs contact. Dist. from lfs-ls contact 150 feet.

28. St caps ridge. N55E dip3S

29. St caps ridge. N84W dip3S.

30. St caps ridge. N5E dip 4W.

31. St. N27E dip 8NW.

32. St. N55E dip 13Nw.

33. Cross rds. St in draw N of cross rds.

34. St-ls(Srh) contact on old road.

35. Cross rds. St in vic. approx. loc.

36. St below ridge. N51E dip 13N.

37. St on Mercy Br. N69W dip 5S.

38. 30 feet W of 37 N10E dip 7SE.

39. Cross rds. lfs float in vicinity.

39A. Lfs float in vicinity.

40. Exc blocks of lfs.

41. Ufs. 3 feet exp. ss. drab mar. fe. N42W dip 10SW. approx loc. only.

42. Cross rds.

43. Ufs. 4 feet exp. ss. drab mar. cr. gr. fe. N25W dip6SW.

44. Cross roads.

45. St exp in creek. approx. loc. may not be in place. S27W dip 7N.

46. Ufs. ss. drab mar. cr. gr. 3 feet exp. N54W dip 17SW.

47. 7 feet otcs. Ufs. ss. drab mar., cr. gr., fe. N5W dip 5W. Sample 4 taken here. up sh. on top of ledge.

48. St in road, may not be in place. N29E dip 9NwW. 30 feet S N4E dip 6W.

49. Start of traverse.

49-69. Traverse points along road to drill holes. Points shot by hand Brunton by one man only.

Sta. Bearing	Distance	Slope	
49. N84E	186 feet	11°	
50. N79°30'E	256 feet	14°	
51. N53E	103 feet	15°	
52. N61E	100 feet	12°	
53. N82E	200 feet	8°	
54. N79E	100 feet	5°	poss. ms-lfs contact
55. N36E	100 feet	11°	poss. ufs-ms contact.
56. N36E	65 feet	11°	top of ufs.
57. N69E	94 feet	7°	
58. N47E	36 feet	0	
59. S75°30'E	110 feet	0	
60. N66E	77 feet	0	Diamond drill hole T6-12A
N45W	100 feet	-2°	
61. N68W	100 feet	0	
62. N48W	86 feet	-5°	
63. N9W	200 feet	-1°	
64. N73E	18 feet	0	T6-15A (Diamond drill hole)

~~65~~ From 64 bearing N50W for 100 feet. Edge of ufs.

~~65~~ Start from T6-12A.

65. N62E	100 feet	0	
66. N62E	100 feet	0	
67. S82E	100 feet	0	
68. N74E	77 feet	0	
69. S67E	115 feet	0	Diamond drill hole T6-13A.
70. S50W	170 feet		bearing from T6-12A. Exc. exp. of ufs. ss. drab. mar. fe. Displays cross bedding. 3 feet exp. N30E dip 13NwW.

71. St stos. N58E 15N.

72. St otcs. cap ridge. N54E dip 15N.

73. Ufs. exc otcs. N30E dip 8N.

74. Ufs. 5 feet exp material variable, many beds barren of fe material. Fe prob 12% or less. N70W dip 2NE. Sample 5 here .

75. Point on road.

76. Poss St otcs on road.

77. Not used.

78. Cross roads. St in creek, mostly float.

79. ~~Cross roads~~ Bulk sample area, from here material was taken for testing.

80. Log loading ramp. St NE of ramp in creek.

81. St. N35E dip 15N. 2 feet of fe. ss. caps ridge in area. This is probably the lowest or third zone of fe. ss. encountered in DDH T6-12A.

Note from 80 to 81 area all shale.

82. St otcs. caps ridge. N36E dip 14N.

83. Approx. loc. only. St otcs. well below ridge on S slope. N30E dip 10N.

84. St. N35E dip 6N. Loc 15 feet Sw of large boundary marker.

85. Point on road near dead chestnut 8 feet tall. Traverse bearing S40E to

86. St-ls contact. N41E dip 12N.

	Bearing	Dist	Slope	Remarks
87.	N49E	100 Feet	0	
88.	N36E	100 feet	0	
89.	N45E	100 Feet	0	
90.	N45E	100 Feet	0	
91.	N34E	100 feet		
92.	N34E	39 ~~100~~ feet	0	
93.	N5E	100 feet	0	
94.	N22E	100 feet	0	
95.	N22E	100 feet	5°	
96.	N20E	166 feet	5°	
97.	N15E	100 feet	5°	
98.	N10E	100 feet	5°	

99. Bearing	Dist	Slope	Remarks
99. N38°30'E	113 feet	4°	
100. N75E	100 feet	6°	
101. N46E	100 feet	5°	
102. N55E	81 feet	4°	
103. N15E	100 feet	7°	Sta 28 at 36 feet.
104. N15E	100 feet	7°	
105. N25E	156 feet	5°	
106. N55E	100 feet	0	
107. N47E	113 feet	0	Sta. 21 Stk-us contact.
108. N52E	100 feet	0	
109. N52E	53 feet	0	
110. E	100 feet	-3°	
111. E	51 feet	-3°	
112. S65E	100 feet	-3°	At 72 feet ush-ufs contact in road.
113. S65E	27 feet		
114. N33E	100 feet	-4°	
115. N20E	100 feet	-4°	
116. N45E	100 feet		
117. N45E	100 feet		At 70 feet beyond 117 fork in road points N .
118. N45E	40 feet		
119. S85E	100 feet	-5°	
120. S86E	85 feet	-5°	

120A At this point chip sample S-1 was taken. 7 feet lfs. exp. ss. drab mar. fn. gr. fe. Bearing to road due S for 219 paces. Came out of traverse at Sta. 117.5

121. S58E	37 feet	0	Cross roads. Sawmill turn-around. Sta 20 15 feet NE.
122. N63.5E	136 feet	0	
123. S72E	97 feet	0	Ufs-ms contact lies parallel to and just N of traverse.
124. N64E	100 feet	0	
125. N32E	100 feet	6°	

	Bearing	Distance	Slope	Remarks
126.	N40E	100 feet	6°	
127.	N26.5E	100 feet	6°	
128.	N35E	73 feet	5°	
129.	N55E	60 feet	0	

130. End of traverse. Old roads fork.

131. North slope of ridge. St etcs. N70E dip 10S. Bearing from Sta. 85 is N20W

132. Stk-us contact. Bearing N20W from Sta 106 for 330 feet.

133. S67E from Sta 132 for 246 feet.

134. N28W for 18 paces. Here Chip Sample S-2 was taken. 11 feet of ufs is exp. ss. drab mar., fn. to cr. gr., fe., thick bedded, displays cross-bedding. N87E dip 15S.

135. Massive ufs etcs. exp. 23 feet thick. Chip Sample S-3 taken here. Ss., drab mar., fn. to cr. gr., fe., displays crossbedding.

136 Ufs. exposures. approx. loc. only. S58E dip 16SW.

137. Ufs., may not be in place. S78E dip 8NE.

138. Line of traverse from Sta. 103 is S30E for 87 paces. Stk etcs. N80E dip 10S?

139. 15 feet N of point St is exposed in creek. N49E dip 8N.

140. Probably ufs etcs. Rough location. N64W dip 7SW? Bearing N83W from large pi ne.

141. Stk etcs. rough location. N22E dip 10N. Bearing N52W from large pine tree.

142. Stk etcs. N44W dip 7SW.

143. Chip sample S-6. Rough location only. Lfs sampled across strike no etcs. seen.

144. Chip Sample S-7. Sampled 2.5 feet lfs. ss., drab mar., fine gr., fe., abundant clay galls.

145. Approx. lfs-ls contact exp. on road.

146. Lfs. 2 feet exp. ss. drab mar., fine gr., fe., thin-bedded. N80E dip 28N.

147. Approx. ls-St contact.

148. Us-ufs approx. contact.

149. Stk-us contact N57E dip30N.

15 0. Prob Stk-us contact.

151. Approx. Us-ufs contact.

152. Approx ufs-ms contact.

153. Approx. lfs-ls contact.

154. Lfs. 8" exp. in road. Ss. drab mar., cr. gr., N67E dip 19N.

155. Ufs-ms contact?

156. Started traverse up old log road. No good otcs. seen.

157. St caps ridge. N45E dip 23N.

158. St caps ridge. N41E dip 16N. Line of traverse from Sta. 158 is N50W.

0-315 feet St.

315-726 feet Covered interval, includes lfs.

726-1040 feet Middle shale.

1040-1139 feet Upper ferruginous sandstone.

1139-1219 feet Upper shale.

1219-1600 feet "Keefer" sandstone.

159. Diamond drill hole T5-14A.

160. Stk just N of old road. Approx. loc. only. N25E dip 15N.

161. St on S slope of ~~Peter~~ Pearis Mtn. N59E dip 29N.

162. 5 feet of lfs. caps ridge. Ms-lfs contact on high point. N63E dip 22N.

163. Exc. otcs. of lfs and ufs exp. in area. Ufs caps ridge. Exc. place for measured section and chip sampling. 12 feet of lfs also exp. ss. drab mar., fn. gr. fe. N40E dip 17N.

Sta.	Bearing	Dist	Slope	Remarks
T5-14A	S40E	100 feet	12°	Stk and Srh float
164	"	"	10°	" " "
165.	"	"	14°	
166.	"	"	15°	Inferred us-ufs contact at 166.5 or 166 plus 50 feet.
167.	"	"	13°	
168.	"	"	10°	Ufs float
169.	"	"	15°	
170.	"	"	19°	Ms-lfs contact located at 170 plus 50 feet.
171.	"	"	19°	
172.	"	"	10°	

	Bearing	Dist	Slope	Remarks
173.	S40E	110 feet	0	Lfs-ls contact at 172 plus 50 feet. Ls caps ridge.

174. St otcs. N71E dip 24N

175. Cross roads.

	Bearing	Dist	Slope	Remarks
176.	S	100 feet	10°	StK otcs and float
177.	S	100 feet	15°	" " "
178.	S	100 feet	7°	Stk
179.	S	100 feet	20°	"
180.	S	100 feet	5°	At Sta. 180 plus 60 feet Stk-us contact.
181.	S	100 feet	9°	At Sta. 181 plus 50 feet approx. us-ufs contact.
182.	S	100 feet	15°	Ufs.
183.	S	100 feet	15°	"
184.	S	50 feet	0	Ufs-ms contact.
185.	S	100 feet	7°	
186.	S	100 feet	15°	At 186 plus 15 feet. Approx. ms-lfs contact.
187.	S	100 feet	10°	Lfs
188.	S	100 feet	5°	At 188 plus 50 feet lfs-ls approx. contact.
189.	S12E	100 feet	5°	Ls, possible lower lower ferruginous sandstone exposed at 90 feet.
190.	S10E	100 feet	0	St-ls contact.

191. Not marked in field distances estimated by pacing to ridge crest.

	S	0-120 feet	St
	S	120-423 feet	St caps ridge crest at 423 feet N60E dip 18N.
192	S	423-606 feet	Oj otcs. at 606 feet N75E dip 18N.

193. St otcs. N70E dip 17N.

194. Not used.

195. St-ls contact in road.

196. Inferred contact lfs-ls.

197. Small clearing.

[illegible] contact lfs-ls in road.

199. Old prospect pit.

200. Lfs-ls contact on road

201. St-ls contact

202. Road junction.

203. Possible lfs-ls contact.

204. Ms-lfs contact in road.

205. Approx. contact ufs-ms.

206. Us-ufs contact in road. N32E dip 10N.

207. Us-ufs contact.

208. Located 270 feet NE of Sta. 199. Ms-lfs contact. N24E dip 15N?

209. Diamond drill hole T2-18A, 800 feet NE of 199.

210. Possible ufs-ms contact. N31E dip 7N.

211. " us-ufs contact.

212. Stk-us contact.

213. Stk exp in road. N56E dip 9NE.

214. Prob. ufs-ms contact.

215. SE of 214 along road. Ms-lfs contact. N26E dip 14N.

216. SE of 214 prob. lfs-ls contact.

217.	Bearing	Distance culm.	Slope	Remarks.
217.	S35E	0-810 feet	15^{0}	At 810 feet fss-shale contact.
218.	"	1443 feet	5°	Ms-lfs contact.
	"	1853 feet	0	Possible lfs-ls contact.
	"	1980 feet	0	Ls-St contact.
	"	2200 feet	0	Old log road.
218.	"	3538 feet	0	Ridge crest St etcs. N71E dip 4N.

219. Poss. us-ufs contact on road.

220. Point on road 225 feet SE of 219.

221. Approx. contact us-ufs in road.

222. Stk-us contact in road.

223. Stk. ss.,wh.,cr. gr., qtzose. N35E dip21N.

224. Stk S87E dip 18N.

226. Us-ufs contact.

227. Ufs. 6 feet ss., drab mar., fn.to cr. gr., fe.,thn. to med. bed., massive float blocks in area.

228. Lfs-ls contact?

229. Old log road off main road.

230. " " " "

231. Approx. contact lfs-ls.

232. Old log road off clearing.

233. Bearing NE on old log road for 537 feet.Lfs etcs. just east of road. 4 feet etcs. ss. drab mar.,fn. gr., fe., thn. bedded. S30E dip 13W.

234. ~~Sharp bend in road,~~ Approx.? Ms-lfs contact.

235. Sharp bend in old road.

236. Ms? shale exposed in flat saddle.

237. Stk wh. qtzite exp. in road. N60E dip 29N.

238. Stk N55E dip 24N. Stk-us contact approx. 100 feet SE of road.

239. Approx Stk-us contact in road.

240. Us-ufs contact in road.

241. Stk-us contact. 241A. Ufs Or lfs? N36E dip 27SW.

242. Road junction.

243. 7 feet lfs etcs. drab mar., fn. gr., fe., thn. bedded. N54E dip 15NW.

244. Ufs approx. loc. 350 feet NW Of 207. S74E dip 15S.

Sta.	Bearing	Slope	Dist	Remarks.
220.	S30E	15°	0-612 feet	Ufs-ms contact at 612 feet
245	"	0	0-210 feet	ms-lfs contact at 210 feet
246.	"	13	432 feet	lfs-ls contact.
247.	"	0	522	ls-St contact at 247 feet.
248.	"	traverse in St.		

249. Cross roads.

250. Lfs-ls contact.

251. Lfs-ls contact.

252. Lfs? possibly lower zone of ferruginous sandstone. N50E 24S.

255. Ls-St contact.

256. Ms-lfs approx. contact.

257. Lfs exp. in road. N43E dip14N.

258. Approx ms-lfs contact.

259. Point on road. Bearing from 259 is S18E for 140 feet to T2-18A DDH.

260. Us-ufs contact.

261. Ufs-ms contact. 15 feet ufs ss., drab-mar., fn.gr., thn. bedded, fe., shaly, N40E dip 14N.

262. Us-ufs contact.

263. Point on road.

264. Point on road. Approx. us- ufs contact.

265. Approx. us-ufs contact. across road.

266.	Bearing	Distance	Slope	Remarks
264.	SW along rd.	110 feet	0	@ 266 Stk-us contact in rd. ss.,drab gr. wh. qtzose, fn. gr., N50E dip 16N.
2 66.	"	140 feet		@267 DDH T2-1A.
267.	"	210 feet		@ 268 Stk-us contact.
268.	"	155 feet		@ 269 Us-ufs approx. contact.
269.	"	90 feet		@ 270 inferred us-ufs contact.
270.	"	242 feet		@ 271 pt. on rd. Stk-us contact lies 90 feet to the NW. N14E dip 14NW.
271.	"	180 feet		@ 272 Us-ufs contact. approx. contact.
272.	"	112 feet		@ 273 Approx. ufs-sh. contact in rd. 14 ft. drab mar., fn. gr., fe., N50E dip 15N.
273.	2""	115 feet		@ 274 ufs-ms contact exp. in road.
274.	"	140 feet		@ 275 ufs-ms contact in road.
275.	"	175 feet to 276		

276. Inferred ms-lfs contact.

New Traveree

267.	S45E	225 feet	14^{0}	No outcrops seen.

277. Lfs caps ridge. 1 foot fe. ss. exp. ss., drab mar., fn. gr. fe., N38E dip 12N.

278. St. N65E dip 14N

279. Stk. 12 foot ledge , massive fn. to cr. gr. gray wh. , qtzose. ss.

280. Stk exp. inroad bend. ss. drab-gray wh.,fine gr., qtzose. ~~12~~ N60E dip 40N.

281. 3 foot exp. ss. drab mar. fn. gr., fe, thn to med. bedded. N77E dip 75SE may be overturned.

282. Road fork. 282A. St? ledge in old road.

283. Diamond drill hole T7-4A.

284. Junction from road to field.

285. From Sta. 284 to Sta 293. These are all 100 foot increment points placed along the Flat top Mountain Road for referance. Since no specific observations were made at these points they were not logged.

285. Cross roads.

286. "Y" roads. Ls-St contact lies approx. 80 feet S on road from this point.

287. Lfs-ls contact lies 60 feet N of 286 on road.

288. "Y" roads, Lfs? possible lfs-ls contact @ 288.

289. Lfs-sh contact 160 feet NW Of 288.

290. "Y" roads. DDH T3-9A lies S5E for 66 feet (by pacing). Evidence of thrusting, brecciated qtzite lies 75 feet NW of 290 on road.

291. Ss. drab mar., fn. gr., thn. bedded, N52E dip 49N.

292. "Y" roads, possible Stk contact.45 feet SE on road.

293. Stk exp. in road 280 feet NW of 292. ss. drab gr. wh., fn. gr., qtzose, may not be in place. N46E dip65N.

294. Possible fe.ss.-sh contact in road.

295. Point on road St float.

296. St-ls approx. contact in road.

297. Inferred lfs-ls contact in road.

298. Pit dug in lfs.

299. Approx ms-lfs contact.

300. Approx ufs-ms contact.

301. Diamond drill hole T4-16A.

302. Point on road.

303. Old log road. 39 feet SW on road fe. ss. exp. on road. ss. drab mar., fn. to med. gr., fe. 2 feet exp. S84E 15S.

304. Inferred contact ls and lfs.

305. ms-ufs approx. contact in road.

306. Stk-us contact. N40W dip 13SW. 45 feet NW reading is N43W dip 14SW.

307. Stk otcs. ss. drab gray, to wh., fn. gr. qtzite. N44W dip 9SW.

308. "Y" roads 75 feet to the NW fe. ss. otcs.

309. Possible fe. ss.-ls contact.

310. Wh. ss. St? N21E dip 4NW?

311. "Y" roads.

312. "Y" roads possible lfs-ls contact.

313. Us-ufs contact approx. loc.

314. Entrance to field.

315. Stk-us contact just W of creek.

316. "Y" roads.

317. Probable us-ufs contact.

318. Prob. ufs-ms contact.

319. Stk-us contact. 4 feet otcs. drab gr. wh., thn. to med. bedded, fn. gr. qtzose.
N46E dip 17N.

320. Us-ufs contact 116 paces from 319.

321. Bearing	Dist.	Remarks
321. N	160-166 feet	Stk otcs. N47E 24Ndip. Ss., drab gr. wh., fn.to cr. gr., Qtzose.
322. S30E	237 feet	us-ufs contact.

323. Not used.

324. Wh. ss. prob. St? exp in road N71E dip 10S. Ss., gr.wh., cr.gr., massive.

325. St approx loc only not marked in field. N59E dip 8S.

326. Point on path lfs.

327. Wh. ss. N43E dip 25S

328. Point on road.

329. " Y" road, ms in area.

330. Diamond drill hole T1-7A.

331. Poss. ufs-ms contact.

332. Poss. ufs-ms contact.

333. Ms-lfs contact.

334. Otcs., gr.,to wh., cr. gr., qtzose ss. N89E dip 23S.

335. Possible ufs-ms contact. 335A. Point on road Bulk sample area.

336. Approx. ufs-ms contact.

337. ms-lfs contact.

338. Lfs-ls contact. # 4 feet ss. drab mar.,Fn. gr., fe., thin bedded.

N75W dip 16S.

339. Ls-St contact. S70E dip 15S.

340. Bend in road.

341. Ufs-ms contact.

342. Ms-lfs contact.

343. Lfs-ls contact?

344. Ls-St contact approx.

345. St-ls approx. contact.

346. Ls-lfs contact.

347. Ms-lfs contact.

348. Curve in road. Diamond drill hole located S35W for 42 feet.

349. Ufs-ms contact.

350. Inferred lfs-ls contact.

351. Poss. ufs-ms caps ridge.

352. St-ls contact just 60 feet W. N75W dip 15S.

353. St. N85W dip 16S.

354. St. S86E dip 5S.

355. Ufs. ss., drab mar., fn.,grained, fe., 1 foot otcs. Beds nearly flat.
S80E dip 2S.

356. Stk otcs. ss., drab gr. wh., fine gr., qtzose., exp. on road. Approx. loc.
N55E dip 14N.

357. "Y" roads.

358. "Y" roads.

359. "Y" roads Stk.

360. Approx. Stk-us contact.

361. Us-ufs approx. contact.

362. " Y" roads.

363. 4 feet otcs fe. ss., drab mar., fn. gr., thn. bedded. slabby. N15E dip4NW.

364. Point on road.

365. Stk, 4 foot otcs., ss., drab gr. wh., qtzose ss. N18E dip 19N.

366. Stk 2 foot otcs. ss., grayish wh., cr. gr., qtzose, rough loc only not marked in field. N35E dip 12N.

367. "Y" roads.

368. Cross roads.

369. 2 foot otcs. ufs., drab mar., fn. gr., fe. N79E dip 15S.

370. Point on road.

371. Stk rough location only. S78E dip18S.

372. "Y" roads.

373. St. S77E dip13S.

374. Otcs. of lfs.? 10 feet thick. N20E dip 10NW.

375. St. N80W dip 21S.

376. Fe. ss., N82E dip 15S.

377. Ufs. 3 feet otcs. ss., drab mar., cr. gr., fe. S87E dip 10S.

378. Ufs. 2 foot otcs. exp. ss. drab mar., fn to cr. gr., fe. N13W dip 2SW.

379. Point on hill on pace traverse.

380. Point on old log road.

BASE MAP SHOWING BLM PERMIT AREAS AND DRILL HOLE LOCATIONS

ANALYSIS OF CORES

HOLE NO.	NO. SAMPLES	DESIGNATION OF SAMPLES (TOP TO BOTTOM)	THICKNESS OF SAMPLE	ANALYSIS %Fe.	ANALYSIS %Phos.	USABLE MATERIAL ⊠ THICK-NESS (FT)	ANALYSIS (AVERAGE) % Fe	ANALYSIS (AVERAGE) % Phos.
1A	11	1	10.5'	8.6	0.170			
		2	2.10'	9.1	0.13			
		3	~~14.10'~~ 13.9	13.6	0.18			
		4	11.10' ⊠	20.1	0.32			
		5	0.70' ⊠	6.7	0.18			
		6	4.80' ⊠	17.7	0.38	33.0'	18.04	0.362
		7	1.60' ⊠	20.8	0.436			
		8	5.10' ⊠	12.2	0.20			
		9	4.60' ⊠	15.5	0.28			
		10	0.60' ⊠	16.6	0.28			
		11	4.50' ⊠	23.7	0.48			
2A	5	1	10.70'	10.6	0.14			
		2	9.8 ~~12.80'~~	13.6	0.15			
		3	4.80' ⊠	23.1	0.265	14.0'	23.56	0.357
		4	7.40' ⊠	21.9	0.32			
		5	1.80' ⊠	32.4	0.76			
3A	6	1	3.75'	9.67	0.114			
		2	9.50'	8.70	0.68			
		3	6.25' ⊠	13.06	0.074	18.41'	18.76	0.142
		4	3.66' ⊠	19.99	0.142			
		5	6.42' ⊠	22.65	0.182			
		6	2.08' ⊠	21.76	0.232			
4A	1	1	5.50' ⊠	16.60	0.206	5.50'	16.60	0.206
7A	2	1	22.83' ⊠	23.18	0.385	22.83'	23.18	0.385
		2	7.83'	17.06	0.185			
8A	4	1	3.50' ⊠	19.64	0.176			
		2	6.58' ⊠	16.10	0.234	26.75'	18.30	0.194
		3	7.33' ⊠	22.86	0.256			
		4	9.33' ⊠	15.29	0.125			
9A	4	1	13' ⊠	19.96	0.155			
		2	14.08' ⊠	23.78	0.267	30.58'	22.08	0.226
		3	1.58' ⊠	20.78	0.254			
		4	1.92' ⊠	25.16	0.391			
10A	2	1	9.50' ⊠	28.85	0.293	heavy 26.92' core loss	21.46	0.164
		2	17.42' ⊠	17.51	0.095			
12A	8	1	10.0'	12.57	0.079	14' stripping		
		2	2.42' ⊠	16.60	0.133	up. zone		
		3	6.75' ⊠	24.02	0.323	Lower Zone 28.0'@ 15.2 (incl. 11.5' shale)		
		4	1.92' ⊠	20.63	0.120	19.34'	24.30	0.318
		5	3.50' ⊠	27.40	0.321			
		6	4.50' ⊠	28.53	0.461			
		7	0.25' ⊠	28.88	0.842			
		8	1.66'	10.80	0.124			
13A	4	1	6.0' ⊠	24.48	0.108	5' overburden		
		2	3.42' ⊠	28.69	0.193	Upper Zone 19'@ 17.5% (incl. 1.6' shale) 24.08'	22.46	0.142
		3	3.58' ⊠	24.48	0.201			
		4	11.08' ⊠	18.96	0.129	Lower Zone		
14A	5	1	3.50'	10.14	0.146			
		2	20.42'	13.50	0.166	13.50 ~~11.50'~~	? 20.71	? 0.424
		3	3.83' ⊠	20.44	0.354			
		4	53.42' ⊠	13.36	0.229			
		5	4.25' ⊠	26.88	0.644			
15A	10	1	6.0'	8.91	0.073			
		2	5.08'	13.29	0.115	20' stripping		
		3	4.25' ⊠	16.70	0.139	up. zone 9.25'@ 13.6 (incl 1.5' shale)		
		4	3.50' ⊠	15.56	0.109	29' intermed. shale		
		5	5.08' ⊠	22.85	0.121	21.07'	19.62'	0.167
		6	0.33' ⊠	24.15	0.135			
		7	3.42' ⊠	25.45	0.190	Lower Zone 23.8'@ 12.1 (incl. 10.5' shale)		
		8	0.66' ⊠	15.07	0.189			
		9	3.83' ⊠	17.51	0.312			
		10	0.16'	27.07	1.569			
16A	6	1	8.50' ⊠	17.34	0.163			
		2	6.42' ⊠	18.64	0.146			
		3	1.08' ⊠	13.62	0.132	30.08'	17.90	0.204
		4	5.50' ⊠	16.37	0.209			
		5	6.0' ⊠	20.10	0.331			
		6	2.58' ⊠	17.67	0.215			
17A	6	1	4.25'	11.20	0.042	3' overburden		
		2	3.92' ⊠	16.80	0.090	upper ore zone		
		3	1.42' ⊠	18.75	0.221			
		4	5.92' ⊠	19.88	0.232	19.10'	22.40	0.202
		5	4.42' ⊠	30.03	0.437	Lower zone 28'@ 13.0% Fe		
		6	3.42' ⊠	25.16	0.372	(incl 12' shale)		
18A	8	1	5.25'	10.47	0.118			
		2	4.42'	10.98	0.108			
		3	7.33'	8.55	0.136			
		4	13.58'	8.23	0.140	NONE		
		5	3.0'	15.98	0.118	MATERIAL CONSIDERED		
		6	5.83'	15.98	0.122	NOT USEABLE.		
		7	7.08'	15.01	0.128			
		8	7.25'	16.30	0.110			
19A	3	1	8.75' ⊠	21.78	0.850			
		2	3.08' ⊠	16.88	0.179	14.66'	22.20	0.226
		3	2.83' ⊠	32.95	0.386			
21A	9	1	2.58'	15.66	0.106			
		2	1.33'	15.17	0.114			
		3	14.83' ⊠	18.40	0.070			
		4	4.0' ⊠	14.85	0.072			
		5	3.0' ⊠	21.79	0.132			

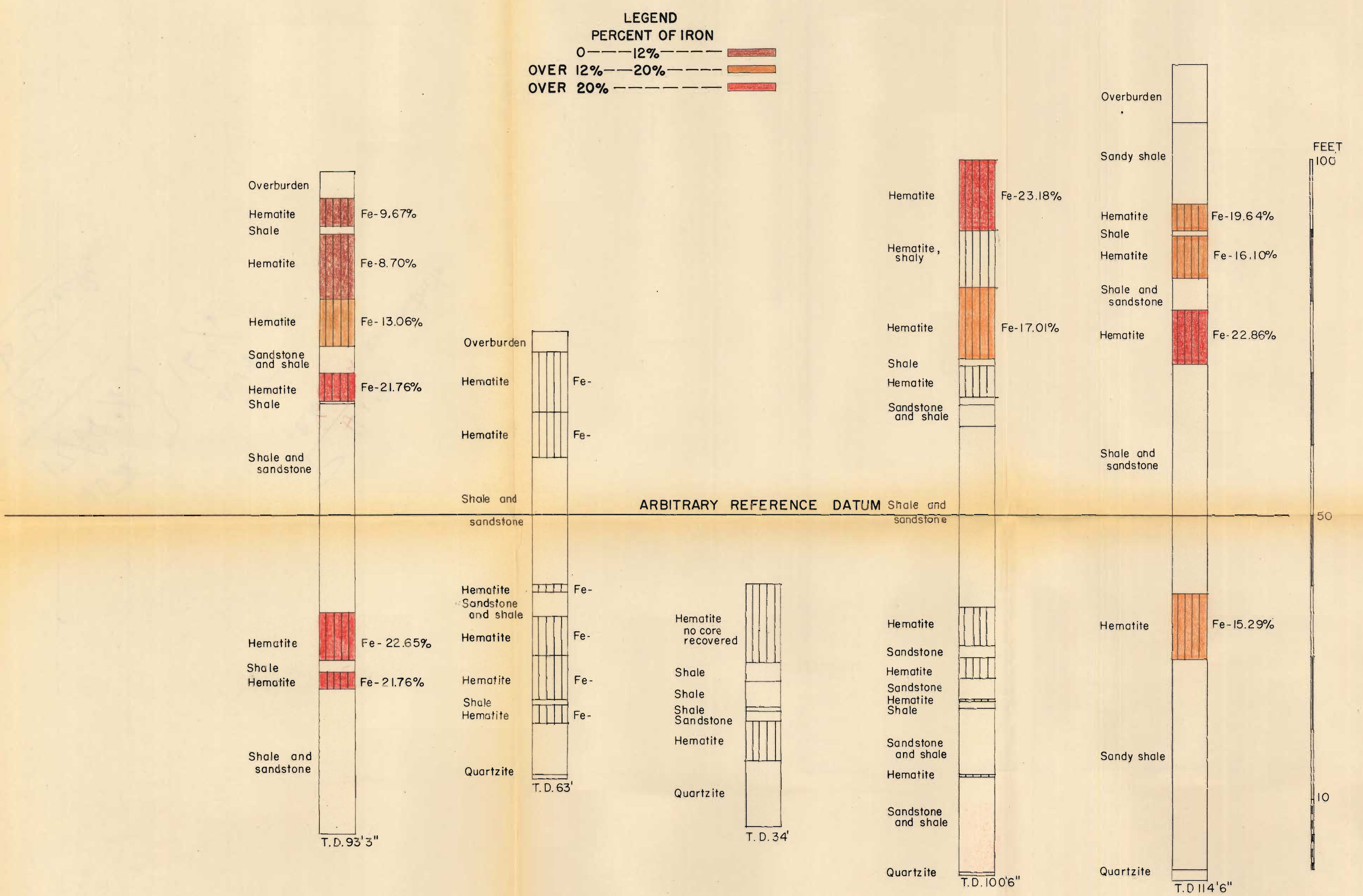
CHART SHOWING DEPTH OF DRILL HOLES & GENERALIZED THICKNESSES OF ORE ZONES

HOLE NO.	T2—1A	T2—2A	T4—3A	T7—4A	T1—7A	T1—8A	T3—9A	T5—10A	T6—12A	T5—13A	T5—14A	T6—15A	T4—16A	T6—17A	T2—18A	T2—19A	T4A—21A
TOTAL DEPTH	168'—6"	181'—11"	93'—3"	34'	100'—6"	114'—6"	95'	59'	155'—5"	107'	196'—7"	95'—6"	63'	78'	102'	65'	81'
OVERBURDEN	Drilled 46' Keefer ss.& sh.	9'	Low Grade 4' Ore	Ore 11' No Core	Ore 10' No Core	8'—6"	7'	5'—6"	Low Grade 4' Ore	5'	22'—6"	Low Grade 4' Ore	3'	3'	4'	2'	4'—7"
DISTANCE, SURFACE TO FIRST ORE ZONE	46'—2"	9'	4'	* 19'	10'	19' *	25'	5'—6"	4'	5'	Keefer 97' * ss.& sh.	4'	3'	3'	4'	2'	4'—7"
THICKNESS, FIRST ORE ZONE	* 31'	* 38'	* 29'	* 6'	24' *	23' ■	13'	32' *	12'	27' ■	30' ■	29' *	15'	10' ■	37' ■	18' ■	24' ■
THICKNESS, SHALE BREAK	30'	28'	29'	9' * hit qtzite	29'	32'	39'	21'—6"	34'	48' *	27'	31'	21	36'	33'	* —	25'
THICKNESS, SECOND ORE ZONE	32'	31' ■	15' ■	—	13' ■	10'	18'	—	* 28'	* 20'	21' □	32' ■	16' ■	27' *	21' *	* —	24' *
DISTANCE DRILLED BEYOND THE SECOND ORE ZONE	29'—6"	75'—11"	16'—3"	—	24'—6"	26'—6"	* —	—	77'—5"	7'	21'—7"	2'—6"	8'	3'	7'	45'	5'
REMARKS	* Includes 4' shale	* Includes 3' shale ■ Includes 15' shale	* Includes 5' shale ■ Includes 6' shale	* Hole loc. in poss. fault zone. 11'—19' shale	* Includes 6" shale ■ Includes 4' shale	* Clinton shale ■ Includes 4' shale	* Hole abandoned due to caving & water hauling difficulties	* Hole loc. in fault zone, heavy core loss	* Includes 13' shale	* Hole loc. in fault zone ■ Includes 6' shale	* Drilled 74' ss & shale. ■ Includes 5' shale □ Includes 9' shale	* Includes 7' shale & ss. ■ Includes 20' shale	■ Includes 4' shale	■ Includes 1' shale * Includes 12' shale	■ Includes 3' shale * Includes 2' shale	■ Includes 3' shale * Hole started in the lower zone	■ Includes 4' shale * Includes 4' shale

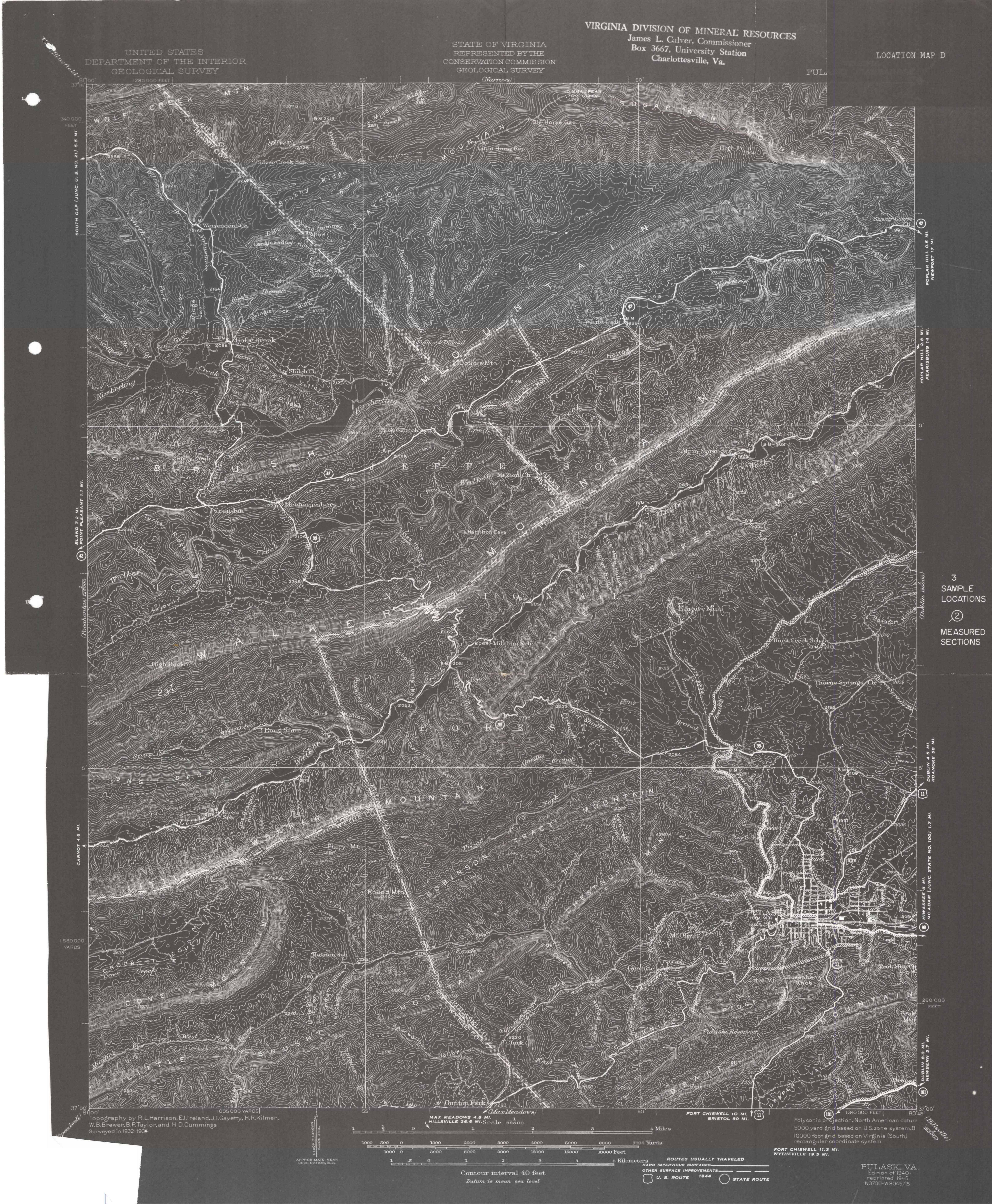
Minerals Development Corp.
Roanoke, Va.
Sept. 18, 1962

CORE LOGS OF CLINTON HEMATITE IN NO BUSINESS CREEK-MILL CREEK AREA

CORE LOGS OF CLINTON HEMATITE IN FLATTOP MOUNTAIN–SUGAR RUN MOUNTAIN AREA



GEOLOGIC CROSS SECTIONS SHOWING MEMBERS OF THE CLINTON (ROSE HILL) FORMATION IN BLM-A-050367, 05068, 052619, 051841, 050369, 051840, & 051911 PERMIT AREAS


VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver, Commissioner
Box 3667, University Station
Charlottesville, Va.
LOCATION MAP D
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF VIRGINIA
REPRESENTED BY THE
CONSERVATION COMMISSION
GEOLOGICAL SURVEY
3 SAMPLE LOCATIONS
2 MEASURED SECTIONS
WALKER MOUNTAIN
JEFFERSON NATIONAL FOREST
PULASKI
Topography by R.L.Harrison, E.I.Ireland, J.J.Gayetty, H.R.Kilmer, W.B.Brewer, B.P.Taylor, and H.D.Cummings
Surveyed in 1932-1934
Scale 1/62500
Contour interval 40 feet
Datum is mean sea level
Polyconic projection. North American datum
5000 yard grid based on U.S. zone system, B
10000 foot grid based on Virginia (South) rectangular coordinate system
ROUTES USUALLY TRAVELED
U. S. ROUTE
STATE ROUTE
PULASKI, VA.
Edition of 1940
reprinted 1945
N3700-W8045/15

LOCATION MAP C

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF VIRGINIA
REPRESENTED BY THE
CONSERVATION COMMISSION
GEOLOGICAL SURVEY

POCAHONTAS 7.5 MI.
BOISSEVAIN 4.4 MI.

GAULEY BRIDGE 93 MI.
PRINCETON 16 MI.

BURKES GARDEN QUADRANGLE

3 SAMPLE LOCATIONS

2 MEASURED SECTIONS

Topography by H.B. Smith, S.L. Parker, R.F. Hamke, and C.W. Buckey
Culture and drainage in part compiled from aerial photographs
Surveyed in 1935-36

BROADFORD 22 MI. (Wytheville)
GREENDALE (JUNC. U. S. NO. 19) 48 MI.

Scale $\frac{1}{62500}$

Contour interval 50 feet
Datum is mean sea level

APPROXIMATE MEAN DECLINATION, 1936

Polyconic projection. 1927 North American datum
5000 yard grid based on U.S. zone system, B
10000 foot grid based on Virginia (South) rectangular coordinate system

ROUTES USUALLY TRAVELED
HARD IMPERVIOUS SURFACES
OTHER SURFACE IMPROVEMENTS
U. S. ROUTE 1944 STATE ROUTE

BURKES GARDEN, VA.
Edition of 1941
reprinted 1944
N3700-W8115/15

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOCATION MAP B

3
SAMPLE LOCATIONS
②
MEASURED SECTIONS

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1947. Field check 1956

Polyconic projection. 1927 North American datum
10,000-foot grids based on Virginia coordinate system, south zone, and West Virginia coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue

Red tint indicates area in which only landmark buildings are shown

Unchecked elevations are shown in brown

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1956

SCALE 1:62500

CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

VIRGINIA
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route

BLAND, VA.—W. VA.
N3700—W8100/15

1956

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

VIRGINIA DIVISION OF MINERAL
James L. Calver, Commission
Box 3667, University Statio
Charlottesville, Va.

LOCATION MAP A

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF WEST VIRGINIA
REPRESENTED BY THE
GEOLOGICAL AND ECONOMIC SURVEY

STATE OF VIRGINIA
REPRESENTED BY THE
CONSERVATION COMMISSION
GEOLOGICAL SURVEY

VIRGINIA
PEARISBU

3
SAMPLE
LOCATIONS

②
MEASURED
SECTIONS

Topography by E.I.Ireland and W.K.McKinley
Surveyed in 1921 and 1931-1932

POPLAR HILL (JUNC. VA. 42) 4.5 MI.
DUBLIN (JUNC. U.S. 11) 15 MI.

ROAD CLASSIFICATION

Heavy-duty — Light-duty
Medium-duty — Unimproved dirt
U.S. Route — State Route

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1932

SCALE 1:62500

1 0 1 2 3 4 MILES

3000 0 3000 6000 9000 12000 15000 18000 21000 FEET

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL

Polyconic projection. 1927 North American datum
10,000-foot grids based on Virginia (South) and
West Virginia (South) rectangular coordinate system
1000-meter Universal Transverse Mercator grid ticks,
zone 17, shown in blue

PEARISBURG, VA.—W. VA.
N3715—W8030/15

1932

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver, Commissioner
Box 3667, University Station
Charlottesville, Va.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOCATION MAP I

EAGLE R

(Rockbridge 1:125000)

67 SAMPLE LOCATIONS

13 MEASURED SECTIONS

(Edge adjusted to Roanoke)

R.B. Marshall, Chief Geographer.
Frank Sutton, Geographer in charge.
Topography by Albert Pike and T.F. Slaughter.
Control by Oscar Jones, R.S. Deemer, T.A. Green,
H.S. Senseney, and N.A. Campbell.
Surveyed in 1908 and 1913.

Slaughter
Pike

Scale 1/62500

1 Mile ... 4 Miles
1000 Yards ... 7000 Yards
1000 Feet ... 18000 Feet
1 Kilometer ... 5 Kilometers

Contour interval 50 feet
Datum is mean sea level

APPROXIMATE MEAN DECLINATION 1913.

Edition of 1915, reprinted 1945
Polyconic projection. North American datum.

EAGLE ROCK, VA.
N3730-W7945/15

LEWISBURG 17 MI.
WHITE SULPHUR SPRINGS 7.2 MI.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF VIRGINIA
CONSERVATION COMMITTEE
WM. A. WRIGHT, CHAIRMAN
VIRGINIA GEOLOGICAL SURVEY
ARTHUR BEVAN, STATE GEOLOGIST

COVINGTON 12 MI.
CALLAGHAN 6.6 MI.

NEWCASTLE

LOCATION MAP H

70
SAMPLE
LOCATIONS

21
MEASURED
SECTIONS

Mapped by the Geological Survey
1945

CRAIG HEALING SPRINGS 4.3 MI.

LOONEY 4 MI.
NEWPORT 30 MI.

CATAWBA 11.5 MI.
SALEM 23 MI.

Scale 1:62500

Contour interval 40 feet
Datum is mean sea level

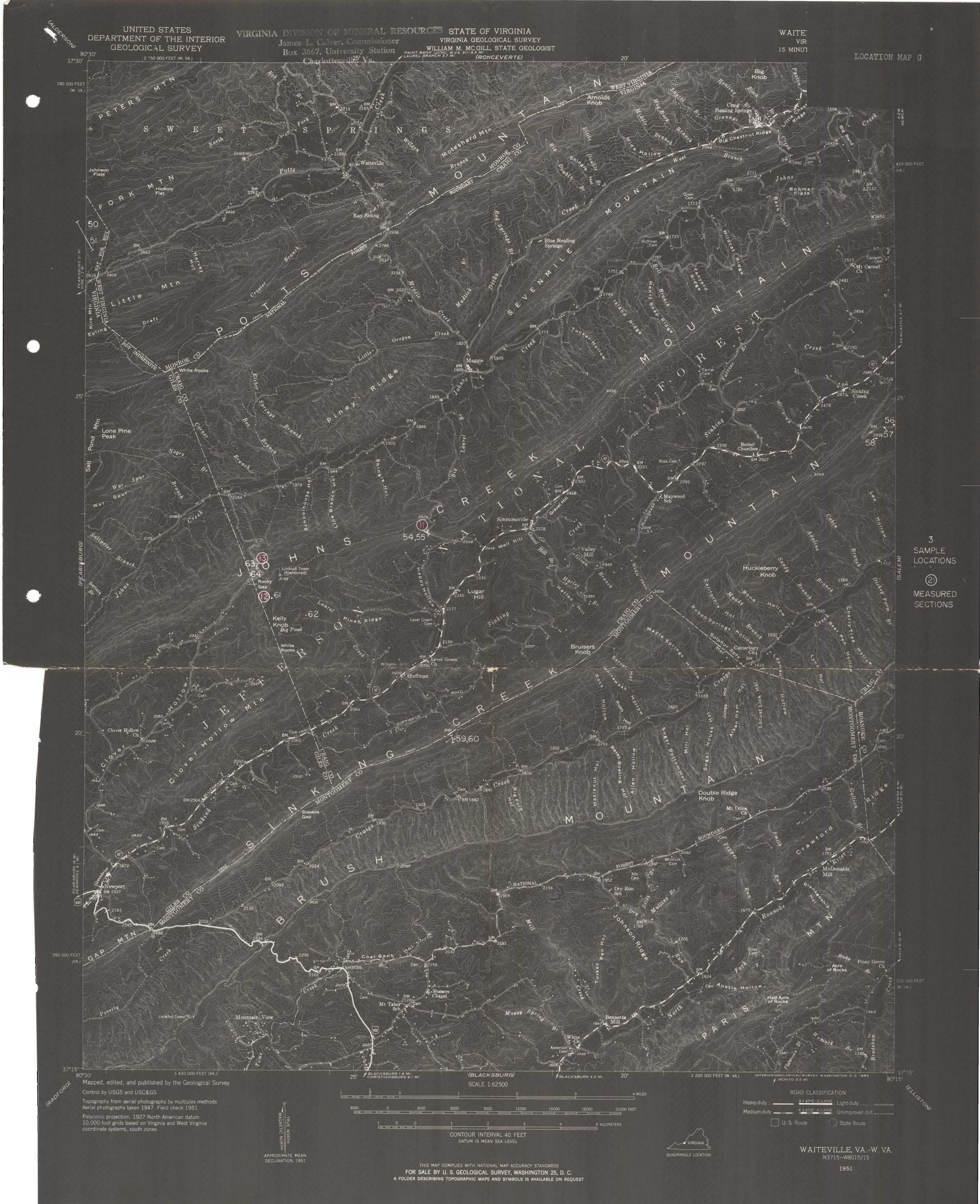
ROAD CLASSIFICATION
1947

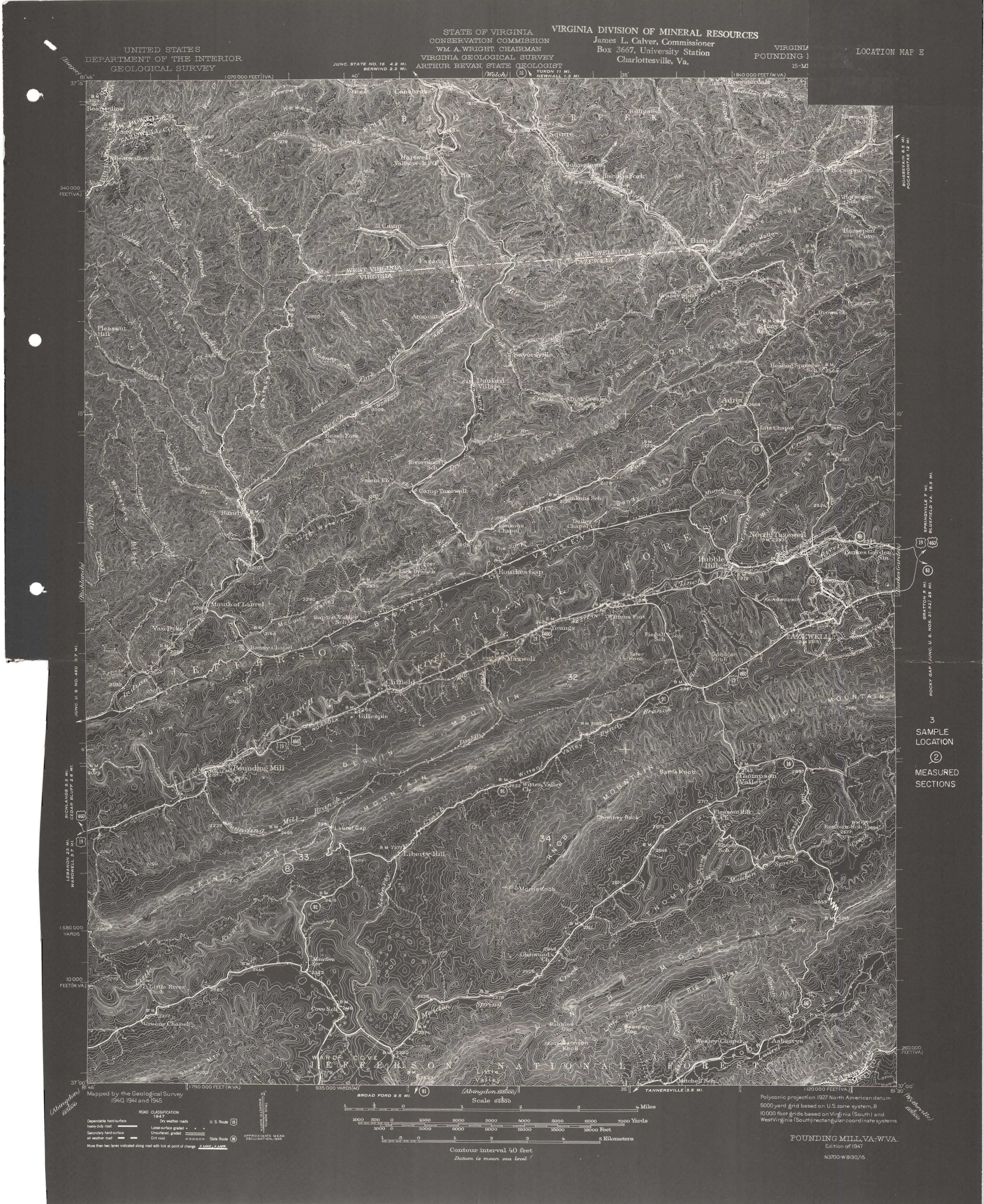
APPROXIMATE MEAN
DECLINATION, 1945

Polyconic projection. 1927 North American datum
10000 foot grids based on Virginia (South) and
West Virginia (South) rectangular coordinate systems

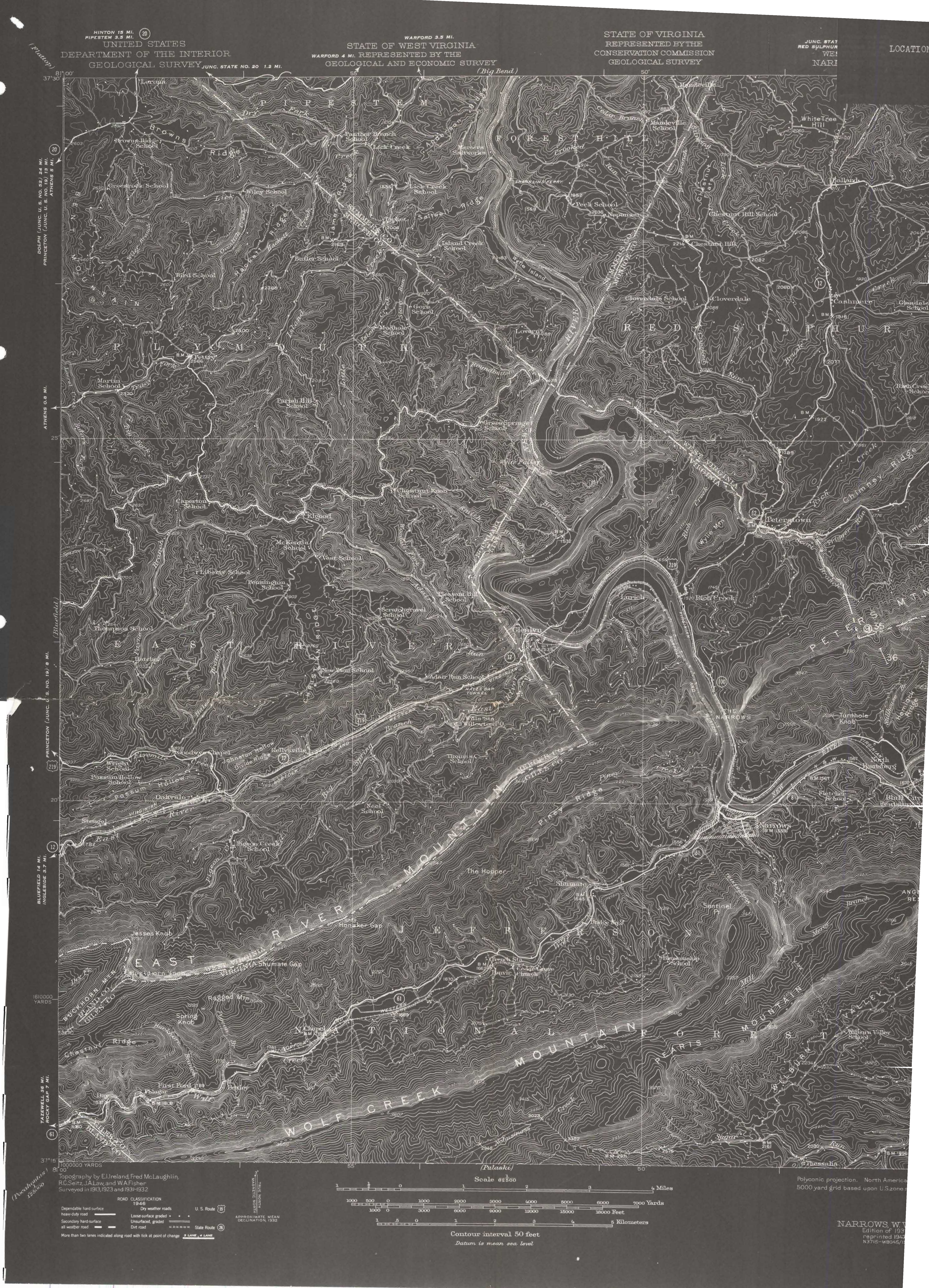
NEWCASTLE, VA.-W. VA.
Edition of 1947

N3730—W8000/15


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver, Commissioner
Box 3667, University Station
Charlottesville, Va.
STATE OF VIRGINIA
VIRGINIA GEOLOGICAL SURVEY
WILLIAM M. MC GILL, STATE GEOLOGIST
LOCATION MAP G
(ALDERSON)
(RONCEVERTE)
(PEARISBURG)
(SALEM)
(RADFORD)
(BLACKSBURG)
(ELLISTON)
PETERS MTN
SWEET SPRINGS
FORK MTN
POTTS MOUNTAIN
SEVENMILE MOUNTAIN
Waiteville
Ray Siding
Arnolds Knob
Big Knob
Craig Healing Springs
Blue Healing Springs
Maggie
Piney Ridge
Lone Pine Peak
White Rocks
JOHNS CREEK
NATIONAL FOREST
MOUNTAIN
Simmonsville
Valley Mill
Lugar Hill
Rocky Gap
Kelly Knob
Big Pond
Huckleberry Knob
Bruisers Knob
Sinking Creek
Bethel Churches
Level Green
Huffman
JEFFERSON
Clover Hollow
SINKING CREEK MOUNTAIN
BRUSH MOUNTAIN
Double Ridge Knob
Stevers Gap
Newport
GAP MTN
Mountain View
Mt Tabor
Bennetts Mill
McDonalds Mill
PARIS MTN
Acre of Rocks
Half Acre of Rocks
Piney Grove Ch
CRAIG CO
GILES CO
MONROE CO
MONTGOMERY CO
ROANOKE CO
WEST VIRGINIA
VIRGINIA
3
SAMPLE LOCATIONS
2
MEASURED SECTIONS
11
54,55
13
63
64
12
61
62
59,60
50
51
56
57
58
Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
Topography from aerial photographs by multiplex methods
Aerial photographs taken 1947. Field check 1951
Polyconic projection. 1927 North American datum
10,000-foot grids based on Virginia and West Virginia coordinate systems, south zones
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 1951
SCALE 1:62500
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL
ROAD CLASSIFICATION
Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
U. S. Route
State Route
QUADRANGLE LOCATION
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
WAITEVILLE, VA.-W. VA.
N3715—W8015/15
1951



VIRGINIA DIVISION OF MINERAL RESOURCES
James L. Calver, Commissioner
Box 3667, University Station
Charlottesville, Va.
STATE OF VIRGINIA
CONSERVATION COMMISSION
WM. A. WRIGHT, CHAIRMAN
VIRGINIA GEOLOGICAL SURVEY
ARTHUR BEVAN, STATE GEOLOGIST
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
LOCATION MAP E
3
SAMPLE
LOCATION
2
MEASURED
SECTIONS
JEFFERSON NATIONAL FOREST
Mapped by the Geological Survey
1940, 1941 and 1945
Scale 1/62500
Contour interval 40 feet
Datum is mean sea level
Polyconic projection. 1927 North American datum
5000 yard grid based on U.S. zone system, B
10000 foot grids based on Virginia (South) and West Virginia (South) rectangular coordinate systems
POUNDING MILL, VA.-W.VA.
Edition of 1947
N3700-W8130/15


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
STATE OF WEST VIRGINIA
REPRESENTED BY THE
GEOLOGICAL AND ECONOMIC SURVEY
STATE OF VIRGINIA
REPRESENTED BY THE
CONSERVATION COMMISSION
GEOLOGICAL SURVEY
HINTON 15 MI.
PIPESTEM 3.5 MI.
WARFORD 3.5 MI.
WARFORD 4 MI.
JUNC. STATE NO. 20 1.2 MI.
LOCATION
PIPESTEM
FOREST HILL
PLYMOUTH
RED SULPHUR
EAST RIVER
JEFFERSON
EAST RIVER MOUNTAIN
WOLF CREEK MOUNTAIN
NATIONAL FOREST
PETERS MT
Peterstown
Glenlyn
Narrows
Rich Creek
Topography by E.I.Ireland, Fred McLaughlin, R.C.Seitz, J.A.Law, and W.A.Fisher
Surveyed in 1913, 1923 and 1931-1932
ROAD CLASSIFICATION 1946
Scale 62500
Contour interval 50 feet
Datum is mean sea level
APPROXIMATE MEAN DECLINATION, 1932
Polyconic projection. North American
5000 yard grid based upon U.S. zone
NARROWS, W.V.
Edition of 193
reprinted 1947

RECONNAISSANCE GEOLOGY OF THE CHESTNUT RIDGE AREA, TAZEWELL COUNTY, VA.

MINERALS DEVELOPMENT CORP. ROANOKE, VA. AUGUST 1963

EXPLANATION

Ds	Devonian shales
Dh	Huntersville chert
Drg	Rocky Gap sandstone
Stk	Tonoloway limestone and "Keefer" sandstone
Srh	Rose Hill formation
St	Tuscarora sandstone
Oj	Juniata sandstone

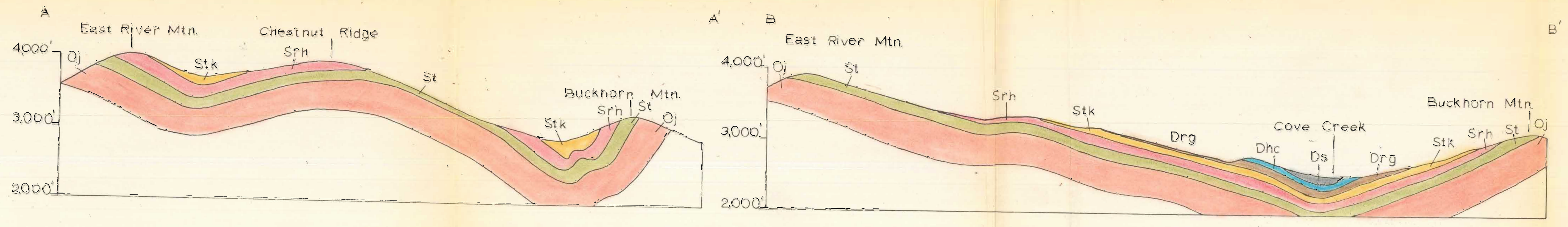
27 Strike and dip of beds

Strike of vertical beds

Horizontal beds

Geologic Section No. 1 Measured sections

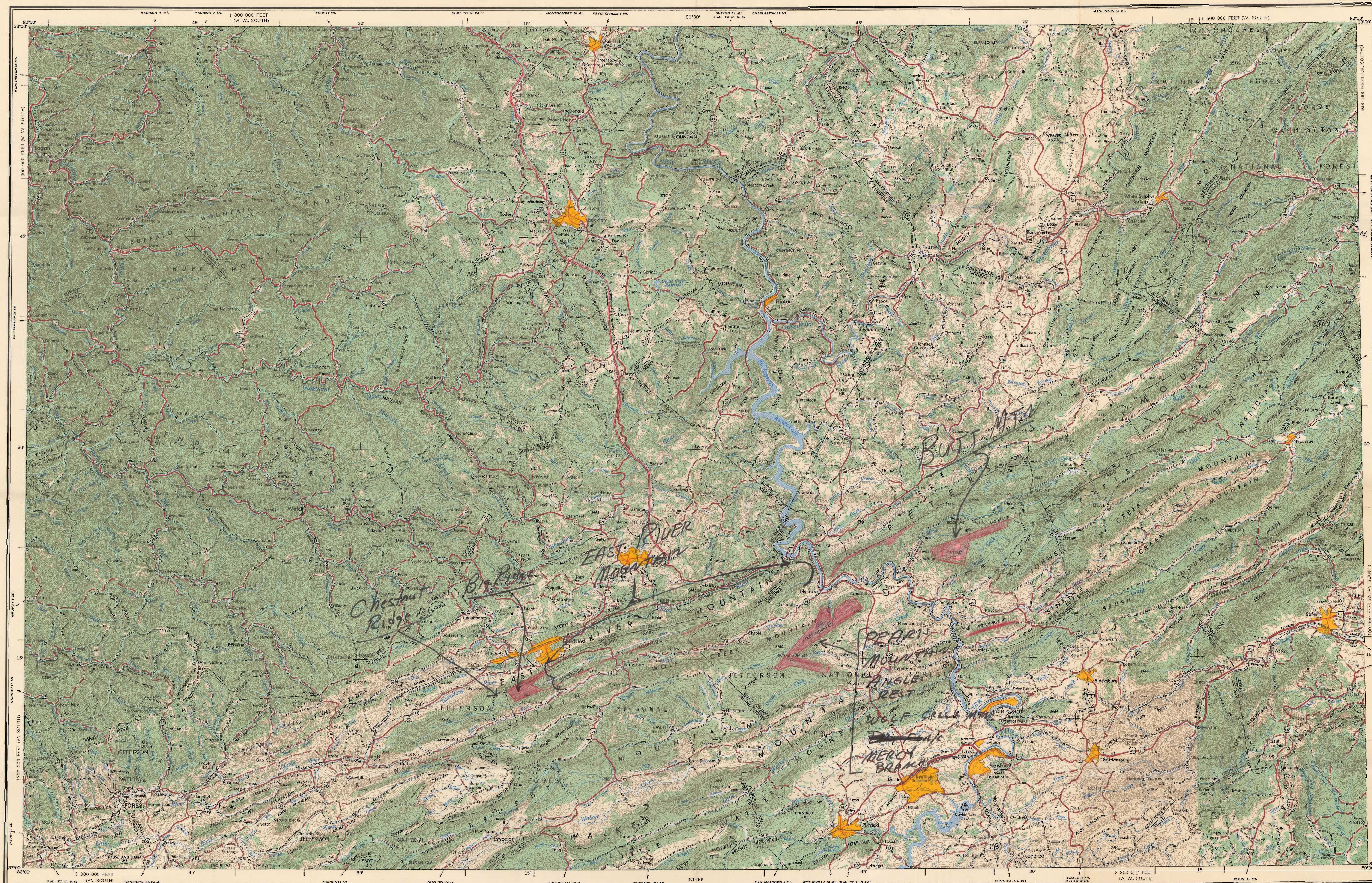
A —— A' Structure sections



EASTERN UNITED STATES 1:250,000

BLUEFIELD

REFER TO THIS MAP AS: NJ 17-8
AMS SERIES V501



AMS V501

Prepared by the Army Map Service (AM), Corps of Engineers, U. S. Army, Washington, D. C. Compiled in 1951 from: United States Quadrangles, 1:24,000, 1:48,000, 1:62,500, and 1:125,000, U. S. Geological Survey, 1909-51; County Highway Maps, 1937-52. Planimetric detail partially revised by photoplanimetric methods. Control by USC&GS and CE.

LEGEND
ROAD DATA 1952

POPULATED PLACES
Over 500,000 — BOSTON
100,000 to 500,000 — RICHMOND
25,000 to 100,000 — ALEXANDRIA
5,000 to 25,000 — Marion
1,000 to 5,000 — Old Dominion
Less than 1,000 — Stowell

Hard surface, heavy duty road, more than two lanes wide — 3 LANES | 4 LANES
Hard surface, heavy duty road, two lanes wide
Hard surface, medium duty road, more than two lanes wide — 3 LANES | 4 LANES
Hard surface, medium duty road, two lanes wide
Loose surface, graded and drained road
Dirt road; Trail
Route markers: Federal; State — 153 259

RAILROADS — Single track — Multiple track
Normal gauge
Narrow gauge
International boundary
State boundary
County boundary
Park and reservation

Landplane airport
Landing area
Seaplane airport
Seaplane anchorage
Woods-brushwood

Spot elevation in feet — 121
Depth curves in fathoms
Swamp, marsh
Reef; Limit of danger line
Intermittent stream
Rocks: Awash; Sunken
Foreshore flats

Scale 1:250,000

5 0 5 10 15 20 Statute Miles
5 0 5 10 15 20 25 30 Kilometers
5 0 5 10 Nautical Miles

CONTOUR INTERVAL 100 FEET

TRANSVERSE MERCATOR PROJECTION

100,000 FOOT GRIDS BASED ON VIRGINIA COORDINATE SYSTEM, SOUTH ZONE, AND WEST VIRGINIA COORDINATE SYSTEM, SOUTH ZONE

1952 MAGNETIC DECLINATION FOR THIS SHEET VARIES FROM 2°00' WESTERLY FOR THE CENTER OF THE WEST EDGE TO 3°15' WESTERLY FOR THE CENTER OF THE EAST EDGE. MEAN ANNUAL CHANGE IS 0°01' EASTERLY.

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.

LOCATION DIAGRAM FOR NJ 17-8

RELIABILITY DIAGRAM

Good — Fair — Photography

Areas for which vegetation information is available

A. Large scale topographic maps, photogrammetric, 1945-51.
B. Large scale topographic maps, controlled ground survey, 1909-35.
Planimetry revised from 1935-47 aerial photography.

PRINTED BY ARMY MAP SERVICE, CORPS OF ENGINEERS, 6-55 91261

LOCATION MAP

1

BLUEFIELD, W. VA., VA., KY.

S-6

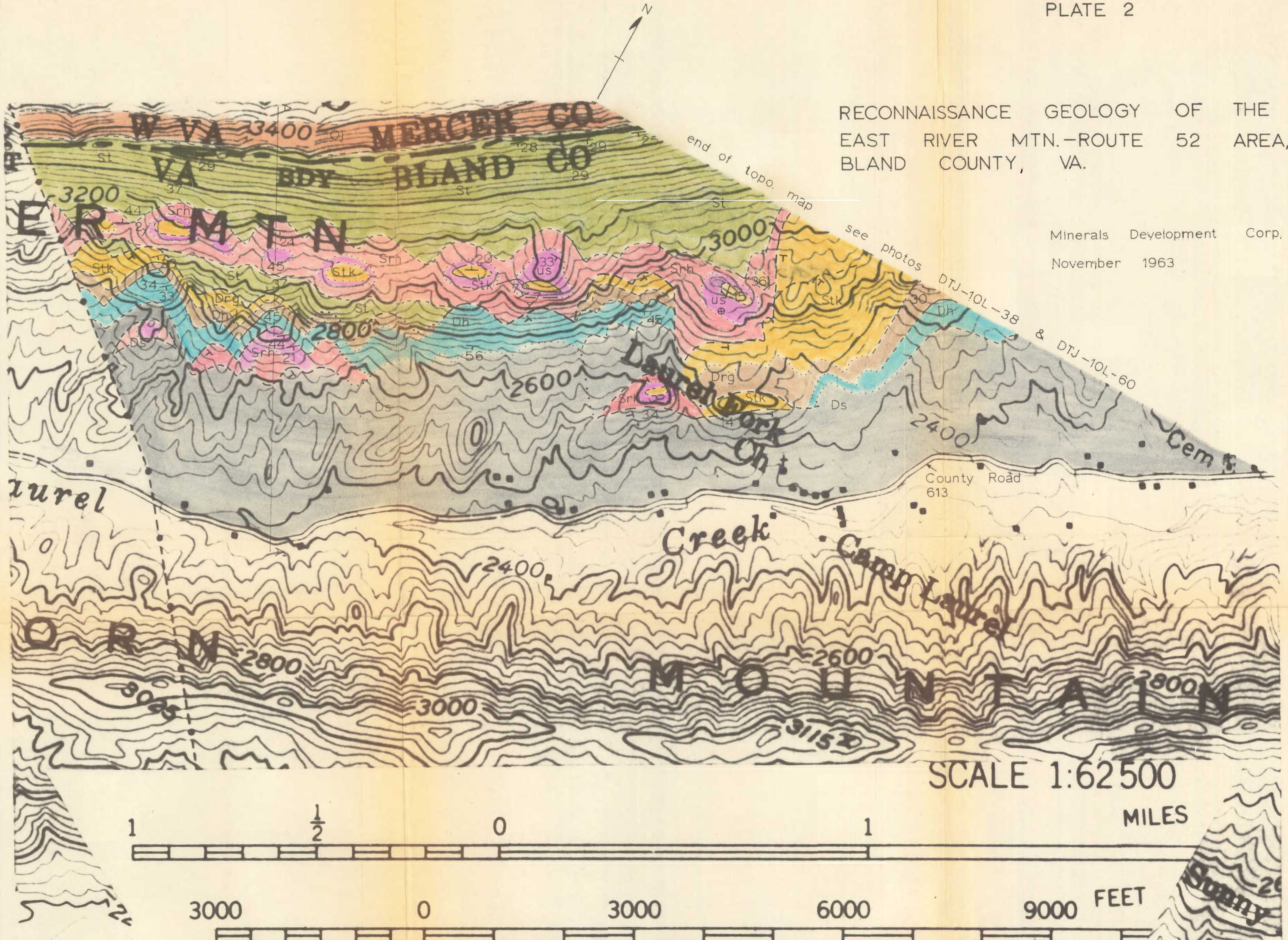
PLATE 2

RECONNAISSANCE GEOLOGY OF THE EAST RIVER MTN.-ROUTE 52 AREA, BLAND COUNTY, VA.

Minerals Development Corp.

November 1963

for adjacent area see Big Ridge report & map



Srh

Rose Hill formation

us

upper ferruginous sandstone

for other symbols see Big Ridge map

PLATE 2

RECONNAISSANCE GEOLOGY OF THE EAST RIVER MTN.-ROUTE 52 AREA, BLAND COUNTY, VA.

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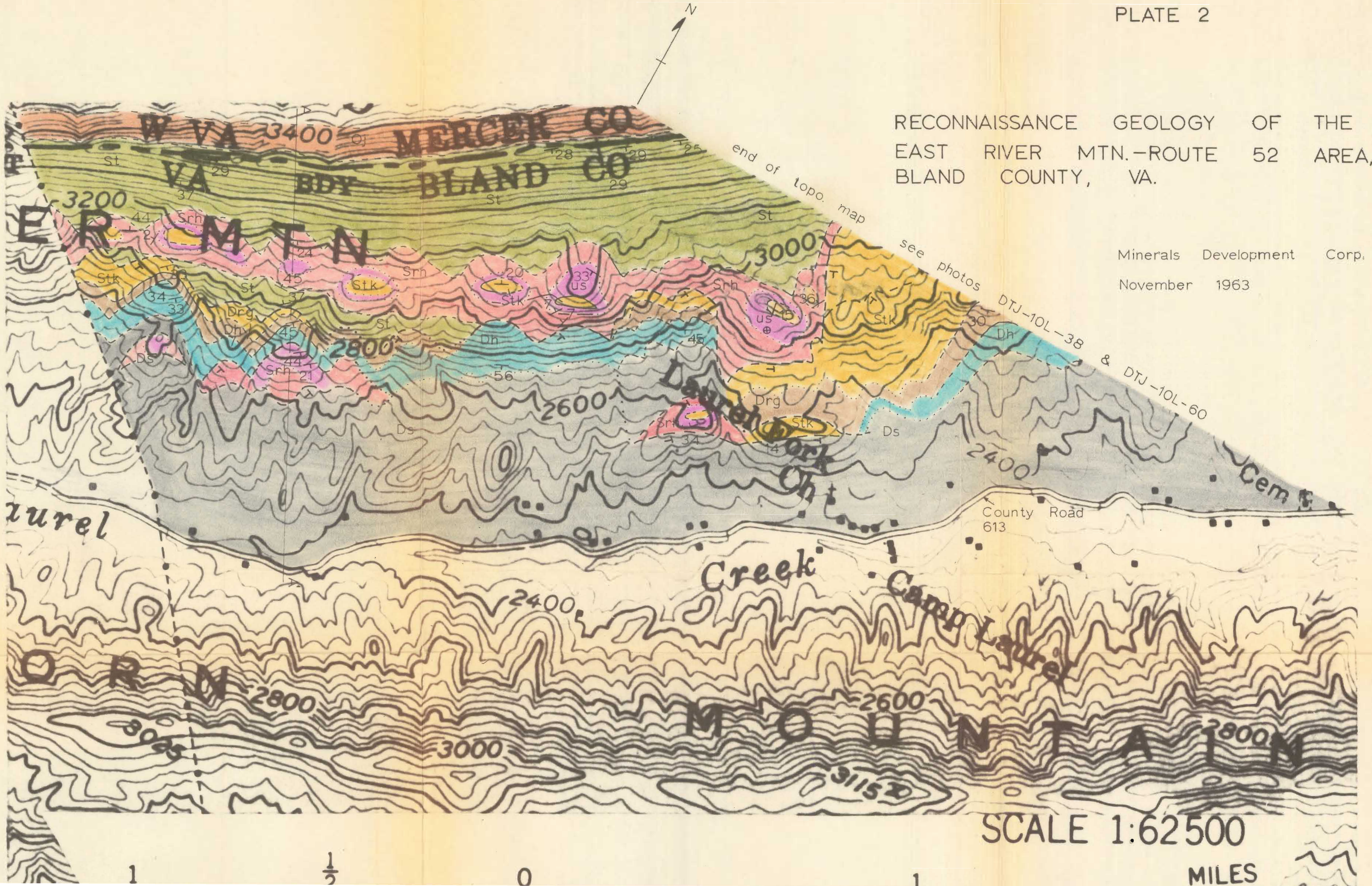
November 1963

for adjacent area see Big Ridge report & map



Srh — Rose Hill formation

us — upper ferruginous sandstone

for other symbols see Big Ridge map

PLATE 2

RECONNAISSANCE GEOLOGY OF THE
EAST RIVER MTN.-ROUTE 52 AREA,
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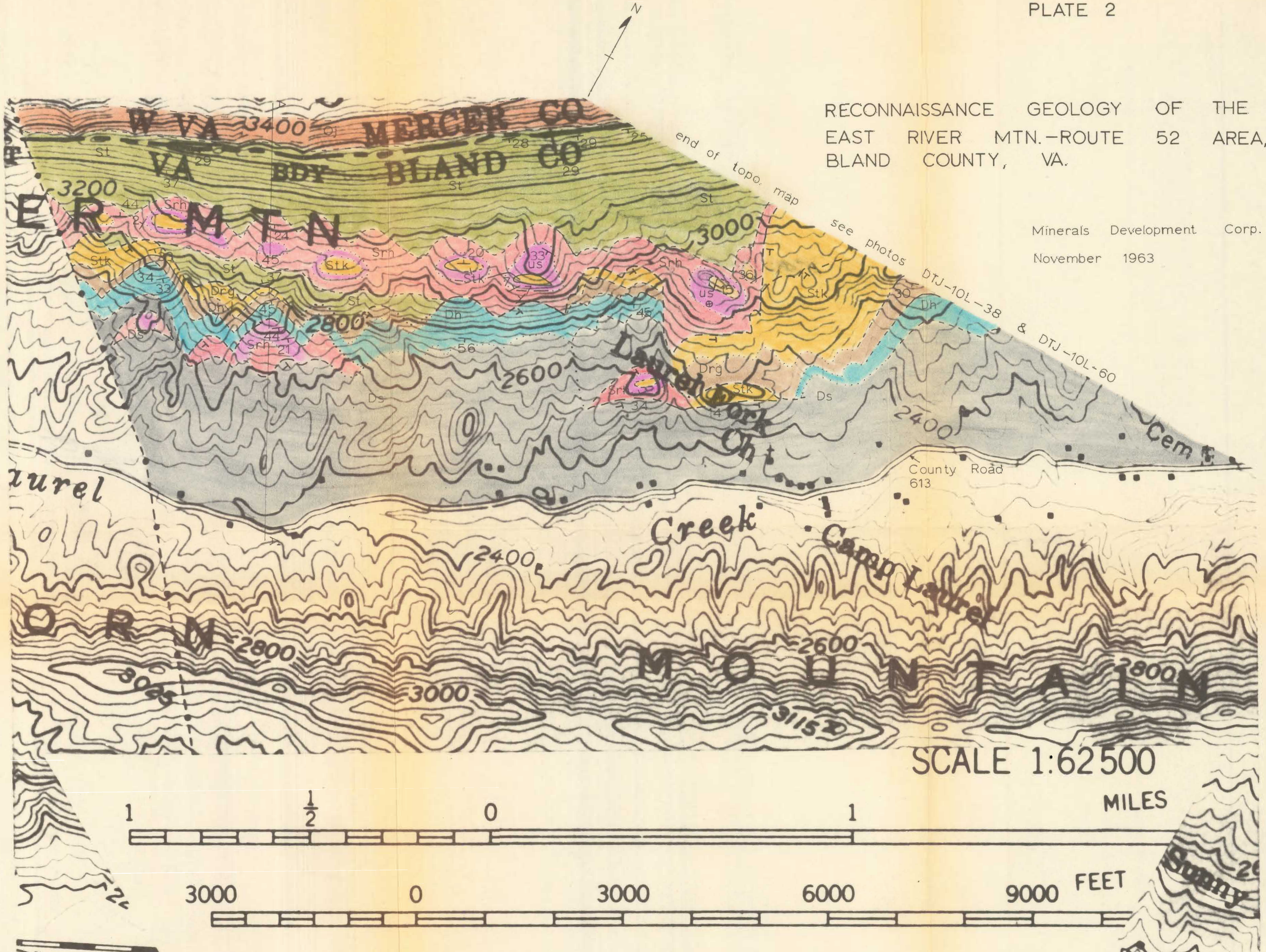
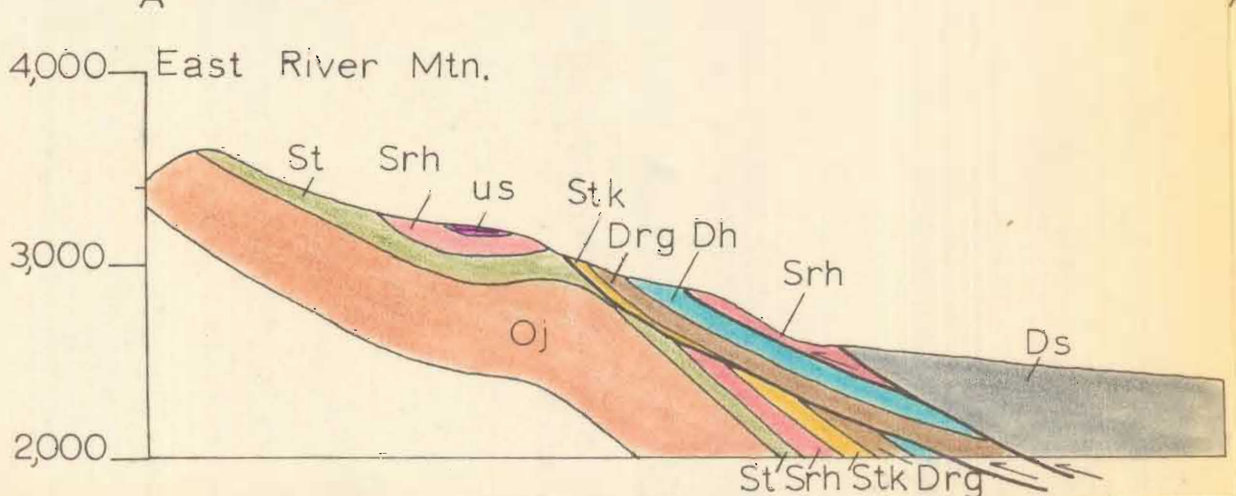


Srh Rose Hill formation

us upper ferruginous sandstone

for other symbols see Big Ridge map



W.A.M.

PLATE 1

RECONNAISSANCE GEOLOGY OF THE BIG RIDGE AREA, BLAND & TAZEWELL COUNTIES, VIRGINIA