UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary
GEOLOGICAL SURVEY
W. E. Wrather, Director

Bulletin 940-B

MANGANESE DEPOSITS OF THE ELKTON AREA, VIRGINIA

BY
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Strategic Minerals Investigations, 1943
(Pages 15-55)

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1943

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.
Price 75 cents

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MANGANESE DEPOSITS OF THE ELKTON AREA, VIRGINIA

By Philip B. King

ABSTRACT

The Elkton area extends along the western base of the Blue Ridge and the eastern edge of the Shenandoah Valley in Virginia. Its indurated rocks range in age from pre-Cambrian to Ordovician and are strongly folded. In the Shenandoah Valley, they are overlain by fanglomerates, terrace gravels, and alluvium of Cenozoic age.

Manganese and iron deposits occur in residual clays derived from the decay of the Tomstown dolomite and Waynesboro formation (shale and limestone), of Cambrian age. The manganese-bearing formations have in part a northwest-dipping monoclinal structure, and in part are folded into pitching anticlines and synclines.

Iron and some manganese were extensively mined in the area between 1880 and 1910, and several mines were operated for manganese during the first World War. The total production of manganese ore during these two periods was about 20,000 tons. The district was inactive in 1941. No estimate of the reserves of manganese ore in the district can be made. The amount of ore in sight at present is small, and if any large bodies exist in the area they have not yet been discovered.

INTRODUCTION

Location.--The Elkton area lies in eastern Rockingham and southern Page Counties, Virginia, and includes the western edge of the Blue Ridge and the eastern edge of the Shenandoah Valley (fig. 2). The maximum relief, from the lowest point on the floor of the valley to the highest point in the foothills of the Blue Ridge, is about 2,000 feet. Three towns, Elkton, Shenandoah, and Stanley, lie within the area, and there are many smaller villages and settlements. The area is traversed by the Norfolk & Western Railroad and by several main highways. Secondary roads extend into all parts of the area.

Manganese and iron have been mined in the Elkton area from time to time since the 1880's. One period of great activity was from about 1880 to 1905, when large quantities of iron ore, and some manganiferous iron ore, were produced, mostly from mines near Shenandoah but partly from mines near Elkton and elsewhere. During the first World War, also, much manganese was produced from mines near Elkton and Stanley and much prospecting was

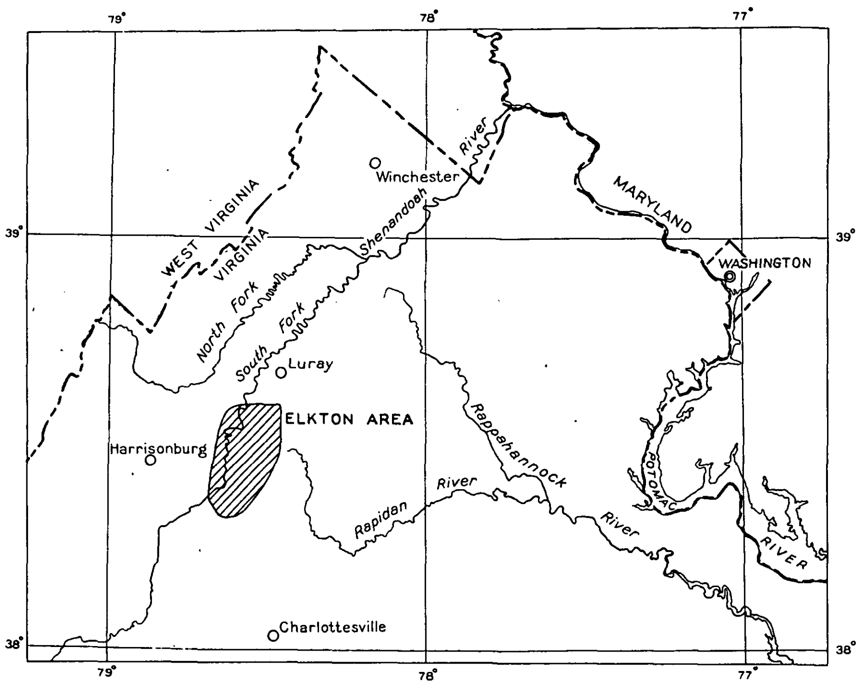

Figure 2.—Index map of Virginia, showing location of the Elkton area.

carried on. From the World War to 1941 the district has been largely inactive, although some prospecting has been done and some of the mines have been operated for short periods.

Field work.--This report is based on six months of field work in the autumn of 1940 and the spring of 1941, during which the writer was assisted by John Rodgers. A belt along the west edge of the Blue Ridge, approximately 18 miles long and 2 to 6 miles wide, was mapped in detail, and adjoining areas were reconnoitered. Observations were plotted on topographic maps of the Geological Survey on a scale of 1:24,000. Considerable use was made of airplane photographs supplied by the Soil Conservation Service.

Acknowledgments.--The field work was supervised by D. F. Hewett, G. W. Stose, and H. D. Miser, who contributed a background of experience which they had acquired in studying the manganese deposits of the area during the first World War.[1] Dr. Arthur Bevan, State Geologist of Virginia, allowed the writer to study the manuscript geological map of the Stony Man quadrangle made by A. S. Furcron and H. P. Woodward, of the Virginia Geological Survey. The staff of the Bureau of Mines, United States Department of the Interior, cooperated fully during the writer's study of their prospecting operations on tracts in the Elkton area.

Much information regarding manganese deposits was contributed by many persons, especially R. F. Watson, Paul Tyler, and the McCarrick brothers.

STRATIGRAPHY

The rocks of the Elkton area include indurated rocks of pre-Cambrian, Cambrian, and Ordovician age, and unconsolidated deposits of Cenozoic age. The indurated rocks, which have an aggregate thickness of about 15,000 feet, have been greatly deformed. The oldest rocks occur in the Blue Ridge at the southeast, and successively younger rocks appear in the Shenandoah Valley to the northwest (pl. 4). The stratigraphic succession in the Elkton area is indicated in the table on the following page.

Formations associated with manganese deposits

The manganese deposits of the Elkton area occur in residual clays derived by weathering from dolomite, limestone, and shale

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[1] Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., Manganese deposits of the west foot of the Blue Ridge, Virginia: Virginia Geol. Survey Bull. 17, 1919.

Table 1.--Geological formations of the Elkton area

Age	Name	Character	Thickness in feet
Quaternary	Alluvium.........	Gravel, sand, and clay........	0-100
	Younger terrace deposits.	Gravels, composed of pebbles and boulders, mainly of quartzite, laid down on two or more surfaces.	0-100
Tertiary or Quaternary	Older terrace deposits and associated fanglomerate.	Gravels, resembling younger deposits, laid down on surface of valley-floor peneplain. Terrace deposits grade into coarse fanglomerates along foot of Blue Ridge.	0-250
	Ancient gravel deposits.	Sand and gravel, unconformable below older terrace deposits. Present only in small areas and not mapped.	0-50
Cambrian and Ordovician	Beekmantown dolomite, Conococheague limestone, and Elbrook dolomite.	Limestones and dolomites not separately mapped.	8,000
Cambrian	Waynesboro formation (Watauga shale of Virginia Geol. Survey Bull. 17).	Shale, calcareous shale, and interbedded limestone.	2,500
	Tomstown dolomite (Shady dolomite of Bull. 17).	Dolomite, rarely exposed; generally represented at surface by residual clay.	1,000
	Antietam quartzite (Erwin quartzite of Bull. 17).	Upper member of brown sandstone with some quartzite beds.	400
		Lower member of massive, white, vitreous quartzite.	400
	Harpers and Weverton formations.	Shale, sandstone, and quartzite; some conglomerate. Not separately mapped.	1,900-2,500
Pre-Cambrian	Injection complex, Catoctin metabasalt and associated sedimentary rocks and volcanic slate.	Not separately mapped.........	....

of the Tomstown and Waynesboro formations (Lower Cambrian), which crop out along the southeastern edge of the Shenandoah Valley, at the foot of the Blue Ridge. The underlying formation, the Antietam quartzite, is well exposed, and in many places gives the chief indication of the structure of the manganese-bearing beds.

Antietam quartzite.--The Antietam quartzite crops out on the crests and western slopes of the outer foothills of the Blue Ridge. On the map (pl. 4) it has been divided into two members, each about 400 feet thick. The lower member is composed of ledge- or cliff-making beds, up to 100 feet thick, of white, vitreous quartzite. The lower parts of the ledges are commonly cross-bedded, and their upper parts are crowded with Scolithus or worm tubes, suggesting that each ledge-maker represents a separate cycle of deposition. In the northern part of the area the member contains three main ledge-making beds, and in the southern part it contains two. The strata between the ledge-making beds consist of thinner-bedded sandstones.

The upper member contains some quartzite beds crowded with Scolithus tubes, which are like those in the lower member, but it consists mainly of buff or brown sandstone, much of it soft and friable, in beds a few inches to several feet thick. It is less well exposed than the lower member; for the most part it forms rounded slopes covered by blocky sandstone float and almost unbroken by ledges.

Tomstown dolomite.--In the Elkton area the Tomstown dolomite is thickly covered with fanglomerates of the same age as the older terrace deposits. The beds next beneath the fanglomerates are generally altered to residual clay, which is described in more detail on pages 24-25. Natural outcrops of the dolomite occur at only one place, in the valley of Fultz Run (pl. 4).

Unweathered dolomite has been encountered, however, in Bureau of Mines test hole No. 2, on the Watson tract (pl. 6 and sec. A-A', pl. 8), and in Bureau of Mines test holes Nos. 1, 2, and 3, on the tract south of Giants Grave (pl. 4).

Because of the poor exposures, no accurate idea of the thickness of the Tomstown dolomite in the Elkton area can be obtained. From its apparent width of outcrop and from sections in nearby areas, the formation is estimated to be about 1,000 feet thick.

In the valley of Fultz Run, the outcrops of Tomstown consist of buff-colored rotten dolomite, containing nodules of chalcedonic chert, and of gray, dolomitic limestone containing some algal reefs. These are overlain by shale of the Waynesboro formation. The dolomite in test hole No. 2 on the Watson tract includes gray, finely crystalline, hackly dolomite, with some interbedded calcareous shale, and dark gray saccharoidal dolomite. These rocks probably belong to a part of the formation lower than that exposed on Fultz Run. Calcareous shale is also interbedded with dolomite in test hole No. 1 south of Giants Grave. Analyses made in the chemical laboratory of the Geological Survey of specimens of unweathered dolomite from the Bureau of Mines test holes show that it contains 10 percent or more of insoluble minerals (clay, quartz, etc.). Every specimen also contains several hundredths of a percent of manganese, partly in the form of carbonate.

The rocks in the lowest hundred feet of the formation, in which most of the manganese deposits occur, have not been seen in unweathered condition either in outcrops or in drill holes, so that their original character is not known. Weathered sections, such as that in the Bureau of Mines incline on the Watson tract (pl. 7), include clays, silty clays, and sands (see pp. 24-25), which appear to represent a heterogeneous deposit, perhaps transitional between the sandy beds of the Antietam and the higher dolomitic part of the Tomstown.

Waynesboro formation.--The Waynesboro formation, like the Tomstown, is in general thickly covered with fanglomerates related to the older terrace deposits. Like the Tomstown, the formation is generally altered at the surface to residual clay, but natural outcrops of unweathered rock occur at a number of places, and unweathered rock has been encountered in many mine workings. The largest outcrops are in the valley of Fultz Run and the next valley to the west (pl. 4). In the latter, 2,400 feet of beds was measured below the Elbrook dolomite, but the total thickness is greater, for the base is concealed by terrace deposits.

The Waynesboro is dominantly shaly. The shales in the lower three-fourths are silty and siliceous, of brown, maroon-red, or greenish-gray color, mostly thin-bedded but in part massive, and interbedded with a few thin layers of sandstones. The shales in the upper fourth are generally calcareous and interbedded with limestone and dolomite. In the section in the valley west of Fultz Run, three main limestone and dolomite members are present, each 100 to 200 feet thick. The lowest of these, which appears to be lenticular, includes massive beds of dark gray, lumpy dolomite, with reticulated weathered surfaces.

Residual clays.--Residual clays have been formed on the surfaces of the limestones, dolomites, and shales of all the Cambrian and Ordovician formations in the Shenandoah Valley as a result of subaerial decay, during which the rocks were leached of their soluble constituents. These clays contain all the manganese and iron deposits of the area that are of commercial value, and the concentration of the manganese and iron oxides seems to have gone hand in hand with the process of clay formation.

The thickest blankets of clay are closely related to previous erosion surfaces, remnants of which form most of the upland areas in the present Shenandoah Valley. These surfaces lie at several altitudes and are of different ages. The highest and oldest surface, or valley-floor peneplain,[2] is now preserved mainly along the base of the Blue Ridge, in the outcropping belts of the Tomstown and Waynesboro formations (see sec. C-C', pl. 4). Lower and younger surfaces lie farther out in the valley, nearer the Shenandoah River, in the outcropping belts of the Elbrook and succeeding formations. Each surface is covered by a sheet of gravel and these sheets constitute the older and younger terrace deposits.

Beneath these erosion surfaces, the clay blanket is thick and continuous, being as much as 50 feet thick on the Elbrook and succeeding formations and 200 feet thick on the Tomstown and Waynesboro formations. The gravels that cover the surfaces lie unconformably and undisturbed on the clay, and contain reworked fragments of iron and manganese oxides derived from it. From these relations it appears that the clays were formed before the gravels were laid down, probably when the erosion surfaces were cut. At such times much of the land surface was near grade, and it may have remained so for long periods; the climate, moreover, may have been unusually moist and warm.[3]

The contact between the residual clays and the unweathered rock beneath is sharply marked at the few places where it has been observed, and pillars or chimneys of unweathered rock project into the clay. This relation is well shown in an outcrop of Conococheague limestone in a cut on the Norfolk & Western Railroad three-quarters of a mile southeast of the railroad station in Shenandoah (fig. 3). Veins and bedding here extend

2/ Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., Manganese deposits of the west foot of the Blue Ridge, Virginia: Virginia Geol. Survey Bull. 17, p. 39, 1919.

3/ Hewett, D. F., Some manganese mines in Virginia and Maryland: U. S. Geol. Survey Bull. 640, pp. 46-47, 1917.

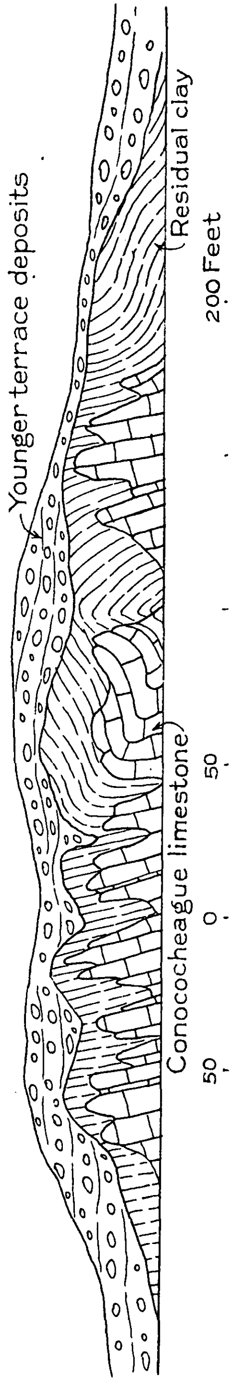

Figure 3.--Sketch of cut on Norfolk & Western Railroad, three-fourths mile southeast of railroad station in Shenandoah. Shows relation of resicual clay to underlying Conococheague limestone and to overlying terrace deposits.

from the unweathered limestone into the clay, showing that the clay formed in place by weathering of the limestone. Similar relations may be seen in the Waynesboro formation in the valley west of Fultz Run and in the southwestern open cut of the Garrison bank (No. 17 in pl. 4), where pillars of unaltered, hard shale project into soft clay. Evidence as to the relation between residual clays and the Tomstown dolomite is afforded by drill holes and underground workings on the Watson tract (sec. A-A', pl. 8). Unaltered dolomite is reached in depth by test hole No. 2, but up the dip, in the incline and in test hole No. 3, its place is taken by clay.

The thickness of the clays developed on the Tomstown and Waynesboro formations is indicated in a number of drill holes and mine workings. On the Watson tract, test hole No. 2 reached unaltered Tomstown dolomite at a depth of 145 feet, but in test hole No. 1 all the Tomstown to the top of the Antietam quartzite, which was reached at a depth of 298 feet, was represented by residual clay (sec. C-C', pl. 8). In the Neisswaner shaft (No. 42 in pl. 4), unaltered shales of the

Waynesboro formation were encountered at a depth of about 200 feet, and were overlain by residual clay.[4] The clays in test hole No. 1 on the Watson tract extend down to the level of nearby Naked Creek, and those in the Neisswaner shaft extend below the level of the nearby Shenandoah River. Similar great thicknesses of clay appear to occur elsewhere over the Tomstown and Waynesboro, for clay is exposed on the banks of Naked Creek and of many other streams that have cut below the level of the valley-floor peneplain, and unaltered rock crops out only in the deeply incised valleys near Fultz Run.

These deep residual clays thus extend to or below the level of the present drainage, although base-level was higher when the valley-floor peneplain was being cut and the clays were forming than it is today. To leach the original rock and produce the clays, therefore, ground water must have been able to circulate many hundreds of feet below the surface drainage as it then existed.

The clays derived from the dominantly argillaceous rocks of the Waynesboro formation show well-marked even bedding, relatively open folding, and straight, clean-cut joints, which have been preserved with relatively little change from the original rock. Such features are well exposed in the artificial openings of the Garrison bank (No. 17 in pl. 4) and the Fox Mountain mine (No. 26 in pl. 4). During the formation of such clays, there has probably been little loss of volume by leaching, a conclusion that was also reached by Hewett[5] from laboratory study of residual clays in the Neisswaner shaft, which were derived from shales.

The clays derived from the dominantly calcareous and dolomitic rocks of the Tomstown are mainly buff or brown, though some layers are red, pink, or white. Most of the beds are

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4/ Hewett, D. F., op. cit., pp. 64-66.
5/ Idem.

tough, dense, and waxy, but a few are silty and perceptibly gritty. Part of the clay shows a lamination that may be a relic of original bedding, but part is massive and featureless. There is some clay breccia consisting of small to large fragments in a matrix of different texture or color. In places the clays enclose masses of chalcedonic chert and, more rarely, masses of brown, dull-lustered siliceous rock that may be silicified dolomite.

The clays derived from the basal part of the Tomstown, within 50 feet of the top of the Antietam quartzite, show more variety than those higher up, and include waxy, silty, and sandy layers, interbedded with layers of sand. Some of the sands are brown and may originally have been glauconitic. Others are white, and contain remarkably well rounded quartz grains up to 2 millimeters in diameter and, in places, fragments of brecciated quartzite. These varied rocks were probably derived from an original transition zone between the Antietam and Tomstown formations.

In contrast to the residual clays derived from the Waynesboro, those derived from the Tomstown have a much more irregular, even a chaotic structure. This may be seen in the incline on the Watson tract (pl. 7). Here the layers that represent the original bedding are sharply and irregularly folded and are broken by small faults, and they pinch and swell so that they are traceable only for short distances. Evidently the Tomstown has undergone a much greater reduction of volume in being altered to clay than the Waynesboro has, and the structure of the clay derived from the Tomstown is in part the result of slump and compaction, and some of this clay may represent cavern fillings in the original dolomite. But some of the folds seen in the incline (as between timber sets 45 and 58 in the incline) lie over folds in the Antietam quartzite and must therefore be partly primary. Even here, however, secondary modification is indicated by the occurrence of quartzite breccia in the sands above the Antietam, probably formed when thin beds of quartzite were broken up because of the leaching of more soluble layers with which they were interbedded.

Ancient gravel deposits.--At the Stanley mine (No. 1 in pl. 4) ancient gravel deposits overlying the residual clay of the Tomstown dolomite fill a steep-sided eroded basin in the residual clay, and are overlain unconformably by fanglomerates contemporaneous with the older terrace deposits (see fig. 4). The ancient deposits consist of cross-bedded red sand, in which deeply weathered rounded pebbles of sandstone and quartzite are embedded. Like the underlying clay, the deposits contain masses of manganese ore, reworked pieces of which occur in the overlying gravels.

This deposit apparently was laid down during the cutting of the valley-floor peneplain, before or during the formation of the residual clays and before the mineralization. Its age is unknown but may be Tertiary. The deposit is comparable to the ancient, manganese-bearing, pebbly clay at the Kennedy mine, south of the Elkton area.[6]

Older terrace deposits and associated fanglomerates.--The older terrace deposits were laid down on the surface of the valley-floor peneplain, and consist of quartzite gravels washed out from the foothills of the Blue Ridge. At a distance from the Blue Ridge, their surface is a gently sloping plain and the deposit is probably thin. Toward the Blue Ridge their surface steepens and the deposit thickens and changes into a coarse fanglomerate. On the Watson tract, close to the foothills, the gravels form a continuous sheet whose greatest observed thickness, in test hole No. 5, is about 140 feet (sec. C-C', pl. 8). Similar thicknesses have been measured close to the foothills,

6/ Stose, G. W., and others, op. cit., p. 106.

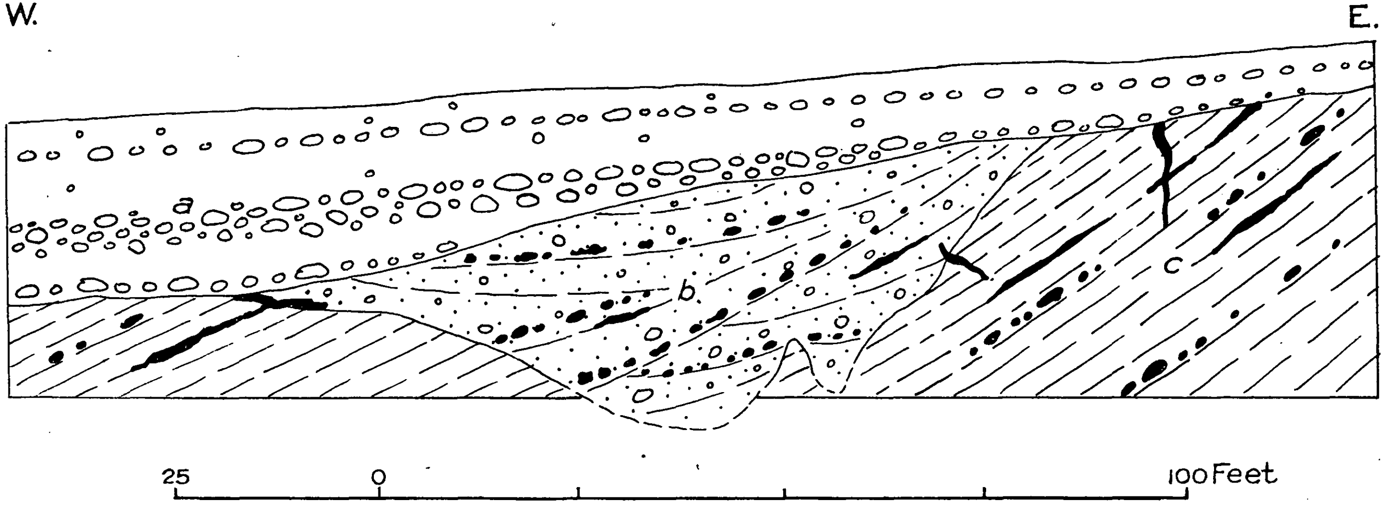

Figure 4.--Schematic section, based on outcrops in southern open cut of Stanley mine, showing relation of ancient gravel deposits (b) to residual clay derived from Tomstown dolomite (c), and to fanglomerates contemporaneous with older terrace deposits (a). Units b and c contain manganese minerals (shown in black) and are older than the mineralization. Unit a contains reworked fragments of manganese minerals, and is younger than the mineralization.

in the shafts of some of the Elkton mines (Nos. 39 and 41 in pl. 4).7/ An unusual thickness of 260 feet of gravel was encountered in Bureau of Mines test hole No. 1, south of Giants Grave and a quarter of a mile northeast of the Crawford prospect (pl. 4). In this hole, gravel lies directly on unaltered Tomstown dolomite, and its base is 100 feet below the level of the nearby Shenandoah River.

The gravels lie unconformably on the residual clays and do not share their irregular structure. They are younger than the mineralization of the clays, for they truncate veins of iron and manganese oxides in the clays and contain reworked fragments of these oxides. They probably were laid down under different, perhaps more arid, conditions than those that existed while the clays were being formed and mineralized. The age of the older terrace deposits is unknown, but they may be late Tertiary or early Quaternary.

STRUCTURAL GEOLOGY

The Elkton area lies between two large, northeast-trending structural features, the Blue Ridge-Catoctin Mountain anticlinorium to the southeast, in which pre-Cambrian rocks lie at the surface, and the Massanutten Mountain synclinorium to the northwest, in which Devonian rocks lie at the surface. The general dip is to the northwest, from the anticlinorium to the synclinorium. The structure is complicated, however, by numerous minor anticlines and synclines and by the occurrence of minor faults parallel or transverse to the strike of the rocks.

The manganese deposits of the Elkton area lie at the western base of the foothills of the Blue Ridge. In this area the foothills follow an irregular course, in places projecting northwestward, in others receding southeastward (pl. 4). The

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7/ Stose, G. W., and others, op. cit., pp. 72-73.

projections lie on upwarps that trend northwestward across the strike of the folded rocks, and the recesses lie on intervening downwarps.

Shenandoah salient

One such projection of the Blue Ridge foothills lies east of the town of Shenandoah and may be termed the Shenandoah salient. In the central part of this salient, the Harpers and Weverton formations crop out over wide areas and are relatively little folded (sec. B-B', C-C', and D-D', pl. 4).

The Antietam quartzite, which crops out around the edges of the salient, is more folded and dips more steeply than the rocks in the center. To the northeast and southwest, this formation is folded into anticlines and synclines that pitch away from the uplift and beneath the younger formations. These folds affect also the Tomstown and Waynesboro formations, which overlie the Antietam, and they therefore influence the distribution of the manganese deposits. On the northeast side of the salient, the pitching folds extend to the Stanley fault, a large transverse fracture whose trace lies a short distance north of the quartzite foothills (pl. 4). North of the fault, the rocks are relatively less folded than to the south (sec. A-A', pl. 4). On the southwest side of the salient, the folds stand en echelon, giving rise to a succession of projecting foothill spurs underlain by southwest-pitching anticlines of Antietam quartzite, separated by recesses underlain by tongues of Tomstown dolomite or its residual clay (fig. 5). On the northwest side of the salient, the foothills present a relatively straight front, following the strike of the Antietam quartzite, which here dips steeply northwestward toward the Shenandoah Valley. The succeeding formations in the valley stand vertical or are overturned and dip southeastward (sec. C-C', pl. 4). This belt of

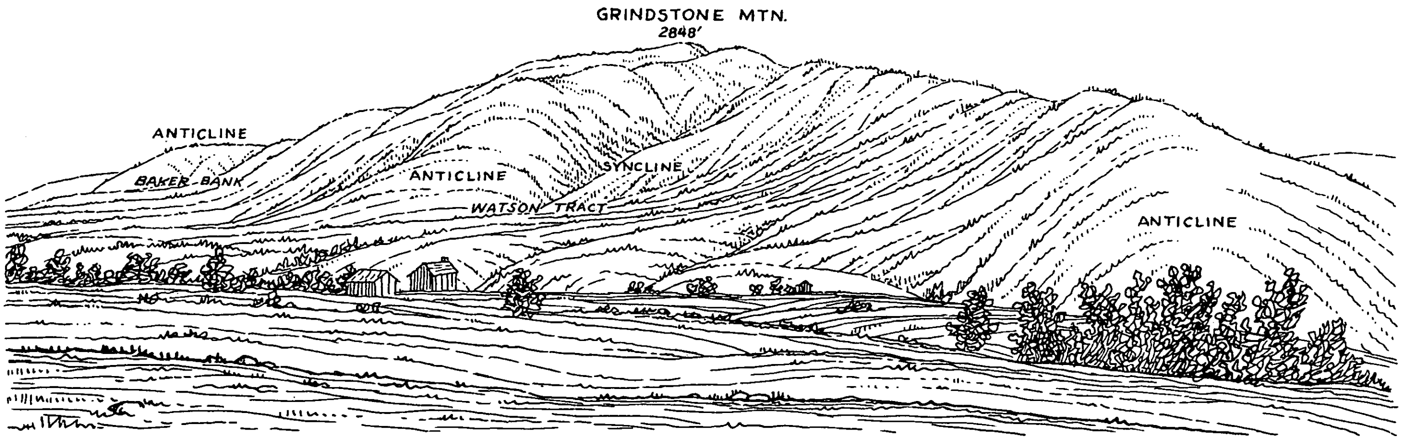

Figure 5.--View of Grindstone Mountain and Watson tract, looking north from opposite side of Naked Creek valley. The ridges reflect the structure of the underlying Antietam quartzite, each spur being on an anticline pitching toward the observer, and each recess on a syncline. Sloping plain at foot of ridges is covered by older terrace deposits and associated fanglomerates.

steeply dipping rocks is cut off on the northeast by the Stanley fault.

Elkton embayment

Southwest of the Shenandoah salient and east of Elkton, the foothills recede to the southeast, so that a broad reentrant of the Shenandoah Valley extends toward the Blue Ridge (pl. 4). This reentrant may be termed the Elkton embayment. Most of the embayment is probably underlain by strongly folded Tomstown and Waynesboro formations, although these are mostly concealed by the older and younger terrace deposits (sec. E-E', pl. 4). The belt of the foothills between the embayment and the Blue Ridge is relatively narrow, because some of the thickness of the Antietam quartzite and older Cambrian formations has been cut out by the Huckleberry Mountain thrust fault (secs. E-E' and F-F', pl. 4).

Salient south of Elkton

Southwest of the Elkton embayment and south of Elkton, the foothills project northwestward in another salient, forming a series of prominent ridges such as Hanse Mountain and Rocky Mount (pl. 4). This projection is caused partly by a rise of the quartzite toward the southwest along northeast-pitching folds, and partly by a group of tear faults trending northwestward, of which the Elk Run fault is the largest. On these faults the southwest side has moved relatively northwestward. Within the salient are many anticlines and synclines in the Antietam and older formations. The anticlines to the northwest enclose synclinal tracts of Tomstown and Waynesboro formations, such as that on the northwest flank of Hanse Mountain (sec. G-G', pl. 4) and that between Giants Grave and Gap Run (sec. H-H', pl. 4).

MANGANESE DEPOSITS

Occurrence.--Most of the manganese deposits in the Elkton area occur in residual clay that lies on the valley-floor peneplain and was derived from the weathering of the Tomstown and Waynesboro formations. Most of the manganese is in the lower part of the Tomstown dolomite; deposits higher in the Tomstown, and in the overlying Waynesboro, are less common. The rocks in the vicinity of the deposits may have either a monoclinal or a synclinal structure. Considering the Blue Ridge area as a whole, deposits in synclines appear to be more productive than those in monoclines,[8] but there is no assurance that all synclinal tracts contain manganese ore, or that every synclinal tract will prove more productive than the adjacent monoclinal tracts.

Not all of the manganese oxide in the Elkton area occurs in residual clays; some has been seen in brecciated Antietam quartzite, along fault zones, and as reworked fragments in the terrace deposits. Only in the clay, however, does the manganese form deposits large enough to be worth mining.

Character.--All the residual clays derived from the Tomstown and Waynesboro formations contain enough iron oxide to color them yellow, brown, or red. Many of them also contain manganese oxides, mostly in the form of wad, which either is disseminated through the clay or forms partings between the laminae and minute cross-cutting veinlets. Here and there, iron and manganese oxides are so concentrated in the clay as to form fairly large deposits.

In the larger deposits, the proportion of iron to manganese varies; some of these deposits consist of relatively pure limonite and other iron oxides, some are mixtures of iron and manganese oxides, and some consist almost wholly of the hard

8/ Stose, G. W., and others, op. cit., pp. 53-54.

manganese oxides psilomelane, pyrolusite, and manganite. Deposits composed dominantly of iron oxides are relatively common in the Elkton area and have been mined in the past. Manganiferous iron ore also is common, and it is reported that in some iron deposits the proportion of manganese tends to increase with depth. Deposits with a high proportion of manganese oxides are less abundant.

The harder manganese oxides commonly occur as spherical, grapelike, or botryoidal nodules ½ inch to 8 inches in diameter, embedded in clay. The nodules consist largely of laminated or massive psilomelane, with veinlets of later psilomelane and pyrolusite and masses of crystalline manganite. The enclosing clay is in part impregnated with wad but in part free from manganese oxides. The nodules appear to be more common in silty than in waxy clay, and in some deposits they are distributed along fairly definite zones or layers, separated by barren clay.

There are also some bodies of fairly hard manganese oxide in the Neisswaner shaft (No. 42 in pl. 4) which have been described by Hewett.[9] Many of these masses follow the stratification in the clay, but they pinch out or change in composition laterally, and in places they form cross-cutting veins. Part of the manganese oxide in such masses appears to have grown into openings, where it has developed botryoidal and stalactitic surfaces. On the Watson tract more ground water was encountered near such masses than elsewhere, as though underground water courses still existed.

Origin.--The manganese deposits have been concentrated in the residuum of deeply weathered rocks, and the original character of these rocks has been so nearly obliterated that the source of the manganese oxides is no longer evident. It is conceivable that they may have been derived from hydrothermal

9/ Hewett, D. F., op. cit., pp. 63-64.

replacement deposits,[10] but it is easier to imagine that they were carried in from overlying or underlying formations,[11] and it seems most likely that they were derived from manganese carbonate disseminated in the sedimentary rocks near the horizons where they are now found.[12] A large proportion of the deposits occur in a single zone, near the base of the Tomstown dolomite, as though this zone once contained primary disseminated manganese minerals; and unweathered specimens of the dolomite contain several hundredths of a percent of manganese (p. 20). No relics of minerals of hydrothermal origin have been reported in the area, and the quartz and calcite veins of the area show no trace of manganese minerals.

The concentration of the manganese in the present deposits took place during the process of formation of the residual clay, or during the cutting of the valley-floor peneplain. "When the rocks weathered, the manganese was dissolved as bicarbonate by circulating underground water, was transported along favorable channels, and was deposited as oxides in the clays produced by the previous decay of impure limestone, dolomite, and sericitic shales."[13] The concentration was a relatively late event in the process, for it followed the deposition of ancient gravels in eroded hollows in the clay or dolomite. Moreover, "the similar distribution of coarse quartz sand in nodules and in adjacent clay and the ragged areas of clay in hard nodules * * * show conclusively that the nodules of manganese oxides have grown by replacing the clay substance in which they are embedded. There is, further, no evidence of the crowding back of the enclosing material such as would occur if the nodules had grown

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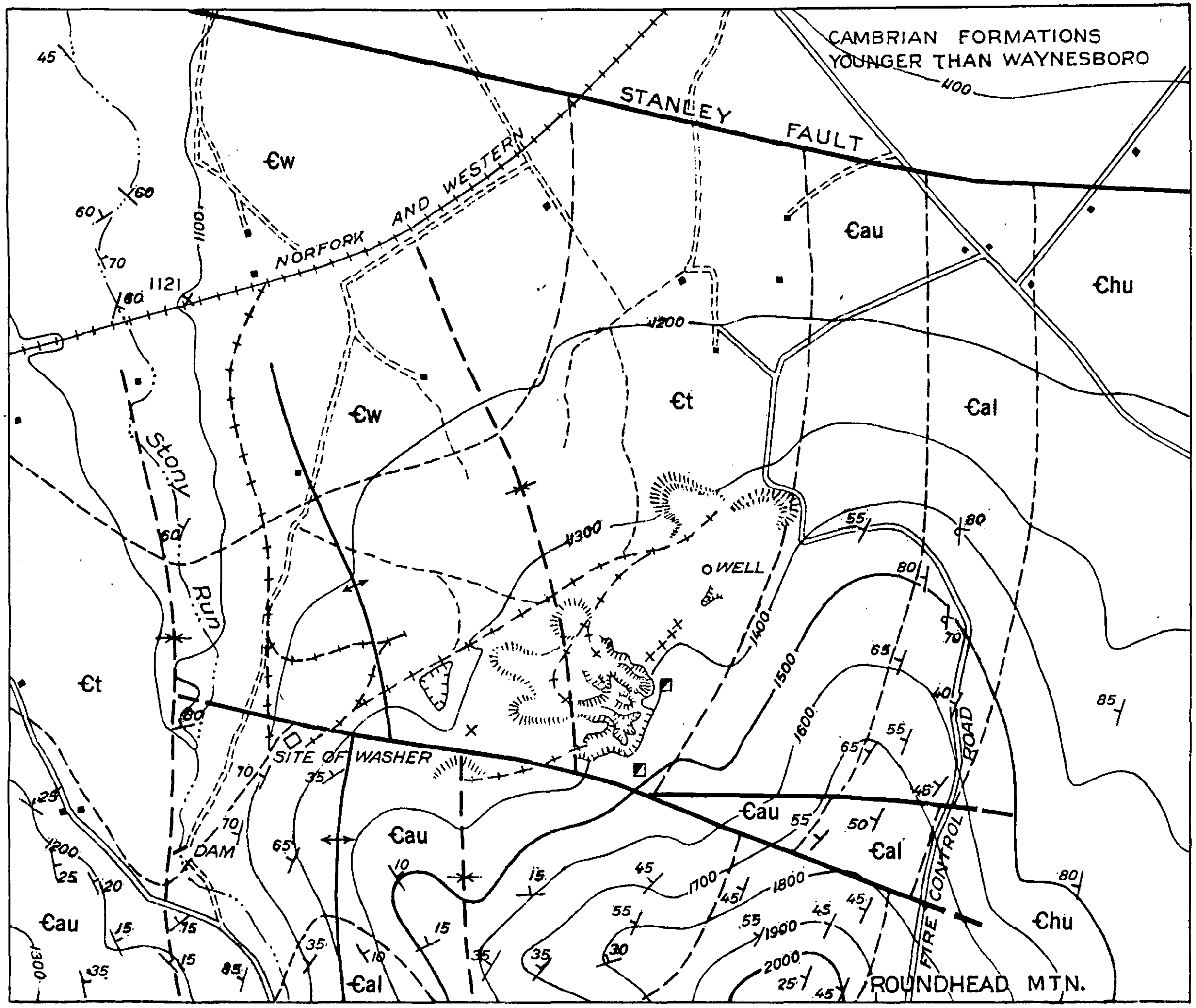
10/ Kesler, T. L., Structure and ore deposition at Cartersville, Georgia: Am. Inst. Min. Met. Eng. Trans., vol. 144, p. 292, 1941.

11/ Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, pp. 100-101, 1910.

12/ Stose, G. W., and others, op. cit., pp. 54-55.

13/ Idem.



EXPLANATION

Fault

50

Strike and dip of beds

70

Strike and dip of overturned beds

Axis of anticline

Axis of syncline

Formation boundaries
(Partly concealed by gravel and talus)

Shaft

Open cut

Dump

×
Prospect pit

Grade of abandoned railroad

€w Waynesboro formation
€t Tomstown dolomite
€au Upper member of Antietam quartzite
€al Lower member of Antietam quartzite
€hu Upper member of Harpers formation

Topography mainly from Geological Survey map of Shenandoah National Park

Geology and mine data by P. B. King and John Rodgers; surveyed in 1941

MAP OF THE STANLEY MINE AND ITS SURROUNDINGS

500 0 2500 Feet

GPO O - 43 - 548760 (Face p. 34)

in the clay without replacing it."[14] Some of the nodules also contain slickensides, inherited from the clay that they replaced.

The relative age of the minerals in the deposits is not fully known. In general, however, the psilomelane and the harder manganese oxides appear to have been derived from wad. "It appears that psilomelane, which contains less water than wad, tends to form most readily in masses of wad."[15] The relations observed in some specimens also suggest that the manganese deposits may have formed somewhat later than the iron oxides.

MANGANESE MINES AND PROSPECTS

Stanley mine

The Stanley mine[16] is a mile south of Stanley, at the north end of Roundhead Mountain. It was opened in the 1890's under the name of Eureka mine, and considerable ore is reported to have been shipped from it before 1910. The mine was reopened in 1918 and operated through 1919. During this period, an extensive plant was installed and large open cuts were made, and 13 carloads of low-grade ore are reported to have been shipped. The mine was again operated from 1928 to 1937, when 4,000 tons, or 100 carloads, mostly of high-grade ore, was shipped. According to Tyler,[17] the ore contained, on the average, during the last period of operation, 46 percent manganese, 3.5 percent iron, 6-12 percent silica, and 0.15 percent phosphorus.

The mine workings lie at an altitude of about 1,400 feet, in residual clay of the Tomstown dolomite (pl. 5). Further up the mountain slope to the southeast and south the clay is bordered

14/ Stose, G. W., and others, op. cit., p. 45.
15/ Hewett, D. F., op. cit., p. 40.
16/ Watson, T. L., Mineral resources of Virginia: Virginia Jamestown Exposition Commission, p. 245, 1907. Harder, E. C., op. cit., pp. 55-56. Stose, G. W., and others, op. cit., pp. 65-67.
17/ Tyler, Paul, personal communication, 1941.

by outcrops of Antietam quartzite. The quartzite on Roundhead Mountain, to the south, has a synclinal structure (sec. A-A', pl. 4) and the mine is situated on the northward projection of the synclinal axis. South of the workings, however, the quartzite appears to be up-faulted against the clay (pl. 5).

The mine workings consist of two large open cuts and a number of shafts and pits. The open cuts expose buff, brown, or red clay, in part sandy, with an obscure, variable dip to the northwest. The clay contains fragments of chalcedonic chert, occasional masses of brown, silicified dolomite, and nodules of psilomelane and other hard manganese oxides. Some of the clays are impregnated with wad, and here and there they are cut by veins of limonite. Operations carried on between 1928 and 1937 near the west end of the northern open cut are said to have revealed a lens-shaped body of solid manganese ore 10 feet thick, which pinched out down the dip. This ore, however, has been entirely mined out.

In the southern open cut a steep-sided depression, 100 feet long and 25 feet deep, in the clay may be seen that was filled with the ancient gravel deposits, which here consist of red sand enclosing deeply weathered sandstone pebbles (fig. 4). This material contains numerous spherical and botryoidal nodules of psilomelane, which, being highly siliceous, have been avoided in mining. Both the residual clays and the ancient gravels are unconformably overlain by fanglomerates, contemporaneous with the older terrace deposits (a, fig. 4), which slope steeply away from the mountain and reach a thickness of 15 feet. The base of the fanglomerate truncates veins of iron and manganese oxides in the clays, and the gravels contain reworked fragments of manganese oxides derived from the clays.

Except for the siliceous ore in the ancient gravel deposits, the amount of manganese ore at present in sight at the Stanley mine is small.

Garrison bank

The Garrison bank[18] lies on a low hill projecting from the gravel plain west of Grindstone Mountain, 2 3/4 miles southeast of Shenandoah (No. 17 on pl. 4) and near the grade of the old railroad from Shenandoah to the Fox Mountain iron mine. It was mined for iron ore and manganiferous iron ore at some time between 1880 and 1900, when four large open cuts were made in the hillside. Analyses, quoted by Harder, of some of the ore mined in the 1880's show over 50 percent manganese, but no record is available as to how much of this ore, or of other types of ore, was produced. At the time of the present investigation (1941), the tract was being prospected by a Lynchburg group and small quantities of manganese ore were being handpicked and shipped. New workings had been opened in the northwestern open cut, and two shafts nearly 100 feet deep had been sunk.

The Garrison bank lies in the belt of outcrop of the Waynesboro formation, and the old and new workings show thinly and evenly bedded brown, red, gray, and white decomposed silty shale. Some pillars of unweathered shale are exposed in the southwestern open cut. These rocks dip in general eastward and may be overturned. The decomposed shales contain lenses and beds of limonite. Manganese oxides were noted in the northeastern and northwestern open cuts, on the dump of one of the shafts, and in the cut of the old Fox Mountain railroad southwest of the tract. In the northwestern open cut, in which the exposures are best, manganese oxides form persistent seams up to an inch thick, which are mostly parallel to the bedding planes but branch here and there into cross-cutting veinlets; manganese oxides also form the matrix of some breccia zones in the shale.

18/ Harder, E. C., op. cit., p. 56.

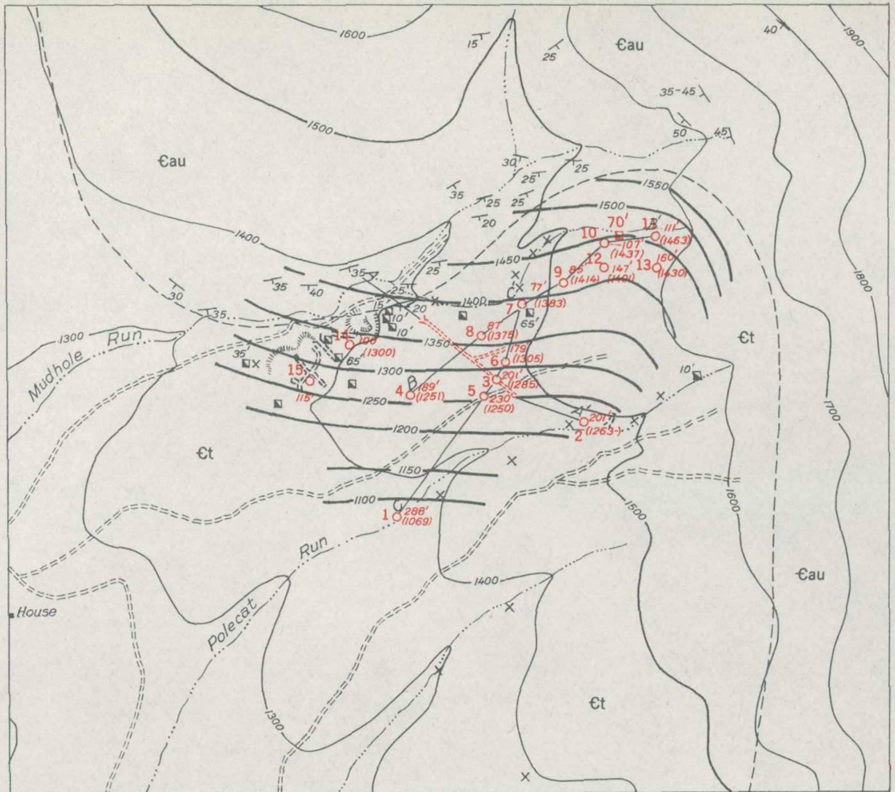
Most of the material consists of the softer oxides, such as wad and pyrolusite, but some psilomelane and manganite are present. The persistent seams of oxide may have been derived from original manganiferous layers in the shale. A solid mass of manganese ore weighing 100 pounds is said to have been uncovered and mined in the northwestern open cut, but no extensive body of ore has been opened up and the reserves appear to be small.

Watson tract

The Watson tract[19] lies in a recess on the west slope of Grindstone Mountain, three-quarters of a mile north of old Furnace Post Office, at an altitude of about 1,400 feet (No. 20 in pl. 4). The first work on the tract was done about 1908, and a small quantity of ore was mined and shipped before 1915. The workings consisted of an open cut, three inclines the longest of which is at least 100 feet long, several shafts as much as 65 feet deep, and many prospect pits (pl. 6). In 1941 the tract was explored by the Bureau of Mines by means of 15 test holes, an incline 540 feet long, and a shaft 70 feet deep. The geologic features revealed by this work are indicated in plates and figures accompanying this report (pls. 6-8).

The Watson tract lies on the northwest flank of a southwest-pitching syncline, flanked on the east by steeply dipping Antietam quartzite, which forms the main ridge of Grindstone Mountain, and on the north by a broad anticline of Antietam quartzite, which forms a subsidiary spur of the mountain (fig. 5). Along Mudhole Run, the top of the quartzite dips 20° to 40° S., and test holes indicate that this dip, with minor variations, continues southward beneath the tract (see structure contours on pl. 6). Within the tract, the quartzite is overlain by a southward-thickening wedge of clay, residual from the lower part

19/ Harder, E. C., op. cit., p. 56. Stose, G. W., and others, op. cit., pp. 69-70.



Topography from plane-table survey by W. R. Wagner, with additions from Geological Survey map of Elkton quadrangle

Geology by P. B. King and John Rodgers
Surveyed in 1940

EXPLANATION

Outcrop of top of Antietam quartzite
(Partly concealed by gravel and talus)

25

Strike and dip of Antietam quartzite

1400

Structure contours on top of Antietam quartzite. (Interval 50 feet)

2 201' (1263')

Test hole

Figures indicate serial number of hole 2 ; depth in feet 201' ; and elevation in feet of top of Antietam quartzite (1263')

10' 70'

Shaft
(Figures indicate depth in feet)

Tunnel, incline, or drift

Open cut

Dump

×

Prospect pit

B B'

Line of structure section (Pl. 8)

Ꞓt Tomstown dolomite
Ꞓau Upper member of Antietam quartzite

Bureau of Mines workings are shown in red, older workings in black

MAP OF THE WATSON TRACT AND ITS SURROUNDINGS

500 0 500 1500 FEET

of the Tomstown dolomite; and unweathered dolomite was encountered near the synclinal axis in test hole No. 2. The clays are overlain by a sheet of fanglomerate, contemporaneous with the older terrace deposits, which attains a thickness of 140 feet.

As shown in the test holes and incline, the residual clays have varied colors and textures and a complex structure. Some of them contain embedded pieces of chalcedonic chert, and many are impregnated or minutely veined with wad. Test holes in the northern part of the tract, within 600 feet of the outcrop of the quartzite, generally encounter hard manganese oxides in the clay in two or more zones between 25 and 75 feet above the top of the quartzite; the lower zone is at some places 7 feet or more in thickness (secs. B-B' and C-C', pl. 8). The oxides consist mainly of nodules of psilomelane lying in clay, but a lens-shaped body of solid ore 5 feet thick was encountered in the incline between sets 76 and 80 (pl. 7). In this lens, however, the manganese oxides are interlayered and intergrown with a considerable amount of limonite, and the lens tapers out within a short distance, its place being taken by stringers of wad and thin beds of limonite. In the shaft, which lies nearer the axis of the syncline, a good deal of manganese oxide was encountered in or near the same zone. Here there are layers of wad and wad-impregnated clay as much as 6 feet thick, enclosing irregular nodules and masses of hard manganese oxides.

These explorations have failed to reveal any ore body of large size.

Tract southeast of Furnace Post Office

Southeast of old Furnace Post Office, west of a ridge of Antietam quartzite and between Naked and South Naked Creeks, is an area in which the Tomstown dolomite has a synclinal structure resembling that on the Watson tract (see pl. 4; for structure of south part of tract, see sec. E-E'). It was pointed out in a previous publication[20] that the geological conditions in this area appeared favorable for the occurrence of manganese ore, and the area was consequently designated as "undeveloped tract No. 3." The area of Tomstown residuum enclosed by the syncline appears to be smaller than that on the Watson tract, and the syncline is broken by a north-northeast-trending fault whose breccia crops out on the south side of Naked Creek Valley a mile east of Furnace. The older terrace deposits in the tract occupy only a small area, having been removed in considerable part by down-cutting of the two creeks.

Three prospect pits close to the steeply dipping quartzite on the east side of the tract (Nos. 28, 29, and 30 in pl. 4),[21] show nodules of hard manganese oxides in residual clay. Another pit farther out, near the south side of Naked Creek valley (No. 27 in pl. 4), shows only gravel. Near the southern pits, called the Smith prospects (No. 30 in pl. 4), residual clay is exposed on the banks of South Naked Creek, where it contains streaks of wad and rare nodules of the harder manganese oxides.

As most of the tract is covered by terrace gravels and alluvium, little is known regarding conditions in the underlying residual clays. Manganese oxides are visible in artificial openings and in small natural outcrops, but there is no evidence of a large body of manganese ore.

Elkton mines

The Elkton mines[22] are a mile southeast of Elkton, on the northwest slope of Hanse Mountain, at altitudes of 1,100 to 1,300 feet (Nos. 36-42 in pls. 4 and 9). Hanse Mountain is

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20/ Hewett, D. F., Stose, G. W., Katz, F. J., and Miser, H. D., Possibilities for manganese ore on certain undeveloped tracts in the Shenandoah Valley, Virginia: U. S. Geol. Survey Bull. 660, pp. 289-290, 1918.

21/ One of these was termed the "Piney Mountain prospect" by Stose, G. W., and others, op. cit., p. 71.

22/ Watson, T. L., op. cit., pp. 250-251. Harder, E. C., op. cit., p. 57. Hewett, D. F., op. cit., pp. 61-67. Stose, G. W., and others, op. cit., pp. 71-77.

carved from an anticline of Antietam quartzite on the northwest flank of which the beds dip from 45° to 60° NW. (sec. G-G', pl. 4). Another, minor anticline about a quarter of a mile northwest of the outcrop of the top of the quartzite is apparently indicated by outcrops of quartzite along State Highway 12 to the west, and by southeast dips in the Waynesboro formation in the Neisswaner shaft (No. 42 in pl. 9). The shallow synclinal basin thus formed is underlain by residual clays derived from the Tomstown and Waynesboro formations, which are overlain by a variable thickness of older terrace deposits and associated fanglomerates.

The oldest workings in the tract, at the Kendall and Flick mine (No. 40 in pl. 9), were opened in 1888 and operated intermittently until 1910, during which time considerable iron and manganese ore was shipped. Total production was about 10,300 tons, of which 5,200 tons was produced in 1908. Harder[23/] quotes analyses of ore that contained 48 percent manganese. The main workings lie in Number Three Hollow at about 1,200 feet, in clay residual from the lower part of the Tomstown dolomite. They include a shaft 256 feet deep, connected with a mule tunnel whose entrance was lower down the slope, and a long open cut. All the workings are now caved and overgrown. According to Hewett,[24/] "iron ore only was taken from the open cuts, but it is reported that some manganiferous iron ore was obtained from the deep workings and removed through the mule tunnel. The walls of the eastern open cut show decomposed sandy shale, here and there impregnated with limonite and containing thin films of manganese." The character of the ore-bearing clay has been described by Harder.

Other old shafts (Nos. 38 and 39 in pl. 9), probably belonging to the Kendall and Flick mine, occur farther east on the

23/ Harder, E. C., op. cit., p. 57.
24/ Hewett, D. F., op. cit., p. 63.

ridge between Number Three and Number Two Hollow, and in Number Two Hollow itself. The dumps of most of these contain clay, chalcedonic chert, and manganese oxides, indicating that they penetrated the residual clay of the Tomstown dolomite. One shaft on the ridge at an altitude of 1,290 feet is reported to have struck quartzite boulders at 110 feet, and the Bartell shaft (No. 41 in pl. 9), at 1,120 feet, in Number Three Hollow, was put down to a depth of 135 feet in 1915, and "encountered only valley wash containing subangular boulders of quartzite."[25]

The Neisswaner shaft (No. 42 in pl. 9), which lies 1,500 feet north of the Kendall and Flick mine, at an altitude of 1,080 feet, was opened by the Pittsburgh Manganese Co. in 1910 and operated almost continuously until 1915. The total production of the Neisswaner workings was about 1,750 tons, ranging in manganese content from 46 to 50.5 percent and consisting largely of psilomelane.

The Neisswaner shaft is 312 feet deep. Its lower part is in barren, hard, unaltered, red and green shale of the Waynesboro formation, and ore occurs at depths between 140 and 206 feet in residual clays derived from the shale. "The zone which yielded the ore * * * was roughly U-shaped in cross-section and about 30 feet in maximum thickness in the arms. * * * Within this zone hard, rounded and slaglike masses of manganese minerals were found, for the most part in dark brown to black wad, which formed highly irregular bodies in soft, variegated clay. Locally, however, the manganese minerals were embedded in pure ocher containing little manganese, but none were observed in white or pale yellow clay. Although some bodies of wad were small and apparently isolated, many of the larger bodies were connected by irregular pipes and seams of wad, and by following these it was possible to locate new bodies in the zone. As the

25/ Hewett, D. F., op. cit., p. 63.

explorations and stoping tended to follow the ore, the result in places was a veritable maze of drifts and raises. Although the round ore nodules are generally solid, many of the slaglike masses are cavernous, and stalactites of psilomelane hang vertically from their walls."26/

In 1916 the tract on which the Elkton mines are located was taken over by the U. S. Manganese Corporation, which put down many test holes and produced manganese ore from two shafts, lying close to the quartzite outcrops, at an elevation of 1,270 feet in Number One Hollow (No. 36 in pl. 9). They are reported to have produced several thousand tons of ore containing 42 to 50 percent manganese, 2 to 5 percent iron, and 8 to 10 percent silica. The northeastern shaft is 210 feet deep. "At this depth * * * it is reported a bed of well-rounded quartzite boulders was struck. These boulders are clearly water-worn and must form a part of a stream channel. All of the ore was found above the bed of boulders."27/ The dumps consist of brown sandy and silty clay, waxy clay, chalcedonic chert, and plates and nodules of manganese oxides. Similar material was also seen on the dumps of two shafts on the ridge to the west, at altitudes of 1,290 and 1,310 feet (No. 37 in pl. 9). This material is clearly residual from the Tomstown dolomite, so that the boulders referred to probably lie in a cavern or crevice filling.

The Elkton mines have produced a large quantity of manganese ore in the past. The part of the tract between and around the mine openings appears to have been well prospected, but without revealing any large bodies of unmined ore.

Tract between Giants Grave and Gap Run

Southwest of the Elkton mines the minor syncline and anticline northwest of the anticline of Hanse Mountain rise so high

26/ Hewett, D. F., op. cit., pp. 63-64.
27/ Stose, G. W., and others, op. cit., p. 76.

that outcrops of Antietam quartzite extend across them in the valley of Hawksbill Creek. Farther southwest, the folds again pitch to the southwest, so that a synclinal area of Tomstown dolomite lies between Giants Grave and the main quartz ridges to the southeast (sec. H-H', pl. 4). This area continues 1½ miles southwestward to Gap Run (pl. 4). It was pointed out in a previous publication[28] that geological conditions were favorable for the occurrence of bodies of manganese ore on this area, which was accordingly designated as "undeveloped tract No. 1."

Manganese oxides are exposed in three prospect pits which were opened on the tract in the early 1900's at the northwest foot of the quartzite ridge to the southeast: these are the Crawford prospect 1 mile south of Giants Grave (No. 46 in pl. 4); the Yancey prospect, three-quarters of a mile further south (No. 47 in pl. 4); and another prospect on the north edge of Gap Run valley, 2 miles south of Giants Grave (No. 48 in pl. 4). The dumps of all the pits consist of buff waxy clay, chalcedonic chert, and hard manganese oxides, indicating that the pits penetrated residuum of the Tomstown dolomite.

Test holes, however, that were put down on the tract in 1941 by the Bureau of Mines have shown unfavorable results. Hole No. 1, about a quarter of a mile northwest of the Crawford prospect and at an altitude of 1,140 feet, and holes No. 2 and No. 3 to the east, at 1,160 and 1,200 feet, encountered unaltered Tomstown dolomite; in the first hole this lay directly beneath gravel at 260 feet, and in the second and third beneath residual clay at 150 and 177 feet. Holes No. 4 and No. 5 bottomed in Antietam quartzite, after passing through only sand and gravel. If these conditions exist widely over the tract, the presence of any large bodies of manganese ore is unlikely.

28/ Hewett, D. F., and others, op. cit., pp. 283-287.

At the Yancey prospect the Allegheny Ore & Iron Co. sank eight prospect pits in 1942. Manganese ore was encountered in a group of pits 10 to 26 feet deep in an area about 45 feet long and 20 feet wide. Eighteen to twenty tons of manganese ore that appears to be of good grade and is estimated to contain 42 to 45 percent of manganese had been washed out of the dirt recovered from the prospect pits when the prospect was visited on September 25, 1942. Crude dirt ready to be washed appeared to contain about 1 ton of manganese concentrates for each 8 tons of dirt. Material of this grade could be worked profitably at the 1942 prices of manganese provided the scale of operation is properly adapted to the amount of ore present.

The ore is in small bodies erratically distributed through residual clays derived from the weathering of the Tomstown dolomite.

Seller mine

The Seller mine[29/] lies southeast of Island Ford station on the Norfolk & Western Railroad, on the south side of the valley of Two-Mile Run, at an altitude of about 1,300 feet (Nos. 49-50 in pl. 4). The workings are in residual clay of the Tomstown dolomite a short distance northwest of outcrops of Antietam quartzite, which dips 40° to 50° NW. Although the quartzite to the southeast is folded (sec. I-I', pl. 4), the structure at the workings is apparently monoclinal.

The workings were opened about 1900 by Kendall and Flick, who sank a shaft 60 feet deep not far south of the valley (No. 49 in pl. 4) and made an open cut, underground workings, and drainage tunnel about a quarter of a mile south of the valley (No. 50 in pl. 4). No record is available as to the amount or quality of iron and manganese ore shipped. The open

29/ Harder, E. C., op. cit., p. 57. Stose, G. W., and others, op. cit., p. 81.

cut was again worked for six months in 1941 by the McCarrick brothers, but in October 1941 the mine was shut down. Three carloads of ore that contained about 30 percent manganese and much iron and phosphorus are said to have been shipped in 1941.

The open cut shows an overburden of deeply weathered gravel, representing the older terrace deposits and fanglomerates, a few feet to 25 feet thick, underlain by buff, brown, and red waxy clay having a steep but obscure dip to the northwest. The clays contain much limonite in irregular masses and veins, and are in part irregularly impregnated with wad. Some large masses of soft wad and of hard psilomelane that were exposed in mining showed slickensides probably inherited from the original clays. There are also nodular masses of the harder manganese oxides, mainly psilomelane. At the time of the last visit (October 1941), most of the larger masses of ore that had been exposed by mining had been taken out, leaving only relatively barren clay.

Other manganese and iron mines and prospects

In addition to the manganese mines and prospects already described, there are many mines that appear to have produced only iron ore, and many prospects opened in searching for iron or manganese. These are listed in table 2.

PRODUCTION AND RESERVES

Information is not complete regarding either the quantity or the composition of the manganese ore and manganiferous iron ore shipped from the Elkton area in the past. The quantity, however, from the figures given in the preceding pages, would appear to have been about 20,000 tons, more than half of which came from the Kendall and Flick and Neisswaner mines near Elkton. The district was not producing in 1941.

No systematic estimate of the reserves of ore in the entire area can be made. Estimates cannot be obtained from surface indications, as the producing beds are for the most part thickly covered with gravel. Most of the workings are either caved, or inaccessible, so that the amount of ore in them cannot be determined, and those that are accessible show only small quantities of ore. The reserves of ore in sight are therefore small, and if any large bodies exist in the area they are still to be discovered.

Table 2.--Manganese and iron mines and prospects in the Elkton area

No. (See pl. 4)	Name	Location	Approximate time of operation	Character of workings	Geology	Material penetrated
1	Stanley mine. See text.	....	....	....	....	....
2	....	North end of Dog Slaughter Ridge, 1½ miles SW. of Stanley.	?	Three prospect pits.	Residuum of lower Tomstown; monoclinal structure.	Eastern pit shows clay and chert; middle pit shows chert and limonite. No manganese minerals observed.
3	....	North end of Cubbage	?	15 or 20 trenches, each about 10 feet deep.	Residuum of lower Tomstown; monoclinal structure (sec. A-A', pl. 4).	Most of the trenches expose clay, containing limonite; two or three to the west show hard manganese oxides.
4	....	East of Honey Run, 1½ miles SSE. of Honeyville.	?	Several trenches.	Residuum of upper Tomstown; monoclinal structure (sec. A-A', pl. 4).	Hard, brown, silty shale, with numerous masses of limonite.
5	Honey Run mine.	West of Honey Run and south of Norfolk & Western Railroad.	1890	Two open cuts, a few shafts, many prospect pits.	Residuum of lower Tomstown; monoclinal structure.	Most of openings expose clay; many show limonite; manganese minerals in eastern open cut and nearby prospects.

6	....	Between two branches of Hickory Run.	?	Prospect pit..	Residuum of lower Tomstown; monoclinal structure.	Yellow, ferruginous silty clay; no limonite or manganese minerals observed.
7	Ingham mine.1/	Head of valley 1 mile ESE. of Ingham.	1890	Numerous small open cuts.	Residuum of lower Tomstown; monoclinal structure (sec. B-B', pl. 4).	Clay, containing much limonite and some hard manganese oxides; mined for iron.
8	....	Across divide ¼ mile south of last.	1890, 1930	One open cut of moderate size.	Residuum of lower Tomstown; monoclinal structure.	Clay, containing limonite and manganese oxides; some manganese taken out and shipped about 1930.
9	Little Ore bank.2/	East of Fultz Run, 1½ miles SSE. of Ingham.	Before 1918	Several prospect pits.	Residuum of lower Tomstown; monoclinal structure.	Buff clay, some chert and limonite; hard manganese oxides in one pit.
10	....	West of Fultz Run on divide, 1½ miles south of Ingham.	1890	One pit.......	Probably residuum of upper Tomstown.	Several carloads of iron ore reported to have been shipped from here.

1/ Stose, G. W., Miser, H. D., Katz, F. J., and Hewett, D. F., Manganese deposits of the west foot of the Blue Ridge, Va.: Virginia Geol. Survey Bull. 17, p. 67, 1919.
2/ Idem, p. 68.

Table 2.--Manganese and iron mines and prospects in the Elkton area—Continued.

No. (See pl. 4)	Name	Location	Approximate time of operation	Character of workings	Geology	Material penetrated
11	....	Southwest of Fultz Run, 2 miles south of Ingham.	?	Several prospect pits.	Residuum of Lower Tomstown; structure monoclinal.	One pit contains brown waxy clay; no iron or manganese minerals noted.
12	Smith mine.3/	South of Fultz Run, 2½ miles ENE. of Shenandoah.	1880-1900, 1930 (for clay)	Two large open cuts, some underground workings.	Residuum of lower Tomstown; structure monoclinal (sec. C-C', pl. 4).	Pink, brown, and white clay, white sand, and chert; large masses of limonite; mined for iron; no manganese minerals observed.
13	....	On slope south of Smith mine.	?	Prospect pits and small open cuts.	Residuum of lower Tomstown; structure monoclinal.	Sandy clay and limonite.
14	....	Near Stony Run, 3 miles east of Shenandoah.	?	Prospect pits, one on north and one on south side of run.	Residuum of lower Tomstown; structure monoclinal.	Northern pit shows white sandy clay; southern shows pink and buff sandy clay with some limonite and hard manganese oxides.
15	Boyer mine.	Near Stony Run, 2 miles east of Shenandoah.	1895-1905	Shaft 160 feet deep; tunnel 1,000 feet long.	Shale of Waynesboro formation; structure unknown (sec. C-C', pl. 4).	Hard brown silty shale, containing masses and veins of limonite; mined for iron; no manganese known.

16	Atwood or Kimball bank.4,5/	North and south of Wolf Run, 2½ miles east of Shenandoah.	1880-1900, 1940 (prospecting)	Three groups of large open cuts, many pits and shafts in intervening areas.	Residuum of lower Tomstown; structure monoclinal.	Northern open cut shows brown and white clay, some wad, and some hard manganese oxide. Middle open cut shows brown clay, containing chert and lumps, nodules, and large masses of limonite, wad, and hard manganese oxides. Southern open cuts show brown and white clay, containing much limonite, some chert, and small quantities of manganese oxides. Mined for iron ore and manganiferous ore.
17	Garrison bank See text.	....	....	....	....	....
18	Baker bank.	North side of Deep Run, 3 miles ESE. of Shenandoah.	1880-1890	Two open cuts, some pits; deeper workings reported.	Residuum of lower Tomstown; structure synclinal.	Brown, waxy clay, some chert, much limonite; manganese only as a stain on the limonite; mined for iron.
19	....	West of Watson tract, 1 mile NNW. of Furnace.	?	Two shafts and 14 pits, some shallow, some deep.	Older terrace deposits.	Two shafts show only gravel on dump; pits show hard, ferruginous clay and some nodules of limonite and hard manganese oxides.

3/ Locally called the "Chalk mine," erroneously described as the "Kimball mine" by G. W. Stose and others (op. cit. p. 68).
4/ Watson, T. L., Mineral resources of Virginia: Virginia Jamestown Exposition Commission, p. 245, 1907.
5/ Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 427, p. 56, 1910.

Table 2.--Manganese and iron mines and prospects in the Elkton area—Continued.

No. (See pl. 4)	Name	Location	Approximate time of operation	Character of workings	Geology	Material penetrated
20	Watson tract. See text.	....	....	....	....	....
21	....	Along Polecat Run southeast of Watson tract, between 1,400 and 1,560 feet.	?	Five pits; 1 tunnel; 1 10-foot shaft at 1,560 feet.	Residuum of lower Tomstown; structure synclinal.	10-foot shaft shows clay; other workings only gravel.
22	....	First ravine SE. of Polecat Run, 1,300 and 1,360 feet.	?	Two prospect pits.	Older terrace deposits.	Pits show only gravel.
23	"Watson prospects."6/	Second ravine SE. of Polecat Run, 1,220 to 1,500 feet.	1917 and later years.	Five pits along ravine, 1,200-1,400 feet; 2 pits on ridge to north near 1,350 feet; 1 cut and 200-foot incline at 1,500 feet.	Residuum of lower Tomstown; east flank of same syncline as that on Watson tract.	Most pits show clay, chert, and some hard manganese oxides; some show only gravel. Cut and incline show clay and hard manganese oxides.
24	....	South edge of Naked Creek Valley, ½ mile W. of Furnace.	?	Prospect pit.	Residuum of Waynesboro; structure unknown.	Silty shale, and perhaps some chert, no manganese or iron minerals noted.

25	....	South edge of Naked Creek Valley, ¼ mile SE. of Furnace.	1895	Prospect pit.	Residuum of upper Tomstown; structure unknown.	Yellow clay with large masses of limonite; some iron ore reported to have been dug and shipped.
26	Fox Mountain mine.7/	Low hill ½ mile SW. of Furnace.	1880-1900	Very large open cut; some smaller cuts.	Residuum of Waynesboro; structure complex (sec. E-E', pl. 4).	Yellow, red, white, and brown silty, decomposed shale, in part sandy, well-bedded, and laminated. Some bands of limonite parallel to bedding, but no large masses of ore are now in evidence; mined for iron.
27-30	....	Tract southeast of Furnace Post Office. See text.	....	....	....	....
31	....	Dry Run, west of road to Furnace, 2 miles NE. of Elkton.	?	Two prospect pits.	Residuum of Waynesboro; structure unknown.	Waxy silty clay, and some limonite.
32	Dean farm water well.	Valley of Wolf Run, $2\frac{1}{4}$ miles east of Elkton.	1930	Water well 40 feet deep.	Just north of Niggerhead fault, probably in Tomstown or adjacent fault breccia.	Dump shows pink and buff clay, small to large botryoidal nodules, and irregular masses of psilomelane, probably low-grade as they contain quartz grains and fragments of brecciated quartzite.

6/ Stose, G. W., and others, op. cit., p. 70.
7/ Stose and others (op. cit.) refer to this as the "Furnace mine" on page 71, and as the "Fox Mountain mine" on p. 82. These authors and T. L. Watson (op. cit., p. 434) erroneously place the Fox Mountain mine in the southeastern rather than the northeastern part of Rockingham County.

Table 2.--Manganese and iron mines and prospects in the Elkton area--Continued.

No. (See pl. 4)	Name	Location	Approximate time of operation	Character of workings	Geology	Material penetrated
33	Old Bartell workings.8/	Junction of Elk and Swift Runs, 1 3/4 miles ESE. of Elkton.	1880-1890	Several shafts and an open cut, all badly caved; outcrops on creek bank to north.	Residuum of lower Tomstown; in shallow syncline between Elk Run and Swift Run faults.	Red and gray waxy to sandy clay, rudely bedded, some limonite; no manganese oxides noted; probably mined for iron.
34	....	Ravine on west side of Swift Run, 3/4 mile east of Hanse Mountain.	?	Prospect pit, reported to have been 20 feet deep.	Residuum of basal Tomstown, making a small remnant in a syncline.	Hard to soft, buff or greenish, sandy clay; manganese minerals reported to have been found.
35	....	Near Elkton reservoir, 1 mile SE. of Elkton.	?	Three prospect pits, 1 on west slope, 2 on east slope.	Older terrace deposits, and underlying residuum.	Western pit shows nothing but gravel; eastern pits show brown, red, and gray waxy clays; no iron or manganese minerals noted.
36-42	Elkton mines. See text.	....	....	....	....	....
43	....	Northwest of Bartell shaft, in Number Three Hollow at 1,000 and 1,060 feet.	?	Two prospect pits or shafts, badly caved.	Older terrace deposits.	Show only gravel.

44	....	Three-fourths mile WNW. of Hanse Mtn. at 1,120 feet.	?	Prospect pit 15 feet deep.	Older terrace deposits, and underlying residuum.	Gravel, overlying red sandy clay; no manganese minerals observed.
45	....	One-fourth mile south of top of Giants Grave, in swale between it and next ridge SE.	?	Shallow prospect pit to north; shallow basin to south.	Older terrace deposits; underlying residuum probably not reached.	Quartzite gravel and some sandy clay; no manganese or iron minerals noted.
46-48	Tract between Giants Grave and Gap Run. See text.	....	....	....	....	....
49-50	Seller mine. See text.	....	....	....	....	....

8/ Stose, G. W., and others, op. cit., pp. 77-78.