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REPORT

ON THE

IRON ORES

IN THE

VICINITY OF CUMBERLAND GAP.

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ON THE IRON ORES IN THE VICINITY OF CUMBERLAND GAP.

The iron ores of economical importance in this region lie on the southeast of Cumberland Mountain, usually in the range of foot-hills known as the Poor Valley Ridge, which is almost always seen at the base of the mountain. Occasionally, this ridge disappears, and we find the ores on the flank of the mountain proper, near its base; but their occurrence in this position is exceptional.

The ores are, consequently, in Virginia and Tennessee; but as they occur so close to the Kentucky line, and are so intimately connected with Kentucky interests, in that they cannot be fully developed without the use of Kentucky fuels, an examination was made of them for a few miles up and down the mountain, from Cumberland Gap, to ascertain something as to their method of occurrence, quantity and quality, and to determine the capabilities of the region to sustain an iron-manufacturing industry.

The manufacture of iron from these ores with charcoal fuel has been, for a long time, carried on in this vicinity in a small way, at a number of places; both pig iron and blooms having been produced. It is, however, upon coal as a fuel that the permanent iron industry must be founded, and the coal which will, in the future, smelt the ores along the mountain for a considerable distance below, and for a still greater distance above Cumberland Gap, must come from Kentucky. There is no coal to the southeast in either Tennessee or Virginia, and Cumberland Gap affords the most feasible passage by railroad through the mountain, from the ore to the great Kentucky coal field.

Such being the case, these ores become of almost as much importance to Kentucky as to the States in which they are

situated, especially when we consider that their development is dependent largely upon a Kentucky railroad enterprise to give them access to market. Either of the projected railroads through Kentucky to Cumberland Gap, will find in the transportation of these ores, and of the iron made from them, one of the most important sources of revenue.

The ores of this region are stratified hematites, belonging to the Clinton Group of the Silurian formation, a group which has been designated as the Dyestone Group by Prof. Safford, in his report on the geology of Tennessee. The ore is variously known as the Dyestone or Fossil ore, and sometimes simply as the Red ore. It is called the Dyestone ore, from the fact that it is sometimes used for dyeing purposes by the residents of the region where it is found.

The rocks with which it is associated are usually shales, sometimes calcareous, which occasionally pass into thin-bedded sandstones. There are also occasional interstratified thin beds of limestone, which increase in frequency toward the lower part of the series, and below the ores.

The thickness of the group in Tennessee, as stated by Prof. Safford, varies from two hundred to three hundred feet. In this vicinity it is usually thicker, ranging from three hundred to five hundred feet. These rocks pass almost imperceptibly into the Medina sandstone below. This sandstone is here thin-bedded, and less marked in every way than it is further southeast, where it is the massive determining rock of Clinch Mountain; but it is still heavy enough to form, with the lower portion of the Clinton beds, the Poor Valley Ridge, or foot-hill range of Cumberland Mountain. The "Poor Valley," between the foot-hill and the mountain, is excavated in the thin-bedded, soft, and easily eroded Clinton rocks, and it is to their silicious nature, and the soil resulting from them, that the infertility of the valley is due. The Devonian shale and the Waverly also help in the formation of the valley to a certain extent, but the Clinton shales are particularly the valley rocks. Usually the shale above the ore occurs in the valley, and the upper ore (of the three to be hereafter described),

with a thin but hard sandstone immediately above it, is the highest and crest-forming rock of the Poor Valley Ridge.

As already stated, the ore occurs in beds or layers, interstratified with shales and limestones. It differs much in quality in the different beds; but when at its best, is an oölitic, greasy-feeling, fossiliferous hematite, formed at places almost entirely of fragments of crinoid stems. Other fossils are numerous, but by no means reach anything like the proportion of the crinoidal remains.

The ore has not been studied in sufficient detail over a large area, where it has been opened in depth, and the overlying rocks are fully exposed, to enable the writer to form a theory of its formation satisfactory in every respect; but the structure of the ore, in most cases, indicates, beyond reasonable doubt, that it was originally a bed of fossiliferous limestone. The original limestone has been dissolved and removed by the solutions which brought the iron and deposited it in the form and place of the limestone. The iron has probably been derived from the rocks above, and has been gradually removed by a process of leaching.

This ore is by no means a local deposit. It is characteristic of the rocks of this period, from New York to Alabama, and it is also found in the same formation in Wisconsin, of a quality that can hardly be distinguished from the New York or Tennessee ore. This marked uniformity of quality and position of the ore show that the waters, at the time of the deposition of these rocks, must have been very uniformly charged with iron over an area hundreds of square miles in extent. There is no similar formation in which iron ore is distributed with anything like so great uniformity, or of which it is so characteristic. Other ores are found usually connected with rocks of a particular formation, but they are by no means coextensive with that formation; they are, on the contrary, "pockety" and erratic. This, however, both in quality and position, maintains its identity along the parallel mountains of the Appalachian series for hundreds of miles. In the aggregate, therefore, it presents a mass of ore which is

practically inexhaustible, and is unequaled by any other deposit in the country.

In New York and Pennsylvania ore of this age is largely worked for the supply of blast furnaces; but south of those States it is almost untouched, although in Virginia and Tennessee a number of small charcoal furnaces and forges have been using it for many years past. Their consumption is so small that, in comparison with the vast amount remaining, what ore they have used is too small for notice.

There are usually found in the region under consideration three beds of ore. These have been found to extend with considerable regularity for five or six miles each side of Cumberland Gap. Whether they are persistent at a greater distance above the Gap than this is not yet known. Ore is found in good thickness at many places above; but the sections taken have not been detailed enough to prove the existence of more than one bed, although there is no reason to doubt that the others will be found when properly sought for. Below Cumberland Gap, at Speedwell Furnace, two ores have been worked, apparently corresponding to the middle and upper of the three above mentioned, with the distance between them considerably increased.

The positions and relative distances apart of the three ores are shown in the sections of the accompanying plate. These sections were all taken within a few miles of Cumberland Gap, and the most of them within one mile and a half. It will be seen from them that the ores are sometimes found at the foot of the mountain proper, and sometimes in the Poor Valley Ridge.

They are of the most value when they occur in the ridge, for the reason that there is then a larger amount of the ore above drainage level, where it can be much more easily and cheaply mined. It is also probable that, at a certain depth below the drainage level, the soft fossiliferous ore becomes hard, calcareous, and poor in iron; in other words, that it approaches the condition of the original limestone, and is no longer profitable to work in the furnace. This opinion is

not founded upon observations in this immediate region, for mining has not yet been carried deep enough to ascertain the fact; but it is based upon reports of mining operations upon the same ores at other and widely separated places. When the ore occurs in the Poor Valley Ridge, it dips nearly with the slope of the ridge on the mountain side, so that there is a large amount of it at a uniformly small depth below the surface; while, when it is in the mountain, it dips directly back from the surface; and even if it does not change its character, and become lean, it will soon become difficult and expensive to mine.

It will be seen from the accompanying sections, that the distance between the upper and middle ores varies from seventy to one hundred and five feet. The distance between the middle and lower ores is from two hundred to two hundred and fifteen feet.

The upper ore is the most valuable of the three in this region. It is soft, very fossiliferous, and much richer in iron than the middle ore, although it is not nearly so thick. It has been seen by the writer varying from fifteen to twenty-two inches in thickness, and it is reported on good authority at one place, where a full measurement could not be obtained at the time of visit, to be twenty-six inches thick. It is the only ore that has been worked in the furnace at Cumberland Gap. There is such an abundance of it in the neighborhood, and it is won so cheaply, that there has been no inducement to attempt to utilize the middle ore, which is both thicker and leaner than the upper. It is hard, silicious, and not very fossiliferous. It has been seen by the writer twenty-seven inches thick, and is reported, at other places, to be thirty inches. It seems to have been originally a silicious limestone, which is now impregnated with iron. It apparently corresponds to the "hard ore" of this same period in Pennsylvania, while the upper ore seems to be the counterpart of the "soft ore" of the same State.

At Speedwell Furnace, about twenty miles below Cumberland Gap, the middle or hard ore has been used in consider-

able quantities to mix with the soft ore, a purpose for which it is well adapted. This is the way in which the two ores can be profitably utilized. The hard ore, although richer and more valuable than is now commonly supposed by iron-makers in that region, is yet too silicious to work easily in the blast furnace alone. Mixed with the soft ore, however, it can be used with very good results.

Owing to its greater thickness, there is a larger quantity of this ore in a given area than of the upper ore, although its specific gravity is not so great.

The lower ore, which occurs about two hundred feet below the middle, is but little known, and never, to the knowledge of the writer, has been mined in this region. In quality, it very much resembles the soft upper ore; so much so, that specimens of it can scarcely be distinguished from the upper ore. It is, however, thin, not having been seen by the writer more than six or seven inches in thickness. Where this ore occurs in the mountain proper, and dips away from the surface, it will be of little value, as it is too thin to be profitably mined at present under such circumstances; but where, as shown in the lowest section of the accompanying plate, it lies near the surface of the ridge for a considerable distance, it can be worked at very reasonable rates, and a large amount of ore be obtained; as, with a thickness of from six to seven inches, each square yard covered by the ore will yield nearly half a ton.

The lowest section of the accompanying plate shows the position of the ores in the Poor Valley Ridge, at Cumberland Gap, just below the Tazewell road. It will be seen that both the lower and the upper ores lie here in the most favorable position possible for easy and cheap mining, as they are both near the surface, and only covered by a slight thickness of overlying material. The upper ore has been mined for the furnace at the Gap, beginning down in the valley and working upwards towards the crest of the hill, throwing the earth behind as each successive bench of ore is raised. In this way

the pits or benches are easily drained. The cost of mining the ore here is only fifty cents per ton.

This fortunate position of the ores in the ridge is continued for several miles below Cumberland Gap, interrupted occasionally by changes in the topography, where longer spurs than usual put out from the mountain, between streams, but returning again to their position on the ridge as soon as these are passed.

The section just referred to shows the slope of the ridge on which the ore lies to be about six hundred feet in width. At places below, on the ridge, it will exceed this measurement by nearly one half. It will, therefore, be safe to estimate the breadth above drainage of the ore stratum running along this slope of the Poor Valley Ridge at six hundred feet, or two hundred yards. The ore varies in thickness from fifteen to twenty-four inches, and it is probably under rather than over the average for this region to place it at eighteen inches; but in the following estimate of the quantity of ore in this ridge it is essential to keep within limits of safety. The ore has, according to the determination by Mr. Talbutt of two samples, a specific gravity of 3.94 and 3.91. Assuming a specific gravity of 3.9, a thickness of eighteen inches, and a breadth of ore belt of six hundred feet, there will be present, for each mile of the ridge holding the ore in this position, 538,319 gross tons. This estimate is, however, too great, in that it assumes the ore stratum and the surface of the ridge to be continuous, unbroken by ravines, gullies, and streams. No accurate estimate of the amount lost in this way can be made without a detailed contour map; but it is believed that one fourth will be more than ample to cover it. Deducting one fourth as lost in this way, we still have 403,740 tons of ore present per mile of the ridge. This estimate is made exclusive of any ore below drainage at the foot of the mountain proper, for the reason that it is as yet uncertain to what depth the ore will be found soft and rich; and it will be a long time before there is any demand upon it in this position. It is

simply desired to show how vast an amount of excellent and easily obtainable ore there is lying almost at the surface.

Where the belt of soft ore is two hundred yards in width, there will be in the same ridge above drainage one hundred and fifty yards in width of the middle or hard ore. This, with a specific gravity of 3.1, and an average thickness of twenty-seven inches, will contain for each mile of the ridge 462,404 gross tons of ore. Deducting one fourth, the same proportion as in the former case, for ore lost by ravines, streams, &c., and there remain 349,303 gross tons per mile. The estimate of one fourth loss in this case is much larger than in the other, as the ore lies so deep that it is not reached by many ravines which have cut the upper ore.

It is impossible to give accurate estimates of the quantity of available ore above drainage, where it does not lie in this favorable position on the Poor Valley Ridge, without a most minute study along the whole outcrop of the ore, and a contour line map showing its elevations at different points, as it varies for every mile of the distance, running out on the ridge when that is high enough to hold it, and again setting back at the base of the mountain as the ridge falls away in height.

Prof. H. D. Rogers, in volume I, of the Geological Reports of Pennsylvania, in giving an estimate of the quantity of ore of this kind, eighteen inches thick, present in the region around Danville and Bloomsburg, Pennsylvania, places it at fifty thousand tons for each running mile of outcrop. This is based upon the assumption that the soft ore will not be found of more than an average depth of thirty yards, ere it changes to hard, lean ore, which cannot be profitably mined. This assumption does not, however, prove true in every case, as Prof. J. P. Lesley states that mining operations at Bedford, Pennsylvania, have yielded the ore in perfect condition, at a depth of several hundred feet below the outcrop. It is probably safe to assume that the amount of available soft ore will average two hundred thousand tons, per mile, for the whole distance, and at many localities will much exceed this, as it grows thicker further up the valley.

About eighteen miles above Cumberland Gap, above where Martin's creek cuts through the Poor Valley Ridge, an exposure was seen, which showed the ore, slightly tumbled and broken, as follows:

Hard silicious ore	10	inches.
Good ore, somewhat broken	21	"
Solid ore	21	"
Total	52	"

The position of the ore at this point was such that it is barely possible there may have been a repetition in this measurement as it lay on a hill-side in a considerably disturbed position. It is not believed that such is the case, however, for it was examined very carefully. A single block of ore was seen lying near, twenty-seven inches in thickness.

At lower Pennington's Gap, the ore was found standing nearly vertical (dip 80°) in the Poor Valley Ridge, and thirty-five inches in thickness. It is commonly spoken of in this region as three feet thick, and probably does reach that thickness at many places. The ore at this point is unusually coarse in structure, being formed of large rounded globules, and containing numbers of small quartz pebbles. It is difficult to account for the presence of these in the ore on the commonly received theory of its formation by replacement of limestone.

At many other places between the above-mentioned points the ore has been seen, but it was usually only in loose outcrop, not in position where its thickness could be measured. It was seen often enough, however, to prove that it extends with great persistency all along the valley, although it may vary in thickness.

The quantity of ore, per mile, increases by many tons for each additional inch in thickness of the ore bed, so that when the above noticed increase in thickness is considered, it will be seen that the estimate of the amount of ore is considerably under, rather than over, the probabilities.

Where the middle or hard ore is present, it is safe to estimate an amount of it above drainage, for each mile, fully

equal to, or greater than the soft ore. It should be distinctly remembered, however, that these last estimates are mere approximations, and are not based upon sufficient data to render them worthy the credit due to the first estimates, which were founded upon more detailed observation.

QUALITY OF THE ORE.

The soft ore is of excellent quality, producing about fifty per cent. of iron, and working easily in the furnace. The hard ore is more silicious and poorer in iron, and will probably require admixture with the soft ore, to enable it to be smelted successfully. The quality of three samples of ore, from the immediate vicinity of Cumberland Gap, is shown by the following analyses by Dr. Peter and Mr. Talbutt, from samples collected by the writer:

	1	2	3
Iron peroxide	73.935	77.380	47.965
Alumina	5.776	3.941	2.130
Lime carbonate	4.510	.420	1.230
Magnesia	.266	. . . .	.194
Phosphoric acid	.319	.319	.575
Sulphuric acid	. . . . .	. . . . .	trace.
Silica and insoluble silicates	11.730	15.960	43.690
Combined water	3.850	2.500	4.000
Total	100.386	100.520	99.784
Metallic iron	51.754	54.166	33.575
Phosphorus	.140	.140	.251
Specific gravity	3.914	3.942	3.190

No. 1 is the upper or soft ore from the valley near the Virginia road, a short distance above Cumberland Gap.

No. 2 is the same ore from the ridge below Cumberland Gap.

No. 3 is the middle or hard ore from the ridge near the same place as last noted.

The above analyses show in all the samples a workable per centage of iron. The amount of phosphorus present is

decidedly less than is usually characteristic of the ore at other places. As a rule in other States, this ore is decidedly phosphatic, and produces a cold-short iron; but it proves to be exceptionally pure in this vicinity.

For comparison, there is herewith appended the following analysis of the hard ore of the same geological period from Dysart's mine, Huntingdon county, Pennsylvania, by Prof. Percifer Frazer, of the University of Pennsylvania:

Sesquioxide of iron	38.48
Protoxide of iron	4.37
Silica	37.99
Alumina	9.56
Lime	1.06
Magnesia	a trace.
Alkalies	2.54
Phosphoric acid	1.48
Sulphur	.05
Loss by ignition	4.50
Total	100.04
Metallic iron	30.34

It will be seen that it is very similar in constitution to No. 3 of the analyses just before given, except that it contains a larger proportion of alumina and phosphorus.

There is also herewith given an analysis, by Dr. Peter and Mr. Talbutt, of the pig iron made at the Cumberland Gap Furnace from the soft ore of the upper bed. It is a cold-blast charcoal iron, of excellent quality and great strength. It is used for car-wheel purposes.

ANALYSIS OF COLD-BLAST, CHARCOAL PIG IRON, CUMBERLAND GAP FURNACE.

Iron	92.828
Graphitic carbon	3.260
Combined carbon	.840
Silicon	1.668
Slag	.480
Manganese	.153
Aluminum	.766
Calcium	.112
Magnesium	.270
Phosphorus	.145
Sulphur	.068
Total	100.590

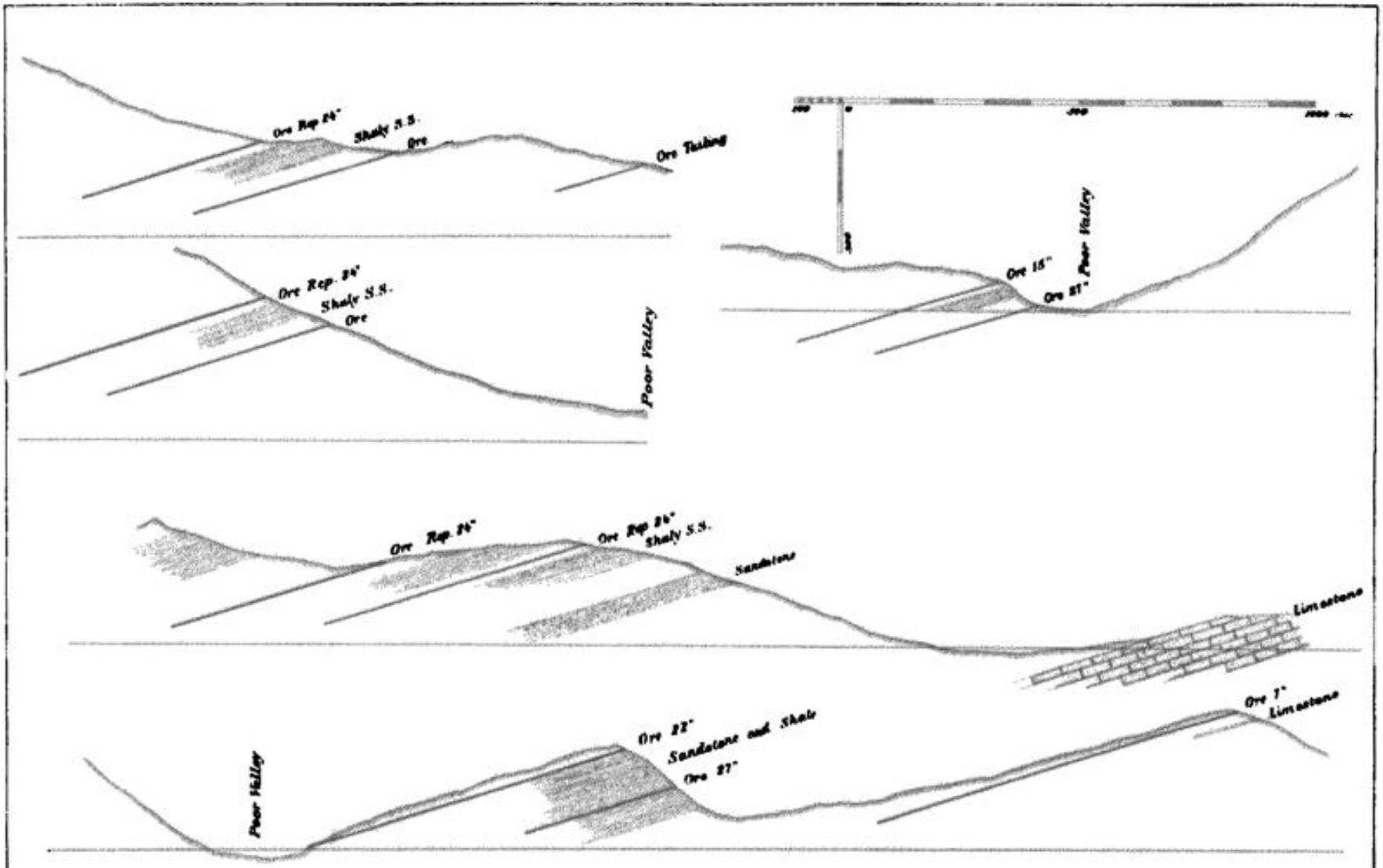
This iron is hauled to the Powell river and boated down to market at Chattanooga at times of high water. It is manufactured very cheaply at the furnace; but the expense, risk, and uncertainty of the transportation to market, greatly reduce the profits on its manufacture, and leave only a narrow margin at present prices for iron.

The cheapness with which iron can be manufactured at this place will be realized when it is understood that the ore is delivered at the furnace throat for one dollar per ton, thus costing only two dollars to the ton of iron for the ore.

Furnaces lower down in Tennessee and in Alabama, smelting ore of this kind with coal or coke, produce iron at as low or lower prices than in any other part of this country. It is stated, on very competent evidence, that the Roan Iron Furnaces of Rockwood, Tennessee, make iron for less than fifteen dollars per ton.

With a railroad from the central part of the State through the mountain at Cumberland Gap, so that the Kentucky coal can be used with this ore, this locality can produce iron as cheaply as any other point in this highly favored valley, and can place it in market at lower rates.

It is destined to be one of the great iron-manufacturing regions of the country, and only awaits facilities for the transportation of its product to inaugurate a wonderful development of its resources in this direction.



SECTIONS SHOWING THE POSITION OF THE FOSSIL ORE BEDS IN THE VICINITY OF CUMBERLAND GAP TO ACCOMPANY REPORT OF P.N.MOORE