On the Mineralogy of the Malvern Hills

By Leonard Horner, Esq.

Secretary of the Geological Society.

§ 1. The Malvern hills are situated in the south-western part of Worcestershire: the boundary which divides the counties of Worcester and Hereford, passes along their western side.

§ 2. They consist of an uninterrupted chain of about nine miles in length, extending nearly in a straight line from north to south; their greatest breadth from east to west not exceeding two miles. The several parts of the chain all present rounded summits, and from one extremity to the other they are nearly covered with a luxuriant vegetation.

§ 3. When viewed from a little distance on the eastern side, we see that there is a gradual rise from south to north, and that there are three hills which form the principal features, as they stand considerably above the general outline. The highest of these is in the centre, and is known by the name of the Herefordshire Beacon; but the greater elevation of this hill above the other two is not very apparent on this side, as it falls back to the eastward, and rather stands out from the general direction of the range. On the top of this hill are the remains of a camp, with a treble ditch. Some have imagined it Roman, because of the praetorium, or centre part, and the name of the
prominent hills are situated nearly close together at the northern extremity; of these, that which is farthest south is called the Worcestershire Beacon, and is the highest of the two; the name of the other is the North-hill.

§ 4. On the eastern side, the hills rise at a considerable angle, from a level plain that stretches to the banks of the river Severn, a distance of between three and four miles. On the western side, the ascent is more gradual, and the country for several miles to the westward is formed of a succession of small hillocks which are covered to their tops with coppice wood: the longitudinal bearing of these, is in general parallel to that of the range. There is a very extensive and beautiful view from the top of the Malvern hills, and the different appearances of the two sides present a very remarkable contrast: on the one hand, the widely extended plain of Worcestershire stretching for many miles to the eastward, the continued level of which is only here and there interrupted by small wooded eminences rising in detached spots; on the other hand, a constant succession of rising ground, which is terminated by the distant Welsh mountains.

§ 5. The eastern side does not present the same continued slope that extends on the western, from the summit to the base, but is very much broken by narrow vallies or water courses that run at right angles to the direction of the range. Besides these, there are some vallies of more considerable extent: two of them are at the northern extremity, the one separating the Worcestershire Beacon from the North-hill, the other dividing this last from what is

"parish, in which the greater part of it is situated, Collwall, that is Collis Vallum. Tho whole circumference of it is two thousand nine hundred and seventy yards, the length one thousand one hundred yards. The whole camp contains forty-four statute acres." Nash's History of Worcestershire.
Mr. Horner on the Mineralogy of the Malvern Hills. 283

termed the End-hill. Where the Herefordshire Beacon falls back to the westward, occurs a wide, and in some places thickly wooded, valley, in the bottom of which is situated the retired village of Little Malvern. All these valleys run from west to east, and gradually widen as they descend. There are none parallel to the direction of the chain.

§ 6. In Nash’s History of Worcestershire, the highest point of the Malvern Hills is said to be 1313 feet above the level of the Severn at Hanley. In the table lately published of the altitudes taken in the course of the Ordnance Survey in different parts of England, the height of the Malvern Hills above the level of the sea is stated at 1444 feet. I am informed by Lieut. Col. Mudge that the particular hill to which this measurement refers, is that situated in the centre of the range, the Herefordshire Beacon. I had not an opportunity of ascertaining the height of this hill above the adjacent plain; I obtained however that of the Worcestershire Beacon and of the North-hill. The instrument I made use of was Sir Henry Englefield’s portable barometer, and the following are the results of my observations. My lowest station was at the north-eastern extremity of the common, called the Links, from which point there is almost a dead level to the banks of the Severn.

<table>
<thead>
<tr>
<th>Location</th>
<th>Height (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Worcestershire Beacon</td>
<td>1238</td>
</tr>
<tr>
<td>The North-hill</td>
<td>1151</td>
</tr>
<tr>
<td>The road before the door of the Crown-hotel, in Great Malvern</td>
<td>273</td>
</tr>
</tbody>
</table>

As the right bank of the Severn, at the termination of the plain from which these measurements are calculated, is between sixty and
seventy feet in perpendicular height, this added to the above elevation of the Worcestershire Beacon, very nearly corresponds with the statement in Nash's History of Worcestershire.

§ 7. The whole range from one end to the other is, as I have already mentioned, almost entirely covered with vegetation. It is only in a few places that the rock projects above the surface; this is more particularly the case at the northern extremity, and there, principally on the eastern side; the western slope hardly offers in any part of it any thing more than a very fine close turf: even the rocks that do appear are in general thickly coated with lichens, and decomposed at the surface; so that it is difficult without a very close examination, to obtain an accurate knowledge of the mineral structure of these hills. There are however several quarries worked in different places and at different heights, and besides the opportunities which these afford to the mineralogist, there are two carriage roads that cross the hill, in the making of which, the rock has been in many places laid bare. The most northern of these, rises gradually along the side to within thirty or forty feet of the summit, where a cut has been made through the hill from east to west, thus exhibiting a transverse section of the rocks: this chasm is known by the name of the Wych. The other, is the turnpike-road from Worcester to Ledbury; it crosses the hill immediately above Little Malvern, passing along the side of the Herefordshire Beacon, and in the making of this road the rock has been in different places cut down to the depth of twenty or thirty feet.

§ 8. Besides the obstacles to accurate observation, that I have already mentioned, there is another difficulty which it requires some patience to overcome. The greatest proportion of the rocks are in that state which the quarriers term rotten; which means, that when a block of the stone is struck with the hammer, it breaks into a number of small irregular fragments, frequently not exceeding the
size of a walnut, the surfaces of which are generally covered with oxide of iron, probably arising from a partial decomposition. This is the case, not merely near the surface, but in some degree even where the rock has been quarried to a considerable depth. This peculiarity renders it very difficult to obtain such a fracture as shews the real nature of the rock, and makes it almost impossible to procure good cabinet specimens.

§ 9. When I first began to examine the rocks of which these hills are composed, I was particularly struck with the great variety that presented itself, for almost every specimen which I detached within a very limited space, offered a new character. A closer examination, however, shewed that there is a greater uniformity than I at first suspected, and that the diversity of appearance depends on the different proportions in which the same materials are united together. Felspar, hornblende, quartz, and mica, forming different compound rocks, and varying as much in the size as in the proportions of the ingredients, constitute the greater part of the range. There are very few rocks in which the size of the component parts is so minute as to give the internal structure a homogeneous appearance.

§ 10. If every “compound granular aggregated rock, composed of felspar, quartz, and mica,” is to be considered as granite, a very great part of the Malvern hills is composed of it; but among the various compounds of that nature, found in this place, there are very few which present the same appearance as the granite of Alpine countries; they have not the decided crystalline structure, which these granites usually exhibit; nor are the several parts so closely intermixed. The felspar is generally red, and predominates considerably in the mass; sometimes the quartz and sometimes the mica is wanting, but more...
frequently the latter. I shall, however, for the sake of brevity in the following descriptions, distinguish all those rocks, in the composition of which these three ingredients are found, however disproportionate they may be to each other, by the general name of granite. I feel the more warranted in doing so, from what Mr. Jameson has said in the definition he gives of granite. "The parts," he says, "vary in quantity, so that sometimes one, sometimes the other, and frequently two of them, predominate. Felspar is generally the predominating, as mica is the least considerable ingredient of the rock. In some varieties the quartz is wanting; in others the mica; and these have received particular names. Such distinctions, however, are useless." But I considered it necessary to give this previous explanation of the peculiarity of their structure, as the mere term granite would convey to most mineralogists, an erroneous idea of the true nature of the rocks I now allude to. I shall also, for the sake of brevity, occasionally distinguish those rocks in which hornblende forms a predominateing ingredient by the general name of sienitic rocks. It would be an endless task to give separate names to the various compounds met with in the Malvern hills, although they certainly have different external appearances; and were I to attempt to do so, I should perhaps be making distinctions, which their origin does not warrant, as all the varieties comprehended in the same class have probably been produced under similar circumstances. But in the present state of geological science, and more especially when the great imperfection of the nomenclature of rocks is considered, it would be well if geologists made a practice of describing the simple minerals of which a rock is composed, wherever they can be distinguished, instead of giving specific names without any explanation of the nature of the

* Jameson's Geognosy, p. 102.
Mr. Horner on the Mineralogy of the Malvern Hills.

compounds to which their terms are applied, and particularly those in which theory is involved. They would thus be following a more precise and more philosophical method, the accuracy of their observations would be more firmly relied on in the present day, and there would be a greater probability of their proving valuable in a more advanced state of the science. Those who have had an opportunity of seeing the various rocks to which the names grauwacke and greenstone are applied, will perhaps agree with me in the opinion I have thus ventured to advance.

§ 11. Before proceeding to a detailed account of the several rocks met with in the Malvern hills, I shall point out the general structure of the great masses. The central part of the range, and nearly the whole of the eastern side consist of the different compounds of felspar, hornblende, quartz, and mica, I have already alluded to. These are irregularly heaped together in large masses, and in no part could I discover them disposed in any way that could be considered as continued stratification. In some instances, the materials of the rock are so arranged as to give it a fissile appearance, and in these cases, the slaty structure is either vertical or very highly inclined. But the masses themselves I never found to be of any great extent, and they are frequently inclined to different points of the compass within a very short space. Except in regard to the granite, I did not discover any uniformity in the occurrence of any one compound in particular situations, but all seem confusedly heaped together. The granite is sometimes found in the highest parts of the hills, but chiefly prevails in the lower parts, particularly towards the northern extremity, either in large masses, or what is very frequent, forming veins which traverse the other rocks. These veins or shoots are for the most part narrow, and, as far as I had an opportunity of ascertaining, they generally become more so, the higher they ascend.
§ 12. The stratified rocks which occupy the country to the westward, rise in some places to a considerable height on the side of the range; the highest point where I found them, was on the Herefordshire beacon, at about one third of the elevation of that hill. The particular arrangement of these stratified rocks I shall relate in a subsequent part of this paper.

§ 13. I have deposited in the collection of the Society, a series of specimens illustrative of the mineralogy of the district I am now describing. Among these, there are several which may at first sight appear to be duplicates, but they all possess shades of difference; and in a collection of the mineral productions of any particular district, it is material that every variety should be contained, for by these gradations the connection between rocks of very dissimilar appearances is frequently made out. The specimens of the unstratified rocks are chiefly from the northern part of the range where the rock is most exposed.

Of the unstratified Rocks.

§ 14. Although some of the rocks I shall describe under this head have a slaty structure, and as such, were probably formed by successive deposition; yet as they are of comparatively rare occurrence, and when found, are only in irregular masses without any continued stratification, I shall employ this term to distinguish the rocks that compose the central part of the range, from the stratified rocks, which, as I have already said, occasionally rise to a considerable height upon the western side of it.

§ 15. The most northern point where the unstratified rocks are seen above the surface, is about a quarter of a mile in a direct line from
Mr. Horner on the Mineralogy of the Malvern Hills. 289

the road which winds round the End-Hill. The rock found in this place is of a dark green colour, of a loose texture, and is composed principally of steatite, with a little felspar and quartz. It is traversed by a slender vein of granite, but as there is a very inconsiderable mass of the rock exposed, I had not an opportunity of tracing the vein but for a very short way.

§ 16. A great part of the End-Hill is composed of granite, particularly on the west side, where it contains veins of quartz in several places. It occurs near the bottom of the hill on the south-east side, and is also found in very large masses on the opposite side of the valley which separates the End-Hill from the North-Hill. In this valley I found a loose block, composed of white felspar, grey quartz, and greenish-black mica, with a little hornblende. In one part of the specimen that I detached from the mass, these materials become more minute, and assume somewhat of a slaty structure. Where this is the case, the mica is more abundant.

§ 17. In the same part of the End-hill, but at a higher elevation than the granite, there is a rock which prevails very much throughout the whole range. It is of a purplish-brown colour, with a fine close-grained texture and an uneven fracture. It is composed of hornblende, felspar, and a little quartz; sometimes contains a small quantity of magnetic pyrites, and slender veins of compact epidote; in the fissures of it, crystallized sulphate of barytes and minute rhomboedral crystals of ferriferous carbonate of lime are also occasionally met with: this rock would probably be arranged with the greenstones in the classification of Werner. On the west side of the End-hill, and in some part of the eastern side, a rock is met with, the characters of which correspond very nearly with those of sienite; it is composed of hornblende and felspar, with a few spangles of mica.

§ 18. On the northern side of the End-hill, a rock occurs
Mr. Horner on the Mineralogy of the Malvern Hills.

which differs very essentially from those that I found in any other part of the range. It is composed of nearly an equal mixture of hornblende and epidote in small grains, with a few specks of mica. It is of a yellowish-green colour, of a close texture, with rather an uneven fracture, and is crossed in all directions by slender veins of compact epidote. In some instances, the surfaces of the irregular fragments into which it breaks, are covered with minute crystals of magnesian carbonate of lime, and with slightly magnetic oxide of iron: the rock itself does not act upon the magnet. It occurs in very large masses, but neither in the disposition of these, nor in the internal arrangement of its parts, does it exhibit any signs of stratification. Within a very limited space, it assumes different aspects; the difference seeming chiefly to depend on the greater or less abundance of the epidote, and also on different states of decomposition.

§ 19. The epidote is found on the End-hill, under various appearances; in some of these, the crystalline forms peculiar to this substance may be seen; but I did not meet with any complete well-defined crystals: it is most commonly found in a compact and granular state, forming small veins of a yellowish-green colour, which sometimes pass through the granite, and sometimes through the sienitic rocks. It is not confined to the End-hill, but I found it in greater abundance there than in any other part of the range, particularly on the northern side of the valley, which separates that hill from the North-hill, and among the loose fragments that are scattered over that valley. It is very often found in veins mixed with quartz and with felspar, but the only place where I found it forming the constituent part of a rock was at the northern face of the End-hill. In some instances, the epidote would scarcely perhaps be recognized, especially where it is much mixed with felspar or quartz; but if a series of specimens be examined, from that in which it is very abun-
Mr. Horner on the Mineralogy of the Malvern Hills. 291
dant, and exhibits the distinctive characters of the simple mineral, to
that in which it is with difficulty perceptible, very little doubt will
remain of its existence in the latter.

§ 20. This mineral is not of very common occurrence in its
simple state, and is probably less so as a constituent part of a rock;
for it is not noticed as such in the Wernerian system, nor am I
aware of its being mentioned in any mineralogical work, except in
a very few instances. Brongniart, in treating of epidote says, "This
" mineral seems to belong exclusively to primitive countries, but it
" does not usually enter into the structure of rocks. It is found
" crystallized in the fissures of these rocks, or in the cavities of veins,
" and even penetrates the substances composing the veins in all direc-
" tions; it is thus that it traverses carbonate of lime, quartz, &c."*
He does not however name any place where it is found to enter into
the structure of a rock. Saussure met with it not far distant from
Mont Blanc: "On the road," says he, "from Modane to Villa-
" rodin, in descending the hill above this village, I found in the high
" road and in the walls of the houses, stones of a very beautiful
" green, sometimes mixed with white. The green parts, some of
" which are yellowish-green, having a sparkling lustre, granular and
" hard, are of the same nature as the green schorl of Dauphiny.
" This schorl I name Delphinite,† to distinguish it from some other
" green schorls of a very different nature. These yellowish parts are
" therefore granular delphinite. The parts of a leek-green, which are
" included in this stone, and which have a schistose or lamellar struc-
" ture, are hornblende. The white parts are crystalline and granular

* Brongniart, Traité Élémentaire de Minéralogie, tom. i. p. 412.
† This substance has obtained a great variety of names. It is called Glassy Actyno-
lite by Kirwan, Thallite by La Metherie, Akanticone by Dandrada, Pistazite by Werner,
and Epidote by Hauy.
"felspar."* From this description, the epidote may be considered as forming a constituent part of the mass, and it accords with some of the varieties I found on the Malvern-hills. But as the rock which Saussure met with was in detached pieces, we cannot determine whether they were not portions of a vein.

§ 21. Since my attention has been directed to the subject, I have ascertained that epidote occurs in Cumberland, and in the Islands of Iona and Rona, two of the Hebrides, in a state similar to some of the varieties I found on the Malvern-hills. In examining some specimens from those places in the collection of Mr. Greenough, I found the following.

1. From Cumberland.

a. Crystallized epidote shooting through quartz, from Wallow Crag near Keswick, very similar to what is found in the valley of Chamouni. It is more distinctly crystallized than any I saw at Malvern. The specimens are evidently portions of a vein.

b. Epidote in a compact state, mixed with reddish felspar, forming a vein in a schistose rock from the same place.

2. From Iona.

Compact epidote disseminated in small veins, through a rock consisting of red felspar and quartz.

* Saussure, Voyages dans les Alpes, § 1225.
3. From Rona.

a. Compact epidote of a bright yellowish-green colour, forming slender veins which traverse a rock principally composed of flesh-red felspar and a little grey quartz. It is very similar to that from Iona, except that this contains less quartz.

b. A rock composed of hornblende and reddish felspar, together with epidote, both as a constituent part and in veins passing through the rock.

These two specimens, and particularly the first, are nearly identical with some of the varieties from Malvern.

c. Compact epidote in small threads passing through vitreous quartz.

Dr. Wollaston, who had the goodness to compare, at my request, the above specimens from the Western Islands, with those I brought from Malvern, has since found the epidote in similar circumstances, in the Islands of Guernsey and Jersey; and he has been so kind as to give me some of the specimens he collected. They are as follow:

a. A granular rock, composed of yellowish-green compact epidote and hornblende, in small grains. It is nearly the same as that which I found on the northern face of the End-hill; the only difference is, that this specimen from Guernsey contains a greater proportion of epidote.

b. This so exactly resembles the specimen a from Rona, that they might be considered as portions of the same mass.

c. Granite consisting of reddish felspar, white quartz and a little greenish-black mica, including a mass of epidote crystallized in slender divergent prisms. This specimen is from Jersey.

§ 22. On the summit of the ridge which connects the End-hill with the North-hill, there is a rock almost wholly made up of horn-
Mr. Horner on the Mineralogy of the Malvern Hills.

blende, with a few spangles of mica and a little felspar. Near this, I found granite, which may perhaps be a vein, as the mass is very narrow, and the hornblende rock occurs on both sides of it; but the turf forms so close a covering, and leaves so very little of the rock exposed, that the relation between the hornblende rock and the granite cannot be determined.

§ 23. The western side of this ridge is principally composed of a rock of a reddish-brown colour, in which the chief ingredients are quartz and felspar, together with mica and a little epidote: in some of the fissures of it there are minute crystals of quartz and of felspar. On this side of the ridge I also found granite, containing subordinate portions of hornblende; in some parts of the same mass, the hornblende becomes the prevailing ingredient, and the mica is wholly wanting; thus passing into sienite. It is of very small extent, and the micaceous rock just mentioned occurs on both sides of it.

§ 24. On the summit of the North-hill, a very small portion of the rock is laid bare, and it is so much decomposed, that a gentle blow of the hammer makes it break down into very small fragments. I succeeded however in obtaining a fracture that shewed the composition of the stone, which is a mixture of hornblende and reddish felspar in very small grains, similar to that noticed § 17 as occurring on the south-east side of the End-hill, and as prevailing very generally throughout the range.

§ 25. A considerable part of the north-eastern side of this hill, is composed of granite. This I have already stated to be identical with that on the opposite side of the valley in the lower part of the End-hill, § 16. This is the only place in the whole range, where I found the arrangement of the rock-masses exhibiting any signs of stratification; but the indications of it are so very indistinct, that I hardly think the rock can be considered as stratified. If it is so,
the strata are very highly inclined, and dip to the east. In the spaces that intervene between large masses of the granite, there is a rock composed of hornblende and mica, with somewhat of a slaty structure and a loose friable texture. It is intersected by veins, which are sometimes very slender, and in that case they consist of red felspar; but when the same vein becomes wider, it is found to contain the usual component parts of granite. These veins are disseminated irregularly through the mass, the line of separation is very distinct, and there is no mutual penetration of the two rocks.

§ 26. On the south-east side of the North-hill, and at the entrance of the valley above Great Malvern, which separates that hill from the Worcestershire Beacon, there is an aggregate rock consisting of small angular and rounded fragments of quartz and felspar, cemented by a ferruginous earthy base; the whole in a decomposing state. It occurs in the lower part of the hill, and is probably produced from the disintegration of a granite, the mica of which has been chiefly decomposed and has afforded the cement. Above this aggregate rock, the hill consists almost entirely of granite, in which the materials are in some places so disposed as to give the rock somewhat the appearance of gneiss. It is fresher than most of the rocks in these hills, that is to say, it is less disposed to break into irregular fragments with decomposed surfaces. It sometimes contains veins of epidote, and in one instance I found in it a slender vein of calcareous spar. Subordinate portions of a mixture of hornblende and felspar occasionally occur in it, and sometimes the hornblende, felspar, quartz and mica are combined in equal proportions, forming a uniform mass. In this part of the hill, I also met with a fine-grained rock, consisting of quartz, felspar, mica and granular epidote, traversed by a narrow vein of granite.

§ 27. The upper part of the Worcestershire Beacon is composed
of granite, and the rocks which rise above the surface, about a quar­
ter of a mile to the south, are of the same nature. On the eastern
side, the greenstone I have described, § 17, forms the prevailing
rock. I found in this place, another compound of hornblende
and felspar, which has perhaps more distinctly the appearance
of a greenstone than the other. The constituent parts are larger
grained, and the felspar is white: magnetic pyrites are disseminated
through the mass.

§ 28. About the middle of the hill on this side, I found a rock of a
brownish olive colour, of a close texture, with an uneven fracture,
and, as far as the fineness of the grain enables me to determine, com­
posed of hornblende and felspar, but chiefly the former; there are also
some detached portions of calcareous spar imbedded in it. It is
attracted by the magnet. When broken, it appears full of angular
fragments; and I in consequence considered it of secondary forma­
tion, but when the fracture is made across the fragments, they are
found to be composed of the same materials as the base in which they
appear imbedded, nor can they be distinguished from it; I am there­
fore of opinion, that the fragmented appearance arises from a dispo­
sition in the rock to split into small irregular pieces with decomposed
surfaces, a peculiarity I have already noticed as being common to most
of the unstratified rocks of the Malvern hills.

§ 29. In a lower part of the hill, and close by the high road,
there is a very loosely aggregated red and white quartzose sandstone,
accompanied with patches of reddish-brown clay, containing fragments
of a granitic rock, and of the sandstone itself. The situation of this
sandstone is remarkable; it occurs at a considerable height above the
plain, it offers no signs of stratification, and is of very small extent,
lying as it were in a hollow of the other rocks. It is very similar to
what is found in the plain below, except that the latter contains some
Mr. Horner on the Mineralogy of the Malvern Hills. 297:

calcereous particles which this does not. It is evidently produced from the disintegration of other rocks, probably those of the chain, and has every appearance of being of very late formation.

§ 30. On the north-east side of the Worcestershire Beacon, and in the road leading from Great Malvern to St. Ann's Well, I found a rock of a loose coarse-grained texture, with an earthy fracture, composed of mica and hornblende in a state of decomposition, mixed with red felspar. It has a slaty structure, which in some places is more distinct than in others from there being a greater proportion of mica, and its disposition is, within a short space, sometimes vertical, sometimes inclined at a considerable angle, and dipping to different points of the compass; having the appearance of large masses irregularly heaped together. This rock is traversed by a vein of sulphate of barytes about four inches in thickness, and which occasionally includes detached portions of the rock through which it passes. The particular spot where I saw this rock, was where an excavation had been made in the hill round a house newly built, and as the rock was cut down to a considerable depth, a good section of it was exposed to view.

§ 31. The western side of the Worcestershire Beacon is covered with turf, so that whatever rocks occur there, are completely concealed.

§ 32. Between the Worcestershire Beacon and the chasm called the Wych, the rocks, on the eastern side, are similar to those I have already mentioned, except in one instance on the top of the hill, where a rock is found composed of greenish-brown mica, intermixed with hornblende. Although mica is the chief ingredient, this rock has not the slaty structure which most micaceous rocks have, but the laminæ which are pretty large, are irregularly grouped together, and cross each other in all directions. It is an insulated mass of
very small extent. In this place, a hundred years ago, a shaft was sunk in the hope of finding metal, but from the following account in Nash's History of Worcestershire, the attempt does not appear to have been attended with much success. "In the year 1711, one Williams of Bristol sunk a mine about a mile from the town (Great Malvern), on the top of the hill as you go to the Holy Well. He at first worked by a level, about eighty yards, then sunk a perpendicular shaft, near 220 feet deep: he built several furnaces, but never extracted any considerable metal; though he asserted that both tin and copper were to be found. He persevered in his trials for ten years, and then gave up the project." It is very probable, that the metallic lustre of the micaceous rock was the cause of the speculation; and to this day, the country people call the scales of mica, which are washed down by the streams in this part of the hill, gold dust. They are, however, so far aware of the difference, that they save themselves the trouble of collecting it. There is now no appearance of the level, and the shaft is almost completely filled up; a large heap of loose stones however lies upon the side of the hill, immediately below the mouth of the shaft, which is probably the rubbish of the mine, although it is so long since it was worked; for there are no rocks above from which they could have fallen down. Among these, I found the following varieties:

a. Composed chiefly of hornblende, mica, and felspar. In some places the mica is crystallized.

b. The same rock as the preceding, but containing a larger proportion of flesh-red felspar. A small quantity of copper and iron pyrites is disseminated through the mass.

c. A friable rock, composed of greenish black mica and green decomposing felspar.
§ 33. In the road which leads up to the Wych, the rocks are laid bare in several places. That which is the most prevalent, is the fine grained greenstone I have mentioned, as forming so great a part of the northern end of these hills, §§17.24. There are besides, several other compounds of hornblende, felspar, quartz, and mica, united in various proportions, which are very similar to those I have already spoken of, and which it is now unnecessary to describe in a more detailed manner. These are traversed in many places by veins or shoots of granite: in one of these, the constituent parts are of a larger size than usual, and the mica is regularly crystallized; but it is decomposed near the surface. In one place, there is a vein of white opake quartz intermixed with silvery mica. All these rocks are so confusedly heaped together, and in so shivery a state, that it requires some attention before their real nature, and their relative situations can be well understood.

§ 34. At the Wych, where the rocks have been cut through, as mentioned in § 7. granite is the prevailing rock; in this, red felspar predominates, and the mica, which is also in some places very abundant, is of a dark green colour. Slender veins of calcareous spar are occasionally met with in this granite. There is a considerable quantity of another rock, which seems to fill up the spaces that intervene between the masses of granite. It is chiefly argillaceous, of a dark olive-green colour, with an imperfect slaty structure, and when broken across, shews an earthy fracture: the flat thin masses into which it splits have smooth and shining surfaces, as if polished by friction; it occasionally contains veins of calcareous spar. In some places it is found decomposed, and in that state it becomes very friable. I did not meet with this argillaceous rock in any part of the range that lies to the north of the Wych. I found here some small portions of a granite partially decomposed, and the surfaces of the frag-
Mr. Horner on the Mineralogy of the Malvern Hills.

ments into which it breaks are covered with dendritical delineations of manganese. The same kind of granite also occurs in a quarry by the side of the road near Little Malvern.

§ 35. Between the Wych and that part of the hill where the road from Worcester to Ledbury crosses it, a distance of about three miles, the rock is seldom seen above the surface of the ground on either side. I examined most of the places where it does appear, but did not find any thing different from what I had met with in the northern part of the range.

§ 36. The road now mentioned, rises along the side of the valley above Little Malvern, and winds round the northern face of the Herefordshire beacon. In making it, the rock has been cut down considerably on one side. I found a greater uniformity in the rocks of this part of the range, than in those which compose the northern half; there is less granite, and hornblende also occurs more rarely. The most prevalent rock is one of a pale flesh colour, of a fine grain, and chiefly composed of compact felspar: it is very full of fissures, so that it easily breaks into small irregular fragments, the surfaces of which are covered with yellow oxide of iron, and on some of these there are minute dendritical delineations of manganese. They are also occasionally covered with small rhomboidal crystals of spathose iron of a golden yellow colour, with a metallic lustre. Calcareous spar, sometimes in distinct crystals, is likewise occasionally met with in it. This rock forms the greater part of the hill to the north of the road, as well as that part of the Herefordshire Beacon through which the road has been cut: but what this last hill is chiefly composed of, I am unable to say, as it is nearly covered with vegetation on all sides.

§ 37. A short way to the south of the Herefordshire Beacon, there is a mass projecting above the surface, which consists of a fine grained
Mr. Horner on the Mineralogy of the Malvern Hills. 301

conglomerate, of a dark brown colour, composed of felspar, steatite, and calcareous spar, united by a ferro-argillaceous base, and containing some minute specks of a greenish yellow substance, in diverging fibres, which is probably actynolite. The rock is attracted by the magnet.

§ 38. In a lane at the foot of the Herefordshire Beacon, on the western side, I found a vein of red hematite, passing through a rock consisting of red felspar and quartz, partially decomposed.

§ 39. The next height to the south of the Herefordshire Beacon is Swinnit-hill.* The upper part of this hill is composed of a granite, that is more distinctly characterized as such, than the greater part of those found in the Malvern Hills: still, however, it is very different from an Alpine granite, the mica is in minute specks, and there is also a very small proportion of it. In the lower part of the eastern side of the hill, the rock has been excavated to a considerable depth at Castle Morton quarry; it consists chiefly of hornblende, with a little reddish white felspar and quartz, and in some places it contains pyrites. Among a heap of large blocks, that had been recently got out of the quarry, I observed this rock penetrated in many places by veins consisting of flesh red felspar and grey quartz: when the vein was narrow, these were the only ingredients; but where it became wider, silvery mica also formed a component part of it, and in some places it was accompanied with steatite. I was prevented from examining the spot from whence these blocks were taken, in consequence of a heavy rain having, a few days before, washed down so much earth from the upper part of the hill, as to fill up the place where the quarriers had been at work.

§ 40. About a quarter of a mile further south, I found a schistose

* I write the name of this hill, as it is pronounced by the country people. I have not seen it in any map, nor in the county history.
rock composed of hornblende and mica, intermixed with a small quantity of felspar, quartz, and pyrites. It occurs in large masses irregularly heaped together, and the relative position of the schistose structure in the different masses preserves no uniformity. It is traversed by granite veins, varying from one to six inches in thickness, branching in different directions, and diminishing in thickness as they ascend. This schistose rock is very similar to one that occurs by the side of the road leading up to the Wych, where it is also traversed by granite veins.

§ 41. A deep but narrow valley separates Swinnit Hill from the Holly-Bush Hill. In this valley, and in the lower part of the latter hill, I found the following rocks:

a. Different varieties of gneiss, imperfectly characterized. It seems to bear the same relation to true gneiss, that the granite of these hills has been described to bear to Alpine granite.

b. A fine grained sandstone, consisting principally of quartz, with a few particles of felspar and mica; in some places it includes large rounded fragments of quartz and felspar, having the appearance of a breccia.

c. Granular quartz, mixed with small white specks of decomposed felspar.*

* The same rock as this occurs in strata, by the side of the road between Bromesgrove and Birmingham, and many of the pebbles of the gravel, that covers so great an extent of country in that part of England, are composed of it.

Mr. Playfair, in his Illustrations of the Huttonian Theory, §§ 336, 337, speaking of this gravel, says, that it might in part have been produced from the detritus of these strata near Bromesgrove. About two years ago, when in that part of the country, I examined a great variety of the pebbles in a gravel pit, about a mile to the north of Birmingham, and I afterwards examined the strata near Bromesgrove. On comparing the specimens from both, I found a perfect identity between several of the pebbles and the stratified quartzose rock. Between these strata and the gravel pit, there is an extent of about ten miles of nearly level country.
These several rocks are all found within a very limited space; but it was impossible to form any conclusion as to their relation to each other, in regard to position, for they are only seen in separate masses projecting above the surface. The gneiss seems, however, to be the prevailing rock on the northern side, as well as in the upper part of the Holly-Bush Hill, and in the latter place, the slaty structure of the rock is perpendicular to the plane of the horizon.

§ 42. On the south side of the Holly-Bush Hill, there is a rock of a dark brown colour, composed of compact felspar, hornblende, quartz, and steatite, with a few detached crystals of felspar imbedded in it, producing a kind of porphyritic structure: this appearance becomes more distinct, when the rock is a little decomposed. It has an earthy texture, with somewhat of an uneven fracture, and is attracted by the magnet. In a small quarry, about a quarter of a mile to the westward, I found the same rock in various stages of decomposition. Where it is most decomposed, it becomes a friable mass of an ochre yellow colour.

§ 43. The last place, where I found the rock exposed at the south end of the range, was about half a mile beyond the Holly-Bush Hill; it was called the Ragstone Hill by some quarriers whom I found at work. The rock that occurs here is different from any other I met with in these hills. It is of an olive green colour, and, as far as the closeness of its texture enables me to say, is composed of felspar and mica, united by a ferruginous clay, forming nearly a homogeneous mass; and occasionally traversed by veins of calcareous spar. It occurs massive, without any signs of stratification.

§ 44. Before concluding this enumeration of the unstratified rocks, I may notice a breccia, of which I found a loose block in a lane near the Holly-Bush Hill on the western side, but which I could not discover any where in situ. It is composed of rounded fragments of
quartz and felspar, united by an argillo-calcareous cement, and the whole crossed by veins of calcareous spar which sometimes cut through the imbedded pebbles. It is very different from the breccia noticed § 41. b, as occurring in the lower part of the north side of the Holly-Bush Hill; for in that, the fragments are united by a quartzose base.

§ 45. In the account which I have now laid before the Society of the unstratified rocks of the Malvern Hills, I have chiefly dwelt upon those found in the northern parts. It is there that the rocks are most exposed, and as I resided at Great Malvern, I had an opportunity of examining that end of the range with more leisure and attention than I could bestow on the more distant hills to the south.

Of the Stratified Rocks on the Western Side of the Malvern Hills.

§ 46. In describing these, I shall observe the same plan I have adopted in regard to the unstratified rocks, by beginning at the northern end of the range, and proceeding towards the south.

§ 47. The first stratified rock that is exposed in turning round the End-hill from Great Malvern, is a coarse-grained sandstone of a purplish-brown colour, composed of rounded and angular fragments of quartz and felspar, but chiefly of the former, few of them exceeding the size of a pea. This rock is loosely aggregated, particularly in those parts where the fragments are largest, as the ferro-argillo-laceous cement is in very small quantity, and even appears to be itself composed of minute grains. It occurs in strata seldom exceeding a foot in thickness, in a vertical position, and bearing N. and S.; a good section of them is exhibited in the side of the road. This sandstone is not however the nearest stratified rock to the Malvern
range, for the road at this place makes a turn towards the hill, and on the left hand side of it, after proceeding a short way to the south, there appear several thin strata also bearing N. and S. and nearly vertical; the slight inclination they have from that position is towards the west. They consist of an alternation of a very compact argillo-quartzose sandstone, and containing a few impressions of terebratulites; of another rock similar to this, but much mixed with calcareous particles; and of a limestone, which contains a great number of the shells I have just named.

§ 48. Proceeding farther south, the road inclines towards the west, and is cut through a compact quartzose sandstone, similar to that mentioned in the preceding section, and containing impressions of madreporites and of terebratulites. It is here however mixed with a considerable quantity of mica, has a slaty structure, and breaks into rhomboidal fragments; giving it very much the appearance of a grauwacke slate. It occurs in thin strata, the bearing of which continues parallel to the direction of the range; but they dip east at an angle of about 60°. The road very soon turns to the westward, at a right angle to its former direction, and as it is still cut through the rocks, exhibits a transverse section of them; and in the space of about a quarter of a mile, they display some very remarkable changes in their mode of stratification. The inclination of the compact sandstone diminishes for some way as it recedes from the hill, but it again begins gradually to increase: to this rock succeed thin strata of an argillaceous limestone coated with a slaty clay, the inclination of which becomes more and more considerable. Thin strata of an argillaceous rock now appear, which very soon acquire a vertical position; they continue so for a short way, and then begin to dip towards the west, with a gradually diminishing angle of inclination. By the fall of the hill, the road very soon comes upon

29
level ground, so that the rocks are no longer cut through. This level ground continues for a short distance, when a limestone ridge suddenly rises up, dipping west at an angle of about 40°. In the sketch No. 1, I have represented the appearance which these strata would exhibit, if a vertical section of them was made in a line at right angles to the direction of the Malvern Hills.

§ 49. It is worthy of remark, that although the coarse sandstone, found at the foot of the End-Hill in vertical strata, lies to the westward of the compact sandstone, as mentioned in § 47; it is not found in the section of the rocks I have now described; nor did I see it in any other part of this side of the range, except in the neighbourhood of Castleditch, at the distance of seven or eight miles to the south.

§ 50. The same argillaceous rock that occurs in this place is met with very frequently on the western side of the range. It is seen under different appearances; sometimes it is of a friable texture, resembling fuller's earth; in other places it contains a great deal of mica, and has a slaty structure; when in this last state, many impressions of shells, principally terebratulites are found in it; it also occasionally contains some calcareous particles, forming a kind of marle. When it is in the earthy state, and with the slaty structure less distinct, it very generally includes lenticular-shaped masses and balls of an argillaceous limestone, containing a few terebratulites, the shell of which is sometimes partly preserved and retains its pearly lustre. In one of these masses I met with a specimen of the orthoceratites. This argillaceous rock is found not only on the eastern side of the limestone hills, but also lies upon the limestone, and in conformable stratification with it.

§ 51. The limestone does not form a continued ridge; but for several miles along this side of the range rises up in different places,
MR. HORNER on the Mineralogy of the Malvern Hills. 307

forming low hills, the longitudinal bearing of which is in general parallel to the direction of the Malvern Hills. The dip of the strata is in general towards the west, but this is subject to much more variation than the bearing. It is in general of a bluish-grey colour, but is sometimes of a pale brown, especially in the strata nearest the surface. It contains a great many organic remains, particularly terebratulites, and occasionally vertebrae of the encrinite, so common in some of the limestones of Derbyshire: these organic bodies are most distinct in the upper strata. It is traversed in many places by veins of calcareous spar. The strata are thin, and present uneven waved surfaces; they are separated from each other by an argillaceous slaty coating, that becomes more compact the nearer, it is to the limestone, to which it adheres so closely in some places, as to seem to be incorporated with it. This limestone is very similar to that found in the neighbourhood of Dudley, both in the mode of its stratification and in the nature of the rock itself.

§ 52. From the point where the road turns to the westward as mentioned in § 48, the ground for a considerable way to the south is covered with trees. There are very extensive plantations of the ash and the alder, all along this side of the Malvern Hills; the former being employed in making the hoops for the cider casks, and the other for hop poles. In the road which leads along the side of the hill from the Wych to Pearly Quarry, I found the argillaceous rock in a very loose friable state; the stratification of it however can be easily perceived. The strata are vertical, bearing N. and S. and they rise to about one third of the height of the hill. Between this place and Pearly Quarry, which is a short way to the westward, the rock is not exposed.

§ 53. At Pearly Quarry, the limestone strata are found; their bearing

2 q 2
§ 54. In the limestone of Pearly Quarry, I obtained a specimen of the vertebra of an encrinite, and which, as I am informed by Mr. Parkinson, is one of a very rare species: the only other specimen of it which he has seen is in the British Museum.

§ 55. To the westward of Pearly Quarry the argillaceous rock is found in conformable stratification with the limestone. It has somewhat of a slaty structure, and includes balls of argillaceous limestone. A road that is cut through this rock exhibits a section of it at right angles to the bearing of the strata: it is of very considerable thickness, as the section is about a quarter of a mile in extent, and the same rock continues the whole way. On this there lies a fine quartzose sandstone in thin strata, dipping W. at an angle of 42°, and bearing N. and S. The quartzose sand is united by a calcareo-argillaceous cement with a few spangles of mica disseminated through the mass. In those places where the mica is most abundant, it acquires a slaty structure, and the slates may sometimes be obtained as thin as coarse paper. The colour of the rock, which is derived from a considerable admixture of oxide of iron, is in general yellowish-brown.
contains in many places dendritical delineations of manganese, and occasionally a small quantity of spathose iron.

§ 56. In the road which leads from the Wych to Colwall-green, and immediately at the foot of the range, the argillaceous rock occurs in strata bearing N. and S. but dipping east at an angle of 60°. It is mixed with calcareous particles, includes, as usual, balls of limestone, and abounds very much in petrifactions. I obtained specimens of the following varieties.*

a. A small madreporite, the stars of which are bounded by circles. In the cells of this there is a small quantity of red sulphate of barytes.

b. Different species of the porpital madreporite.

c. A turbated madreporite, with a longitudinal section of a ramose madreporite.

d. A ramose madreporite, with terebratulites.

e. A coralloid, neither the form or structure of which can be defined.

I am informed that the chain coral is also to be met with in this place, but I did not find any specimen of it.

§ 57. About two hundred yards beyond this argillaceous rock, the limestone appears dipping towards the west, but as there is very little of it exposed, I could not make any exact observations as to its position. A short way to the westward is Stony-way quarry, where the limestone strata are seen in a very different position from what I found them in any other part; for in place of their direction being parallel to that of the range, as is generally the case with all the stratified rocks, particularly towards the north, it is at right angles to it: their bearing is E. and W. and they dip N. 35°.

§ 58. Near Eventon, there are very large quarries of limestone,

* I am indebted to Mr. Parkinson for this description of the organic remains.
which exhibits some remarkable changes in its stratification. The strata rise to a considerable height on the side of the hill, bearing N. and S. and dipping W. 60°. As they ascend, the ends of the strata become more inclined, and at the place where they crop out, they are nearly vertical; exhibiting the same appearance as the limestone strata of Pearly quarry, represented in sketch No. 2. About a hundred yards to the westward of this place, another quarry is worked in which the strata have the same bearing as in the quarry above, but they dip E. 60°, so that if a transverse section were made of the limestone in both quarries, the strata would be seen to meet like the sides of the letter V.

§ 59. A long ridge, called Old Castle Bank, extends from the Herefordshire Beacon, with a gradual slope towards the west. This ridge is almost entirely composed of the argillaceous rock, containing balls of limestone, in strata bearing S.W. and N.E. and dipping N.W. 18°. On the side of the Herefordshire Beacon, and on the left of the road from Worcester to Ledbury which passes along the top of this ridge, there are thin strata of limestone alternating with the argillaceous rock: but the strata in this place have a direction from N. to S. and they dip E. 60°. This is the highest point where I found the stratified rocks rising upon the Malvern range, and it is about one third of the elevation of the Herefordshire Beacon.

§ 60. To the south of Old Castle Bank, in a wood belonging to Lord Somers, there is a limestone quarry immediately at the foot of the Herefordshire Beacon, where the strata occur in a vertical position, with a direction from N. to S.

§ 61. In the extensive limestone quarry on the right hand side of the road to Ledbury, and near that town, the bearing of the strata is in one part N. and S. with a dip to the E. of 18°. Within a very short distance, both positions are completely changed, the
bearing becoming E. and W. and the dip N. at an angle of 20°: at the point where the change begins to take place, the strata are very much twisted and broken. The limestone contains large veins of calcareous spar, which in some places has red sulphate of barytes disseminated through it. I also observed that mineral in the interior of the shells that are found in the limestone. In the quarry on the opposite side of the road, there is also great irregularity in the position of the limestone strata: in some places their bearing is N.E. and S.W. with a dip to the N.W. of 40°; in others, their bearing is N. and S. and their dip E. In this quarry I found a specimen of a madreporite, resembling in form the lithostrotion of Lhwyd, but much smaller in size. This is the same fossil that is represented in plate V. fig. 3 and 6 of the second volume of Parkinson's Organic Remains.

§ 62. In the road from Ledbury to Longdon, by the Holly-Bush Hill, the argillaceous slaty rock, which is the most prevalent, varies considerably in its direction and dip. In the place where I first observed it, after leaving the limestone hills above Ledbury, its bearing was N. and S. with a dip of 65° to the E. rising up to these hills; as it recedes from them, the angle of inclination gradually diminishes. At Low Hurst, the bearing is from N.E. to S.W. with a dip of 50° N.W. Near Castleditch, the seat of Lord Somers, I found the same coarse sandstone that occurs in vertical strata at the foot of the End Hill, as mentioned in § 47; the bearing of the strata in this place is N.E. and S.W. with a dip of 30° N.W. Proceeding eastward, towards the Malvern range, the argillaceous rock again occurs upon the rise of the Holly-Bush Hill, in thin strata bearing N. and S. and dipping W. at an angle of 70°.

§ 63. It appears from the preceding account, that the direction of the stratified rocks is, with a few exceptions, parallel to that of
Mr. Horner on the Mineralogy of the Malvern Hills.

the range; but that there is a great irregularity in the dip, even within a very limited space, § 58; that the strata nearest the unstratified rocks are in general vertical, §§ 47, 52, 60; or inclined at a considerable angle with a western dip, § 58; but that in some places they dip in an opposite direction, that is, towards the hill, § 56; and they are found in that position, at the highest point to which they rise upon the side of the range, § 59. I did not, in any situation, discover the actual contact of the stratified and unstratified rocks.

Of the Rocks on the Eastern side of the Malvern Hills.

§ 64. From the bottom of the hills to the banks of the river Severn, there is a wide extended plain, the uniform level of which is only interrupted in a few places by low wooded eminences.

§ 65. At the foot of the hills, immediately below the surface soil, there is a coarse gravel, consisting chiefly of angular fragments, which I found to be the same as the unstratified rocks of the range. These are mixed with a small quantity of red clay, that seems to be produced from the decomposition of the rock, many of the fragments being quite friable.

§ 66. The ground is quite unbroken in the whole extent of the plain, except where an occasional rising has been cut through for the sake of preserving the level of the road; and as the rock is not adapted to economical purposes, there is no quarry where it is exposed. But at the termination of that part of the plain which is opposite to the Worcestershire Beacon, the right bank of the Severn is nearly 70 feet in perpendicular height, so that a good section of the rock is exhibited in that place. It is a red argillaceous sandstone, with occasional beds or long patches of a white quartzose sandstone: it does not offer any signs of stratification, except that these white
Mr. Horner on the Mineralogy of the Malvern Hills.

sandstone beds are in a horizontal position, and are parallel to each other. It is the same red sandstone that prevails over the greater part of Worcestershire.

Of the Mineral Waters of the Malvern Hills.

§ 67. There is no river, and scarcely a brook of any consequence, that takes its rise in these hills, but throughout the whole extent there are several small springs, some of which are found to be mineralized. Malvern Wells have been long celebrated as a watering place, and still continue to be very much resorted to.

§ 68. The mineral waters of this place were first examined by Dr. Wall of Oxford, who published an account of them in 1756, and they have since that time been analyzed by Dr. Wilson of Worcester, whose treatise appeared in 1805. There are three different springs that have been examined; the Holy Well which is the most celebrated, situated at Malvern Wells; St. Ann’s Well, and the Chalybeate in the neighbourhood of Great Malvern. I shall state the results obtained by Dr. Wilson, as his experiments were made at a more advanced period of chemical science; but he has only yet published the analyses of the Holy Well, and of St. Ann’s Well.

§ 69. The Holy Well water afforded no other gaseous contents than atmospheric air. A gallon of it yielded 14,6109 grains of solid ingredients, which were found to consist of:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonate of soda</td>
<td>5,33</td>
</tr>
<tr>
<td>Carbonate of lime</td>
<td>1,6</td>
</tr>
<tr>
<td>Carbonate of magnesia</td>
<td>0,9199</td>
</tr>
<tr>
<td>Carbonate of iron</td>
<td>0,625</td>
</tr>
<tr>
<td>Sulphate of soda</td>
<td>2,896</td>
</tr>
<tr>
<td>Muriate of soda</td>
<td>1,553</td>
</tr>
<tr>
<td>Residuum</td>
<td>1,687</td>
</tr>
</tbody>
</table>

\[ \frac{14,6109}{2} \]
§ 70. *St. Ann’s Well* water afforded no other gaseous contents than atmospheric air. Its solid ingredients are precisely of the same nature as those of the Holy Well, but in much less quantity. A gallon of the water yielded 7,395 grs. which consisted of:

- Carbonate of soda ........ 3,55
- Carbonate of lime ......... 0,352
- Carbonate of magnesia .... 0,26
- Carbonate of iron .......... 0,328
- Sulphate of soda ......... 1,48
- Muriate of soda .......... 0,955
- Residuum ........ 0,47

**7,395**

§ 71. The chalybeate spring, according to the analysis of Dr. Wall, contains about 6 grains of solid ingredients in a gallon.

§ 72. I was informed by Mr. Wallett, Surgeon at Great Malvern, that a spring on the western side of the Herefordshire Beacon, known by the name of Walm’s Well, has been long used, by the country people in the neighbourhood, as an outward application in cutaneous diseases. The water flows in a pretty copious stream, and at the place where it issues from the hill, is collected by an embankment, so as to form a large bath. Through the kind assistance of Dr. Marcet, I have made the following examination of this water, with the view of ascertaining merely the nature of its contents, without any regard to proportions, as the quantity I brought away was much too small for that purpose.

§ 73. The water, as it issues from the hill, is perfectly transparent, and remains so after exposure to the air. It produced no change on tincture of red cabbage.

Its specific gravity is 1000,10.
Mr. Horner on the Mineralogy of the Malvern Hills. 315

Six cubic inches of the water were boiled for some minutes, and the gaseous contents were received over mercury. On the admission of caustic potash, no absorption took place. The transparency of the water remained undisturbed.

The following tests produced no change. Litmus paper, violet paper, turmeric paper, lime water, muriate or nitrate of barytes, tincture of galls, and prussiate of potash, even after the addition of a little muriatic acid.

Caustic potash, oxalate of ammonia, and nitrate of silver, all occasioned a turbidity. On the addition of barytic water, there is also a cloudiness, even after the water of the spring had been boiled; although neither muriate nor nitrate of barytes produced any effect. Super-carbonate of ammonia with phosphate of soda occasioned at first no change; but after standing for some time, the rod left white streaks wherever it was drawn along the sides of the glass vessel.

Eight ounces of the water slowly evaporated to dryness, yielded 0.75 gr. of solid ingredients. On adding cold distilled water to this, only a small part was re-dissolved. To the solution the following tests were applied:

a. Violet paper, slightly changed to green.
b. Oxalate of ammonia, no change.
c. Muriate of barytes, a cloudiness.
d. Nitrate of silver, a dense precipitate.
e. Super carbonate of ammonia with phosphate of ammonia, a slight cloud, and the rod produced white streaks on the sides of the vessel.
f. Nitrate of lime, a considerable precipitate.
g. There was no change produced by tincture of galls, or by prussiate of potash, even after the addition of muriatic acid.

To the residuum insoluble in water there were added:

2 R 2
Mr. Horner on the Mineralogy of the Malvern Hills.

b. A few drops of dilute muriatic acid, which dissolved the whole with a brisk effervescence.

i. Oxalate of ammonia, a copious precipitate.

k. The solution from which the lime was thrown down, by the last experiment, was filtered, and the same test applied as in exp. e. which produced a similar effect, but in a very slight degree.

The water of Walm's Well therefore contains about 12 grains of solid ingredients in a gallon, which appear to consist of:

1. **Carbonate of lime** as the principal ingredient; by exp. b. i.

2. **Carbonate of magnesia** in minute quantity, by exp. a. k. and by the effect of the barytic water in the preliminary experiments. From the change produced on the violet paper, in exp. a; and from the action of the barytic water, which last test occasions a precipitate with carbonate of soda, I suspected that there might be a small quantity of that alkali existing in the water of the spring; but by comparative trials I found that, on applying these tests to a solution of carbonate of magnesia in water, exactly the same effects were produced.

3. **Muriate of soda, or magnesia**, by exp. d, e; probably the latter; for in one experiment, the entire solid ingredients were, by accident, dried at a heat that must have decomposed the muriate of magnesia, that earth being found in the insoluble residuum in greater quantity than when the evaporation had been carried on with a gentle heat, and there was only a trace of it discovered in the part soluble in water.

4. **Sulphate of soda, or magnesia**, by exp. c, e, f; probably the former; as the proportion of sulphuric acid indicated is more considerable than that of magnesia, and that earth seems to be combined with muriatic acid.
IN the account which I have now laid before the Society, of the
physical structure of this interesting range of hills, I have, I fear,
exhibited the task I have undertaken in a very imperfect manner;
but I have endeavoured to avoid all theoretical speculations, and
have confined myself as much as possible to a description of the
facts as they present themselves. Before concluding however, I shall
take the liberty of offering a few remarks on the phenomena I have
described, and of examining by what theory they may, in my
opinion, be most satisfactorily accounted for.

With the exception of the small bed of red sandstone on the
eastern side of the Worcestershire Beacon § 29, all the unstratified
rocks seem to belong to the primitive class of the Wernerian system,
and in general, accord very much with the account given by Mr.
Jameson in his Geognosy of the third or newest granite formation.
The structure of the granite is very irregular, it is generally of a red
colour, and it is found in veins that probably shoot from a great
body of rock: it is frequently traversed by veins of quartz, and is
not stratified. The rocks in which hornblende exists correspond
with some of the varieties of primitive trap, and of sienite, as de-
scribed in the same work.

The stratified rocks on the western side, are probably of very
early formation, as the organic remains that are found in them are
such as only occur in the oldest of the secondary rocks. The cha-
racters of the limestone quite agree with those of the transition lime-
stone of Werner; and although the argillaceous rock does not exactly
 correspond with any of the transition rocks enumerated by Mr.
Jameson; yet as the same organic remains are found in it, as in the
limestone, and as it occurs in some places on both sides of the lime-
stone-strata, in conformable stratification, it is very probable that
both belong to the same class. The argillaceous rock may perhaps
be a grauwacke-slate, as that name has so very wide a range; but it is
in general much less indurated than any rock I have yet seen, to
which that denomination has been applied.

Whether I am correct or not in the application I have made of
the Wernerian names to the individual rocks of the Malvern district,
if we consider their geological arrangement, we shall find that they
exhibit appearances very inconsistent with the Wernerian system of
Geognosy.

The most remarkable feature of this district is the very great con­
trast between the two sides of the range. On the eastern side, a level
plain, extending for many miles; on the western, a constant suc­
cession of hills. Now if the unstratified rocks in the centre are
to be considered as the oldest, and if the stratified rocks have been
deposited upon them, how does it happen that they are only found on
one side, that not a vestige of the strata that occur on the western side
is to be met with on the eastern, and vice versa, that the red sandstone
of the eastern side is not to be found on the western; at least for
three or four miles all along the range, beyond which my observa­
tions did not extend. Besides, if the stratified rocks were deposited
on the unstratified central rocks, we should expect to find their
bearing always parallel to the direction of the range, and their dip
uniformly towards the west, corresponding with the slope of the
hill, supposing, what is maintained in the Wernerian system, the
possibility of a stratified rock being deposited in any other than a
horizontal or nearly horizontal position. We should also expect,
in so short an extent as that of the Malvern range, that the same
kind of stratified rock would always be found next to the unstratified.
But I have shewn that neither of these things occur. It is true
that the direction of the strata is in general parallel to that of the
range; but there are some remarkable exceptions to it, as in the lime­
stone of Stony-way Quarry, where the direction of the strata is from E. to W. exactly at right angles to that of the range: again, the strata nearest the range are in general quite vertical, and even in some places dip towards it, that is, eastward at an angle of 60°; and so far from the same stratified rock always occurring next the unstratified, it is in some places sandstone; in others, the argillaceous rock; and in others, limestone.

The unstratified central rocks are so much concealed, that any inferences with respect to them are liable to more uncertainty than those we are enabled to draw from the frequent exposure of the stratified rocks on the western side. But wherever they can be seen to any extent, they exhibit a great degree of irregularity, the different kinds of rock being found in large masses confusedly heaped together. The granite chiefly occurs in the lower part of the hill, and the veins of it, which penetrate the other rocks, become more slender as they ascend, in all those places where they can be distinctly traced.

Such remarkable variations in the direction and dip of the stratified rocks, can only be accounted for, on the supposition of some violent force, that has elevated them from the horizontal position in which they must have been originally deposited, and thrown them into the different situations in which they are now found; and the Huttonian Theory offers, in my opinion, a more satisfactory explanation of these phenomena, than any other with which we are yet acquainted. The situation of the granite, and the veins of it that penetrate the other rocks, in almost every part of the range, perfectly accord with the supposition of its being of later origin, and of its having been thrown up from beneath them: it is also probable that the elevation of the granite has produced the great disturbance in the strata, which I have described. The direction of the force seems to have been from West to East, and its action appears to have ceased where the
unstratified rocks broke through, and appeared above the surface; and as these have been thrown up in a line between N. and S. the bearing of the elevated strata ought in general to be parallel to that line, and this has been shewn to be the case: the force would be greatest at the point where the unstratified rocks burst forth, and accordingly we find the strata there generally vertical, and in those places where they dip towards the range, they seem to have been raised, not only into a vertical position, but even thrown back and in some degree inverted.

The elevation of the strata in different places, forming the low hills which occur on the western side of the range, and in which the strata exhibit such remarkable changes in their position as at Stony-way quarry, Eventon quarry, and the quarries near Ledbury, seems to point out very distinctly, that the force has acted unequally, and has had an occasional increase in different places, sufficient to throw up the strata, but not so great as to raise the unstratified rocks above the surface. The bending up of the ends of the strata into a vertical position, where they crop out, as is represented in sketch No. 2, clearly shews that they have been acted upon by some violent force.

With regard to the red sandstone of the plain on the eastern side of the Malvern Hills, it is very evident that it has been produced from the disintegration of other rocks; but it is not I think equally clear that it owes its origin to the detritus of the unstratified rocks of this range. For if that were the case, it would probably be found on the western side as well as on the eastern, but not a vestige of it is to be seen there; and instead of a level plain beginning immediately at the foot of the hills, there would be a gradual slope towards the east. It appears to me more likely that this red sandstone existed previous to the elevation of the range, and that it covers stratified rocks similar to those found on the western side:
but the granite which raised these strata from their horizontal position having burst forth, the force ceased, and the red sandstone remained undisturbed. The disappearance of it on the western side may be accounted for, from its being of a very loose friable texture, and if it was much broken during its elevation, it would be easily disintegrated, and gradually washed away. Perhaps it may be found covering these strata, further to the westward than my observations extended, and where the disturbance was not so great. It covers a great extent of country in Shropshire, considerably to the westward of the line of the Malvern Hills.

As I have related the facts I observed, independently of any theory, if they are at all valuable in the geological history of this country, their value will remain undiminished, whether the speculations I have entered into are just or fallacious. If the geologist strictly guards himself against the influence of theory in his observations of nature, and faithfully records what he has seen, there is no danger of his checking the progress of science, however much he may indulge in the speculative views of his subject.
PLAN & SECTIONS OF THE MALVERN HILLS, & PART OF THE ADJACENT COUNTRY.