ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF WISCONSIN.

BY JAMES G. PERCIVAL.

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1855.
GEOLOGICAL REPORT.

To His Excellency, Wm. A. Barstow,

Governor of the State of Wisconsin:

In presenting this report on the Geology of Wisconsin, it is proper that I should state the circumstances under which the materials for it have been collected. On receiving my commission as State Geologist (Aug. 12, 1854;) I proceeded, agreeably to your instructions, to examine the mineral district, included in the southwestern counties of the State. It was my intention, in this examination, to make a preliminary reconnaissance of the entire district, so as to enable me to present, in my first report, a general view of the arrangement, both as exhibited on the surface and in the interior. In previous examinations of the same kind, I had found the great advantage of such general views, in preparing for a more just appreciation of particular facts, and of their mutual relations. One of the most important objects of a Geological Survey, indeed the most important, is to determine the system of arrangement, and the principles connected therewith, which may serve as a guide through what would be otherwise an inextricable labyrinth. This cannot be done satisfactorily without a minute and thorough investigation of particulars, but this should be made throughout with a view to the entire arrangement, and for this purpose a preliminary reconnaissance is required. Although I lost no time in pursuing this object, yet I found it impossible to visit the entire district, this season, and November 23, I returned to Madison, and after a brief examination of the country between that place and
Janesville, in reference to the strata, I applied myself to the preparation of my report.

I have visited, during this season, all the considerable diggings from the south line of the State to a line drawn from east to west, north of Cassville, Beetown, Potosi, Platteville, Mineral Point, Yellow Stone, and Exeter, and from the Mississippi to the east part of Green county. Some of the less important diggings, within these limits, may have escaped my notice, but I have endeavored to make such an examination of those I have visited, as my limited time would allow. I have also employed, in preparing this report, such facts as I had collected the former year, in the employment of the American Mining Company (N. Y.) in exploring different localities in the same district, and particularly in examining the different strata, in reference to the probable descent of the mineral through them. On this point, of so much importance to the mining interest, I had then ascertained a series of facts, which seemed to prove that all the limestones, from the surface of the upper magnesian to a considerable depth, at least, in the lower magnesian, were good lead-bearing rocks. My researches, this year, have enabled me to add many convincing proofs to what I had before ascertained, the whole showing a regular descent of the mineral through all the rocks, within the limits above indicated, except the upper sandstone. I have had no opportunity, this season, of extending my researches in the lower magnesian, its outcrop occurring chiefly in the northern part of the district, which I have not yet visited. I had, the former year, also applied myself to the investigation of other points of much economical interest, and have made them, this season, leading objects in my survey. Such are the surface arrangement of the ranges, by which they are combined into different groups, which are themselves also arranged in connected series, showing a regular system of arrangement, apparently pervading the whole district, so far as I have yet examined it; the vein character of the different deposits of mineral, recognizable in all their varied modifications; and the different character of the openings in the different limestone strata, show-
ing that while all of these are lead-bearing, yet that each presents some peculiarities in the arrangement and character of its mineral deposits. The facts, which I have thus far collected, on these points, appear not a little encouraging, as exhibiting regularity and order in arrangement, and striking analogies to the best mines in corresponding situations in Europe. The opportunities for examining the interior of mines, are not now so frequent as I could have wished, but I have improved every opportunity which has presented, and have been able, during the two seasons, to examine the interior of more than two hundred different mines, of varied extent from the smallest to the greatest.

From the short time that I have been employed by the State, it cannot be expected that I should prepare a complete report. In this, I have had in view the immediate interests of the mineral district, and I have endeavored to give it a practical bearing. My object has been to give general views of more immediate importance, and rather to point out the method I design to pursue than to give the results of a survey. Local details, and such as have no direct bearing on my present object, are reserved to another occasion.

I have confined myself, in preparing this report, chiefly to my own observations, and have proceeded no farther than the facts, which I have myself collected, would seem to warrant. Although I have not yet been able to explore the whole mineral district, and may therefore have failed to ascertain some facts, which may have an important bearing in determining the entire arrangement, yet I have felt warranted, from what I have already ascertained, in stating, with some confidence, the conclusions to which I have already alluded.

The mineral district is of such relative extent; its resources, mineral and agricultural, are so great, that whatever interests that must largely interest the whole State. The act, making the appropriation for this survey, requires that that district should be first surveyed; but occasional opportunities may, in the meanwhile, be taken to examine such other points as may be of immediate im-
portance. The survey of the whole State must be the work of
time; to be valuable, it should be made deliberately, and as far as
possible, in a connected order. As long as I am entrusted with
this object, I shall endeavor to give it such a direction, and partic-
ularly to make it contribute to develop the great resources of the
State.

Herewith I have the honor of submitting the following report:

Very respectfully,

JAMES G. PERCIVAL,
State Geologist.
REPORT.

The Mineral District in Wisconsin, so far as I have examined it, includes all that part of the State between the Mississippi, on the west, and the valley of Sugar river, on the east, south of the line already indicated. Small quantities of lead ore are reported to have been found farther east, between Sugar and Rock rivers, and even in the quarry at Janesville, on the east bank of Rock river. In general, the diggings are more frequent and more extensive towards the west, and become more detached and lighter towards the east, but with some important exceptions. These will be noticed hereafter, more in detail.

STRATIFICATION.

The rocks, in this district, form a series of strata, overlying each other nearly horizontally, already noticed in preceding reports. In describing them, I shall point out such characters and distinctions as I have myself observed, and which have appeared of practical importance. It has been noticed in other mining countries, that different rocks have different relations to particular minerals; that a given metallic vein, in one stratum, will yield more abundantly than in another, and will present peculiar characters in traversing each stratum. Such appears to be the case in this mineral district, and it hence becomes important to mark, as far as possible, all the different modifications in the strata.

The surface of the mineral district may be regarded in general as a plain, traversed in different directions by valleys and ravines, radiating from the principal water-courses. Seen from a distance,
these are less obvious, the higher points of the surface, themselves on nearly a common level, commanding the view, and giving to the whole the appearance of a vast plain. Above this plain rise a number of elevations, called mounds; some isolated, such as the Blue Mounds, the Platte Mounds, and the Sinsinawa Mound, in Wisconsin, and others forming connected chains of highlands, such as the range east of Galena, in Illinois, and the Highlands along the west side of the Mississippi, in Iowa. These mounds are composed of strata, overlying the strata occupying the general plain.

The strata, in this district, appear nearly horizontal, but have slight dips in different directions. A general dip to the west of south has been recognized in former reports. A general dip to the south appears obvious, even if the part of the district examined by me be alone considered. Such a dip to the south would, in a general plane surface, bring the lower strata to that surface successively towards the north, and such, in the whole, appears to be the fact in this district. A general dip to the west has appeared to me less obvious, though favored by many facts, particularly the great extent of the mound rocks, in the Highlands of Iowa, and the greater thickness of the upper strata generally towards the west.

Besides this general dip, local inequalities in the stratification may be observed at various points, indicating extraordinary elevations of the strata at those points. These appear to be rather detached elevations at different centres, than along extended lines of anticlinal axes. They occur generally in connexion with the deeper valleys, where there has been a considerable degree of denudation, and at such points the lower strata are brought to the surface at extraordinary elevations, and exhibit striking inequalities within short distances. Such points of elevation may be observed on Fever (Galena) river, between Benton and Shullsburg; on the West Pecatonica, near Mineral Point; on the East Pecatonica, near Argyle; on the waters of Sugar river, near the line of Dane and Green counties, and on the Platte river, between Platte-
ville and Potosi. From these centres of elevation the strata dip in different directions, by which the higher strata are found successively overlying the lower on the north as well as on the south. Thus the extraordinary dip to the north from the centre of elevation on Fever river presents the overlying strata on the surface to the north of the outcrop of the lower strata, and has given place for the occurrence of the mound strata at the Platte Mounds. In the same manner, there is at Dodgeville, though six to seven miles north of Mineral Point, a greater thickness of strata than at the latter, near which the lower magnesian is even brought to view.—The details respecting these elevations will be given after the description of the different strata.

The series of strata, which I have had an opportunity of examining, may be thus arranged. 1. The Mound Strata, consisting of three distinct beds of limestone; the upper, middle and lower. 2. A bed of Blue Shale, separating the mound strata from the next lower limestone series. 3. The Upper Magnesian of Owen, also consisting of three distinct beds. 4. The Blue Limestone, including the Blue and the Buff Limestones of Owen (1st Rep.,) also presenting three distinct beds. 5. The Upper Sandstone. 6. The Lower Magnesian of Owen. This last I have not yet had an opportunity of examining through its whole depth, but I have observed, in its upper portion, two distinct beds, well characterized. 7. The Lower Sandstone. This I have not yet had an opportunity of examining in connexion. The arrangement of each of the limestone series, at least of the three upper, in three distinct beds, is worthy of attention. Other minor distinctions may be noticed, and have in different places attracted the attention of miners, as of practical importance. These I have endeavored to ascertain, and shall mention, so far as I have been able to determine them; but from their nature, they can be fully determined only by a more complete survey than I have yet made.

MOUND STRATA.

The Mound Strata, within the limits of the mineral district in Wisconsin, occupy only a few detached points, considerably ele-
vated above the general surface. These are: the Sinsinawa Mound, a detached summit near the south line of the State and on the limit of the towns of Hazel Green and Jamestown; the Platte Mounds, two detached summits, one east, the other west of Belmont, with a smaller elevation of the same character between them; the Blue Mounds, two summits forming part of a connected range, near the line of Dane and Iowa counties; and the northeast point of a range of mounds, extending from near Galena towards Shullsburg.

The three distinct beds, above mentioned, are most complete in the southern mounds, and are apparently partly denuded in the northern. They may all be distinguished in the Sinsinawa Mound, but the upper appears there less complete than in the Table Mound, an outlier of the Highlands, south-west of Dubuque. The entire series is composed chiefly of a thick-bedded limestone, fine-grained and nearly white, when unstained, and well adapted for building. The upper bed is characterized by a great abundance of corals, of which the Catenipora* is the most distinctive. The middle bed abounds more or less in hornstone (flint,) arranged conformably to the stratification. This, in the southern mounds, is less abundant, and more in detached nodules, while in the northern mounds, it is more abundant, and even, in the Blue Mounds, almost replaces the limestone. In the northern mounds particularly, it is distinguished by a reddish-brown colour. It may thus have given origin to the layer of red flint in clay, which immediately overlies the rock on the general surface throughout the mineral district. The lower bed contains little flint, and is less abundant in fossils, particularly corals, than the upper. It appears, however, thicker bedded, and is more important for lime and building. The mound limestone has never been found to contain any considerable deposit of lead ore. Traces of mineral are reported to have been found in it, and some fruitless excavations have been made, one of which I have examined on the top of the Sinsinawa Mound, but have observed there no appearance of lead ore.

* C. escharoides.
BLUE SHALE.

The Blue Shale, wherever I have had an opportunity of observing, underlies the limestone of the mounds, and separates it from the Upper Magnesian limestone. It is composed of a thin even argillaceous slate, quite hard in its natural state, but more or less subject to decomposition into a soft clay, sometimes retaining its original blue color, but more usually stained yellow, and forming then what is called by the miners, a pipe clay. Its surface, from its tendency to decomposition, is always concealed by earth, unless exposed in ravines or by excavation. It extends to a greater or less distance around the mounds, and graduates by decomposition into the pipe clay, which overlies its undecomposed part, when thickest, and replaces it entirely on its outskirts. Thus at the Jamestown Mine, near the Sinsinawa Mound, it was found, in the engine shaft, immediately overlying the upper magnesian, unchanged, and itself overlaid by the pipe clay, while in shafts more remote from the mound, it was found entirely converted into the pipe clay. This bed is less open and pervious than the limestones, and consequently the water from the mounds issues in springs above it, marking the line of its upper surface.

The shale itself contains few, if any fossils, but at its junction with the upper magnesian, there is a very thin bed, (two to three inches thick,) composed almost entirely of very small fossils and concretions, usually firmly cemented by iron, and therefore called hard-pan by the miners, but sometimes softer and with a more calcareous cement. Usually one or more thinner layers (about one inch thick) of the same character are found interposed in the blue shale, within the first 2—4 feet above the upper magnesian. These fossiliferous and concretionary layers are important as serving to determine the formation of the pipe clay, overlying the upper magnesian, from the blue shale. In the shafts, at the Jamestown Mine, where the pipe clay immediately overlies the upper magnesian, these layers are found precisely of the same character and in the same position, as where the unaltered blue shale meets the same rock. In different places on the higher points, where the upper
magnesian is most complete, that rock is found overlaid by pipe
clay, in which the same fossiliferous and concretionary layers are
found, in the same position as I have already stated. This
I have observed very perfectly at the Muddy Diggings, on high
ground, north of Cassville, at the distance of several miles from
the mound rocks; the nearest position of these being in the High-
lands of Iowa, beyond the Mississippi. In other places, the pecu-
liar fossils and concretions of these layers are observed on the
surface of the upper magnesian, where the pipe clay is less obvi-
ous. This I have noticed in different places on the higher grounds
in Hazel Green, six miles from the Sisininawa Mound, and still
farther from any other locality of the mound strata. These facts
seem to indicate a former general extension at least of the blue
shale, over the surface of the upper magnesian.

UPPER MAGNESIAN.

The Upper Magnesian* consists of a series of limestone beds, of
great thickness, in which the greater part of the lead ore, raised
in the mineral district, has been found, and from that circumstance,
it has been sometimes called the mineral rock. But the other beds
of limestone, underlying it, (the blue limestone and the lower
magnesian,) have been found to be good lead-bearing rocks, and
consequently this latter term can no longer be regarded as dis-
tinctive. The prevailing character of the rock in this series, is
that of a light grey thick-bedded limestone; sometimes uniformly
fine-grained and even compact, but more often partly fine-grain-
ed and compact, and partly coarser grained and more distinctly
crystalline, or even with small geodic cavities. This latter struc-
ture occurs more particularly in connexion with mineral deposits,
or in what is called the opening rock. In such instances, either
the compact or the more crystalline portion may be the ground,
through which the other is disseminated; the former as nodules or
concretions; the latter as geodes or approaching such.

*This term, introduced by Owen in his first report, has been generally adopted in the
mineral district, and for that reason I have preferred to retain it.
The rock of this series is generally more or less subject to decomposition, and the coarser grained portions most so, which often gives to it a peculiar cavernous character. This circumstance renders it less valuable for building, although occasionally fine-grained or compact beds occur of superior quality for that purpose. The quarry from which the Catholic Church at Benton has been erected is one of that character. This rock too, in the openings, is often found decomposed in part to a fine sand, retaining its structure unchanged, in which the harder compact concretions lie loose in their original position, and are called tumbling rock by the miners. It has been called, from this circumstance, sand-stone and sand-rock, by the miners, but as these names are liable to confound it with the proper silicious sandstone, they should be rejected.

There is generally a thin bed of a thinly schistose subargillaceous limestone at the upper surface of the upper magnesian, called shingle-rock by some miners. Layers of shale occur occasionally through the whole extent of the series; sometimes distinct; sometimes firmly attached as a coating to the layers of the limestone. The original color of these is generally blue, but they are often stained green or yellow. They are usually found decomposed to clay in the openings, and are then called, in some places, clay randoms, and are regarded as useful guides in determining the position of the miner. In the lower bed of this rock, layers occur of a very thin black or dark brown shale, more or less bituminous, accompanying particularly the green and brown rock openings at Mineral Point and between Benton and Shullsburg. Thin fossiliferous layers are also met with throughout the series, but most frequently in the lower part. The thicker bedded rock usually contains but very few fossils, and those of large size comparatively, while the thin fossiliferous layers abound in them, and those of small size and usually delicate texture. Some layers are found chiefly composed of minute fossils and concretions. The distinctive fossil of the entire series is the coral, called honey-comb or sun-flower, (Coscinopora.) I have observed it in all the beds of this series, but in none of the other limestones.
The upper bed of this series contains few or no flints, and is usually much thicker than either of the lower beds, and indeed, where it has suffered no denudation, is at least equal in thickness to the two lower combined. The middle bed abounds in flints, arranged in regular layers of nodules, usually white or light grey, but sometimes dark grey or black. The lower bed usually contains but few flints, but these are sometimes more abundant, particularly in the openings.

The character of the lower bed has not appeared as uniform as that of the two higher beds. Like the upper bed, it sometimes is light grey or bluish and compact, and is then valuable for building, when not too much jointed; but it is more often much traversed by argillaceous seams, separating or marking the surface of the layers. This bed is farther characterized by two peculiar rocks, known as the brown or black rock and the green rock, which occupy corresponding positions, but are usually found in different sections of the mineral district. On the Mississippi and Fever river, the brown rock, is generally found connected with the openings in the lower bed, and contains more or less calcareous spar (träff) disseminated through it. The green rock is found in a similar position in the northern and northeastern diggings. The original color of these rocks is bluish, but they have derived their present tint from the decomposition of iron pyrites disseminated through them. The brown rock is of a more or less deep red brown color, usually pervading it uniformly, and from its peculiar tint, was called the chocolate-brown rock by Locke (Owen's 1st Rep.) The green rock is usually less uniformly stained, sometimes only on its seams, and apparently derives its color from the green hydrate of iron. Thin layers often occur in this bed, composed chiefly of flattened fucoidal concretions, but rarely containing any fossils. Similar layers are occasionally found in the higher beds.

Bars of a hard blue limestone often traverse the upper magnesian, in its different portions, more usually in a horizontal position, like beds, but sometimes in a vertical position, like veins. They are more or less intersected by iron pyrites, and are appa-
rently connected with mineral deposits, to which they have
an important relation. They often interrupt the progress of min-
eral veins, and are then said, by the miners, to cut off the mineral;
whence the opinion has prevailed that the blue limestone cuts off
the mineral, an opinion erroneously transferred to the blue lime-
stone of Owen, to which it has properly no reference. This sub-
ject will be farther discussed in connexion with that of mineral
deposits and veins.

BLUE LIMESTONE.

The Blue Limestone series includes the blue limestone and the
buff limestone of Owen's first report. These both evidently belong
to the same series; the first including the two upper beds, the
second the lower bed, already indicated. The three beds, of
which the series is composed, are of nearly equal thickness.

The upper bed is chiefly composed of thinner more fossiliferous
layers, between which are interposed some thicker and less fossil-
erous. Some of the layers are almost entirely composed of fossils,
and in some instances are subject to decomposition, leaving the
fossils loose and entire. Thin layers of bluish shale alternate with
the layers of limestone, and are often found decomposed to a soft
clay, usually stained yellow or green, particularly in the openings.
The layers of limestone are marked by a peculiar parallel or lamin-
ated structure, distinct from that of the upper magnesian, and are
partly light grey and compact, furnishing the best lime, and part-
ly blue and more distinctly parallel in their structure, and appa-
rently subargillaceous. Some of the latter kind have been found
to furnish a good hydraulic cement. This bed is usually overlaid
by a bed of brown rock, in thin layers, and breaking in small
jointed fragments, with more or less calcareous spar disseminated,
but with few or no fossils. It is interposed, in the northern dis-
tricts, between the green rock and the blue limestone, and may be
considered as the lowest member of the upper magnesian. In some
instances, a bed of blue shale, decomposing into a soft clay in the
openings, is interposed between the upper magnesian and the blue
limestone.
The middle bed of the blue limestone is composed of more uniform and thicker bedded very even layers, less abundant in fossils, but presenting some which have not occurred to me in the upper bed, such as trilobites, and the acorn (Streptelasma.) In the western districts, where most distinctly developed, this bed may be divided into three distinct portions: an upper, of a very fine crystalline grain, and of a light grey color, subject to a brown stain in connection with openings; a middle, of a dark grey color, hard and compact, breaking with a smooth conchoidal fracture, and called glass rock, in most of the diggings where it occurs; and a lower, forming a transition to the lower bed, and consisting of alternations of grey compact and bluish parallel seams, firmly connected, the former resembling the glass rock, the latter the prevailing rock of the lower bed. This lower portion is more fossiliferous than the two others, particularly on the surfaces of its layers. This distinction is well marked in Quinby’s quarry on the Shullsburg Branch, north of New Diggings. In the most eastern districts, yet examined, this distinction appears less marked, nearly the whole bed being composed of a uniform fine-grained light grey rock, resembling the upper portion. The glass rock is there hardly represented. Nodules of flint occasionally but rarely are found in this middle bed, particularly in its upper fine-grained portion.

The lower bed, corresponding to the buff limestone of Owen, consists chiefly of a thick-bedded even rock, marked by a distinct parallel arrangement, and composed in a great measure of flattened vermiciform and fusoidal concretions, most strongly marked on the surfaces of the layers. That these are merely concretions and not organic, appears to me very evident. The same structure is equally remarkable in certain thin subargillaceous layers, observed in the upper magnesian, particularly in its lower bed. The same appearance is observable in the transition from the sandstones to the lower magnesian, particularly on the surface of the layers, where marked by argillaceous seams. It would seem to be common wherever there is a combination of lime and alumine. This lower bed furnishes a brown lime, and in some portions of it, a good hydraulic
cement, which alone indicates its subargillaceous character. The natural color of this bed is a light blue, but it is very much subject to stain, buff or yellow,* from disseminated iron pyrites. Indeed in some districts, particularly the eastern, the whole series is generally found, at least near the surface, of a yellow color, only a few portions retaining their original blue color. The rock of this lower bed is easily dressed, particularly the middle portion of it, and in some instances is capable of a fine polish, forming, by its concretionary structure, a beautifully clouded marble. Quinby's quarry, above noticed, furnishes fine specimens. The same bed, in the quarry at Monterey (Janesville,) has been used for that purpose, but its effect is injured by small geodic cavities. This lower bed contains comparatively few fossils, particularly in its middle portion. Trilobites have been found in it, as well as in the middle bed. At its junction with the upper sandstone, there is usually a transition from one rock to the other; a number of subsilicious and subargillaceous layers intervening, the former of which are more or less oolitic in their structure.

**UPPER SANDSTONE.**

The Upper Sandstone forms a bed of a generally uniform character, and of no great thickness, composed usually of fine grains of quartzose sand, very slightly cemented, and consequently very little coherent, often in the interior in the state of loose sand. The surface is generally more or less indurated, but often this harder coat is of very little thickness. The natural color of this rock is white, but it is very subject to stain yellow, red, and sometimes green, from the decomposition of disseminated iron pyrites. These stains are most remarkable on the surface and near the seams, and particularly near the junction of the rock with the adjoining limestones. At the junction of this rock with the blue limestone above, it is usually coarser grained, and often contains concretions of quartz, sometimes geodic, which have been evidently formed.

* It has been called, from this circumstance, the buff limestone, but might, with more propriety, be called the blue and buff limestone.
by chemical action. In this position too, concretions of iron pyrites, or of hematite resulting from its decomposition, are frequent; the latter often including a portion of the pyrites unchanged. Small nodules or seams of hematite, sometimes with iron pyrites, occur also in this part, filled with grains of quartz of a hyalitic appearance. This layer, which has been apparently so subject to chemical action, is usually of a dark red brown, or of a deep green color, (the latter from the green hydrate of iron,) and occasionally the adjoining sandstone, to a considerable depth beneath, is more or less stained green from the same cause. This rock is usually too incoherent to answer well for building, although generally sufficiently fine grained and thick-beded for that purpose. It furnishes, however, a superior sand for mortar, and sometimes so hardens by exposure, as to be useful for building. In some districts, particularly on some of the eastern branches of the East Pecatonica, near the line of Green and Lafayette counties, this rock is composed of thin nearly schistose layers, and its lower part is then more or less filled with minute white calcareous grains, giving it a firmer texture.

LOWER MAGNESIAN.

This rock I have not yet examined through its entire depth, having had an opportunity of viewing it only in its southern and eastern outcrops, on the Platte, Blue, Pecatonica and Sugar rivers, and in a ridge 2—3 miles S. W. of Madison. The greatest depth to which I have yet seen it exposed, is nearly 100 feet, on the Big Platte, in Ellenborough. A thickness of more than 200 feet has been given it, on the Mississippi, by Owen, in his reports.* Wherever I have seen it, this rock has presented peculiar external characters, by which it can be readily distinguished from the preceding limestones. Among the distinctive marks which I have observed, the most striking are a peculiar concretionary nodular structure, and the occurrence of geodes lined with minute crystals of quartz, and of layers of flint less inter-
rupted and nodular than in the preceding limestones, either white and abounding in geodes of quartz, or striped red-brown and yellow, resembling a striped jasper, and then more rarely geodic. Fossils are very rare, nor have I yet observed them in this formation.

Where I have had an opportunity of observing it continuously underlying the upper sandstone, on the Blue and Platte rivers, it has presented two distinct beds, an upper and a lower. The first is composed of a series of alternations of subargillaceous and subsilicious limestones, more or less decomposable, with occasional interposed layers or beds of a purer and harder limestone. The subargillaceous layers sometimes form a marly shale, decomposing into a soft clay, and the subsilicious layers have often a remarkable concretionary structure, and resemble, in their grain at least, the silicious limestone of Fontainebleau. Sometimes layers of nearly pure sandstone occur even in the lower part of this bed. Flints, such as I have described, occur in this bed, particularly in the purer limestone, and in connexion with openings; but they have appeared less abundant in this bed than in the lower. From the decomposable character of the greater part of this bed, its surface is generally covered with earth, forming a sloping declivity. The lower bed is composed of a hard and purer thick-bedded grey limestone, resembling in its external appearance the corresponding middle bed of the upper magnesian, but distinguished by its structure, and its peculiar flints already noticed. This lower bed has been seen by me only in its upper portion. It appears, both on the Blue and Platte rivers, only as a low bluff (10—20 feet high) sinking below the surface. From its character, and particularly the great abundance of flints, it is apparently the middle bed of the entire series; a lower bed underlying it, corresponding in some degree to the upper bed already described. This, however, I offer only as a conjecture.

LOWER SANDSTONE.

This formation I have not yet had an opportunity of observing in immediate connexion with the overlying stratum (the Lower
Magnesian.) The sandstone in the quarries west of Madison, from which that town is supplied with its material for building, is quite different in its character from the upper sandstone, and is apparently less purely silicious, and consequently less incoherent in its texture. It is overlaid in the quarries, particularly in those on the south (Larkin's,) by subcalcaceous and subargillaceous layers, resembling not a little those which occur at the junction of the upper sandstone and the lower magnesian. Concretions of a flinty quartz are found in some of these, resembling similar concretions in the latter situation. From these circumstances, I should rather regard the sandstone in those quarries as belonging to the Lower Sandstone. This is farther rendered probable by the occurrence of those quarries on the north of a ridge, extending along the south side of Dead Lake, occupied by the lower magnesian, while the country to the south of that ridge is occupied by the blue limestone and the underlying upper sandstone.

It is worthy of remark that each of the limestone series admits of a three-fold division, distinct in the three upper series, and at least probable in the lower magnesian. A general character, independent of its fossils, pervades the whole of each series, by which it may be distinguished from the others, while each subdivision or distinct bed has its own distinctive characters. The middle bed in each is distinguished by an abundance of flint or hornstone, arranged in layers conformable to the stratification, either in detached nodules, or more connected. This is less obvious in the middle bed of the blue limestone; still nodules of flint are there of occasional occurrence, particularly in the upper fine-grained portion.

Estimates of the thickness of the different strata have been given in former reports; but such can be considered only as approximative, the strata apparently varying considerably in thickness in different localities. It may be considered a moderate estimate to reckon the thickness of the Upper Magnesian at 240 feet (120 feet for the upper, and 60 feet for each of the lower beds;) that of the
Blue Limestone and Upper Sandstone each at 60 feet; and that of the Lower Magnesian at 220 feet.

**EXTENT OF THE STRATA ON THE SURFACE.**

The extent of the mound strata has already been indicated. The mound limestone is immediately confined to the mounds themselves. The underlying blue shale extends but to a limited distance around the mounds, although traces of the pipe clay, formed from its decomposition, have been found in different places very remote from them, as already stated. The upper magnesian occupies the remaining surface of the mineral district, so far as I have examined it, from the Mississippi to the valley of Sugar river, except at the points of extraordinary elevation already indicated. Viewing the surface of the mineral district as a general level, the upper magnesian has been subject to denudation by the general rise of the strata towards the north, and by the extraordinary elevations above referred to. The valleys and ravines have farther caused a removal of the upper strata, and an exposure of the lower, and this to a greater degree towards the north, and at the points of extraordinary elevation. The rock occupying the surface is thus subject to frequent variation, and can only be determined exactly by long continued observation. I can only, at present, make some more general statements, leaving the particular determination to a farther opportunity. This is, however, a question of no little practical importance in mining. By determining precisely the stratum occupying the surface at any given point, the miner will know what depth of mineral-bearing rock he may there expect; how many openings and of what character he may reasonably expect to meet. Where the whole thickness of the upper magnesian is known to be present, and this can be very satisfactorily determined by the occurrence of a bed of pipe clay with the accompanying fossil layers at its junction with the upper magnesian, and hardly less so by an abundance of the fossils of those layers lying loose on the surface of that rock, the extent of mining ground, other things equal, is of course greatest, and this
will be diminished in proportion to the number of beds which are found to be denuded. Still where a great amount of the upper beds has been removed, particular localities, from the great richness of the deposits in the strata remaining, have been among the most productive in the district. Mineral Point is a remarkable instance of this, where most of the mining has been in the lower part of the upper magnesian, and in the blue limestone.

The effects resulting from the general rise to the north are so much involved with those caused by the extraordinary elevations that the subject will be best presented by first detailing the latter. The first of these elevations, which I shall notice, is that along Fever (Galena) river. The point of greatest elevation is on that river, about three miles north of Benton, and about E. S. E. of Buzzard’s Roost (Meeker’s Grove,) where the upper sandstone rises about twenty feet above the surface of the river. In the ravine descending north from Meeker’s Grove to that river, the blue limestone is elevated at least thirty feet above the bottom of the ravine, on its east side, while immediately on the west side of the ravine, the brown rock (lower bed of the upper magnesian) sinks below the bottom, the strata on both sides remaining nearly horizontal; thus indicating a fault at that point. Proceeding north from that point, the lower strata soon disappear, and the different beds of the upper magnesian successively occupy the surface; first, the lower bed (brown rock;) then the middle flint bed (at Elk Grove village and the Strawberry Diggings ;) then the upper bed (at the North Elk Grove Diggings,) and this continues to the base of the Platte Mounds, where it is overlaid by the blue shale and the mound limestone. Proceeding south from the point of greatest elevation, the sandstone soon disappears, but the blue limestone is exposed generally in the bluffs of Fever river, to a point about two miles south of New Diggings. It does not, however, sink uniformly towards the south, but presents a series of undulations, rising and falling, and that sometimes quite abruptly; but no other instance clearly indicating a fault has yet occurred to me. The blue limestone sometimes appears more elevated on
one side of the valley than on the opposite side, but this may have been the result of undulation merely. It also appears along the branches of the river to a greater or less distance from their junction, particularly along the Shullsburg branch, where the same undulations occur as on Fever river. The blue limestone, in its progress south, apparently sinks below the level of Fever river, but again rises, at least twenty feet above its level, at Buncombe, and farther south, alternately sinks below and rises a few feet above the river, to its last appearance near the Galena and Chicago road. There would seem, in this instance, to have been an extraordinary elevation at the point near Meeker’s Grove, above mentioned, causing a fault, with a gradual subsidence to the South, modified however by local elevations in its progress. This elevation would seem to have acted along the valley of Fever river, as an axis, throwing up the strata on each side. Thus the higher grounds, for about three miles south of Meeker’s Grove, immediately adjoining Fever river on the west, and in the point between that river and the Shullsburg branch, are chiefly occupied by the lower bed of the upper magnesian, and the diggings are there mostly in that bed. Farther south, the higher beds of that rock approach the river, but the diggings there, near the river, are in the flint or lower bed, chiefly in the former, and those in the upper bed only occur in the highest grounds, more remote from the river.

The next point of extraordinary elevation is that along the West Pecatonica, near Mineral Point. The highest point of elevation is apparently in the fork of the Pecatonica and Pedlar’s creek, north of the Mineral Point and Platteville road. The lower magnesian there rises above the level of the river, presenting low bluffs (10—12 feet high) along its banks. Its exact junction with the upper sandstone is there concealed; a considerable interval, corresponding to its upper portion, intervening. From that point the strata sink to the north, as well as to the south. The sandstone, towards the south, sinks to the level of the Pecatonica, not far south of Bonner’s branch. The bluffs of the same rock obviou
ously decline towards the north, but I have not traced them far in that direction. There are, in this district, the same appearances of sudden local elevation as in the preceding. Thus on the east side of the Pecatonica, opposite Bonner's branch, the sandstone rises but a few feet (5—6) above the river bottoms, while not more than two miles farther north, it occupies two thirds the height of a bluff, about 60 feet high, overlaid by the blue limestone. At Mineral Point village, the blue limestone rises high on the sides of the ridges, leaving only a moderate thickness of the flint bed at their summits, while the mineral openings are principally in the lower bed of the upper magnesian, and in the blue limestone. At the Dreadnought Mine, three miles north of the village, the main body of the flint bed is present, with its peculiar openings, and at Dodgeville, nearly eight miles north, a considerable portion of the upper bed of the upper magnesian is also present. At the Heathcock Mine (Linden,) six miles N. W. of Mineral Point, the blue limestone rises but a few feet (8—10) above the level of Pedlar's creek adjoining. These facts indicate a dip of the strata from the highest point of elevation towards the north. A similar dip is observable to the west, towards the Platte Mounds, and to the east, towards the high prairie ridge, separating the east and west branches of the Pecatonica.

Another point of elevation occurs on the East Pecatonica, at or near Argyle. At that point, there is an extensive basin, in which rise several low ridges, either composed entirely of sandstone, or of sandstone capped with the blue limestone. Different branches of the river here meet, from the north and the east, and along them lines of elevation may be traced, for several miles, in bluffs of sandstone, gradually sinking from the centre, but subject to local elevations, as in the preceding districts. This centre of elevation is bounded on the north by the high ridge extending west from the Blue Mounds, on the east by a range of high prairies extending south-east from the Blue Mounds towards Monroe, and on the west by the ridge separating the east and west branches of the Pecatonica.
Returning towards the west, another point of elevation occurs on the waters of the Platte, the centre of which is apparently on the Big Platte at Bald Bluff in Ellenborough, where the lower magnesian rises nearly a hundred feet above the level of the river. The exact line of junction with the sandstone is there concealed by the earthy slope covering the upper bed of the lower magnesian. The next lower bed of that rock rises in a low bluff from the water's edge. In tracing down the Big Platte, the lower magnesian appears to rise about 30 feet above the river level at the Red Dog bluff, and not more than 10 to 12 feet at the ferry on the Galena and Potosi road. At the latter point, the sandstone forms a low ridge in the valley of the Platte, on the west. This is below the junction of the Big and Little Platte rivers, and in this vicinity, the different strata appear at a higher elevation on the west than on the east side of the river, the upper surface of the blue limestone, on the east, appearing but little higher than that of the sandstone on the west. This point of elevation is connected with that on the Mississippi, by which the sandstone is raised above the water level from Sinipee to some distance above Potosi, and the blue limestone, towards the south, to a point, on the east side, near Gregoire's Ferry (opposite Dubuque,) but on the west side, only to Eagle Point (above Dubuque;) the strata being there apparently most elevated on the east side of the river. On the north, I have not had an opportunity of tracing the limits of this centre of elevation. On the east, it extends to the vicinity of Platteville, and is limited by the country adjoining the Platte Mounds, and on the south, it is confined by the high prairie between the Mississippi and Fever river, near the centre of which rises the Sinsinawa Mound.

Another centre of elevation apparently occurs on Grant river, south-east of Beetown, near the junction of Pigeon creek. At that point the sandstone is elevated 30—40 feet above the river, while lower down on the same river, at Waterloo, it is not exposed. The same is true on Rattlesnake creek, towards the west, and on the Beetown branch, towards the northwest; only the
blue limestone appearing there at the surface. On Boyce's creek, south-east, towards Potosi, the blue limestone appears more elevated than in the vicinity of Potosi, as if within the limits of this centre of elevation. These limits are apparently the ridge of Boyce's prairie on the east, the high ridge between Grant river and Cassville on the south-west, and Blake's prairie on the northwest.

The excavations in the mines, in the vicinity of these extraordinary outcrops of the lower strata, are a farther proof of sudden elevations of the strata; the shafts being often sunk in the upper strata to a greater depth than would be sufficient to reach the lower, if the range of the latter from their outcrop was horizontal.

From the details of the above arrangement, some idea may be formed of the manner in which the different strata occupy the surface in the mineral district. On the higher portion of the ridges and prairies bounding the centres of elevation, the upper bed of the upper magnesian occupies the surface; most so towards the south, conformably with the general dip to the south. On some of the higher points, even remains of the pipe clay, with its fossiliferous layers, are observable, as already stated. These I have observed most distinctly at different points on the high prairie between the Mississippi and Fever river, both in Wisconsin and Illinois; on the higher grounds at the Blackleg Diggings, on the line of the two States; and on the high ridge east of the Mississippi, north of Cassville. Throughout these higher districts, the diggings are in the upper bed of the upper magnesian. On approaching the centres of elevation, or the general northern outcrop, a zone occurs, where the flint bed occupies the surface, sometimes quite narrow, and at other times, particularly in the forks of rivers, more extensive; the upper bed either thinning off gradually, or terminating more abruptly. In the former case, the diggings are often both in the upper and flint bed, near the outcrop of the latter. Still nearer the centres of elevation or the general northern outcrop, the lower bed of the upper magnesian occupies a similar zone of the surface, and here the same remarks are appli-
cable as in the former instance. The blue limestone, and the
strata underlying it, are generally exposed, in these centres, only
along the sides of valleys and ravines, and rarely occupy any ex-
tent of surface. It would require long continued observation to
collect the facts necessary for a map exactly exhibiting the extent
of the different strata occupying the surface. Such a map would
be very useful, not only in determining the mineral value of pro-
erty to some extent, but also the probable character of soils, from
the underlying rock.

In the north-eastern part of the country examined by me, along
the valley of Sugar river, and west of Rock river between Mad-
ison and Janesville (south of the outcrop of the lower magnesian,)
there has been obviously an extensive removal of the upper strata,
but not accompanied, as far as I have observed, with such remark-
able evidences of local elevation as in the mineral district. In
the valley of the west fork of Sugar river, south east of the Blue
Mounds (in the town of Primrose,) the lower magnesian rises, how-
ever, near 30 feet above the bottom of the valley, while the surround-
ing high prairie ridges are covered by the upper bed of the upper
magnesian. From the valley of Sugar river, north east of Exeter
to Rock river, north of Janesville, I have observed no appearance
of the upper magnesian. It may occupy the surface of the high
prairie, extending west from Rock river, at and south of Janes-
ville, but I have not yet had an opportunity of determining it.
It however occupies the surface farther west, at least to the east
of Monroe. The country north of that prairie, to within 5—6
miles of Madison, is traversed by numerous ridges, more or less
isolated, with intervening basins; the higher ridges, so far as I
have examined them, overlaid or capped by the blue limestone,
and underlaid by the upper sandstone; the lower swells sometimes
formed entirely of the upper sandstone. I have observed the low-
er magnesian in only one instance in this district, where it was
reached in an excavation for a well, at sixteen feet, in the plain on
the east side of Sugar river, near the foot of an isolated tabular
ridge, formed of the upper sandstone overlaid by the blue lime-
stone. The blue limestone, in this district, sometimes presents all its beds distinctly, as in Donaldson's quarry, near Stoner's prairie, south-west of Madison, and in the Monterey quarry at Janesville, and sometimes only the middle and lower beds, or the lower bed only, according to the degree of denudation. In this district, the middle bed of the blue limestone has presented only a uniform fine-grained rock, resembling the upper portion of that bed in the mineral district. The compact glass rock has not occurred distinctly. Along the northern border of this district of the blue limestone and upper sandstone, extends a narrow ridge, occupied by the lower magnesian, presenting the peculiar characters of its middle bed, as observed in the mineral district. This ridge ranges E. S. E. along the south side of Dead Lake, and in an E. S. E. direction, by the map, from the Wisconsin near Arena. The sandstone quarries, west of Madison, lie 2—3 miles north of it, in a parallel range, as if in the position of the lower sandstone.

I have made these statements in order to correct an error in former reports, which presents a singular anomaly in the outcrop of the strata, and might lead to embarrassment, particularly in examining the eastern border of the mineral district. It has been stated by Mr. Lapham, in a communication in Foster and Whitney's Report (P. II, 1851, p. 169,) that the limestone at Janesville is the lower magnesian, underlaid by the lower sandstone. This has been adopted by Owen, in the map accompanying his last Report (1852,) in which the outcrop of the lower magnesian is drawn from a point near the Wisconsin river, north of the Blue Mounds, along the east side of Sugar river, south-east to Janesville. The limestone at Janesville is clearly the blue limestone, presenting its three beds with their distinctive characters and their peculiar fossils. The underlying sandstone has as strictly the characters of the upper sandstone, particularly at its junction with the blue limestone. The same is true at Donaldson's quarry, where all the beds of the blue limestone are present, well characterized, and the sandstone underlying that and the other more northern localities of the blue limestone is equally marked as the upper sandstone.
SURFACE DEPOSITS.

The rocks, in the mineral district, are overlaid by a deposit of earthy materials of greater or less thickness, in some places to a depth of more than thirty feet. This consists generally of a strong clayey loam, called surface clay, of a light brown color, forming a subsoil at once free and retentive, and itself fertile. Formed apparently by subsidence from still water, from the decomposition of the upper rocks of the district, in which limestones, alternating more or less with shales, predominated, it has at once the characters of a calcareous and argillaceous soil, mixed with sufficient silicious matter to render it easy of tillage. It is only in very wet seasons that its adhesive quality is found inconvenient. In dry seasons, when other parts of the country, where the soil is lighter or more entirely clayey, have suffered from drought, this district has not been affected by it, and has yielded abundantly. It thus offers the rare combination of agricultural capabilities of the first order, united with mineral resources fully equal. Wherever the limestones form the surface rock, this clayey subsoil prevails. Where the upper sandstone is brought to the surface, there is a greater predominance of silicious matter; but this occurs to a small extent in the mineral district. In the valley of Sugar river, and in the country extending east from that to Rock river, north of the parallel of Janesville, where the upper sandstone is exposed to a larger extent, more sandy soils are frequent, but still fertile, and wherever the blue limestone extends in the swells and ridges, more loamy soils are observable.

Beneath the brown surface clay, there is usually found a layer of red clay, more or less filled with red or yellow flints, immediately overlying the rock, and often found extending to a greater or less depth into the open crevices. It is different from the clays occupying the openings and immediately investing the mineral, and has been apparently formed by subsidence, like the overlying surface clay.
The mineral district does not appear to have been invaded to any extent by the gravel and boulder drift, which has covered so extensively other parts of the surface in this and the adjoining states. Apparently the bold escarpment, backed by the high ridges and prairies, along the south side of the Wisconsin river from a point not far east of the Blue Mounds, has obstructed the course of the drift current, and turned it east and south around the east point of the ridge at those mounds. An opening near the source of Sugar river seems to have given passage to that current, by which large accumulations of gravel drift have been formed along the west side of the valley of that river, near Exeter, and of boulder and gravel drift farther east, while scattered boulders, usually of no great size, are found in the side valleys, and on the slopes of the adjoining ridges and prairies, towards the west, as far south at least as the vicinity of Monroe. In the tract of country occupied by the blue limestone and upper sandstone, between the high prairie, west of Janesville, and the ridge of the lower magnesian, south of Madison, accumulations of such diluvial drift are comparatively small and infrequent, but with occasional exceptions, while on the north of that ridge they are large and extensive; that ridge having also acted apparently as an obstruction to their progress. My observations in that part of the country, covered more or less by this diluvial drift, have been very limited, and a farther consideration of its extent must be deferred to a future occasion. The boulders and smaller rock fragments, composing this drift, are chiefly derived from primary and trap rocks, though partly from the flints (hornstones and quartz) accompanying the limestones, particularly the lower magnesian. Small nodules of hematite, and of iron pyrites partly converted into hematite, such as occur at the junction of the blue limestone and upper sandstone, are frequently found in this drift and scattered on the adjoining surface.

In the immediate vicinity of the Mississippi, on the surface of the higher ridges and prairies adjacent, accumulations of drift are occasionally found, in some instances quite extensive, composed of
a fine sand, usually yellow or light brown, as if formed from the sandstone adjoining that river towards the north. These are generally arranged in hillocks, with intervening round hollows or basins, such as are common in drift districts. This sand, on the surface, is mixed more or less with mould, forming a light soil, but at a small depth is sufficiently pure for mortar. A tract of 2–3 square miles, covered with such drift, and remarkable for its hillocks and hollows, extends from the bluffs of the Mississippi to the valley of the Great Menominee, S. W. of Jamestown village, and similar accumulations are met with on the high lands, adjoining the Mississippi, between Potosi and Cassville. On the summits of the river bluffs, particularly in the vicinity of Cassville, small rolled fragments of the same materials as those composing the gravel drift, above noticed, are often profusely scattered. These facts indicate the passage of a peculiar drift current along the course of the Mississippi, and it is worthy of remark, that the points where those accumulations are most remarkable are a little below two large bends in that river, namely, that from south to southeast just above Cassville, and that to the south between Dubuque and Potosi. Such a deflection would naturally cause an eddy, and thus lead to those accumulations.

MINERAL DEPOSITS.

The first object of the present survey is the investigation of the Lead Mines of the mineral district, and of the different useful minerals connected with them. The previous description of the strata is important, as fixing definite limits in mining, and from their peculiar connexions with the mineral deposits.

The metallic ores found in the mineral district are chiefly the sulphurets of lead, zinc, iron and copper. Other ores of these metals are also found, formed apparently by recomposition from the decomposed sulphurets. Such are the sulphate and carbonate of lead, the carbonate and silicate of zinc, the sulphate and hydrated oxyd of iron, and the carbonate of copper. The black oxyd of
manganese also frequently accompanies the mineral deposits. Of these ores, the sulphuret of lead (galena) is the most important, and that which has been hitherto the sole object of mining in the mineral district, except in one instance (that of the copper, at Mineral Point.) I shall therefore make it the first object of my attention, and notice the others only as far as they have an immediate connexion with it. The term mineral, in the mining district, is restricted to the ores of lead, and without addition to the sulphuret, and is the term generally used there for the latter. I shall for convenience use it in that sense, in what follows.

The first subject to be considered, is the manner in which the mineral is deposited. It is a matter of great interest to determine, whether the mineral is arranged in continued veins, or in detached and casual deposits. The prospects of mining must be much greater, if the former arrangement prevails, than if the latter. During the whole course of my examination of the mines, I have made this a particular object of attention, and although interruptions in the deposit of the mineral are general, as I believe is the case in all veins, yet the characters of a vein arrangement have appeared every-where to predominate.

The mineral deposits, whatever may be their character, are usually arranged along continued lines, having a certain direction, thus forming ranges or leads (lodes.) These ranges are mostly combined, in a certain systematic order, into different groups, called diggings, between which there is a greater or less extent of country in which little or no mineral has been discovered. These groups are also connected, in a corresponding order, in more extensive series, showing the general prevalence of systematic arrangement. As little has been done in deep mining, and the deepest shafts yet sunk have been abandoned, I have had fewer opportunities than I could wish, of tracing the mineral, at the same point, through different strata. Still in several instances I have followed it without interruption, or with only such minor interruptions as are common in veins, through different strata. The mineral deposits exhibit too, in the different strata, peculiar arrange-
ments, which are common to each throughout the mineral district, subject only to local modifications; thus showing the prevalence of arrangement in a vertical as well as horizontal order.

The ranges or leads have different directions, which preserve a great degree of regularity in the different groups or even more extended series. Three different classes of ranges are recognized, according to their direction, namely, East and West, North and South, and quartering; the last intermediate between the two latter. Of these, the East and West are the most important, and apparently have had a leading influence in the arrangement. The term East and West is not limited to such as are due east and west, or nearly so, but in different groups is applied to the predominant ranges having a general east and west bearing, although in some instances they may deviate even 45° from a due east and west course. The term North and South is also applied to ranges which deviate considerably from a due north and south course, but rarely to those which deviate more than one sixteenth. Quartering ranges (called by the miners swithers and contras) include all such in a group as do not belong to either of the preceding divisions. They are such ranges as meet a leading range, particularly an East and West, at an oblique angle; consequently when the leading East and West ranges deviate from a due east and west course, a due East and West range would be considered quartering.

In general, the space in which the mineral is deposited, or through which it is distributed, if of much extent, is called an opening. This is sometimes filled with loose materials, and these by settling often leave a void between them and the roof, usually of no great extent; but in some instances larger cavities, or eaves, have been so formed. In other instances, the opening is merely a certain extent of the rock, more or less modified, through which the mineral is distributed. Indeed, in nearly all those instances in which the openings are filled with loose materials, these appear obviously to have been derived from the decomposition of the rock, and not from materials deposited subsequently. Such open-
ings differ from those in which the rock is only modified, by the greater degree of decomposition the rock has undergone. The rock immediately adjoining the openings is usually harder and more compact than the rock in general. That included in the openings is generally softer and more decomposed, and more or less stained with oxyd of iron. Different substances are also deposited in it, besides the mineral, such as other metallic ores, clay, calcareous spar and sulphate of barytes.* Openings, according to their direction and the manner in which the mineral is arranged in them, are vertical, flat (horizontal,) or pitching (oblique). The two first mark an important distinction in the arrangement in the different strata; the vertical openings predominating in the upper part of the upper magnesian; the flat openings in the middle and lower portions of the same; and in the blue limestone.

Although there are certain general principles which seem to have governed the arrangement of the mineral, yet numerous modifications occur, the details of which may be first given, before stating the former. In this detail, I shall commence with the arrangements observed in the upper part of the upper magnesian. The first and simplest form is that of the crèvice. This may be either a joint in the rock, marked by an iron stain, or a fissure of little width, occupied by a seam of clay, or of ochre and iron rust (hematite); the two latter derived from the decomposition of iron pyrites, which sometimes, though rarely, is found in their place. Though the walls of the fissure are nearly parallel, yet it is usually marked by enlargements and contractions of little extent. In such a fissure, the mineral occurs as a sheet, either closely wedged in the rock, or separated from it by a thin seam of clay or iron. Such sheets usually conform on their surface to the adjoining sub-

* Silex, in the form of quartz or otherwise segregated, except as flint, rarely accompanies the mineral, or is disseminated in the opening rock. In one of the North and Souths, at Skidmore’s Diggings, a fine-grained silicious grit accompanied the sheet of mineral, as a matrix, arranged in sheet form between it and the rock; and in a brown rock opening, on the west side of Coon Branch, near Benton village, crystalline quartz was found disseminated through the opening rock, in place of the calcareous spar usually disseminated.
stance, but occasionally present a more or less regular form, where the fissure is somewhat enlarged and the sheet is imbedded in clay. They are usually less interrupted than other forms of arrangement; in some instances, very little interrupted; in others, more so, when they are called broken sheets. When interrupted, they are replaced by clay or iron ore, and sometimes by calcareous spar, sulphate of barytes or zinc ore; but very rarely by the three latter in the upper part of the upper magnesian. Calcereous spar not unfrequently interrupts the vertical sheets in the lower part of that rock, and the mineral, when in contact with it, shows the same tendency to regular forms, as when imbedded in clay.* These sheets vary in thickness from a mere seam or film to a foot or more, and when even less than an inch in thickness, are generally profitable, from their little interruption, and when of great thickness, are, from the same circumstance, of extraordinary value. They may be either vertical, pitching or flat (horizontal;) but the flat sheets are rather parts of a more complex arrangement, while the vertical and pitching sheets may occur separately. These last are found with all the different bearings above specified; but the North and South sheets are the most common and the most important. Not unfrequently two or more sheets are connected; the rock between them being softer and more jointed, and forming properly an opening. In such instances, more clay and iron are usually present than where a single sheet only occurs. Such sheets often unite, in their course, in a single sheet, which again divides, or are connected by cross sheets, usually in a quartering direction. In such instances, there is generally an enlargement at the junction of the sheets, where the mineral often assumes its more regular forms, and even loses its sheet character, and takes that more peculiar to the wider openings.

Vertical sheets have been sometimes worked to a great extent and with little interruption, vertically as well as horizontally, and

* The calcareous spar in such instances is sometimes distinctly crystallized, particularly in the form of dog-tooth spar.
have been traced through different beds in the same instance, and in different localities have been observed traversing some of all the limestone strata above the upper sandstone. I have observed such sheets followed to the depth of 80—90 feet through different beds of the upper magnesian, and at the lowest depth still continued, sometimes increasing in thickness. Others are reported to have been followed to the depth of considerably more than 100 feet and left still going down.*

When the crevice is of much width, and its walls are nearly parallel, it is called a crevice opening. The space, traversed by two or more connected sheets, might be called such; but the term is usually applied to an opening of a foot or more in width, in which the mineral occurs in some other form than that of a sheet. Such openings are nearly always quite vertical, but occasionally local pitches occur. The walls of such openings are rarely strictly parallel, but there is usually a series of enlargements and contractions. This tendency to enlargement and contraction is common, and is accompanied more or less by lateral cavities of different size and form. Indeed it may be said that those openings, which continue with little variation in width to a great extent, vertically or in the direction of their course, are one extreme, and that a series of isolated openings or cavities (called pockets,) connected by mineral seams, such as have been mentioned, are the other, between which almost every degree of alternate enlargement and contraction may be found. Openings are more rarely found of much extent vertically than in the direction of their course. Thus in sinking on a crevice, different openings will be found, one beneath another, little interrupted in the direction of their course, but generally separated from each other by close rock, traversed only by a mineral seam, yet occasionally connected in part by long narrow crevices, or by shorter and wider passages; the last sometimes rising to a greater or less height above the

* The largest North and South sheet at the East Blackleg Diggings is said to have been followed down to the depth of 140 feet, at the engine shaft, and left still going down, although with diminished thickness.
upper opening, and then called chimneys. In some instances, instead of this series of openings, one beneath the other, separated by close rock, there is only a series of enlargements, corresponding to the openings, separated by alternate contractions; the crevice remaining open throughout the descent. Different ranges in the same group occasionally differ in this respect; one being marked by distinct openings, and another adjacent, only by enlargements and contractions. Different ranges are also distinguished in the same manner, in the direction of their course; the openings in one presenting a series of isolated cavities or pockets, in that direction, separated by close rock, marked by a mineral seam, and in another, only alternate enlargements and contractions. Whenever, in such cases, the pockets or enlargements rise to a considerable height above the range of the opening, they are also called chimneys.

These are the most usual forms assumed by the vertical openings in the upper part of the upper magnesian. They commence at different depths in the rock, sometimes near or at its upper surface, sometimes at the depth of many feet. Where the whole thickness of the upper magnesian is present, together with the overlying blue shale or pipe clay, I have never seen the crevices or openings penetrate the latter, or even the thin bed of schistose limestone, called shingle rock, sometimes overlying the thicker layers of the upper magnesian. But often the crevice is struck immediately on entering the thicker layers of that rock, and the opening soon after, and in some instances, I have observed the openings rise to its upper surface, and immediately overlaid by the pipe clay or blue shale. Where these or the upper part of the upper magnesian have been denuded, such openings reach to the surface of the rock, and are called open crevices. More generally, although the crevice may at times be struck at little depth in the rock, the opening is not reached till at a greater depth, which in each group is usually common to all the ranges. This may be called the level of the openings, and it is at this depth,
known by experience in the different localities, that openings are expected.*

The openings sometimes gradually expand from a narrow crevice, but more usually terminate above in a low arch, or are flat-roofed. The rock immediately above the opening is called the cap, and when one opening lies below another, the rock separating them is the cap of the lower. It has been already stated, that the rock immediately adjoining the openings is harder than the rock generally. This is particularly true of the cap, and when in sinking on a crevice, the rock becomes unusually hard, an opening is expected.

The openings, now under consideration, are usually filled with soft and loose materials, which seem to have been formed by the decomposition of the rock originally occupying them. These are usually what are called sand, clay and tumbling rock; the sand derived from the decomposition of the limestone; the clay, from that of shale or claystone; while the tumbling rock is but the harder and more compact portion of the limestone, which has resisted decomposition. In examining these materials, I have almost invariably found the sand and tumbling rock conforming distinctly, in their arrangement, to the stratification of the limestone, and the clay either arranged as distinctly in the same order, or appearing as an original matrix of the mineral.

I have already stated that the term opening is also applied to

* The crevices are not only interrupted above by the blue shale and shingled rock, but often by many feet of the upper magnesian, and are sometimes struck only at a short distance above the opening. A mineral crevice usually first shows an iron stain on its walls, and lower down a seam of clay or hematite (iron rust) and often still nearer the opening, a sheet of mineral, or detached pieces of the same in a sheet or vein position, leading to the opening. Often a seam of black ocher (oxyd of manganese) precedes the mineral, indicating its near approach, and the latter, when first met, is usually more or less coated with the carbonate. Not only is it common to find a seam of clay, bordering sheets and veins, or otherwise investing the mineral as a matrix, but I have observed flat-roofed or low-arched vertical openings lined by a smooth unbroken seam of joint clay, more or less completely investing them, and yet the materials inclosed, except the mineral and its immediate matrix, arranged conformably to the stratification, and apparently altered or modified portions of the rock.
limited portions of the rock, less disintegrated, marked by certain peculiar characters, and traversed by the mineral, or through which it is disseminated. In such instances, other substances, besides the mineral, may traverse the rock, or be disseminated through it, such as other metallic ores, clay, calcareous spar and sulphate of barytes. Iron pyrites is always originally present in such portions of rock, and has generally suffered more or less decomposition, leading to the disintegration of the rock, and to the ferruginous stain common to all openings. The limestone, in such openings, even when least altered, appears to be made up of hard compact concretions, little or not at all subject to stain or disintegrate, imbedded in a ground of more granular structure, more or less subject to stain and disintegrate from disseminated pyrites. When this part of the rock is stained, as is usual, the rock of the opening has a peculiar mottled appearance, and is called calico rock, in some localities. This is peculiarly characteristic of the flat openings in the lower beds of the upper magnesian, particularly in the flint bed. In the vertical openings in the upper part of the upper magnesian, the tumbling rock corresponds to the harder unstained nodules or concretions in the calico rock, but usually of a much larger size, and the sand to the stained and softened ground of the latter.

In the vertical openings in the upper part of the upper magnesian, the mineral, in general, is arranged vertically. In these openings, it shows a greater or less tendency to assume its regular cubic form. When its form is more regular, it is called square mineral; and when a number of cubes are combined, particularly in a sheet, it is called cog mineral. When its form is more irregular, showing only an approach to its regular cubic form, but in more or less detached masses, it is called chunk mineral.

The cubes or more irregular forms are arranged, in the vertical openings, in a certain order, more or less distinct, which may be called the Vein order. This is most distinct in the East and West ranges, but may be traced more or less even in the North and South sheets, where an approach to the cubic form is observable, and
may be also recognized in the arrangement of the mineral in the flat openings. In this order, the cubes or masses deviate from a direct line, alternately to the right and left, forming a zig-zag, but in such a manner as to continue the general direction. When a crevice is of little width, it is usually traversed by a single vein, or course of mineral in vein order, usually accompanied by clay as its matrix. But if this be examined strictly, it will be generally found double, or divided by a middle seam into two series of cubes or less regular forms, and the same is equally true of the sheets, which, as I have observed, occasionally in the wider parts of their crevices approach the regular form of the mineral. This too is often observed where the sheets are met by cross crevices. When a narrow crevice widens, the single vein divides, each of its symmetrical parts being continued along its wall, or sometimes only one of them, the other being interrupted. The surface of the mineral next the wall is then less regular, and conforms in general to the surface to which it adheres; that towards the middle of the crevice, which is usually occupied by clay, is more regular; the whole vein, in this instance, forming a more or less perfect geode. Where the crevice alternately widens and contracts, the same alternation will be observed in the arrangement of the vein. Such geodes or more irregular deposits, in the enlarged portions of the vein, are called bunches. In some veins there is a greater tendency to form bunches than in others, and in such cases the intervening portion of the vein is usually diminished or even interrupted. The arrangement of the vein thus corresponds to that of the openings.

Where the opening is wide, and includes considerable masses of tumbling rock, it may contain several such veins or courses of mineral, separated by the masses of rock, which may either unite, or be connected by smaller cross veins. Sometimes the wider vertical openings are traversed longitudinally, to a greater or less extent, by one or more vertical masses of rock, called key-rocks; but these rarely divide the openings completely, but are more or less insulated, corresponding to the horses of English
miners. These are particularly connected with an important arrangement observed, in several instances, in the upper part of the upper magnesian. This occurs, when, in a wide opening, with a flat or slightly arched roof or cap, the lower part is chiefly occupied by one or more key-rocks, rising towards the roof, but leaving an interval of greater or less width above. Veins of mineral rise in the intervals between the walls and key-rocks, or between the key-rocks themselves, and pass over the top of the key-rocks in the manner of a flat sheet; the whole being thus connected. Some of the heaviest bodies of mineral have been found thus arranged. The lead struck about a year since, at Turner's Diggings, east of the Sinsinawa Mound, and one of the most productive for the time it has been worked, is of that kind. In some few instances, large bodies of mineral have been found on the surface of the rock, where it had suffered denudation, lying between two vertical veins in the rock; apparently resulting from such an arrangement. A remarkable instance of this kind occurred at Selkirk's Grove, west of Benton village, and a similar body of mineral was found in a ravine, near the lead at Turner's, lying on the surface of the rock, on one side of which at least a vertical vein was seen entering the latter.

An analogous arrangement is observed in the wide openings, called caves, remarkable instances of which occur in the Dubuque district. Veins rise there along the sides, and are continued upwards into the sides of the roof, and at the same time send flat sheets along the roof, the two from the opposite sides meeting at a middle crevice in the roof, and sending up through it a vertical vein, which often presents a geode as it enters the crevice, as if formed by the junction of the two. In one instance, where a cross section of the roof was exhibited, (at Stewart's cave,) the lateral vertical veins sent across other flat sheets through seams in the cap-rock to the middle vertical vein. The flat sheets, crossing under the roof and in the rock above, are generally thinner and more interrupted near the middle point between the side and middle vertical veins; a fact generally observable in flat sheets interposed
between vertical veins, as if the formative action proceeded from the latter.

In some instances, in wide openings, where no key-rocks are present, an arrangement similar to that in the roof of Stewart's cave is observed in the soft ground of the opening itself; flat sheets not only extending across under the roof, but at intervals below; the opening being then occupied by decomposed rock, arranged conformably to the stratification. Sometimes the flat sheets extend only a short distance from the side veins, and in other instances, the side veins rise only partly towards the roof, and terminate in flat sheets extending but partly across the opening. In one instance, in such a wide opening (at the east end of Hughlett's lead, north of Galena,) a layer of hard rock was interposed in the soft ground in the lower part of the opening, as if dividing it into an upper and lower, below which a flat sheet extended across the opening, while the lateral vertical veins were continued uninterruptedly on its sides.

The same vertical opening sometimes presents different arrangements in different parts of its course; in one part, only a single vertical vein, occasionally enlarging into bunches or geodes; and in another part, arrangements such as have been last described; the opening enlarging and varying in form correspondingly. Thus a wide cave opening will sometimes pass at no great distance into a narrow crevice opening, and the arrangement of the mineral will change from that of lateral vertical veins, meeting by cross flat sheets in the roof or below in the opening, to that of a single vertical sheet or vein. This latter will, in some parts of its course, form a proper sheet; in others, a vein marked by cubes, more or less distinct, in regular vein order; and in others, geodes or bunches, and these last either connected by intervening sheets or veins, or more or less detached and interrupted. In the latter case, however, the connexion may be traced by a mineral seam, more or less distinctly marked.

I have already observed that the same crevice sometimes includes distinct sheets or veins, occasionally uniting in one, or con-
nected by cross sheets or veins. In like manner, distinct crevices, with their veins, sometimes unite or are connected by cross crevices and veins. At such points of junction, there is usually an extraordinary increase of the mineral, and the smaller vein is then regarded as a feeder of the larger. The East and West veins are usually the leading veins, and the North and South and quartering veins are then subordinate and regarded as feeders. But usually where cross veins meet a leading vein at such an accumulation or bunch of mineral, they extend only a limited distance from it, and are rather lines proceeding from it as a centre than feeders contributing to form it. When a quartering vein meets a leading vein, on entering the crevice of the latter it often runs parallel to it for some distance, the two connected by a net-work of cross veins, and at last uniting in one common vein. In some instances, two parallel leading veins are connected by such quartering veins, and in others, one leading vein will leave its regular course, and pursue a quartering direction till it unites with a leading vein adjoining. Cross veins are differently affected on meeting a leading vein. Sometimes they pursue the same course, without interruption, on the opposite side, but more usually they are interrupted (cut off,) or else shifted to a greater or less distance. In the latter case, I have sometimes observed particles of mineral disseminated in the rock opposite the vein at its junction with the leading vein, apparently indicating that the shift was not caused by any shift in the rock, of which there were besides no indications. Not frequently a leading vein, on meeting a cross vein, will be interrupted or cut off, with its crevice, and apparently shifted by the cross vein to another parallel vein. In one instance, I observed an East and West vein, from which a quartering vein had proceeded at some distance, interrupted in this manner by a North and South, and apparently shifted by it to the quartering vein, when the latter became the leading East and West vein. In other instances an East and West vein will terminate less abruptly, and be shifted to another east and west line, commencing there in the same manner it had terminated; the two overlapping each other to some
extent, and sometimes connected by a cross vein or seam near their termination. Usually the cross vein, in such cases, is small, and serves only as a leader from one East and West vein to the other, or the connexion is formed only by a seam of ochre or clay. These arrangements have an important relation to the grouping of veins, and will be farther noticed under that head.

Another mode of lateral shifting is sometimes observed in East and West vertical veins, where the mineral is arranged in a series of more or less detached deposits or bunches. These last range in a direction oblique to the general course of the vein, and usually thin out at each extremity. Each succeeding bunch overlaps the preceding in such a manner that the general course of the vein is continued.

The mineral in the vertical openings is sometimes found only near their cap or roof, and sometimes only in their lower part; sometimes both above and below, but not between; and at other times, more uniformly throughout their whole depth. Not unfrequently it rises and falls alternately in its course, occupying only a moderate extent vertically at any one point, but rising and falling to a much greater. The opening, when it is low and capped over with hard rock, rises and falls, in such cases, with the mineral. This rising and falling is usually by a succession of flats and pitches, or steps, rather than on an uniform line. A similar arrangement occurs in the flat openings in the lower beds. Often the mineral rises above the common level of the openings in the chimneys already described (p. 36-7); in such cases forming bunches at the intersection of the chimney with the horizontal opening, extending upward into the former.

Flat (horizontal) sheets or veins have been already noticed in connexion with the wider openings, both in the soft ground of the opening, and in seams in the cap rock. In some instances, such flat sheets have been observed, of considerable extent, overlying a number of parallel crevices traversed by vertical veins, and in others, of less width, overlying only a single opening or vein. When such a sheet is struck in the upper part of the upper mag-
nesian, it is considered as indicating the near approach of an opening or vein.

More usually, in the upper part of the upper magnesian, the East and West ranges present vertical openings of some width, traversed by veins composed chiefly of square (cubic) or chunk mineral, arranged in the vein order above indicated, while the North and South ranges are only narrow crevices traversed by sheets, marked only rarely by an approach to regular forms. But in some instances, similar sheets traverse East and West crevices, and these are often combined in groups, intervening between or appended to the larger East and West openings. Sometimes a considerable width of rock is found traversed, at short intervals, by such vertical East and West sheets, connected throughout by cross sheets, both vertical and horizontal. These cross sheets, in such cases, are usually thinner and more broken, or even quite interrupted, at the middle point between the East and West vertical sheets, indicating that the latter are the leading veins, to which the former are subordinate. The rock thus traversed is usually softer and more stained, at least towards its seams, and may be considered as forming one common opening.*

In the upper part of the upper magnesian, the crevices and openings are usually of less width and more detached than below, and the leading veins arranged vertically, the flat sheets being only appendages to them. The openings, even when widest, such as the large cave openings, are also more generally occupied with looser materials, from a greater decomposition of the rock and matrix. As we descend to the lower part of the upper bed, the openings become wider, although in most instances the vertical arrangement continues to prevail. In this part of the upper bed, very wide openings are found, occupied by portions of the limestone rock, either decomposed to sand, or in detached harder masses (tumbling rock,) and intersected throughout in different directions by mineral veins, usually accompanied with seams of clay and iron; the East and West vertical veins predominating.

* An example of this occurs in one of the ranges of Norris & Haskins, at Vinegar Hill,
The mineral in these veins is usually in more or less detached masses (square and chunk mineral,) but sometimes in thinner sheet forms, usually broken. In some instances at least, those remarkable bodies of mineral, called patches, found directly beneath the surface clay, appear to have been such openings exposed by denudation. Those to which I here refer are no longer worked, but are found in the same position in the strata, and in some instances, in the vicinity of such openings, and from the description I have received, corresponded to them in character.*

Another class of wide flat openings, called flat sheet mines, are found in this lower part of the upper bed. Here the horizontal arrangement predominates; the mineral having a sheet form, similar to that of the vertical sheets, and closely wedged in the rock, or more usually in a narrow flat crevice, in which it is bordered by seams of clay or iron, and occasionally interrupted by the same, or by calcareous spar. These flat sheets appear more subject to interruption than the vertical sheets, and then often form a series of lenticular masses, thickest at their centre and thinning off towards their edges. They vary, like the vertical, in thickness, from a fraction of an inch to several inches, and are connected by cross vertical sheets, in different directions, which are small and subordinate; but occasionally the flat sheet gives out as it approaches a vertical sheet, and the latter assumes the place and direction of the former. Two and sometimes three such flat sheets are connected together in this manner, the rock between them being softer and more stained than that immediately above and below, forming properly a flat opening, but not marked by the peculiar characters of the opening rock in the flint bed below.†

In some instances, when from the vicinity of valleys or ravines, or in deep mining, shafts have been sunk through the upper bed in-

* The Finney Patch, in the S. W. Platteville Diggings, and Jones' range, N. of Elk Grove, may be referred to as examples.

† Examples: Harris' flat sheet mine, S. W. of Galena, and Jackson's, on Bull Branch (Benton.)
to the flint bed, as at Shullsburg, vertical crevices have been traced down through the former into the flat openings in the latter. In such cases, in the lower part of the upper bed the vertical openings spread out laterally, and at the same time that they carry down a vertical vein, in the middle line, from the crevice above, present flat deposits of mineral, similar to those in the flat openings of the flint bed, but less extensive; thus marking a transition from the vertical openings above to the flat openings in the lower beds.

The flat openings in the flint bed are remarkable for their horizontal extent and their arrangement. They vary in width from less than ten to 40—50 feet, and are wider in some localities than in others. Generally they are traversed by vertical crevices, marked by seams and sometimes by openings in the roof, but these are sometimes wanting, and the vertical crevices are then found traversing the hard rock between the flat openings. Thus it is common at Benton, to find narrow vertical crevices between the wide flat openings, and these last are sometimes arranged in pairs with a vertical crevice between; the interval separating the two being much less than that separating them from the flat openings adjoining. The two thus combined, with their intermediate crevice, are considered as forming one range. In one instance (at Shaw's Hollow, S. W. of Benton,) a wide flat opening, without a vertical crevice, adjoined on the north a number of narrower flat openings, each with its vertical crevice; but in this instance, the whole extent, at least of the latter, might be regarded as one common opening or soft ground. The rock in these flat openings usually presents a peculiar mottled appearance, whence it is called calico rock in some localities. The cause of this I have already referred to. This rock appears to have resulted from the decomposition of a hard blue or grey rock, intersected more or less completely by seams of iron pyrites, or rather of rock more or less filled with disseminated pyrites, dividing it into small rounded nodules, more compact than the intervening seams. This structure can not have been derived from the fracture of the rock and the injection of the seams, but has been the result of a process of se-
gregation, by which the more compact limestone was formed at centres, around and between which the more crystalline portion with the pyrites was arranged. The strong tendency of iron pyrites to decompose, under certain circumstances, particularly when minutely disseminated, has caused the disintegration of the limestone in which it was dispersed, and its own conversion into oxyd of iron, giving the stain to that part of the limestone. This hard blue pyritiferous rock is still found unchanged, in some of the flat openings in the flint bed, as in Champion's level (New Diggings,) where it occupies the position of the opening or calico rock, and like that is more or less productive in mineral similarly arranged.

The mineral in the flat openings is generally arranged in horizontal courses adjoining the roof or the floor, but sometimes in intermediate positions. Sometimes it forms a connected sheet of some extent, but more usually occurs in larger or smaller detached masses. These are generally more or less convex on one side and concave on the other, and are so arranged that the convex side is directed downwards. The concave side usually embraces a portion of the limestone harder and less stained, and sometimes the mineral is observed more or less completely surrounding the latter, but much thicker below than above. In this case, the mineral appears to have been formed around the nucleus of limestone in the same manner as the iron pyrites, as above explained. The courses of mineral are very often if not generally accompanied with a layer of flints, usually above the mineral, sometimes below, and occasionally the mineral is interposed between two layers of them. Sometimes the mineral, when detached and isolated, is associated with flint in the same manner. Though the mineral is chiefly arranged in flat courses, yet it is often found detached in every part of the opening, but is then arranged horizontally.

Vertical seams of mineral occasionally pass from one course to another, or traverse the opening as cross sheets, and at the crossing of these or even of a barren seam only, there is usually an increase of mineral in the flat courses, sometimes enlarging them so as to form geodes lined with regular cubes. When vertical East and
West crevices traverse these openings, they usually carry a vein of mineral arranged in vertical order, intersecting the flat courses; but in some instances I have observed such vertical veins on the sides of the openings, inflected under the roof into the horizontal course, with an enlargement of the mineral at the turn, sometimes forming there a geode. In some instances, the vertical crevices, which have been traced from the rock above into or between the flat openings, have been found to carry mineral more or less through their whole extent; but in other instances, the mineral extends in them little or not at all above or below the opening.

The lateral limits of these flat openings are generally marked by a slight turn in the courses of mineral from a horizontal to a vertical position at the sides of the opening, beyond which the rock soon loses its opening character; thus showing the definite extent of these horizontal deposits.

Some peculiarities, worthy of notice, are observed in different localities. In the flat openings at Benton, particularly at Swindler's ridge, a layer of hard rock, 1—2 feet thick, called the false cap, immediately overlies the openings, above which is a layer of flints, usually accompanied with a flat sheet or course of mineral, often of workable value. This layer requires support, and when such support is withdrawn, after the opening is worked out beneath, soon falls and exposes the mineral above it. The rock above, called the true cap, usually remains firm, even in the widest openings. In the flat openings at New Diggings, a layer or bed of hard rock with flints, about three feet thick, overlies the opening rock, and is overlaid by a thin subargillaceous layer, called the grey shale, apparently of a concretionary structure, and interrupted by mineral, arranged in a horizontal sheet form, detached or more connected. The rock above this contains very few flints; the proper flint stratum commencing in the bed immediately below it. A layer closely resembling the grey shale in character occurred at the Dry Grove Diggings, west of Benton, in sinking on a vertical sheet, at the upper surface of the flint bed.
The flat openings of the flint bed, occupied by the calico rock, are found throughout a large portion of the mineral district, where openings have been worked in that bed, and are the most general and characteristic of those in that bed. I have observed them, well marked, at Beetown, Potosi, Brushhill, Platteville, Elkgrove, Benton, New Diggings, Shullsburg, and the Dreadnought mine near Mineral Point. In some of these openings, the rock is much more disintegrated than in others; its ground, in such cases, being reduced to the state of loose sand, with more or less tumbling rock; while in others, although distinctly marked, the rock is so hard as to require blasting. Openings of the former kind are called sand openings, and are common at Benton, while at Shullsburg openings of the latter kind are more frequent.

Occasionally in the localities above mentioned, and more so in the more eastern diggings, the mineral is collected more in bunches, particularly along the line of vertical crevices, and is then more accompanied with clay and iron, and more disposed to assume regular cubic forms, approaching in these respects the arrangement in the vertical openings in the upper bed. But in such instances, the intervening rock is more or less altered and stained, the whole forming a common opening. In some cases, as at Chenaworth's mine, near the Dreadnought (above noticed,) this arrangement in bunches, along the lines of crevices, appears to have arisen from masses of rock, intersected throughout, as in the calico rock, by distinct seams of iron pyrites, accompanied with more or less mineral, which by their decomposition form masses of ochry earth and hematite, including the mineral as in the rock. These masses are sometimes so rich in mineral as to be very productive. Sometimes they will be found entirely decomposed; at other times, only partly so; and even in some instances, entirely unchanged; thus showing satisfactorily the origin of the former from the latter, and their relation to the calico rock. It might indeed be expected that where the pyrites is so concentrated as in these instances, it would be less extensively diffused through the rock, and more segregated in bunches, whereas the calico rock, in
which the pyrites is more disseminated, would be found characteristic of larger and more uniform openings. This arrangement in bunches is more peculiar to the flat openings, east of the parallel of Shullsburg and Mineral Point; but these openings form ranges as regular in their course as the more uniform flat openings farther west.

Calcereous spar is generally very rare in the flint openings; but occasionally it is found, either disseminated through the opening rock, or more frequently accompanying the layers of flint and mineral; the regular order from above downwards, being then calcereous spar, flint and mineral. Even in some instances where there are no traces of a mineral opening, calcereous spar is found accompanying the layers of flint in the same order. I have observed, in one instance, in Stephens' mine (Shullsburg,) a mass chiefly composed of calcereous spar (tiff,) occupying a large extent of an opening, and arranged like the masses of hard blue pyritiferous rock in some openings, as in Champion's level (New Diggings.) These masses rise sloping inwards from the bottom of the opening to a ridge near the roof, and apparently extend downwards in the manner of a lode, but have not been proved in that direction, and terminate abruptly or taper out at the extremities. The mass of tiff, in Stephens' mine, terminates abruptly towards the west, and apparently tapers out towards the east. At its west end, it is bordered by a thin layer of hard rock, in nearly a vertical position, as if out of place, but more probably formed in its present position by segregation. This layer is traversed by small vertical veins of mineral, and in the calcereous spar adjoining, which is there more massive, the mineral is found accumulated, usually in very regular cubic forms, although closely imbedded in its matrix. In some other parts of the mass, similar accumulations of mineral were found, but in general the mineral is only sparsely disseminated. The entire mass appears to be a portion of the rock arranged conformably to the stratification, the greater part of it composed of the calcereous spar, disposed in segregative order through a base of the granular limestone, through which iron
pyrites and more or less of copper pyrites are disseminated; the latter also collected at particular points in small bunches.

The flat openings in the flint bed are usually not more than four to six feet in height, particularly the wider and more uniform openings, and two openings are generally found, one above the other, separated by a layer of hard rock, about two feet thick, forming the cap of the lower. In a few instances, a third opening has been found. These may all be considered as one common deposit, with which the flat sheet above the false cap is connected. These openings, like the vertical openings in the upper bed, sometimes rise and fall in their course, by a succession of flats and pitches; or this rising and falling, as in the latter, is only confined to the mineral, the opening remaining unchanged. The most uniform flat openings are more or less subject to interruption in their course by transverse bars of rock, and in some instances, the detached portions have a form more or less rhomboidal, analogous to the form of the bunches observed in some vertical East and West ranges in the upper bed (p. 44) and also succeed each other in a corresponding order. This is observable in the flat openings at Swindler's ridge (Benton,) where the longest diameter is from north-west to south-east, corresponding to the general direction of the ranges (E. S. E.)

In the lower bed of the upper magnesian, flat openings are the most general; and even more extensive than those in the flint bed. In some instances, such openings have been worked across more than a hundred feet, without reaching their limits. In one instance (at A. Looney's level, north of New Diggings,) a side drift was carried from the middle crevice near fifty feet before reaching the limit of the opening ground. This limit was very distinctly marked by a vertical line, the adjoining rock losing at once the peculiar characters of that of the opening. I have already observed that the rock in the lower bed is less uniform than that in the flint bed, and the same is true of the openings. The black or brown rock and the green rock, in their different districts, have important connexions with these openings, gene
rally overlying and including them, whence they are usually called the black or green rock openings. In some instances, however, the rock in these openings resembles that of the flat openings in the flint bed, or the calico rock, and is then more or less accompanied with layers or nodules of flint, which seem to be confined to the opening rock, or are at least most abundant in it. But even then this opening rock is distinguished from that of the flint bed by the great abundance of calcareous spar (tuff) disseminated through it, as is common in the brown rock, and usually more or less of it has, by its stain, the character of that rock. When the opening rock resembles the calico rock of the flint bed, the adjoining rock is usually very hard and compact, and of a light grey color, resembling the hard nodules found in the opening rock, particularly of the flint bed, and the more compact layers of the upper bed of the blue limestone. This adjoining rock is destitute of the ferruginous stain and the disseminated tuff, characteristic of the openings.

In this lower bed the mineral is usually found more accompanied with the sulphurets of zinc and iron than in the two upper beds. The sulphuret of iron, or the result of its decomposition, is always present, more or less in the openings in the upper beds. Usually the sulphuret has been there converted into the oxydyd, causing the ferruginous stain and the deposits of ochre and haematite (iron rust) found in those openings. The sulphuret of zinc (black-jack) and the carbonate (dry-bone,) the result of its decomposition, are more rare in the upper openings, but are occasionally found there, more frequently, so far as I have observed, in the vertical openings in the upper bed than in the flint openings. But there is a class of veins (the flat and pitching sheet veins,) which have been traced through all the beds of the upper magnesian into the blue limestone, in which zinc ores are usually found more or less accompanying the mineral. Not only in these, and in those instances where the zinc ores accompany the veins in the upper vertical openings, but also in those where they accompany the mineral in the flat openings of the lower bed and the blue
limestone, there is an order of arrangement which I have found invariable. When the ores of lead, zinc and iron are all present, the iron ores are arranged in a sheet or layer next the rock, then the zinc, and then the lead, in succession, towards the interior of the opening. In the Marsden lead, below Galena, (a flat and pitching sheet mine,) where the mineral is usually accompanied with zinc and iron, this order is distinctly observed, and in different geodes, processes, like nipples, are observed projecting into the cavities or geodes between the cubes of the mineral, which are found occupied in the centre by a square process from the sheet of iron pyrites, like an elongated cube, surrounded with a coating from the black-jack, sometimes with points of mineral adhering to the surface. The flat and pitching sheet veins with zinc and iron, usually called flat and pitching dry-bone sheets, have been found to commence in the upper bed of the upper magnesian, and have been traced down through the different beds of that rock and of the blue limestone to the upper sandstone. At the west end of the Heathcock range (Linden,) the same sheet has been followed down from the flint bed to at least ten feet in the upper bed of the blue limestone, and is there found large and productive, and without any sign of interruption. These veins appear indeed to be the most uninterrupted, and in some instances have been worked more than twenty years without exhaustion, and with a very uniform product. *

The ores of zinc are rare in some of these flat and pitching veins, the mineral being then connected immediately with the ores of iron. But where the zinc ores are more abundant, they are sometimes nearly or quite wanting in parts of the vein, and then usually the lead ore is increased in proportion, while in other parts of the vein the zinc ores predominate. Thus in one part, the vein will be found narrow or divided in the rock of the opening, and the mineral more or less disseminated in the zinc ore, so as to require separation by crushing and washing; then, where the vein

* This is reported of the Heathcock range (Linden) and the Dry-bone mine on Bull Branch (Benton,) both of which are still worked to advantage.
is wider, the mineral will form a middle sheet, detached from the zinc ore, and where still wider, a geode will be formed and the mineral be arranged in cubes on the interior surface of the zinc ore. Still farther in its course, the zinc ore will disappear, and a thick and solid sheet of mineral be found, separated from the rock only by a seam of iron. Such thick and solid sheets are usually found on the flats, and the geodes at the turn from a flat to a pitch, extending more or less along the latter. These flat and pitching veins sometimes pitch in opposite directions from the same flat, forming what is called a saddle-back. In some instances, such a flat is apparently at the highest part of the vein, forming a longitudinal ridge along its middle, from which it pitches on each side, either in one uniform slope, or by alternate flats and pitches. Such is the arrangement of the sheet in the Heathcock range, where it forms a flat, at its summit, in the flint bed, from which it pitches on each side into the lower strata; on the south, at least into the upper bed of the blue limestone. This flat is much wider towards the west, where the sheet pitches on each side more uniformly, but narrows out towards the east, where the sheet pitches uniformly on the north, but on the south, descends more in alternate flats and pitches, and apparently divides into 4—5 smaller sheets, connected in a common opening. In some instances, such flats are only on the general pitch of the vein; the vein rising, then turning over a flat, and then pitching again in its regular course. I have not yet had an opportunity of tracing such a vein lower than the upper bed of the blue limestone; but I have been informed by J. Bracken, Esq., that such a vein, in the Victoria range (Mineral Point,) was followed down to the base of the blue limestone, and that the accompanying zinc and iron ores were even traced into the upper sandstone. These veins, like the vertical sheets, thus appear to have an extensive range through the strata, and are not confined to one particular bed, like the flat openings in the lower strata, and the more limited vertical openings in the upper bed of the upper magnesian.

The flat openings in the lower bed may be divided into three
classes: Sand, ochre and dry-bone openings. The first class includes those, where the opening rock resembles the calico rock of the flint openings, and is usually accompanied with more or less flint, like the latter. The mineral is here arranged in flat courses, or disseminated horizontally through the rock, as in the flat flint openings. These openings too are traversed by vertical crevices, (either of more uniform width or forming a series of pockets,) usually occupied by loose materials, and adjoining which the rock is more decomposed than in the remoter parts of the opening. The mineral is most abundant in the loose ground of these crevices, and in the adjoining parts of the opening, where the rock is most altered. Generally, in the loose ground of these crevices, a much greater quantity of iron is found, in the form of unaltered pyrites, or recomposed into ochre and hematite, than in the openings or crevices in the upper beds. In some such instances, the iron pyrites appears to have replaced the mineral, and extensive bars occur in the course of the crevice, in which the mineral is wanting, but the iron ores are proportionally more abundant. Such a bar, at the west end of A. Looney's level, in the middle crevice of the opening, replaced the mineral, after it had continued productive for 800—900 feet, and in this the ores of iron were found in every stage from the original pyrites to the ochre and hematite, exhibiting: in their change, fine specimens of green copperas, and small pockets of alum, where clay was more abundant, and also, though more rarely, of native sulphur. This mass is now partly worked out, the former character of the opening being resumed beyond it. The loose materials in these crevices are arranged conformably to the stratification; the layers of flints crossing them regularly in the line of those in the adjoining rock, only sometimes slightly lowered by the settling of the materials. This loose ground differs from the adjoining rock only by a greater proportion of clay, sometimes forming layers, or segregations investing the mineral as a matrix, and by the quantity of iron intersecting it in the manner already described (p. 47-8.) The more altered rock adjoining resembles the corresponding rock in the flint openings, and is more or less disintegrated in the state of loose sand.
The ochre openings are characterized by the great abundance of iron ore (iron pyrites and the results of its decomposition) accompanying them throughout their extent. Clay also abounds in them, in layers and pockets conformable to the stratification, and in seams corresponding to the outline of the opening. This clay is strongly marked by the smooth joints common to the clay of openings, particularly to the seams of clay which traverse and line them, and is called joint clay and soap clay, by the miners. The latter term is more particularly applied to a bluish clay, breaking in small jointed fragments, which usually invests the mineral when imbedded in clay. The mineral, in these openings, is either arranged in uniform horizontal courses, or in a series of flats and pitches, limited to the openings. In the former case, it resembles, in its arrangement, the mineral in the flat flint openings, but is more connected with clay and iron. In the latter case, it is arranged more in sheet form, bordered by a sheet of iron, and replaced by the same, when interrupted. Usually the mineral is largest and most uninterrupted on the flats, or on the turn from a flat to a pitch, and is smaller and more interrupted, and often entirely wanting, in the pitches, resembling, in this respect, that in the flat and pitching veins already noticed. A remarkable instance of this occurs in a very productive mine, worked by Earnest and Spenceley, on the Shullsburg branch, north of New Digging.*

The zinc or dry-bone openings are, on the whole, the most frequent in the lower bed, though in some instances more rare, particularly in the eastern districts. In these the mineral is arranged in sheets, with the ores of zinc and iron, in nearly or quite the same manner as in the flat and pitching dry-bone sheets already noted. The same order is observed in the arrangement of the different ores in relation to the rock, and the same arrangement of the mineral in the sheet, sometimes disseminated in the zinc ore, and sometimes forming a separate sheet, between the

*I have observed in some of the ochre openings, layers or more detached masses of a white limestone, usually much disintegrated in the state of sand. A similar rock also occurs in the Upper Pipe-clay openings in the blue limestone.
lateral sheets of zinc, but more usually, in these openings, the former. The sheets, in these openings, are sometimes regularly horizontal, but more usually uneven, presenting a series of flats and pitches or undulations, sometimes along slopes of large extent and in different directions, but still limited by the extent of the opening; both in a vertical and horizontal direction. In some instances, although these sheets have been worked to the width of a hundred feet, their lateral limits have not been reached, their sides thinning out so as not to repay the expense of working. In these dry-bone openings different sheets are found, as well as different courses in the flat flint openings; usually one near the roof, and another near the floor, and sometimes others intermediate; the whole more or less connected by cross veins or seams. The opening rock is usually very much decomposed and stained, and more or less accompanied with seams and pockets of clay, as in the ochre openings. Both the ochre and dry-bone openings are traversed by vertical crevices, in which the mineral is arranged in vertical vein order, and is more regular in its form, as in the upper vertical openings. The mineral in these crevices, when they traverse the dry-bone openings, is not accompanied with zinc ores, but resembles that in the crevices in the ochre openings. Usually the mineral in the flat openings is larger and more abundant adjoining the crevices, and in the dry-bone openings, the sheet is enlarged, and the mineral more distinct from the zinc ore, sometimes even forming geodes. The dry-bone and ochre openings generally alternate, either one by one, or in successive groups. In some instances, the same range will in one part of its course be an ochre opening, and in another, a dry-bone opening. I have known the same range commence, on the west with a mass of iron ore, then become a productive ochre opening, and terminate towards the east in a dry-bone opening.

The great quantity of calcareous spar (diaph) disseminated in the opening rock, and even in the rock generally, in the lower bed, particularly in the brown rock, has been already noticed. In some of the openings in this bed, large masses of calcareous spar are found, usually in horizontal courses, with more or less of a geodic
arrangement, the crystals aggregated so as to present the appearance of rounded bosses of a peculiar form. These masses usually occur along the lines of vertical crevices, and are sometimes found, in such cases, in small caves; the opening being only partly filled with the spar and the loose materials accompanying it. The latter are usually derived from the decomposition of subargillaceous layers, more or less accompanied with iron pyrites, and sometimes with the black oxyz of manganese (black ochre.)

Beds or baux of pyriticiferous rock also occur in the openings of the lower bed, more remarkable even than those in the openings of the flint bed. They either underlie the opening rock near the base of the upper magnesian, or rise in the openings, as has been noticed of the bars in the flint openings, and consist of regular beds of the limestone, nearly filled with seams and bunches of iron pyrites, accompanied with more or less calcareous spar;* the whole forming by its decomposition a bed of ochry earth and hemitite, and presenting during the process of decomposition the same appearance as have been noticed in the bar at the west end of A. Looney's level. In one instance (at Blinkiron's mine, north of New Diggings,) I observed such a bed underlying the opening, and overlaid by a bed of bluish grey limestone largely filled with bunches and geodes of calcareous spar; in small and often very perfect tabular crystals of great clearness and beauty.

The openings in the lower bed, particularly in the eastern districts, sometimes present a succession of pockets or bunches traversing the general opening rock, corresponding to a similar arrangement in the flint openings. In some instances, I have observed such an arrangement in smaller upper openings immediately overlying the large and uniform flint openings in this bed. The brown or black rock generally accompanies the openings in the lower bed in the south-western districts, and the green rock in the north-eastern districts; whence at Mineral Point and in its vicinity, the

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* The calcareous spar generally forms segregations invested by the iron pyrites, and on the decomposition of the latter is sometimes found changed to the sulphate of lime (selenite.)
openings in this bed are known as the green rock openings, while in the south-western districts they are called the black rock openings.

In some instances, detached vertical crevice openings are found in the lower bed, traversed by a vertical vein, from which flat courses of small extent (2–3 feet) enter pockets in the sides of the crevice, showing a tendency to the formation of a wide flat opening, traversed by a vertical crevice and vein. These resemble the openings of an intermediate character between the vertical and flat openings, already noticed in the lower part of the upper bed. Small quantities of copper pyrites have been observed, in different instances, in the openings in the lower bed, particularly in the vicinity of Fever river, accompanying iron pyrites or calcareous spar. Frequent traces of it occur in the masses of iron pyrites in the openings of the lower bed at W. Gillet's diggings (Buncomb,) and in connexion with the large masses of calcareous spar in openings in the same bed, above noticed, in different ranges between Fever river and the Shullsburg branch, east of Benton. In the latter case, the copper ore occurs near the junction of the spar with the rock, where the two are more or less blended, much in the same manner as it occurs in the large mass of tiff in Stephens' mine (Shullsburg.). The copper pyrites is always accompanied, in these instances, with more or less of the green and more rarely with the blue carbonate. The copper ranges at Mineral Point have also been worked chiefly in the lower bed.

It has been a common opinion that the blue limestone cuts off the mineral, and this has been understood of the blue limestone of Owen, or the formation immediately underlying the upper magnesian. This opinion has properly no reference to that rock, but to beds of hard blue rock found in different positions in the upper magnesian, which in many instances have been known to interrupt the mineral in its descent, both in sheets and in wider openings. This rock is usually more or less intersected with iron pyrites, and has been found at the bottom of openings in all the beds of the
upper magnesian, and sometimes rising into the openings and forming obstructions in their course, or intervening as a bar between contiguous openings. It may be considered as properly an opening rock, and when cutting off the mineral, as playing the same part as the masses of loose ferruginous materials which interrupt the mineral in the course of openings or veins, particularly in the lower bed of the upper magnesian. I have described the different openings, in their descent, as forming series at different levels; two in the upper bed (the upper and lower, the flat openings in the flint bed, and those in the lower bed (the brown and green rock openings.) These beds or bars of pyritiferous rock appear to underlie occasionally all of these openings. In sinking on a vertical sheet traversing different beds, it is found liable to interruption on meeting such bars, but not always so; instances having occurred in which the sheet has traversed them, but usually more or less diminished in its passage. When such a bar underlies an opening, or interrupts a vertical sheet, usually for a certain distance beneath more or less of the mineral is disseminated through it in particles or seams. I was informed by Mr. Haskins of Dodgeville, that in one instance a vertical sheet, on which he was employed, was cut off clean by a floor of blue limestone, only small particles and seams of mineral being found in it for a short distance below the sheet. On examining the rock, I found it was only a modified portion of the common rock of the locality (the flint bed of the upper magnesian,) forming such a bar as I have described.*

The Blue Limestone of Owen is a good mineral-bearing rock, and like the upper magnesian, not only has its openings in each of its three beds, but is traversed by vertical and pitching sheets or

* These bars have been met in sinking below the different openings, and in following down vertical sheets, and from their great hardness have discouraged from farther pursuing the mineral downward. From observation it has appeared to me evident, that they are parts of a mineral range, in which iron pyrites replaces the mineral, and are of limited extent, and need not obstruct the progress of mining. Before attempting to work through them, it would be well to determine their extent by boring, which might be effected with comparatively little expense.
veins, which in some instances are said to have been traced through it to the upper sandstone. I have myself traced pitching sheets from the upper magnesian into the upper bed, and vertical sheets to the lower bed or buff limestone. The regular openings in the blue limestone are wide and flat, like those in the two lower beds of the upper magnesian.

The openings in the upper shell bed are called the pipe clay or brown rock openings. The former name is taken from layers of clay which traverse the openings, derived from the decomposition of the layers of shale which are interposed in the upper bed; the latter, from a bed of brown rock, already noticed, immediately overlying the upper bed; and forming a more or less immediate cap to the openings. These openings are merely a certain extent of the rock, which has suffered more or less decomposition, and through which the mineral is disseminated in flat courses, usually imbedded in the layers of clay above noticed. The rock in these openings is, on the whole, less stained than in the openings in the upper magnesian, and the mineral is less accompanied with iron. It is also more regular in its form, sometimes in very perfect cubes, but more often tabular, varying in size from very small, called dice mineral, to very large; the latter usually adjoining a vertical crevice. The mineral, whether large or small, is imbedded in the clay or shale, in the same manner as iron pyrites in pyritiferous shales, and is either quite isolated, or a series of cubes or tables is arranged in horizontal vein order, sometimes forming sheets of considerable extent. These openings are usually wide, sometimes equaling in width those in the lower bed of the upper magnesian, but in such cases the mineral is more confined to the vicinity of vertical crevices, although the intermediate rock is much decomposed and contains more or less mineral disseminated. In some instances, I have found this change in the rock, with the accompanying mineral, extending only a few feet (6—8) on each side of a vertical crevice; the adjoining rock having the usual characters of the unaltered blue limestone and abounding in fossils, while in the altered rock of the opening the fossils are so decomposed as to be
hardly distinguishable. In some instances, as in the Irish Dig-
gings near Mineral Point, the openings in this bed are very fermen-
ginous, and the mineral is then sometimes accompanied with zinc
ores, forming flat sheets similar to those in the lower bed of the
upper magnesian. In some instances too, masses or bars of hard
compact rock are found in these openings, intersected by very thin
seams of mineral, and with small points of it disseminated, ana-
gous to the hard blue bars in the upper magnesian. The openings
in the upper bed have been worked at Mineral Point and Platte-
ville, north of New Diggins, on the Yellow Stone, and in other
localities in the eastern districts. In some instances, these
openings have been very productive, particularly at Mineral
Point, in the McKnight range, and in Bracken and Murrill's
range on the Mineral Point branch, south of the village. Near
Platteville, at the Back-bone (a narrow ridge between the Little
Platte and the Rountree branch), the occurrence of zinc mineral
(in the upper bed of the blue limestone) has been long known, and
openings in that bed are now worked there to advantage.

The openings in the middle bed of the blue limestone are usually
called the glass rock openings. They are situated either in the
lower more compact parts of that bed, the upper fine-grained por-
tion overlying them as a cap; and more or less stained of a brown
color; as it approaches the opening, or beneath the middle part or
proper glass rock, in the lowest division of the bed; adjoining the
buff limestone. In the glass rock openings, more variety has
been observed than in the pipe-clay openings above mentioned.
In some instances, they are dry-bore openings; the mineral be-
ing accompanied with zinc ores, forming sheets, arranged as in
the corresponding instances in the upper magnesian. These sheets
are generally quite horizontal, though irregularities in their course
are sometimes observed, particularly where crossed by vertical
crevices. The same alterations of enlargement and contraction
are observed in the sheets, as already noticed; the mineral, in the
latter case, being disseminated through the zinc ore mostly in
the middle line of the sheet, and in the former, usually forming a
distinct middle sheet, and sometimes a geode. These geodes are sometimes occupied in the centre by calcareous spar or sulphate of barites, or by the two in distinct segregations. At the crossing of vertical crevices, there is usually an increase of the mineral, in larger and more regular forms. In some of these dry-bone openings, the sulphuret of zinc (the original ore) has been very little changed; in others, it has been chiefly converted into the carbonate or silicate (dry-bone.) The former is the case at Haswell’s mine, west of Mineral Point village, and the latter at the Falling Spring mine, south of the village. The cause of such a difference is not very obvious. The finest specimens of the carbonate of zinc yet seen by me, were found in the dry-bone sheets in the openings in the blue limestone near Mineral Point, particularly at the Irish Diggings. In other instances, the glass rock openings are without zinc ores; the mineral being found under circumstances similar to those under which it is found in the pipe-clay openings. The greater part of the openings in the South Forked-Deer Diggings, on Wood’s branch, are glass rock openings of this character. Only one dry-bone range (Woffal’s) occurs in those diggings, parallel in its direction to the other ranges. In these openings, there are usually two courses of mineral; a lower, in a layer of grey shale, similar in its character to the grey shale in the flint openings at New Diggings, in which the mineral is of the same cubic or tabular form and imbedded in the same manner as in the layers of clay in the pipe-clay openings; and an upper, in which the mineral forms a flat sheet, more or less interrupted or broken by interposed clay and calcareous spar. These openings are of great width, but low, and the rock between the courses of mineral is generally hard, which renders it difficult to work them by drifting.

In a few instances, flat openings of no great width have been found in the middle bed, chiefly occupied by masses of calcareous spar, arranged horizontally between layers of clay with more or less iron and sometimes with large quantities of black oxyd of manganese (black ochre.) These closely resemble in structure similar
masses of calcareous spar, already described as occurring in the lower bed of the upper magnesian. From the settling of the loose materials accompanying the spar, there is usually a small vacuity below the cap, forming a cave. A remarkable instance of this kind occurs in the middle bed of the blue limestone, just north of Quinby's quarry, already referred to. Such openings with calcareous spar have not yet been found productive in mineral. An opening of a similar kind, but of greater width, has recently been found at Meeker's Grove (Buzzard's Roost) in the glass rock, chiefly occupied by similar horizontal masses or beds of sulphate of barytes, accompanied laterally with small quantities of calcareous spar. There are two such beds of sulphate of barytes, one above, another below, separated by a bed of clay with small points of calcareous spar, barytes and iron disseminated. In these beds of sulphate of barytes, mineral is found firmly imbedded, and in such quantity as to be worked to good advantage; usually of a regular form and brilliant surface; a series of larger more detached pieces arranged along the middle of each bed, and a more connected series or sheet of smaller pieces along the sides, above and below. This is the only instance of the kind I have yet observed; but mineral has been found imbedded in sulphate of barytes, in openings in the lower bed of the upper magnesian in that vicinity. The glass rock openings have been worked most extensively at Mineral Point, where some of them have been very productive.

Openings have been found in the lower part of the lower bed or buff limestone, generally wide and flat, and strongly resembling good mineral openings in other beds, but have not yet been fairly proved. They are sometimes traversed by layers of clay, derived from the subargillaceous layers of the rock, and in such cases resemble much the upper pipe-clay openings, from which circumstance they have been called the lower pipe clay openings. In other instances, they are found to contain large quantities of calcareous spar, in masses similar to those in some of the glass rock openings, with more or less mineral and some zinc ore connected. Large openings of this kind, in the lower bed, have been reached.
by sinking below the glass rock opening, at the south Forked-Deer Diggings, and at Haswell's mine near Mineral Point. In a few instances, near the latter place, considerable quantities of mineral are reported to have been taken from openings in the lower bed near its outcrops.

A remarkable opening in the blue limestone occurs at the Aspen Grove mine (Shook's Prairie, Green Co.,) apparently traversing different beds of the rock, and in its character, unlike any other which I have examined. It forms a very wide vertical East and West crevice, with regular walls, occupied by an opening rock, more or less traversed by seams of mineral and iron pyrites, distinct or combined, intersecting the rock in a manner similar to the arrangement noticed in some of the flint openings (p. 50.) The mineral in these seams is composed of small cubes, more or less regular, grouped in sheets or small bunches, and is accompanied by more or less of crystallized carbonate of lead, often very distinct and regular. This is sometimes in large quantity, but has appeared to me only subordinate to the sulphuret. The opening is divided towards the west by a large key-rock, running out in a point towards the east, adjoining which the mineral is said to have been most abundant.

The Upper Sandstone, so far as I have been able to ascertain, has not yet been found to contain mineral either in crevices or openings; but a sheet of zinc ore and iron pyrites at Mineral Point, already referred to (p. 55,) is said to have been traced 2—3 feet into that rock, in the line of a crevice bearing mineral to the base of the blue limestone. Copper ore is also said to have been found in the sandstone at the depth of several feet, in the same vicinity. It is thus not improbable that if the mineral is interrupted in the sandstone, ores of zinc and copper may be found there in its place.*

If the mineral is interrupted in the upper sandstone, it reap-

*The Ulster lead mine (N. Y.) is in a bed of sandstone, interposed between two beds of limestone. This fact offers some encouragement to expect that mineral may yet be found in the upper sandstone.
pears in the Lower Magnesian. Numerous instances are stated of the occurrence of mineral in the lower magnesian in Owen's reports (1847, 1852,) and several other localities have been mentioned to me by different individuals, near the Mississippi, and in the country between it and the Kickapoo, north of the Wisconsin. I shall however confine myself here to my own observations. I have not yet had time to explore the country occupied by the lower magnesian to any extent, and have visited no other workings in that rock, but those in the vicinity of Blue river, known as Olenking's Diggings. These however furnish satisfactory evidence that the mineral occurs in that rock, in as proper openings, in as large masses, and arranged as regularly as in the upper magnesian. These workings are in the sides of a ravine, 60—70 feet deep, leading to the Blue river, about three miles west of Franklin village. The lower magnesian occupies the sides of the ravine nearly to the summit, where it is overlaid by a low bluff of the upper sandstone. About three fourths of the descent below the sandstone is occupied by a steep slope, formed by the softer upper bed of the lower magnesian, below which is another low bluff formed by the harder middle portion of the same rock. Three successive openings, one above the other, appear to occur here in the lower magnesian; one 8—10 feet below the sandstone, another just above the harder middle bed, and a third below the bottom of the ravine, in the latter bed, and at the depth of about 70 feet in the lower magnesian. The openings appeared partly narrow and vertical, partly wide and flat, with appearances of decomposition and stain in the rock, deposits of clay and ochre, and arrangements of the mineral, similar to those in the upper magnesian. Flint, such as is peculiar to the lower magnesian, is found in the openings, and is connected with the mineral in the same manner as has been noticed in the flint openings in the upper magnesian. The mineral in these openings generally appeared in more or less detached masses (chunk mineral,) often very large, weighing more than 100 lbs; a few even more than 500 lbs.* It was what is.

*One mass was reported to have been found weighing 3000 lbs.
called pure mineral, free from iron and zinc ores, and strongly resembled that found in the upper vertical openings in the upper magnesian. After examining this locality, I could not doubt that the lower magnesian is a good mineral-bearing rock.

I have thus been able to trace the mineral in a series of crevices and openings from the summit of the upper magnesian to the depth of 60–70 feet in the lower magnesian, and have found all the different beds of limestone good mineral-bearing rocks, each with one or more openings, besides vertical or pitching sheets or veins. The small depth to which mining has been extended does not allow one to trace the mineral through the whole of the extent downward in any one instance, but wherever circumstances permit of examination, the order of succession in the openings is found to be regular, and in multiplied instances vertical crevices and veins have been found passing down from one opening to another. It is then probable that the series is generally continued through the whole downward extent indicated, subject only to such interruptions as are more or less common in all veins. The arrangement appears most analogous to that of the lead mines in the North of England, where the veins traverse different beds of limestone, separated by beds of other rock (sandstone or grit, shale, and toadstone or amygdaloid,) but the mineral is chiefly confined to the limestone, the other beds being generally considered barren, and where there is a similar combination of vertical crevices and veins with more or less extensive flats, corresponding to the flat sheets and openings in the mineral district.

In resuming the statements in relation to the openings in the different strata, it will be seen that at least seven well ascertained openings, not reckoning their subdivisions, have been found in the upper magnesian and blue limestone, namely, two in the upper bed, and one in each of the two lower beds of the former, and one in each of the beds of the latter. The lower magnesian apparently presents three in the instance above specified: two in its upper bed (an upper and a lower,) corresponding to the two in the upper bed of the upper magnesian, and one in the lower bed
at that locality, which is apparently the middle bed of the whole. Admitting a third lower bed with its opening, the whole number of openings in the lower magnesian would be four, and in the whole series of mineral-bearing limestones (upper magnesian, blue limestone and lower magnesian,) eleven.

SURFACE ARRANGEMENT.*

In exploring the different diggings, it will soon be evident that there is a great degree of order in the surface arrangement. The East and West as well as the North and South ranges will be found combined in groups, the different ranges in which are almost invariably parallel. The East and West ranges are obviously the leading ranges, to which the North and South and quartering ranges are appended, but the two latter, particularly when arranged in groups, play an important part in the arrangement, and either interrupt the East and West ranges, or shift them laterally to a greater or less distance. But groups of North and South ranges are sometimes interrupted and even shifted by a single East and West range. The bearing of the leading ranges, known as the East and West ranges, it has already been stated, is rarely, if ever, due east and west, even deviating from that course as much as 45° in some instances; but this bearing is uniform in each group, and often in an extensive series of groups. In a single group of East and West ranges, it will be generally found that the ranges have a common limit towards the east and west, but this limit is rarely at right angles to the direction of the ranges; each range successively receding so as to throw the limit into a direction more or less oblique to that of the ranges. The whole group of ranges will thus take a rhombic form, and if we begin at the most western point of the group, will bear either north-easterly or south-easterly, according as the ranges recede from that point.

*My views in regard to the surface arrangement were first formed soon after I commenced my examinations for the American Mining Company in May, 1853, and were stated in reports communicated to the Company in July and August of that year.
on the north or the south. This is called, by observing miners, the
direction of the body or weight of the mineral. A remarkable
instance of this occurs in the three large ranges, adjoining the
village of Platteville, on the Galena road, (Flynn’s, Bevins’ and
the Rountree range.) The north range (Flynn’s) extends farthest
west, and terminates towards the east nearly opposite the middle
of the next range (Bevins’), which again terminates towards the
east nearly opposite the middle of the south (the Rountree)
range; the body of mineral thus bearing south-easterly. In this
instance, the successive ranges recede much more strongly than
is usually the case in such groups. In other instances, such
strong recessions take place by groups rather than by single
ranges; the particular ranges in each group receding but slightly,
while the groups recede in the manner above indicated, or even
more strongly. An instance of this kind, where the groups suc-
cceed each other so as to overlap the adjoining but about half the
length of the ranges, occurs in the body of mineral extending
from Vinegar Hill (Ill.) to South Buncomb (Wisc.) near the
State line. In this instance, the groups of East and West ranges
are limited on one side by groups of North and South sheets,
which shift apparently by pairs from the east to the west side of
those groups. The bearing is to the north-east, but that of the
whole body more oblique than that of any single group.

The bearing of the body of mineral may be either north-eas-
terly or south-easterly according as the ranges or groups recede
to the east on the north or south side of the most western point.
In the instance at Platteville, the bearing is south-easterly; in
that at Vinegar Hill, north-easterly. In some instances, there is
a combination of both, the ranges or groups receding eastward
from a given point, both on the north and south sides of it. This
is apparently the case in the body of mineral at Vinegar Hill,
which, from a point not far south of that locality, recedes east-
ward both on the north and the south; the whole body making a
bend or curve at that point from north-west to north-east in pro-
ceeding from the south.
The groups, in some instances, are not marked by a recession in the direction of the ranges, but are shifted (heaved) transversely, at or near their extremity, the entire width of the group, or only partly so. A remarkable instance of this occurs in a body of mineral traversing the South Hazel Green Diggings, where the bearing in each group is N. N. Easterly, but the successive groups shift to the north to a greater or less extent, and are connected at each shift by quartering ranges bearing north-easterly. In this instance, the bearing of the entire body is very oblique to that of each group, and the groups appear shifted successively to the north by the passage of the quartering ranges. But though in this instance the successive groups are shifted to the side on which the ranges recede eastward, namely, to the north, yet they may be shifted in like manner to the opposite side or the south. This occurs at the Hoss Diggings, at the northern extremity of the Hazel Green Diggings, where the body of mineral appears to fall back and curve around from the north-east towards the east and south. In some instances, the groups shift alternately to the north and the south, preserving in the whole the same general direction, and in these instances also, North and South or quartering ranges mark the points of shifting. This may be observed in an extensive body of mineral bearing E. S. Easterly (the direction of the individual ranges,) through Swindler’s ridge (Benton.) This may be traced more or less distinctly along a line of 2—3 miles, showing a succession of groups shifted alternately to the north and south, and in some instances marked distinctly by cross ranges at the points of shifting. Thus the eastern group (D. Murphy’s) is limited on the west by two cross sheets bearing north by west, and is succeeded, after an interval traversed only by a quartering range bearing north-westerly, by another group (Ellis’) shifted to the north, and this by another (J. Edwards’) shifted to the south by a cross range bearing south by west. The same succession may be traced still farther west, but less distinctly. In other instances, a series of successive groups or ranges will be shifted to the north for a certain distance, and then to the south, so as to give to the whole a curved outline, like a bow. An instance of this occurs
at Shullsburg, in the ranges on the hill south of the village, more particularly in the south range, where the shift is to the north on the west, and to the south on the east, in proceeding eastward. Other instances of curvilinear arrangement appear to arise from successive changes in the direction of the ranges, marked, in some instances at least, by the passage of ravines. Ranges or groups with such curved outlines are called horse-shoes by the miners. The Heathcock range at Linden, and the body of mineral at Dodgeville, on which Washburn & Woodman’s engine is placed, have such an arrangement.

I have thus far traced the arrangement of ranges into groups, and of groups into larger bodies of mineral. But even the latter appear connected in more extensive series, traversing a greater or less extent of the mineral district. In such cases, the different orders of succession, above noticed, may be combined; in one part of the series, the groups merely receding to the east, like the ranges, and in another, shifting to the north or south across the ranges; the direction, in the former instance, approaching north and south; in the latter, east and west. The different series also appear conformable to a certain extent in their outline; thus showing a tendency to a general systematic arrangement throughout the whole. This more general arrangement will be best pointed out in connexion with the detail of the local arrangement, and by the aid of the map representing that arrangement.

The relation of the North and South and quartering ranges to the East and West ranges is a subject of much interest and importance. It has already been observed that the East and West ranges are apparently the leading ranges, those which predominate and give the prevailing direction to the mineral. When the North and South or quartering ranges are small and insulated, they are often cut off or shifted by the East and West ranges. They are then considered as feeders of the East and Wests, but are rather only offshoots or branches of the latter. North and Souths and quartering ranges, when larger or grouped, frequently either entirely interrupt or cut off the East and Wests, or cause them to shift
to the right or left a greater or less distance. Groups of cross ranges are frequently placed at the termination of groups of East and West ranges, in one or both directions. When the direction of the body of mineral approaches north and south, and the successive groups only recede, or slip by each other, I have sometimes observed these groups of cross ranges only at one extremity of the East and Wests, and alternately, singly or in pairs, on the east and the west. In such cases, they seem to mark the limits of the East and Wests, as well on the side where they are placed, as on the opposite; the ranges being limited in the last direction by the line drawn between the successive groups on that side. This arrangement is observed in the body of mineral extending from Vinegar Hill to Buncomb. In this instance, it is worthy of note that large quartering ranges extend from one group towards another, apparently governed in their direction by the arrangement of the North and South groups; bearing E. N. Easterly, where the North and South groups succeed each other from west to east, and W. N. Westerly, where they succeed each other from east to west.

When the groups of East and Wests are shifted to the north or south, at or near their extremity, the groups of cross ranges serve to connect the contiguous East and West groups at the point of shifting. A series of these may be traced, more or less distinctly, along the whole course of the body of mineral traversing the South Hazel Green Diggings.

In some instances, extensive series of North and South groups occur, traversing a body of mineral in the direction of its bearing, and in these cases, the successive groups are shifted by the passage of one or more East and West ranges. The entire series may be considered as one body of North and South mineral, successively interrupted and shifted by the East and Wests. Two lines of such groups of North and Souths occur in the east part of the North Hazel Green (Jefferson) Diggings, where the North and Souths are shifted to the east towards the south, and to the west towards the north, by the passage of the East and Wests. In one instance, I observed there a North and South sheet apparently
rising as it approached the opening in the East and West range, as if to pass above it. In other instances, a group of North and Souths will be interposed between two corresponding groups of East and Wests, generally towards one extremity of the latter; the North and Souths stopping short of the East and Wests, and even of short North and Souths leading towards them from the East and Wests, and the space between the latter, not included in the group of North and Souths, presenting but slight indications of mineral. The group of North and Souths, at South Hazel Green, known as the Phelps lot, is such an instance.

Generally, when ranges having different directions meet each other, one will predominate, and the other be cut off entirely, or if continued, be diminished and soon run out. At the same time, there will be usually an increase of mineral at the point of junction. But in some instances, the two apparently interrupt each other, leaving a space, at their passage, in which little or no mineral is deposited. In such cases, the different ranges appear slightly to affect each other and soon resume their former course. Such instances occurred at the crossing of East and Wests and North and Souths, in the West Diggings at Shullsburg.

The most extended bodies of mineral are usually formed by the groups of East and West ranges, whether arranged in a series bearing north-easterly or south-easterly, or more directly east and west; but in some instances, North and Souths form very extended series. Thus a line of North and Souths may be traced at intervals from the large North and Souths at the East Blackleg Diggings, which cross the eastern extremity of a large group of East and Wests (the West Blackleg,) to the western extremity of the Shullsburg Diggings, at S. Townsend's, where the mineral again takes an easterly direction. The series is apparently continued in another body of North and Souths, extending from the East and Wests at Shullsburg, 3—4 miles N. N. Easterly, through the Irish Diggings, to the Stump Grove Diggings, where the East and West direction is again resumed.

The East and Wests generally form wider openings in which the
mineral is in larger and more detached masses, and in more regular forms, while the North and Souths usually present only narrow crevices, traversed by more even and uniform sheets; but East and Wests not unfrequently take the character of the North and Souths and carry sheets, while North and Souths, but much more rarely, present wide crevices (carrying large and square mineral, like that of the East and West openings,) and even flat openings in the lower strata.* Wide North and South crevice openings, with well marked East and West mineral, have been observed by me, at B. Coe’s, on the west side of Fever river (north of Benton,) in the lower bed of the upper magnesian, and at the Irish Diggings, north of Shullsburg, in the upper bed of the same rock, and a North and South flat opening, crossing one of the regular East and West flat openings, at the Brushhill Diggings, in the flint bed. East and West sheets are very rare in some districts, but very frequent in others. Thus, at Dubuque and Fairplay, the East and Wests are generally crevice openings or wider vertical openings, while at Hazel Green, East and West sheets are very frequent, grouped with wide openings, as if appendages of the latter. At Vinegar Hill, a large group of East and West sheets (8—10 in number) is interposed between two of the wide openings. These instances all occur in the upper bed of the upper magnesian. It is a question with the miners, whether these groups of East and West sheets may not lead to large openings beneath. This has been shown to be true at Shullsburg, where mining has been continued from the openings in the upper bed of the upper magnesian into the flint bed, and where different crevices above, bearing mineral, have been found to enter a common flat opening below. Generally, in the wide flat openings in the lower strata, several crevices will be found to traverse the roof, often carrying sheets of mineral.

In the different groups of ranges, whether East and Wests or North and Souths, there will usually be found some one range

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*In one instance (at Shaw’s Hollow,) I observed a North and South sheet terminating at a certain depth (in the flint bed,) in a small cave opening, filled, except near the roof, with loose materials containing much of the black oxyd of manganese (black ochre.)
larger than the rest, called the champion or master range. But in some groups, particularly where the openings are generally large, this distinction is less obvious.

I have already observed that the term East and West is applied to the leading ranges, although they may deviate even 45° from a due east and west course. On comparing the different diggings, it will be found that a certain order prevails in the bearing of the leading East and West ranges; the different ranges in each usually having a common bearing, and a number of different diggings being found combined into a more extended series by the common bearing of their ranges. Thus the general bearing of the leading East and West ranges is, by the compass, E. 8° N. in the Hazel Green, Fairplay and Lower Menominee Diggings, and in those in the adjacent parts of Illinois and Iowa (at Vinegar Hill, north of Galena, and at Dubuque); E. 5° N. in the Brushhill, Whig and Platteville Diggings; E. 20° S. in the Potosi, Upper Menominee, Patch and Benton Diggings; also in the Shullsburg and Mineral Point Diggings, and in a large extent of the eastern diggings, chiefly in the northern part of Green county; E. 10° S. in the Cassville and Beetown Diggings; also in the S. E. Platteville and Elk Grove Diggings; E. 5° S. at North Bunoomb, Shaw's Hollow and New Diggings; and S. E. in the range of diggings near Fever river, extending from Buzzard's Roost to the Shullsburg branch at Quinby's mill. The bearing of the ranges has thus an important connexion with the systematic arrangement. It should be viewed in this connected manner to give it interest both in a scientific and practical point of view.

On looking at the map, in which I have attempted to give the local arrangement of the diggings, so far as I have examined them, a systematic order presents itself, pervading the whole district, which indicates that the mineral deposits are not casual, but regularly arranged. This may be regarded as an important confirmation of the facts already stated in relation to the arrangement of the mineral in veins. My object, in this map, is not to
give all the particular ranges, but only the mode of arrangement, and the relative extent of the diggings. It includes only that part of the mineral district in Wisconsin, already examined, with some of the connected diggings in the adjoining part of Illinois. Had I been able to make a reconnaissance of the whole of the mineral district, the arrangement would have been more complete, and some of the series better filled than they now are; but such as it is, it will serve to illustrate the view I have taken of the subject, and the mode in which I should proceed to investigate it.

The first point to which I would direct attention is the occurrence of several extensive connected series of ranges between which little or no mineral has yet been discovered. These series exhibit a general conformity in their arrangement. Beginning at the south-west, they first bear northerly, then easterly, and then south-easterly; thus forming an extensive curve. I have already observed that one of these series (that at Vinegar Hill, Ill.) first bears north-westerly (N. N. W.) and then north-easterly. This course may also be traced in the series next west (that at Hazel Green,) and the observations which I have thus far made in other series would seem to indicate this as the general arrangement.

The different series, which I have been able to trace, are the following, beginning at the north-west: 1. That commencing at the Muddy Diggings, north of Cassville, then passing N. N. E. to the North Diggings, and then east to the Beetown Diggings, where it expands particularly towards the north, and towards the east shows a bearing to the south-east. This is probably connected with the Pigeon Diggings and other diggings farther east, north of the line of my present exploration. On the south-west, it may be connected with the diggings in Iowa opposite Cassville. 2. That extending from near the mouth of Grant river through the different groups of the Potosi Diggings to the Red-Dog Diggings in a north-easterly (N. N. E.) direction; then east by the Brushhill and Whig Diggings to the Platteville Diggings, where it expands towards the north; and then in an E. S. E. direction through the South-East Platteville and Elk Grove Diggings to the Strawberry
Diggings, where it is interrupted by a wide extent of prairie farther east, in which no ranges have yet been traced. This is probably connected in range with the diggings west of the Mississippi, in a direction south from Potosi, (the Macoqueta and Dubuque Diggings,) which would farther complete it on that side. 3. That commencing near the south line of the State in the Fairplay Diggings, and extending northerly (first N. N. E. then N. N. W.) through the Lower Menominee to the Upper Menominee (Jamestown) Diggings; then bearing E. N. E. through the latter, then shifting north-easterly to the Patch Diggings, then passing E. S. E. to the Buzzard’s Roost Diggings, and then bearing south-east to the Shullsburg branch, north of New Diggings. This is probably connected with the Lower Galena Diggings, in the forks of Fever river and the Mississippi, S. S. E. of the Fairplay Diggings.

4. That including the Hazel Green Diggings, which may be traced from those diggings into Illinois, first S. S. W. then S. S. E. to the Upper Galena Diggings (north of Galena.) On its western border, in the Hazel Green Diggings, it bears N. N. E. to the Hess Diggings, and then curves around to the E. S. E. through the Benton Diggings to Fever river at Benton. 5. That including the Vinegar Hill Diggings, bearing N. N. W. to Vinegar Hill, then north-easterly to Buncomb and Shaw’s Hollow, and then easterly through the New Diggings. 6. East of the south-east point of series 3, the E. S. E. direction of series 4 (at Benton) is resumed at Earnest and Spenceley’s Diggings on the Shullsburg branch, and continued through the Shullsburg Diggings. These are intersected by the extensive range of North and Souths leading from the East Blackleg (connected with a series of East and Wests on the East Fork of Fever river) through the North and Souths at Townsend’s and the Irish Diggings to the East and Wests at Stump Grove, N. N. E. of Shullsburg. 7. A series of small groups may be traced easterly, in a line east from the Strawberry Diggings, through Skidmore’s and Halstead’s Diggings, by Darlington, to Whiteside’s Diggings, whence it bears south-easterly to the W iota Diggings. 8. Another series, commencing at King’s and the
Forked Deer Diggings, west of the West Pecatonica, extends first E. N. Easterly by the Duke's Prairie Diggings to the Yellow Stone Diggings, then through these in a general easterly course to the East Pecatonica, and to Biggs' and the Badger Diggings, and then south-easterly by Shook's Prairie (the Aspen Grove Mine) to Skinner's Diggings and others north and east of Monroe. 9. The diggings at Mineral Point apparently form part of another series, commencing on the south-west at the forks of the West Pecatonica and the Mineral Point branch, and thence bearing N. N. Easterly, but the course of which I have not yet had an opportunity of tracing satisfactorily to the north-east and east. This series perhaps extends by Dodgeville, Ridgeway and the Blue Mounds to Exeter; first bearing N. N. E. to Dodgeville, then east to the Blue Mounds, and then south-east to its termination at the valley of Sugar river.

These series are in some instances connected by intermediate groups. Thus the South-West Platteville Diggings may be considered as intermediate between series 3 at the Patch Diggings and series 2 at the main body of the Platteville Diggings. Other instances will be stated in the details following. In no part of the mineral district examined, have I observed so great a connexion of different series as at Benton and New Diggings, where several seem to concentrate.

The grouping of the East and Wests by their bearings does not correspond strictly with this arrangement in connected series, but has important relations to it. Thus the bearing E. 10° S. prevails through series 1, as far as yet examined, and in the east part of series 2, where it bears E. S. E.; but these two divisions are remote and detached. That of E. 20° S. prevails in the Potosi Diggings in series 2, the Upper Menominee and Patch Diggings in series 3, the Benton Diggings in series 4, and the Shullsburg Diggings in series 6. These extend across the country in a general E. S. E. direction, and include all the diggings in their course, except the south-east point of series 3. The same bearing is observed in the Mineral Point Diggings and in most of the diggings.
east of the East Pecatonica in Green Co., including those in the east part of series 8. The bearing E. 8° N. prevails in the southwest part of series 2, 3, 4 and 5, presenting one great body of mineral from west to east, the most remarkable and that which shows best the predominance of the East and West ranges. Different ranges are supposed to be continued through the whole extent from the Dubuque Diggings on the west to the Hazel Green Diggings on the east, and even farther, and some are said to have been traced through by survey. At least it may be affirmed that the series formed in nearly an east and west line, by the Dubuque, Fairplay and Hazel Green Diggings, and continued through those at Benton, New Diggings and Shullsburg, is the most connected and regular and in the whole the most productive of any in the mineral district.

Some series of less extent or more interrupted may be traced, conforming in their arrangement to the more extended series, and perhaps indicating the course of bodies of mineral which have not yet been explored. Thus one such may be traced from a group of ranges S. S. E. of Sinsinawa Mound (Gautier's and others,) N. N. E. by Turner’s Diggings to the Findley Diggings on the west fork of the Sinsinawa, and to the source of the east fork of the same. The large bodies of mineral recently found at Turner’s Diggings would seem to indicate that farther important discoveries may yet be expected along that line. Slighter indications of another such series may be traced, between the Mississippi and the Great Menominee, from Gilbert's and Henderson's diggings, just south of the State line, by Sinipee to the Wolf Diggings, near Dickeysville (Paris,) west of the Jamestown Diggings. These lines of detached diggings, although they may be as yet of little importance, are worthy of notice, in connexion with farther searches for mineral, or as guides for prospecting.

In tracing the different series, it will be found that the different groups succeed each other in a certain order, variously modified indeed, but yet tending to a general system. The following detail will serve better to illustrate the arrangement of the series.
Thus, following the west border of the first series, it will be found to bear north-easterly from the Muddy Diggings (1 a) to the North Diggings (1 b), and then east to the south-west point of the Beetown Diggings, which first present a large group of East and West ranges (the Muscolunge Diggings, 1 c) extending northerly along the east side of Rattlesnake creek. This is marked towards the north by a line of quarterings, bearing north-easterly, at Brown's range, indicating a recession to the north-east. On the south, this group is connected with a group farther east (the Nip and Tuck Diggings, 1 d), in which numerons North and Souths are combined with fewer East and Wests, marking a similar direction to the north. Next succeeds the main body of mineral in this series (the proper Beetown Diggings, 1 e), in the ridge between the Beetown branch and Grant river, and in a position, on the whole, farther north than the two latter groups. The bearing of this is south-easterly; the more northern ranges extending farther west, and the more southern farther east, and this bearing is further marked by quarterings and North and Souths, bearing in the same general direction.* A detached group (Haslett's Diggings, 1 f) N. N. E. of the north-west point of the proper Beetown Diggings, forms the northern limit of this series, and is apparently continued E. S. Easterly in a small group of diggings on the east side of Grant river.†

The series 2 also presents a similar succession of groups. The South Potosi Diggings (2 a,) commencing on the east bank of Grant river, near its mouth, extend N. N. E. along the east side of Rigby hollow to the summit between Potosi (Snake) hollow and the waters of the Platte, and from this line bear E. S. Easterly, extending much farther east towards the north than towards the south; the group forming a curve, analogous to that of the entire series, directed towards the Patch and Upper Menominee Diggings. After a considerable interval, another group (Craig's

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*The ranges called North and Souths have here a N. W.—S. E. bearing.

†This last group probably forms a connexion between the Beetown and Pigeon Diggings.
Diggings, 2 b) commences at Buenavista, where it is marked on the west by a line of North and Souths, bearing around from S. S. E. on the south to N. N. E. on the north, and limiting the East and Wests in this group on the west. The south-east border of this group is also marked by North and Souths bearing N. N. Easterly. This is followed by a series of groups successively receding to the east towards the north (Coyle's, Rockville, Pinhook and Red Dog Diggings,) the last of which (2 e) terminates on the east in a bluff on the west side of the Big Platte. This last group is particularly marked by quartering crevices, indicating a change in the direction of the series to the east. In the interval from the Red Dog Diggings to the Platteville Diggings, only two considerable groups, the Brushhill and Whig Diggings (2 d—2 e), bearing nearly east and west, mark the course of the series. The Platteville Diggings (2 g) then form an extensive body of mineral, bearing north-easterly from the South-West Diggings (3 f) through the line of diggings along the south side of Platteville village, including the three ranges on the Galena road already noticed, to two large groups north of the village, successively receding east. A line of ranges, east of the village, also bears north-easterly from the east point of the group south of the village, extending east, at its north-east point, in a projection crossed by North and Souths. The series is then continued in a direction E. S. E. from the group south of the village, through the South-East Platteville Diggings (2 h) to the north-west point of the Elk Grove Diggings (2 i) at J. Phillips' farm. The principal groups in the Elk Grove Diggings extend N. N. E. from their south-west point at Hutchinson's Diggings, along the west side of the west branch of Fever river to their north-west point above indicated, and then bear E. S. Easterly to the North Diggings near the Elk Grove and Mineral Point road. A few more isolated ranges lie south of the latter towards Elk Grove village. Farther in the same E. S. E. direction, is a large detached group (the Strawberry Diggings, 2 j,) on the east side of the east branch of Fever river, also extending N. N. E.; marked, on the south, by a remarkable change in the direction of
the ranges from a south-east to an E. S. E. bearing (that of the ranges in the main body of the group towards the north.) East of this group, there is a wide interval in which no ranges have been discovered. The series 7 commences at Skidmore's Diggings nearly east from the south point of the Strawberry Diggings, and in the direct interval between these, traces of mineral have been discovered at the Light-House tavern, on the Platteville and Shullsburg road, perhaps indicating the passage of ranges along that line.

The next series (3) commences on the south with a very extensive group (the Fairplay Diggings,) extending, along its western border, from its S. W. point near the State line, in a N. N. E. direction, with a series of recessions to the east, most strongly marked towards the north. This may be divided into two subordinate groups, separated by the east and west hollow at Fairplay village. The South group is divided into two parallel series, bearing northerly, in which the ranges generally correspond, but separated by an interval in which most of the ranges are apparently interrupted or have not been followed. The ranges, however, are more connected towards the north; the two series uniting in the ridge south of Fairplay village. The western series (3a,) along the east side of the Fairplay branch, was discovered and worked five years before the other, along the west side of the Sinsinawa Mound at the Jamestown Mine.* The most northern ranges and the most southern in the eastern series (3b) extend or at least have been worked, much farther east than the intermediate ranges. The Northern group (3c) projects slightly to the west at its S. W. point, and then recedes to the east, at first more slightly in a number of extensive ranges, and then largely towards the north, where it forms a subordinate group of less extent from east to west, and terminates in a detached range on A. Taylor's farm. From this point the series projects to the N. W.; its course in that direction being marked by three successive groups of East and West, crossed by N. West quartering ranges.

* The diggings in the West series were struck in 1841-2; those in the East, in 1846-7.
leading towards the west point of the Upper Menominee Diggings. Of these groups, the second (the Lower Menominee Diggings, 3d) is the most considerable. The Upper Menominee (Jamestown) Diggings (3e) present a series of East and Wests (bearing E. S. E.,) the most southern commencing farthest west, and the more northern receding successively to the east in groups overlapping each other more or less, the bearing of the whole body of mineral being E. N. E. On comparing the series subordinate to series 3 on the east, the first group will be found S. S. E. from the S. E. point of the Fairplay Diggings; the second, east of that point; the next (Turner's,) nearly east of the subordinate group at the N. E. point of the Fairplay Diggings; the next (Findley's,) nearly east of the Lower Menominee Diggings; and the last (at the source of the east fork of the Sinsinawa,) E. N. E. of the east point of the Upper Menominee Diggings and south of the Patch Diggings. The Patch Diggings (3f,) the next in succession to the Upper Menominee Diggings, lie considerably to the N. E. of the latter, in a direction towards the Platteville Diggings, and occupy an intermediate position between them. They consist chiefly of a main body of East and Wests, crossed on the west and east by groups of North and Souths, which serve to mark the limits in those directions. In the interval between the Patch Diggings and the Buzzard's Roost Diggings, in an E. S. E. direction, I have observed only a small group, a little S. E. of the forks of the Platteville and Elk Grove roads. The Buzzard's Roost Diggings (3g,) are the commencement of a series of diggings (3h,) already mentioned, bearing south-easterly across Fever river to the Shullsburg branch. These diggings are in the lower bed of the upper magnesian and in the blue limestone, principally in the former. They include those along the west side of Fever river to the Missouri branch near Benton, and those between Fever river and the Shullsburg branch to the Benton and Shullsburg road. This is the only instance I have yet observed of such a S. E. direction of the leading ranges. That this direction is not derived from the strata in which the diggings are situated is shown by the
different direction of the ranges in the same strata both at Mineral Point and in the immediate vicinity in the dry-bone diggings west of Shullsburg. The Lower Galena Diggings, in the forks of Fever river and the Mississippi, S. W. of Galena, are in a S. S. E. direction from the Fairplay Diggings (conformably to the arrangement observed in series 4 and 5,) but I have not yet traced a direct connexion between them.

Series 4 may be considered as commencing in the Upper Galena Diggings, on the west side of Fever river, adjoining Galena on the N. E. It extends north-westerly from these by Comstock’s Diggings to the Camp Ground, west of the Galena and Mineral Point road, whence it bears northerly, west of that road, to the S. W. point of the Hazel Green Diggings, in a series of North and Souths (4a,) combined with East and Wests, particularly towards the south. West of this line of North and Souths are several groups, chiefly of East and Wests, extending towards the Sinsinawa river. The Hazel Green Diggings commence near the north point of the line of North and Souths, just mentioned, in the remarkable body of mineral (4 b) traversing them in an E. N. E. direction, already referred to. This presents a series of eight groups, shifting successively to the north, or to the left, and extending about two miles, in an almost uninterrupted series, from the S. W. corner of the diggings to Bull Branch, on their eastern border. Two large groups of North and Souths (the northern known as the Phelps lot,) with East and Wests intervening, extend north from the fourth group to a detached group of East and Wests, nearly west of the eighth group. North of the S. W. point of this body of mineral, a large group of East and Wests (the Purdy lot, 4 c) projects to the west, and not far N. E. of this a series of North and Souths commences and extends first along the west border of the main body of the diggings to Culver’s group, bearing N. N. E., then crosses towards the east side of the diggings (at 4d,) and is there continued to their northern border, first bearing N. N. E. and then more directly north. East of this line of North and Souths, before its shift to the east, different groups of East and Wests
cross the diggings more or less conformably to the course of the body of mineral on the south. Farther north (at Jefferson village,) a number of large East and Wests, accompanied with smaller, particularly on the east, cross the North and Souths, interrupting and shifting them in their course. Farther north-west, is a series of ranges (Rocky Point and Waterloo Diggings,) bearing more E. N. Easterly, and the whole series is limited in that direction by two detached groups, nearly in line, one of N. N. Easts (the Dutch lot,) west of Culver’s group, and the other of E. N. Easts, on the north, (the Hoss Diggings, 4a,) in smaller groups successively shifted to the south, marking the turn of the series from north to east.

The body of mineral along the south border of the Hazel Green Diggings is continued in a series of groups, also shifting to the north, through Langworthy’s Diggings to Coon Branch (south-west of Benton,) east of which the series is continued in a direction east by south towards the New Diggings. East of the North and Souths at the north-east point of the Hazel Green Diggings, a large group of East and West sheets (the Sheet lot) extends across the high ridge west of Coon Branch towards the Benton Diggings, and is bordered east by groups of North and South sheets (Selkirk’s and the Dry-Grove Diggings.) The northern border of series 4 bears E. N. E. from the Hoss Diggings to a small group of East and Wests* not far east of the Platteville road, whence a series of groups extends E. S. E. to the east point of Swindler’s ridge (4f,) north of Benton village; more interrupted towards the west, and more approximated towards the east. These have been referred to (p. 71,) as shifting alternately to the north and the south through their course. Three parallel lines of ranges, with a similar E. S. E. bearing, occur farther south, towards the Sheet lot, the most considerable of which commences on the west in the Pole range and extends with some interruptions to the diggings at the south end of Benton village (4g.)

* These at their commencement on the west bear E. N. E., and then E. S. E. in a direct line towards the ranges at Swindler’s ridge.
Series 5 commences on Fever river near the junction of the east fork (in Illinois,) and extends north-westerly to the south-west point of the Vinegar Hill Diggings, and then north-easterly again to Fever river at Buncomb, forming a well marked curve. This part of the series is marked throughout by a succession of groups advancing west to Vinegar Hill and then receding east to Buncomb, almost uninterrupted in the latter direction, forming there the main body of the series (5a,) already referred to as showing the direction of bodies of mineral obliquely crossing the bearing of the ranges (p. 70.) It is also characterized throughout the greater part if not the whole of its extent by groups of North and Souths bordering the groups of East and Wests on the east or west. This arrangement is remarkable as the North and Souths border the East and Wests alternately in pairs on the east and the west; quartering ranges, in a corresponding direction, at the same time marking the shifts of the North and Souths. At Buncomb, the series divides; the most connected portion (5b) extending north, up Bull Branch, towards the east point of the body of mineral crossing the south part of the Hazel Green Diggings; the other (5c) shifting to the east to the west side of Coon Branch, and then continued north through W. Gillet's diggings to the diggings at Shaw's Hollow, where it approaches the east point of Langworthy's Diggings, above noticed. From this point the series is continued easterly to the New Diggings (5d.) In this series, at Buncomb, are two important flat and pitching dry-bone (zinc) mines; one (Coxe's) on the west side of Bull Branch; the other (Gillet's) on the east side of Fever river, opposite the north-east point of the main body of the series just mentioned. The bearing of the ranges in this main body is north of east (E. 8° N.;) that on Coon Branch, south of east (E. 5° S.;) and this bearing is continued in a few groups of diggings between Coon Branch and Fever river leading from the diggings at Shaw's Hollow to the New Diggings, and throughout the latter, which terminate the series on the north-east. The series is most largely developed in the main body on the south-west and in the New Diggings,
even more largely in the latter than in the former. Between the New Diggings and the south point of series 3, there is a large group of East and Wests (the Democrat Diggings, 5e,) between Fever river and the Shullsburg branch, in which the bearing of the ranges is E. 10° S., and in nearly the same East—West line, farther east, is the great Dowd and Maginnis range, with several accompanying East and West ranges, (5f,) limited on the east by a large North and South (the Ellis range.)

The E. S. E. direction of the ranges at Benton is again resumed on the north side of the Shullsburg branch, east of the south part of series 3, in Earnest and Spaceley's Diggings (6a,) in the lower bed of the upper magnesian. This E. S. E. series (6) is continued in the Shullsburg Dry-bone Diggings (6b,) in the same bed, and then shifting south across the branch to Townsend's Diggings (6c,) is farther continued, with little interruption, through the main body of the Shullsburg Diggings (6d,) terminated on the east by numerous North and Souths traversed by a few East and Wests. The diggings in the east part of the series, south of the branch, are in the upper and middle beds of the upper magnesian. They commence, on the west, in large North and Souths, at Townsend's Diggings, which are apparently in the line of the large North and Souths at the East Blackleg Diggings, as already noticed. Then occurs an extensive group of East and Wests, crossed by many North and Souths, some of them extensive, followed by the diggings on the south of Shullsburg village, beyond which are the North and Souths terminating the series. The diggings south of the village have been worked extensively by draining in the middle (flint) bed of the upper magnesian, and have been among the most productive in the whole mineral district. North of the west part of the diggings at Shullsburg village, the Irish Diggings (6e) extend from the Shullsburg branch in a series of groups of North and Souths, crossed by a few East and Wests towards the south, successively shifted to the east or to the west, and continued across the summit between the waters of Fever river and the Pecatonica to a group of East and Wests at
Stump Grove, as already noticed. East of the series 6, there are only a few small detached diggings which I have not yet visited.

The next series (7) is of less importance from the extent of the diggings, but is arranged conformably to the prevailing order. I have already noticed its connexion with the east part of series 2. Skidmore’s Diggings (7a,) the first towards the west, consists of an extensive North and South range or group of ranges, connected with a few small East and West ranges. Next in the series, are two small groups of North and Souths at the head of a branch of the W. Pecatonica, north of Centre, and then two small groups of East and Wests (Halstead’s and Read’s,) lower down the branch. The line of the series passes by Darlington, and after a long interval the series is resumed in Whiteside’s Diggings (7b,) a group of East and Wests crossed towards the west by several North and Souths. There is then an interruption in a south-east direction to the W iota Diggings (7e,) where two extensive lines of East and Wests are closely connected by North and South and quartering ranges. The bearing of the body of mineral is there to the south-east, while the quartering ranges bear north-easterly.

The next series (8) commences on the west in the Forked-Deer Diggings, west of the West Pecatonica. In these diggings, there are at least four parallel lines of East and West ranges, included between Wood’s branch on the south, and Bonner’s branch on the north. In the south line (8b,) along Wood’s branch, the diggings are in the blue limestone; in the other lines (8a,) in the middle and lower beds of the upper magnesian. The general bearing in these diggings is E. S. E. King’s Diggings (8a,) on the south side of Wood’s branch near the W. Pecatonica, are more detached, and less regular in their bearing; presenting two groups of E. N. E. ranges, one on the north, the other on the south, connected by S. S. E. ranges. The series is continued E. N. E. in the Duke’s Prairie Diggings (8d,) only a few small and detached diggings intervening, such as Pillins’, on the east side of the W. Pecatonica, opposite Bonner’s branch, and Scott’s, on Otter creek, nearly east of King’s Diggings; both in the lower
bed of the upper magnesian. The diggings at Duke's Prairie present two principal lines of East and Wests, receding east towards the north, north-east of which, 1—2 miles distant, are two other lines of East and Wests (White's and Graham's) apparently receding east towards the south. The series is still farther continued, nearly east from the latter, in the Yellow-Stone Digging, which extend in a general direction nearly east and west, 5—6 miles, from the Yellow-Stone branch to the E. Pecatonica. This line of diggings may be divided into three sections; one on the west side, along the north side of the Yellow-Stone, bearing nearly east and west; another extending south-easterly, along the south-west side of McClintock's branch; and a third (8°) bearing nearly east and west from McClintock's branch to the E. Pecatonica. The course of the series farther east is marked only by a few detached diggings, at first bearing more east and west, and then more south-easterly to the diggings north and east of Monroe. The line first shifts to the north to the North Grove Diggings, west of the E. Pecatonica, then to the south to Biggs' Diggings, and again to the north to the Badger Diggings, where it takes a south-easterly direction by the Aspen Grove Mine (8°) Skinner's Diggings and others of less note to a point east of Monroe. South of this line is a short detached series of three groups, east of Argyle, including H. and J. Scott's Diggings, but apparently in the general line of series 7.

The last series (9) I have only partially traced at its commencement on the south-west in the Mineral Point Diggings. These present a series of East and West ranges, more or less grouped, extending from the West Pecatonica across the Mineral Point branch to Rocky Branch, and forming a body of mineral bearing N. N. Easterly towards the diggings at and west of Dodgeville. The general bearing of the ranges is E. S. E. (E. 20° S.) A part at least of the ranges in these diggings are lead-bearing on the west and copper-bearing on the east; the general body of mineral being thus divided, in the direction of its bearing, into two parallel sections. I have not yet traced this series farther north than
the Dreadnought Mine, already noticed; but from a hasty view, I have considered it as continued north-easterly to the Dodgeville Diggings, and then in a general easterly direction, through the diggings at Messersburg, Porter's Grove and Ridgeway, to those at the Blue Mounds, when it apparently takes a south-easterly direction to Campbell's Diggings, north of Monticello, and the Sugar River Diggings at Exeter. The last form a group of East and Wests, bearing E, S. E., and at first receding east towards the south, thus forming a body of mineral bearing south-easterly. The most southern ranges, however, appear to recede to the west; the whole body, thus forming a curve.

The preceding remarks will serve to show that there is a degree of orderly arrangement in the succession of the diggings, such as to indicate that they are not merely casual deposits, but parts of a connected whole. I have yet been able to make only a general reconnaissance, except in the few localities I had examined before my engagement in the present survey. Further opportunity would enable me to develop my views in detail.

It may be interesting to notice the different strata in which the mineral has been worked in the diggings examined by me. As the depth to which mining has been carried on has been generally limited by that of the water level, it has rarely exceeded 100 feet, and has been usually much less; in many instances, only 30—40 feet. Consequently only a small depth of rock has been penetrated in any one instance, and it is thus necessary to judge of the probable downward extent of the mineral by a comparison of different localities, where different strata are brought to or near the surface. This has shown that all the beds of limestone have, in such instances, been found good mineral-bearing rocks, and that the openings succeed each other in regular order, and are connected by vertical veins and mineral crevices, passing from one to the other. When the entire thickness of the upper magnesian is pres-
ent, the diggings are confined to its upper bed. As the strata become denuded, they commence in the lower part of the upper bed and extend to the middle bed. When the strata are still more denuded, they commence in the middle bed and extend to the lower or through that to the blue limestone, or they even commence in the lower bed and extend through the blue limestone. It is only towards the northern border of the district, where the lower magnesian is exposed in a deep ravine, that I have observed any diggings in that rock.

In tracing the diggings through the different series, it may be stated generally, that in the Muddy and North Diggings mining has been carried on only in the upper bed of the upper magnesian; in the Beetown Diggings, in the upper and middle beds, and adjoining some valleys and ravines, in the lower bed; in the Potosi Diggings, in the same; in the Brushhill, Whig and Platteville Diggings, in the upper and middle beds, chiefly in the latter; in the Patch, South-East Platteville and North Elk Grove Diggings, in the upper and middle beds, chiefly in the former; in the South Elk Grove and Strawberry Diggings, in the middle bed; in the Menominee, Fairplay and Hazel Green Diggings, also in the Dubuque, Upper Galena and Vinegar Hill Diggings, in the upper bed; in the Benton and New Diggings, in the upper and middle beds, chiefly in the latter in the wide flint openings; in the southeast part of series 3, from Buzzard's Roost to the Shullsburg branch, in the lower bed and the blue limestone, chiefly in the former; in Earnest and Spenceley's and the Shullsburg Dry-bone Diggings, in the lower bed; in the rest of the Shullsburg Diggings, generally in the upper bed, but in those where depth has been gained by draining, as in those at the village and at Townsend's, also in the middle bed, at the former in the wide flint openings; in the Blackleg Diggings, chiefly in the upper bed, but in the deep shafts on the large North and Souths, also in the middle bed; in the Wiota Diggings, in the upper and middle beds; in the South Forked Deer Diggings, in the blue limestone; in the North Forked Deer and King's Diggings, chiefly in the lower
bed of the upper magnesian; in the Mineral Point Diggings, in the middle and lower beds of the upper magnesian, and in the blue limestone (in the upper and middle beds.) The blue limestone is there reached only in those diggings where the rocks are most denuded, namely, towards the south-west, and adjoining the valleys and ravines; in the more northern diggings (at the Dreadnought Mine,) mining is chiefly confined to the middle bed of the upper magnesian. At Dodgeville, adjoining the village, the diggings are in the upper and middle beds of the upper magnesian; at Duke's Prairie, in the same; at the Yellow-stone Diggings, in the two lower beds of the upper magnesian, and in the blue limestone, chiefly in its upper bed; at J. Scott's Diggings, east of Argyle, in the lower part of the upper magnesian, and at H. Scott's, in the blue limestone; in the other diggings in Green Co., chiefly in the middle and lower beds of the upper magnesian, and in a few instances, as at the Aspen Grove Mine, in the blue limestone. It may be just added, that in the Heathcock range (Linden) the mineral has been chiefly worked in the middle and lower beds of the upper magnesian, but has been recently followed into the upper bed of the blue limestone.

Copper ores (the sulphuret and carbonate) have been found in large quantity in the mineral district (south of the Wisconsin) only at Mineral Point. Smaller quantities have been found in other localities, particularly at Lost Grove, west of Mineral Point, and 4—5 miles south of Wiota, but these I have not yet visited. I have already noticed the occurrence of small quantities of copper ore in the openings in the middle and lower beds of the upper magnesian, particularly in the middle bed at Shullsburg, and in the lower bed on Fever river, at Buncomb and north of New Diggings. Traces of copper are said to have been found at the Wolf Diggings (west of Jamestown,) in the upper bed.

The copper ores at Mineral Point occur distinct from the lead ore, in ranges apparently in the same East—West line with cor-
responding lead ranges; the same ranges being lead-bearing on the west, and copper-bearing on the east; the lead and copper ores being at the same time more or less intermixed at the point of junction. There are thus presented two bodies of mineral, lead on the west and copper on the east, bearing N. N. Easterly across the bearing of the ranges. The width of the body of copper ore is apparently 1—2 miles. Both the vitreous and yellow sulphurites are found in the rubbish; more or less accompanied with iron pyrites; but as none of the ranges are now worked, their relative proportion cannot be determined. The earth from the openings has a deeper red tint than that from the lead openings, where such a tint would be considered unfavorable. The arrangement of the body of copper ore, in this instance, across the bearing of the ranges is very remarkable, but corresponds with the general transverse arrangement of the bodies of lead ore, already indicated. The copper has been worked here chiefly in the lower bed of the upper magnesian, but occurs also in the blue limestone.

I have already observed that the original ores, in the veins and openings in the mineral district, are apparently the sulphurites, namely, of lead, copper, zinc and iron. These ores are more or less subject to decomposition, and to recomposition into other ores; those of lead least, of iron most so.

The sulphurite of lead is chiefly recomposed into the carbonate; the sulphate being rarely observed. The carbonate sometimes forms merely an earthy incrustation on the surface of the sulphurite; but in other instances, the sulphurite is converted to a greater or less thickness, sometimes throughout its entire mass, into the carbonate, still retaining its form unchanged. Sometimes the earthy coat becomes detached and loose, and is then called mineral ashes. In a few instances, the massive carbonate, still retaining the form of the sulphurite, has been found in large quantity, forming bunches in the openings or veins; in one instance, it is said, at Potosí, to the amount of more than 7000 lbs. Crystals of
the carbonate are occasionally found, adhering to the surface of the sulphuret, or occupying cavities in it, generally in small quantity, but in some openings more abundant. The largest quantities I have yet noticed, were in the Aspen Grove Mine, in the blue limestone. The formation of the earthy carbonate on the surface of the sulphuret is apparently going on at present, particularly on the outskirts of the veins. The conversion of the whole or the greater part of the sulphuret to a massive carbonate, and the formation of crystals of the carbonate, appear to be rather the results of former agencies than of those at present operative. The carbonate is called white mineral by the miners, and is more easily reduced than the sulphuret, though yielding a less percentage of lead, but has not yet been found in sufficient quantity to be of much importance.

The sulphuret of copper is recomposed into the sulphate and the carbonate. The former is too soluble and too subject to decomposition to be permanent; the latter generally accompanies the sulphuret as a coating, and sometimes in crystals, but not in sufficient quantity to be important. Both the blue and green carbonate occur, but the latter is most common.

The sulphuret of zinc is recomposed into the sulphate, the carbonate and the silicate; but the former, like that of copper, is not permanent. The carbonate and the silicate are permanent, and are called dry-bone by the miners. They resemble each other, but the carbonate is most common and the most important. They usually replace the sulphuret (black-jack), without much change of form, the general arrangement of the vein or sheet being retained, but the dry-bone being usually less compact, and sometimes apparently stalactitic. In such cases, however, it retains very nearly the original form of the sulphuret, which exhibits too the same botryoidal arrangement. Not unfrequently the interior of the dry-bone is found occupied by the sulphuret unchanged. These recomposed ores of zinc are more abundant in some ranges and openings than in others. The sulphuret of zinches has appeared more subject to decomposition in the lower openings than in the upper; and in the lower openings, it will be found little changed in one
range, and mostly converted into dry-bone in another not far distant. The local causes of this difference require farther investigation to determine.

The sulphuret of iron is recomposed into the sulphate and the hydrated oxyd. The sulphate is frequently found in the openings, but like those of zinc and copper, is not permanent, and it results in the formation of the oxyd. The oxyd occurs chiefly in the form of ochre and the brown hematite. The former is generally too much mixed with earth to be of much importance. It gives the peculiar stain to the earthy materials and the rock of the openings. This varies from yellow to red brown, and the distinction of the tints is regarded as of practical importance. A red brown tint is considered by the miners very unfavorable for the occurrence of mineral, and the ground is then said to be burnt.* An orange tint is considered most favorable for lead, and a redder tint for copper. The brown hematite, called iron-rust by the miners, is a very common accompaniment of veins and openings. It occurs in very various forms, from thin sheets and porous slaggy masses to balls arranged in concentric coats with a radiated fibrous structure and botryoidal surface, resembling very exactly the hematite ores of Salisbury (Conn.) and of other ore beds in the same range. That it is formed by recomposition from the sulphuret, without any obvious change of form, is very evident in all the diggings where I have examined it; the sulphuret presenting all its different forms, and every degree of transition being observable from the unchanged sulphuret to the complete change to the hematite; in some instances, only a film of the hematite coating the sulphuret, and the change in others continued gradually to the centre of the mass, sometimes by successive coats, sometimes more by lines from the surface to the centre, some of the radiated fibres being found changed, and others intermixed with them unaltered. Sulphur is occasionally set free by the decomposition of the sulphuret of iron, and is found collected in pockets in the resulting mass. In some

* This merely arises from the abundance of the hydrated oxyd of iron, resulting from the decomposition of iron pyrites.
instances, calcareous spar occupies cavities in the sulphuret of iron, and on the decomposition of the latter has been found converted into the sulphate of lime. The hematite is sometimes found apparently as perfectly formed as in the Salisbury ore beds, and in such cases would probably yield a superior quality of iron. Care should be taken in selecting such only as has been completely recomposed, as the presence of sulphur would injure the product. In some of the diggings, particularly in the openings in the lower bed of the upper magnesian adjoining Fever river, in Benton and New Diggings, large quantities of this ore might be obtained, sufficient perhaps to feed a furnace, and even the ochry earth of the openings might in some cases be rich enough in iron to be reduced to advantage.

The earthy black oxyd of manganese (black ochre of the miners) is often abundant in the crevices and openings, and is considered a good indication of the presence of mineral. It is usually found accompanying or imbedding the mineral in the form of a matrix, but is sometimes found filling cavities or geodes in its interior. These facts seem to indicate it of contemporary formation with the mineral, and analogy would lead to the conclusion that its original form was the sulphuret, and that its present form has resulted from the decomposition of the latter. The sulphuret of manganese is said to have been found in the lead mines of Missouri, but I know of no instance in which it has been found in the mineral district.

The ores of zinc, although very abundant in many instances, particularly in the flat and pitching sheets, and in the lower openings, have never yet been turned to any account. There can be no doubt that they must be hereafter sources of profit, when we consider the large and increasing demand for zinc, both in its metallic form (sheet zinc) and as an oxyd (zinc paint). The zinc ores found in the mineral district may all be used to advantage. The dry-bone (carbonate and silicate) is most easily reduced, and can
be readily converted into the oxyd, and will thus probably be the first to attract attention, but the black-jack (sulphuret) contains the greatest proportion of zinc, and may soon be considered equally available. The proportions of zinc in the three ores are: in the carbonate 51.6, in the silicate 53.12, and in the sulphuret 66.72; that of lead in the sulphuret of lead (galena) is 86.55. The actual product of lead from the sulphuret is considerably less; from average specimens of the ore, about 70. It would not be unreasonable to consider the zinc ores as containing no greater proportion of impurities than the lead ore, and thus the relative product of the pure ores may be properly taken for comparison. The price of zinc is now rather greater than that of lead, in the proportion of about 6 to 7. As soon as an easy connexion is formed between the deposits of the zinc ores in the mineral district and the coal beds in Illinois by means of railroads, it may be reasonably expected that these ores will become objects of importance. The Galena branch of the Illinois Central Railroad, with the Shullsburg and Mineral Point branches, would open an immediate connexion between the coal-mines near La Salle and two of the localities most abundant in zinc ores (that between Benton and Shullsburg, and that at Mineral Point.) Either the fuel might be taken to the ore, or the ore to the fuel, as should be found most advantageous. Other routes of communication would soon be opened, and thus, with American skill and enterprise, a new mining interest would be created, which would compare favorably with the present.

The leading object of the detail which I have given of the arrangement of the mineral in the crevices and openings in its distribution through the different strata from above downwards, and of the surface arrangement of the ranges in groups and more extended combinations, has been to show that a systematic order prevails throughout, and that the mineral deposits are not detached and casual, but combined in regular series. I might have en-
tered into much more minute detail, but as I have intended this report more as a statement of certain general facts which I conceived were of immediate importance to the mining interest and as an outline of the mode of investigation I have designed to pursue than as the result of a survey, I submit it, such as it is, with the hope that its deficiencies will be excused in consideration of the very brief time in which I have been engaged.

The general result, in relation to the vertical arrangement, is that series of openings containing deposits of mineral are found at certain levels in all the limestone strata from the upper part of the upper magnesian at least to the middle part of the lower magnesian, varying in character in the different strata or beds, but strikingly analogous in the same stratum or bed throughout the whole extent of the mineral district, and that these are combined with vertical crevices and veins or sheets, traceable, where opportunity is offered, from one opening to another, or through different strata when not immediately connected with the openings; that the crevices and openings are distinguished from the adjoining rock by peculiar characters and the presence of substances not found beyond their limits; that they are bounded by regular limits, usually marked by vertical lines, like the walls of veins, as well in the widest flat openings as in the narrower vertical crevices; and that the mineral is arranged in these crevices and openings in a peculiar vein order, more or less evident, but always in some degree distinguishable. The mineral is sometimes arranged in more continuous and uniform sheets; sometimes in more detached deposits or bunches, connected however by mineral seams. These may be considered as the extremes, between which there is a graduated transition, and a more or less intimate connexion. In the upper part of the series, there is a greater tendency to a vertical arrangement; in the middle and lower parts, to a horizontal arrangement, and this increases as we descend, at least to the base of the blue limestone. The arrangement in the lower magnesian appears to commence as in the upper, but the opportunities for examination are there too few to decide satisfactorily, but sufficient to show that
the mineral is there arranged conformably to the arrangement in the strata above. The probabilities are thus strongly in favor of a continued descent of the mineral to a lower depth in the strata than is yet ascertained. The appearances seem no less to indicate the origin of the mineral and the accompanying ores from beneath, probably from the primary rocks underlying the lowest secondary; and that they rose in such a condition that they were diffused through a certain definite extent of the materials of the rocks, and then segregated in their present form, and this along certain lines which have determined their arrangement. It would be premature to offer a theory until a more complete exploration had been made, and all the important facts which such an exploration might offer were collected and arranged. But even now I have a strong impression that the mineral has been derived from beneath, and that the prospects of deep and continued mining are here as favorable as in other more established mining districts. The depth to which I have traced the mineral in its regular descent through the strata, assuming their estimated thickness, and including the Upper Sandstone, is 430 feet: Upper Magnesian 240, Blue Limestone 60, Upper Sandstone 60, Lower Magnesian 70 feet; not including the Upper Sandstone, in which no mineral has yet been certainly traced, 370 feet. Including the whole thickness of the Lower Magnesian, rating it at 220 feet, the entire depth would be 580 feet. The order of succession in the strata, at a lower depth, is probably not yet sufficiently settled to determine what farther may be expected. I have already enumerated (p. 68-9) the series of openings which may be expected in penetrating to the base of the lower magnesian. These, not reckoning their subdivisions, may be stated at ten or eleven. The known productiveness of single openings, in many instances, will sufficiently indicate the prospects which such a series would offer to the miner.

The traces of order and connexion in the surface arrangement appear no less remarkable than in the vertical arrangement. What I have here given is only a small part of what might have been stated; but I trust it will suffice to show that the ranges, in their
bearing, and in their grouping from the smallest to the most extended combinations, have been governed by some general laws, and have not been merely local accidents. I might have stated many facts which seem to show a regularity in the distance between different ranges in the same group; but such a statement would require a degree of detail incompatible with my present object. Such a regularity is not only probable in the arrangement of each group, but in the combination of groups into larger bodies and more extended series. To determine this satisfactorily would require an exact topographical survey of the mines, which may hereafter become an object well worthy of public attention. The diggings, as they now exist, seem to show a limited extent of mineral bearing lands, only a small part of the surface having been yet broken in search for mineral. That the present diggings represent nearly the surface extent of the ranges yet struck appears not improbable, particularly when we consider the position of the ranges crossing the leading ranges, and apparently limiting their extent. But although the different groups yet worked may have this limited surface extent, it does not follow that all the ranges have been yet discovered. Perhaps diggings as extensive as those yet worked remain still undetected in the wide intervals between the latter, and the indications of such stated in this report (p. 80, 83) may be only a very small part of what yet remain to be discovered. The order which I have attempted to trace in the different series of diggings may serve as a guide in directing farther search, and may lead to such results as will give to prospecting some degree of certainty. Experienced miners have been already influenced by such considerations, and in many instances have found them reliable. The study of the surface arrangement may thus become an important aid to discovery.
MAP
representing the Surface arrangement of the Diggings in the MINERAL DISTRICT.