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Geological conditions and genesis of the ore deposits of the Rush Creek District, Marion County, Arkansas

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THE SIS
FOR THE DEGREE OF
BACHELOR OF SCIENCE
IN
MINING ENGINEERING

JUNE, 1900.

W. M. WEIGEL.
GEOLOGICAL CONDITIONS AND GENESIS OF THE ORE DEPOSITS OF THE RUSH CREEK DISTRICT, MARION COUNTY, ARKANSAS.
GEOLOGICAL CONDITIONS OF RUSH CREEK DISTRICT
MARION COUNTY, ARKANSAS.

1st. The Formations.

The rocks of the district consist of alternating formations of heavily bedded magnesium Limestone and Sandstone of Silurian age, overlain by residual chert of the sub-carboniferous.

The classification of the formations occurring within limits of the district shown on accompanying map is given in table below.

<table>
<thead>
<tr>
<th>Sub-carboniferous - Residual Chert.</th>
<th>Silurian</th>
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<tbody>
<tr>
<td>First magnesium Limestone</td>
<td>Second magnesium Limestone</td>
</tr>
<tr>
<td>First Sandstone</td>
<td>Second Sandstone.</td>
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<tr>
<td></td>
<td>Third magnesium Lime.</td>
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</tbody>
</table>

In the table the names of the Silurian formations have been taken from the Missouri classifications. This was done in order to simplify matters and then the lithological characteristics and the relative positions of the different formations seemed to indicate that they correspond to formations of the same name in Missouri.

The area included has been greatly eroded and very little soil covers the rocks. Precipitous bluffs are frequent, giving excellent sections for study of the exposed strata.

Rush and Clabber Creeks traverse the district from northwest to southeast, Rush Creek being fed by tributaries from the south and Clabber Creek from the north.
The area between the two is a high divide or ridge un-traversed by water courses.

3rd. Magnesium Limestone. This is the lowest formation exposed in the district and forms the beds of all streams except where over-lying formations remain, due to faulting.

This formation is made up mostly of massive magnesium limestone, varying in color from a light gray to drab.

The upper layers just below the second Sandstone are highly siliceous and often cherty, and are rather thinly bedded, sometimes being almost shaly and on exposure to the weather separate into thin laminae.

These upper beds hence weather more rapidly than the ones below and form a slope, while the lower ones stand out prominently in the form of bluffs, often overhanging where the streams have cut into their bases.

On exposure to the weather this lower portion becomes covered with a yellow or slate colored coating, entirely hiding the bedding planes, although the bedding planes are perfectly distinct on a fresh fracture. All the rocks of this formation are fine grained.

Second Sandstone.

Although in the district considered this formation is rather thin, (five to six feet) it is persistent throughout the whole country.

It is composed of irregularly sized grains of quartz with a cementing material of Carbonate of Lime. It is friable but weathers well, standing out prominently along the hillside.
The lower portions merge into almost a quartzite with frequently spotty accretions.

Weathered surfaces when broken show a peculiar greenish layer about one-eighth of an inch thick, lying about one-eighth to one-fourth of an inch under the surface which, in the First Sandstone, is always brown. A fresh piece when broken up is snow white and closely resembles granulated sugar in appearance.

Second Magnesium Limestone.

The strata of this group consists of limestone and Magnesium Limestone less heavily bedded than the third magnesium but more crystaline.

Some fossils are also found, mainly Crinoids and Gastropods. In color they vary from a dark grey to light grey and pink.

This formation is strongly magnesium and the occurrence of Dolomite crystals is very common, usually filling the jointplanes and small fissures in the rock.

One stratum in particular is peculiar. It is a grey magnesium lime, rather crystaline, and the laminae and bedding planes instead of being planes have a wavy, or crumpled form, uniform throughout. The breadth of wave or ripple from crest to crest is from three to five inches and the depth from three-fourths to one inch.

The laminae are often separated and the space between filled with Dolomite crystals and if ore-bearing with small crystals of Sphalerite. In the vicinity of large ore-bearing fissures the stratum is usually replaced by a quartzite or flint.

About twenty feet above this a pink Magnesium Limestone occurs from three to four feet in thickness. It is highly silicious and a very tough rock, and the bedding planes are indistinct.
Above this the more evenly bedded limestone extend up to the First Sandstone.

The thickness of the Second Magnesium averages about two-hundred feet.

First Sandstone.

This like the second sandstone is very friable but weathers less easily, forming bluffs for almost its entire thickness wherever it outcrops. It is rather variable in thickness which ranges from thirty to fifty feet.

On weathering it separates into characteristic irregular rhombohedrons, often of large size.

Exposed surfaces when broken into show a brown layer about a quarter of an inch thick, immediately under the surface, probably due to the oxidation and concentration of the small amount of iron contained, similar to the green layer in the Second Sandstone.

This is one of the most prominent formations of the district and can easily be distinguished at a distance by its rounded surface and precipitous bluffs.

It is composed of irregularly sized quartz grains, with a cementing material of Carbonate of Lime.

An excellent place for study of this formation is along the second tributary of Rush Creek, coming in from the South.

Here the stratum has been brought down to the level of the branch by the Rush Creek fault and forms the bed and banks for nearly half a mile.

About one hundred and fifty yards before the branch empties into Rush Creek it falls over an overhanging ledge of the sandstone into the Second Magnesium below.
First Magnesium Limestone.

This formation extends from the First Sandstone up to remains of the Sub-carboniferous, as the Devonian age is lacking and it is of varying thickness.

On the south side of the Rush Creek fault where it has been lowered by that fault it attains its greatest thickness, as here the weathering and erosion has been longer delayed.

It consists of successive strata of limestone, marble and chert.

The limestones are generally crystalline, often containing small crystals of Calcite which shows up well on a fresh fracture.

Immediately above the First Sandstone the Limestone are coarse grained and immediately above this changing to a finer grained grey Limestone.

From fifty to sixty feet above the First Sandstone the Red Marble occurs with an average thickness of about seven feet. This is composed of a fine grained, reddish brown matrix, containing larger white specks or crystals due to fossils, mainly crinoids, which give the marble the appearance of Porphyry. It takes an excellent polish, and is used locally as a lining for furnaces as it has excellent fire resisting qualities. With cheaper transportation facilities it will probably become of considerable economic importance.

It resists the elements well, much better than the formations directly above and below it. The matrix weathers faster than the fossil forms. Thus on exposed surfaces these stand sometimes for half their thickness above the rest of the rock, and sometimes four to five inches long, showing distinct branches.
Above the Red Marble come alternating strata of Limestone and chert up to the residual chert which caps the tops of all the hills, and is probably the remains of the erosion and removal of the sub-carboniferous formations. Hence its thickness is variable. This chert is composed of masses of all sizes from sandstone up to pieces weighing a ton and occurs as white, green, brown, grey, etc., according to the amount and condition of the iron contained.

Second. The Structure.

The whole district has been subjected to uplifting and tilting by the Ozark Uplifts and one important fault traverses the district, namely, the Rush Creek fault, called so because this Creek follows the line of fault for almost its entire length.

On the north side of the fault the strata dip slightly northeast up to about the middle of the district and from here on east the dip is slightly greater. On the south side of the fault near the line of fault, and from about the middle of the district on west, the dip is southwest, giving the impression at first of a reverse fault, but this is local, for on proceeding further to the southwest the general dip is found to be northwest, indicating a normal fault.

The average dip is about five degrees, the greater dip being about seven degrees.

On the south side of the fault a syncline occurs with the axis perpendicular to the line of fault.

# See Geological Map and Structure Sheet.
About a mile and a half Southwest of the fault line beyond the district shown on the accompanying map the strata regain about the same elevation that the corresponding ones have on the north side.

The maximum throw of the fault is about two hundred and fifty feet.

Mineral Resources.

The only ores of commercial value in the district are Smithesomite and Sphalerite. This is found in both the second and third magnesium limestone. To what depth it extends is not known as it has been found as deep as has been thus far explored.

The chief mines of the district are the Morning Star, McIntosh, White Eagle, Philadelphia and Leader.

It will be noted from the map that most of the mines occur nearly in a straight line, approximately parallel to, and near the Rush Creek fault.

A discussion of the probable causes of this feature of the ore occurrence follows.
GENESIS OF THE ORE DEPOSITS OF RUSH CREEK DISTRICT,
MARION COUNTY, ARKANSAS.

In making a study of the genesis of the deposits of this region the chief difficulty met with was the lack of development, especially development carried on to any depth below the surface as most of the work has been done on the hillside and the nature of the deposits to any considerable depth is as yet unknown.

Of one thing there can be no doubt, that is the deposits are of secondary origin.

This is proven by the fact that in almost all cases the ore and gangue minerals occur as the cementing materials of a breccia, in many cases filling in the joints and bedding planes of the fissure walls, showing that the deposit of mineral has occurred after the wall rock has been uplifted and crevassed, or broken.

Another prominent fact is that the large ore bodies are found along or in close proximity to the fissures caused by the uplifting and tilting of the strata.

A striking example of this is found along the north side of Rush Creek. Here the outcrop can be easily traced along the hillside for a distance of nearly a mile, and at no point is it greater than three hundred feet from the average line of the Rush Creek fault.

This outcrop extends across Buffalo River, and can be followed on that side for a distance of half a mile or more to the
the Silver Hollow Mine, the most easterly point at which it has been
worked. The general course of this line is W.N.W. However Sphalerite
does not occur along the full length of this fissure in paying
quantities and in fact in some places it is difficult to find traces
of the ore, the crevices being filled at those points with flint, clay or gauage minerals, Dolomite or Calcite.

On the west side of Buffalo River, where the outcrop occurs along the south slope of the hill, it has been worked to a con-
siderable extent and runs back into the hill, following the bedding
planes of the accompanying strata, beyond any exploration that has been
done in that direction. How far it goes back one can only surmise
but it follows up the line of least resistance, occurring in planes
parallel to stratification, varying from six inches to five feet
apart. These beds or layers follow up strata that have been easily
replaced and leaving the intervening hard non-porous rock, in most
cases completely barren, except where it has been fractured or
fissured in which case the fissure is filled with Sphalerite usually
almost free from gauage minerals. See Plate I.

These fissures often broaded out into openings or
"pockets", the walls of which are covered with a deposit of ore, from
one inch to ten inches thick there remaining either an open space
or clay in the center.

In the sketch "a" represents the ore and vein-stuff, quartz
calcite and dolomite. The middle stratum has a wavy formation
similar to ripple marks. On the south side of the fissure this is
barren, but on the north side, the laminae seems to have been spread
apart, and the space between filled with "Jack" quarts and Dolomite.
Wherever this has taken place, the original Magnesium Limestone of which
it was composed has been metamorphosed to a quartzite. This was probably due to the replacement of the Dolomite by the silica held in solution by the percolating water, the Dolomite concentrating and forming crystals in the inter-laminal spaces.

The clay in the pockets known as "tallow clay" varies from a light to a dark red, due to its iron contents, and is perfectly free from grit or sand, having a characteristic unctious feel to the hands. It is found in all openings or pockets whether ore bearing or not and thus accompanying open or fissured ground and is considered an indication of the presence of an ore body of some size.

The evidence obtained from all the mines points to the fact that the ore was deposited from a state of solution. Of course the theory that it comes from a great depth in a fused state is entirely out of the question as in that case the walls of the deposit would show evidence of contract metamorphism, and such is not the case. Also some of the gaugue minerals could not exist at the temperature required for the fusion of Zinc Sulphide, for instance Calcite.

The theory of lateral secretion from the wall rock has also been advanced, it being supposed that the Zinc was originally deposited with the rock forming minerals, forming an ordinary limestone, which by a secondary alteration was changed into Magnesium Limestone, and the Zinc concentrated during this process.

This might seem plausible were it not for the fact that the zinc was evidently deposited after the rock was uplifted and fissured which must have been after the change from Limestone to Magnesium Limestone, if such a change took place.
Also the ore does not occur in small fissures or openings unless there has been some communication with larger crevices which evidently extend down to an unknown depth. Small isolated fissures or joint planes never carry any ore, which should not be the case were its origin due to concentration from Magnesium Lime Stone.

Then again the ore is found uninterruptedly from the highest sandstone, which we will here call the first sandstone down through all the formations as far as has been explored. In many cases being found in the river and creek beds, or through a vertical distance of from three hundred to three hundred and fifty feet. The vein minerals being the same through all this distance.

It hardly seems probable that all this thickness of strata could have been deposited Zinc bearing, especially as about midway in this distance occurs what we will call the second sandstone, varying from three to five feet in thickness, which evidently indicates a change in the conditions of deposition.

The non-occurrence of the ore above the first sandstone may be accounted for by the fact that wherever fissures or faults have occurred the formations have been eroded far below the first sandstone, so that it and the superimposed strata only extend over the unbroken areas.

The mode of occurrence of the ore and vein stuffs seems to be conclusive evidence that the ore was deposited from solution.

The original ore was Sphalerite and the gangue minerals are quartz, calcite and dolomite.

The quartz is well crystalized in most cases forming almost perfect crystals, which could only have been deposited from solution.
The Cleavelite occurs either as Rhombohedrous or Scalenohedrous, the latter being less common. The Dolomite occurs in its characteristic pink crystals and is probably of later formation, due to decomposition of the Magnesium Limestone by percolating waters.

The sphalerite occurs usually massive, disseminated ore being the exception.

A very strong point in favor of deposition from solution is the fact that often crystals of quartz are wholly enclosed in the "Jack" and sometimes on breaking open a large piece of "Jack" a small cavity will be found coated on the inside with fine crystals of quartz or drusy quartz.

Assuming that the ore was deposited from solution, then we must impose the conditions that the solutions were first hot and second alkaline.

Solutions flowing from a great depth upwards would necessarily be hot and the heat would possibly result from the conditions accompanying the upheaval of the Ozarks.

The great solvent power of heated water under pressure is well known, but it is not unreasonable to suppose that the solutions were hot for at the present time "hot springs" are met with at different points in the Ozarks, namely "Hot Springs" where the temperature of the water, at the surface, is in some cases as high as one hundred and sixty degrees Fahrenheit and it can be reasonably assumed that they could be at much higher temperature at great depth and under high pressure.

The slight metamorphism which exists in the fragments of wall rock in the veins and in the walls themselves demonstrate the
agency of heat.

The solutions were undoubtedly alkaline because alkaline sulphides and carbonates are the only natural solvents of quartz, and the great quantity of this mineral in the vein could hardly have been deposited by any other means. It often occurs as a coating on the rocks and ore to a depth of one to two inches, beautifully crystalized, and this occurrence of quartz crystals is only found in close proximity to the vein.

The above seems to be the best explanation for the deposition of the quartz and vein minerals, and with the close association of them and the ores, the only possible conclusion to draw is that the ore was deposited from the same solution.

Assuming then that we have a hot solution of silica, Alkaline Carbonates and metallic sulphides coming up through the fissure; then by decrease in pressure and gradual cooling the contents would be slowly deposited in the form of crystals in which they are found.

The theory of deposition of the ores from hot alkaline waters, coming from below therefore seems to be the one best upheld by the conditions, and the least hypothetical.

The formation of the dolomite occurring in the vein was evidently subsequent to that of the Sphalerite and other vein minerals Calcite and quartz, for it always occurs as a coating on these and is never enclosed in them as is true of the other; for instance crystals of calcite and quartz are often enclosed in crystals of Sphalerite, but Dolomite is never found in this position. It was evidently formed from the side walls by the action of percolating
surface waters.

A cross section of the vein at the Morning Star Mine is shown in Plate II. (This sketch also shows the slight fault about four feet between the walls of the fissure).

The first ore taken out at the surface was entirely Smithsonite while now, at a depth of sixty to seventy feet from the surface Sphalerite is beginning to predominate. This sequence of "Carbonate" and "Jack" is true of all the deposits, very little Calamine being found in the locality.

At the White Eagle Mine, about a mile east of the Morning Star, on the same vein, ore is being taken at about twenty feet below the level of Buffalo River, all the ore taken out here being "Jack".

The Morning Star, where a mixture of Jack and Carbonate is being mined is about one hundred and eighty feet above level of Buffalo River.

The Carbonate is evidently an oxidation product of the "Jack". This is born out by many facts. First as you go down from the surface the percentage of Smithsonite decreases and that of Sphalerite increases. Second on breaking open a nodule of Smithsonite the inside is found to be composed of "Jack, usually with a thin layer of quartz crystals between.

Third, it was evidently deposited in the presence of percolating waters. This is shown by its formation, occurring in some instances almost in perfect stalactites, and by a section normal to the surface it is shown to have been deposited in layers just as in stalactites, the layers being distinguished by alternating light and dark ones. It usually separates easily along these lines, showing a pearly scale between. It has the characteristic botryoidal structure, occurring sometimes from three to four inches thick.
It is often massive and sometimes single pieces have several
square feet of unbroken surface.

It sometimes replaces the Limestone, taking up the latter's
form in every respect, showing the bedding planes and crystalization.
In this form it can hardly be told from the Limestone except by
chemical test or weight. Assays of samples of this showed in some
instances as high as forty-eight to fifty percent of metallic zinc.

The Smithsonite as a rule is rather fine, running as high as
fifty-one to fifty-one and a half percent metallic zinc, the
theoretical being fifty-two percent. This is caused by the impurities
of the "Jack" having been dissolved out and carried away.

Another oxidation product occurring with the Smithsonite
is the mineral known as Marionite. It is a white amorphous mineral
much resembling chalk in structure, usually occurring in thin layers
on the Smithsonite or between layers of it.

In composition it is something near Hydrozincite although
sometimes its zinc contents are greater than the theoretical for
that mineral. Its zinc contents varies from fifty-six to sixty-four
percent. It occurs in too small quantities to be of commercial
value and is probably not a true mineral species.

The mineral "Turkey fat" is a carbonate of zinc, carrying
from one to two percent of Cadmium. Its structure is identical with
that of Smithsonite. Its color varies from a pale green-yellow to
orange. It may be that its color is due to Cadmium in the form of a
sulphide as considerable quantities of greenochite are often met
with occurring with the "Jack". This mineral also only occurs in
small quantities.
The Sphalerite of the district varies from a light brown to almost a black; although the latter is of rare occurrence.

On exposure to the air it often takes on a bluish cast on the surface.

Its zinc content varies from sixty-two to sixty-five percent, sixty-four percent being about the average. It contains practically no lead and the deposits are almost free from Pyrites.

Further development in this direction will doubtless throw more light on the subject and make the theory of its origin, here advanced more conclusive, if that be necessary.