The Mechanical Preparation of Ores in England

Galena, and Mixed Galena and Blende
at the Lisburne Mines, Cardiganshire.

Lessons given in 1865 at the School of Mines
by M. L. Aloisienet
Mining Engineer.
By direction of the Minister of Public Works I gave at the School of Mines in 1864 and 1865 some lessons on the methods adopted in England for the mechanical preparation of Coals. The present memoir is the development of the subject treated in 1865.
Galena and Galena-Bleude at the Cilwern Mine, Cardiganshire.

Lessons given in 1865 at the School of Mines. *

Introduction

Galena is worked in England in two very distinct positions: on the Carboniferous Limestone on the one hand, and on the other in the ancient schists of the Silurian and Devonian formations.

During the decennial period 1848-1859 the United Kingdom produced

Lead Ores. 923,445 tons. (g 21 cwt)
Metallic Lead. 632,926 tons.

More than half this produce was yielded by the mines opened in the Carboniferous Limestone of the North of England and the Northeast counties of Wales. But while abounding in Lead this formation yields silver sparingly; the mean yield of the different districts varies from 6% to 12% of fineness per ton of ore of Lead.

The ancient schists on the contrary contain the two varieties; lean ores, and
argentiferous ores. Thus in Cardiganshire, the mean yield of silver reaches 14 ½ oys; in the Isle of Man 17 20 ½; in Cornwall 34 0 ½; and in Devonshire 39 0 ½.

Some mines yield parcels of lead ores which are very rich in silver, but this is a purely accidental occurrence; so that for the precious metal no deposit actually worked in England is comparable to the French mines which maintain a regular production of lead yielding 114 oys, 163 cwt, and upwards.

A brief study of the preparation of English lead ores should include three examples, chosen with a view to show the modifications which result, (beyond local usages) on the one hand, from the nature of the gangue; and on the other from the yield of silver.

It would thus be necessary to examine the treatment of:

1. Poor galena from the Carboniferous limestone of the North of England.
2. Poor galena from the Silurian schists of Wales.
3. Argenitiferous galena from the Devonian schists of Cornwall and Devonshire.

It is the second type alone which I propose to study in the present work.

† Records of Mining and Metallurgy. 1854.

clay carbouable
describing the dressing floors of the Lisburne Mines in Cardiganshire.

Some notices on the preparation of lead ores in Wales have already appeared; Professor Warington Smyth has described the method adopted at Cwmnaur where the average yield of silver reached 290 lb.; Phillips and Darlington have briefly described the method and the appliances used in Cardiganshire.

Under the term Lisburne Mines are included several works, the principal of which are, Bronogoch, East Loglas, and Flogbach. These mines supply two dressing floors.

The Bronogoch dressing floor is reserved for the mine of that name; that of Level Fawr, situated at the entrance of to the great Loglas drainage and drawing level, receives also the Flogbach ores. Notwithstanding numerous points in common, these two floors present well-marked differences, which besides correspond to the varieties of the ores and the conditions of the work.

At Level Fawr the gangue is shale and carboniferous limestone; the yield of galena is 20 to 22 per cent of the material brought out of the mine; the smelting is numerous tributors are employed.
Crompythwith, situate west of Logylass, belongs to a company distinct from the Lisburne Mines but is placed under the same management.
which compels the lots extracted to be prepared separately; and lastly, the ground on which the floors are formed is hilly and from the head to the tail there is a great difference of level.

At Prouocholi the gauque is quartz; the galena scarcely reaches 6 per cent of the stuff extracted; there are no tributers; the works extend on a gentle sloping ground; and lastly and above all, the ore is notably sandy.

The method at Level Favor may be considered as the typical in Cardiganshire; it is applied to the important mine of Cwm-yntworth*; it has been followed at Prouocholi; but the recent introduction of a very ingenious apparatus, the Ceburne Riddle, has just brought about, at Prouocholi a notable modification in the course of operations.

Not only does the Ceburne Riddle facilitate the delicate operation of separating the sand from the Galena, but it, singularly simplifies the labour of concentrating the two ores. Its part can only be properly understood by considering the two systems of management, that is, that preserved at Level Favor and that judiciously modified at Prouocholi. So to avoid repetition I think it useful to describe, side by side, the
This memoir comprises the following divisions: 

Chap. 1: Description of the Localities, Bearings.
Chap. 3: Description and working of the apparatus.
Chap. 4: Economical results.

I express here my thanks to the skilful managers of the Lisburne Mines, Messrs. Taylor and their Agents; especially to Captain Buge, the Superintendent of the dressing floors.

Chap. 1.
Description of the Localities. Bearings.

Topographic Sketch. — The port of Aberystwith serves for exporting the minerals, and importing stores & provisions for great part of the neighbouring mines. Its situation in the mouth of Cardigan Bay, and its picturesque shores, have made it the favourite place of resort tourists in the West and the retreat of such sea-bathers as seek a certain retirement.

The town stands near the confluence of the rivers Rheidol and Ystwyth; the first comes from the East, the second from the Southeast.
The argentiferous mines of Goginan, Warren & others lie to the North, on the right bank of the Kleinol at about 10 miles from its mouth; those with which we are concerned are near the Ystwyth.

From the port to Loglas is 114 miles; the route first follows the spur which divides the two valleys, then skirts the Ystwyth and passes on the left bank to Port Clandaff; hence, by an occupation road 3 miles long, leads to the works at Level Furn; established on the flanks of the mountain and bounded by the escarpment of the river bank.

Logfas lies a mile to the Southeast of Loglas, in an elevated region; Trongoch, 3 miles to the North-west of the same point (114 miles from Aberystwyth by the direct road); lastly, at 4 miles eastward, on the right bank of the river.

In this region the Silurian shales are intersected by deep valleys; some are nearly straight with a length of several miles, and a considerable width; the bottom is occupied by watercourses, sinuous in ordinary times, but large when swollen by rains; drift with pebbles of shale occurs on the sides, witnessing a former superfluous level.

Other valleys are deep, narrow and generally toritous; they open upon the preceding
I will instance two quarries, one near Slaghead Mine, the other on the bank of the yet with half a mile east of fort Lauderdale.
Surrounding Rocks. The shale is usually foliated, passing into slate; its colour is a bluish grey, more or less dark; in certain places, the cleavage is less defined, and the more compact rock may be quarried for building purposes. Even in this case, the blocks obtained are very irregular from the number of oblique joints.

From Aberystwith to Cogflat, the general strike of the measures is southwest and northeast (magnetic) and is sensibly of the Longmynd system; near the town, the beds dip to the southeast, but after several plications, they are seen clearly to lie in line towards the northwest in the district of the mines. Here the shale is more compact; its colour being a somewhat clear blue grey.

Directions. Most of the lead veins of Cardiganshire have a bearing of east-west, to northeast—southwest; but notwithstanding this general resemblance, as happens in most cases, there are many exceptions. We shall be able to judge without going beyond the restricted space which we are now considering. Here are some mean bearings taken from a small scale plan, and which
are somewhat rude approximations; besides the metallic veins they comprise powerful quartzose veins whose position has been ascertained.

Going from the south-southeast to the north-northwest, there occur in succession:

<table>
<thead>
<tr>
<th>Name of Veins</th>
<th>Direction Reduced to True North</th>
<th>Lead eastwards</th>
<th>Length of Lead to a Half of Feath.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead Veins of Clogair-y-Morgyn</td>
<td>E 44° N</td>
<td>north</td>
<td>37.6&quot;</td>
</tr>
<tr>
<td>&quot; &quot; Glogfaeli</td>
<td>E 23° N</td>
<td>do</td>
<td>17.6&quot;</td>
</tr>
<tr>
<td>&quot; &quot; East Logglas</td>
<td>E 31° N</td>
<td>south</td>
<td>24.6&quot;</td>
</tr>
<tr>
<td>&quot; &quot; Old Logglas</td>
<td>E 40° N</td>
<td>do</td>
<td></td>
</tr>
<tr>
<td>Quartz Vein</td>
<td>E 40° N</td>
<td>do</td>
<td></td>
</tr>
<tr>
<td>Lead Veins of Grogwagnion</td>
<td>E 10° N</td>
<td>do</td>
<td>3 ft</td>
</tr>
<tr>
<td>Its prolongation to Pont-rhgyd-y-grog</td>
<td>E 5° N</td>
<td>do</td>
<td></td>
</tr>
<tr>
<td>Quartz Vein</td>
<td>E 40° N</td>
<td>do</td>
<td></td>
</tr>
<tr>
<td>&quot; &quot; E 35° N</td>
<td>do</td>
<td>2 ft 6&quot;</td>
<td></td>
</tr>
</tbody>
</table>

The ancient systems of upheaval are as well known strongly impressed on the contour of Wales; almost everywhere it is easy to recognise the characteristic influence of some of them.

If we examine on the maps of the Geological survey the triangular space having
Aberystwith at its northern, Garregfald at its southern, and Logyglas at its eastern angle, we may remark that notwithstanding numerous protruberances, the ground is far from being so hilly as in the neighbouring regions. Parallel to the Caets for a length of 2 miles, the slopes are easterly following the Longmynd system; from Aberystwith to Logyglas, the mean direction of the River Ystwith is that of the system Morbehan, intersected near Glannfawr by that of the Longmynd, then near Llanrheul, by the Westmoreland system. Lastly the southern side of the triangle is traced nearly by a straight line from the river Cwm-y-wras, for 8 miles, between Garregfald and Pen-y-Carraw, towards the north foot of the chain of Muncold Bach; then, after having crossed a defile, by the course of the Ystwith from Pont Glannfawr to Logyglas, the sinuous prolongation of the same line would extend to the Cwm-y-stwithhine. The line thus marked out being not less than 14 miles long and following the system of the Caets’ end.

On the south, east, and north of Logyglas, the most obvious directions are those of the systems Longmynd, Morbehan, and Westmoreland. This latter system often appears deviated by the anterior influence of the system Finifer and
Probably also of the Conquynd.

There is sufficient to warrant the supposition that the period of the filling of the veins by lead galena, here as in Flintshire, may have extended to the epoch of the System Ballons; that is, has been posterior to the deposit of the Carboniferous limestone.

The direction proper to the System Ballons is met with more rarely in the fissures, much as the earth had been so extensively fractured by the previous upheavals, how if we consider only one epoch as the time of formation of the lead galena, in Cardiganshire, it is easy to understand how the contents of the veins might be variable. In fact the tolerably constant direction of the strike of the beds (Conquynd) forms very different angles with the auriferous systems, such as the Sinisterre, Westmorland and Hands End; ultimately from the further disturbances produced under the influence of the System Ballons, new angular differences have been brought into play; lastly in each locality the nature of the shale has been more or less favourable to the formation of clefts.

In the before mentioned mines we find as ruling directions, the system
The declination at the Lisburne mines in 1860 was estimated at 22 1/4°; the magnetic bearings E 18° N and E 15° N reduced to true north become E 40° 1/2 N and E 3° 1/2 N. Now the system Westmorland represented by the great circle of the corresponding pentagon, has a bearing:

At Holywell, Flintshire  E 38° 16' N,
At the point of Cornwall E 40° 24' N.
Westmoreland at Eldari-y-mwyn: the Westmoreland modificate wundry degrees at Glofaclch and Loglas; lastly the liquid lands end and egn Rallone, at Frugoch and Grogrojion.

Deposits: The Eldari-y-Mwyn is a true fracture; its general direction is E 44° N, and it attains 30 feet in width; the mass of the lode consists simply of broken shale, traversed by corss veins, some of which contain galena almost free from gangue. Gossau is here found to a considerable depth.

At Loglas and Glofaclch, the lodes are less powerful but more regular; the branches are richer than the main lode, and it is chiefly at the points where it meets the branches that the main lode becomes productive.

In the ancient open works on the outcrop at Loglas, still open and evidently made on the rich parts, bear E 18° N magnetic. In the mine the profitable parts bear E 15° N; whilst in the direction E 10° N the lode has been followed entirely barren and even scarcely discernable.

At Glofaclch E 18° N is also the useful direction, it is precisely that of the system Westmoreland.

At Loglas as almost everywhere, ground...
Since 1860 the yield of silver appears to have notably increased at Glogfach. Mr Robert Hunt's statistics for 1862 show a production of:

Ores 445 tons yielding 5 Lead 612 tons.
Silver 9,800 ozs.

Being about 12.65 ozs of silver to the ton of merchantable ore.
A middling hardness is favorable to the richness of the deposit.

The lode is principally filled with broken shale, the fragments of which tend to have a bearing; the vein shale is generally hard and quartzy; in places, it often contains minerals and gangue in the form of small veins. Hence it happens that mineral of a somewhat high mean yield is extracted but not in large masses.

Accompanying the lode are of a very quartzose shale or capel which sometimes contains much disseminated galena.

Looglas and Glogfach present a very similar assemblage of minerals. There occur cleavable galena, brown haüyne, carbonate of lime, sometimes crystallized and hyaline, but generally cleavable, opaque and of a slightly rust colored white; this galena in moderate quantity is considered a good indication. The quartz is there crystallized by but is not abundant; iron pyrites is rare.

At Looglas, the galena yields 30 oz. of silver to the ton of washed ore; at Glogfach, the yield reaches 62 oz. (in 1860). Trougoech mine is opened on a powerful
quartz, lode, containing galena and blende. The working has extended a length of over 1300 yards; the width of the vein varies from 10 to 30 feet. Courses of ore paying ore have been met with 30 to 50 fathoms long; these deposits dip to the West, as do the shales of the enclosing ground.

The great quartz vein bears 8° to 12° North of true East, that is, corresponding with the system Land's End, whilst galena is also met with in the branches from the main lode, and which bear 24° to 45° North of West. (Ballons.) This is notably the case in the 50 fathoms level east of Taylor's shaft.

The favourable shale is of a clear grey and traversed by veins of quartz.

Besides quartz, which always predominates and is sometimes well crystallised, the lode contains quartz of shale or imperfect calp. There are two varieties of galena; the one laminated and cleavable, the other fine grained, called "steel lead" and which is less plentiful. In each variety, the yield of silver is 3 ozs. to the ton.

The blende is brown; it is found according to the part, more or less mingled with the galena; the two often forming what might be termed,
In some places they are in
veins and large patches in the quartz; still the
mixture is not completely pituitate.

In the extracted minerals the proportion
of blende to galena is about one to eighth.

At the east of the mine, the explorations
made on the back of the lode, have yielded a
large quantity of blende mixed with oxide of
iron; a sort of blende gossan. At the 21st
fathom level the veinstuff abruptly changed
and galena takes the place of the blende. Still
it has been observed that in depth the blende
without being abundant extends over greater
lengths in the levels, whilst the patches of galena
seem to become more contracted.

Principal facts in the Working. In these
notes on the mode of occurrence of the deposits of
ore, I will add a few more on the state of the
works executed at the Lisburne Mines, and on the
resources available for working them.

Lisburne Mine certainly owes its present
prosperity to the great adit, which having been
driven 364 fathoms has just cut the lode at
60 fathoms deep. There are nine levels, at 20
38, 44, 60 (the adit), 70, 90, 105, 120 and 130
fathoms. The last is 130 fathoms below the
level of mean sea.

..
surface of the ground and only 1/10 fathoms below the adit level. In 1860 the most active explorations were at the 105 and 120.

Glogzech, much more recent, but rapidly being opened, has only four levels as yet, those at 48, 53, 73, and 88 fathoms.

At Shorgoch, although the works are very extensive in a horizontal direction, they have not yet attained great depth; two shafts are being sunk below the 48 fathom level; the adit, only drains down to the 24 fathom level; below this are the 34, 44, 56, 66, and 78 fathom levels.

The drivings in these various explorations both in the lode and in the adjoining measures require a large quantity of timbering; everywhere the ground is solid, although at Glogzech it is not so hard as at Shorgoch, as appears from the following figures:

<table>
<thead>
<tr>
<th>Name of Mine</th>
<th>Average price paid in 1859 per linear fathom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In the lode</td>
</tr>
<tr>
<td>Glogzech</td>
<td>£3.4.6</td>
</tr>
<tr>
<td>Logglass</td>
<td>£3.2.4</td>
</tr>
<tr>
<td>Shorgoch</td>
<td>£6.5.0</td>
</tr>
</tbody>
</table>

The resistance of the rock may be

* at 25 francs to the pound wired. 25.57 to a pound in blasts.
They consume 100 to 120 tons yearly of coal brought from Ruabow.
compared with that of other mines by bringing together the price per fathom and the wages and mean of costs of the miner hereafter given.

Water is not abundant in the works; but there is a sufficient surface supply for the dressing of the ore, and numerous falls have been made and utilised by bucket wheels. (overhead). The motive power is entirely hydraulic, an almost vital condition in a locality where coal costs 25 shillings per ton.*

A long conduit, ending above the outcrop of the lode at Logylas served two water wheels, one 30 ft diameter and 4 feet wide for pumping and the other 40 ft diameter and 4 feet wide for winding the stuff. These have merely to lift the water and stuff to the adit level. After leaving these wheels the water rushes down the hill side and at about 110 yards lower arrives at the Level Saint dressing floors.

At Strongowle to guard against want of water recourse has been had to vast reservoirs; the principal wheel is used for pumping; it is not less than 55 feet diameter and 4 ft. 6 ins wide and is estimated at 60 horse power.

Persons employed. The agents or captains are 5 Cornishmen; this is enough.
distributed;

<table>
<thead>
<tr>
<th>Item</th>
<th>Number of Men</th>
<th>Wages earned in 1859</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sutwork</td>
<td>222</td>
<td>£144 1s. 6d. 1f.</td>
</tr>
<tr>
<td>Tribute</td>
<td>102</td>
<td>3s. 8d. 16. 9f.</td>
</tr>
<tr>
<td>Totals</td>
<td>324</td>
<td>119s. 4d. 2f.</td>
</tr>
</tbody>
</table>

The following are the average monthly earnings of the workmen according to the wage books and the cost of materials debited to them,

<table>
<thead>
<tr>
<th></th>
<th>Average per month per man</th>
</tr>
</thead>
<tbody>
<tr>
<td>at Sutwork</td>
<td></td>
</tr>
<tr>
<td>at Tribute</td>
<td></td>
</tr>
<tr>
<td>Earnings</td>
<td>£2. 12. 3f.</td>
</tr>
<tr>
<td>Materials</td>
<td>£3. 3. 4f.</td>
</tr>
</tbody>
</table>

The difference between the earnings of the sutworkman and the tributo is not abnormal, since the tributo is likely to display more thought and intelligence; the costs of materials however require some explanation.

The costs are more than the real expense, in fact the company furnishes the workmen with powder, fuse, candles, tools, etc., at a known tariff, but fictitious as to the real value of these materials, and high enough to form a strong incentive to economy on the part of the workmen. Besides this at

 terrorists the tributo pays the cost of drawing the stuff from the mouth to the dressing floor.
and the costs of dressing which are fixed at 15s. 0d. per ton of merchantable ore placed to his credit.

The dressing floors of Bronococh and Level Saw each employ 40 to 60 hands: there are few men, a certain number of lad and young girls, and a large proportion of young women. The men are paid by the mouth according to their strength as surface labourers; the lads and females by the day.

The daily wage varies from 10d. to 11d. and averages 9d. If we assume 26 working days per month these prices give as limits £1. 35. 10d. and as an average £1. 32. 2d. per month.

In 1859 the cost of labour on the two floors was £1669. 18. 4d. or say about 4d. 55 per cent of the total expenses of working. There were 20,125 tons of stuff received at the floors and they delivered for sale, 14,114 tons of galena and 110 tons of blende.

These figures suffice to show the importance of the dressing arrangements at the limestone mines.

On the whole the company commands excellent aids to successful working, water power, and good workmen who are content with...
Chapter 2.
Methods of preparation. Systems of Treatment.

1. Level Fawr Dressingfloors.

This second chapter will be purely descriptive. We shall study successively the dressingfloors at Level Fawr and Gronoeh, and for each we shall give:

- A summary sketch of the various steps of the operations, and of the purposes of the apparatus employed.
- A description of the establishment in detail; the form of an explanation of the sketches Figs 1 and 2, Plate 1;
- A detailed examination of the operations;
- Tables of the methods of Treatment.

A Sketch of the Operations. At Level Fawr the circumstances favourable to the work are, the already high richness of the stuff as drawn, (20 to 22 per cent), the somewhat muddy
The somewhat hard shale in the Llanslas lode gives little mud; the quartzy shale and quartz of Stronowr produces still less. In this respect the ore stuff drawn at Llanslas is analogous to that of Wheal Treawny a silver-lead mine in Cornwall; at opposite types I may cite Carzoll, a rather wet mine in clay shale in the district of Newlyn in the same county, and in France, the softer parts of the lodes at Pontfleau near Rennes.
nature of the gangue*, a plentiful supply of water, and a considerable and well regulated slope of the ground on which the floors are situated. We might add the proximity of the River Ystwyth, which receives and carries away the refuse.

As special difficulties may be noticed the dissemination of the galena in the gangue, the necessity of preparing the ore for sale of as great richness as possible, and the introduction of the tributing system, which compels the separate preparation of the lots sent out by the several gangs of men.

The floor is divided into two unequal parts by the road leading to Aberystwith; the higher contains the crushing rollers and jiggers, and yields alone nearly 84 per cent of the saleable ore; the lower one receives only the finer and crushed products of all the washed ore which issues from it belongs to the company without royalty to the tributors. A third floor, called the halbert-floor, treats the slimes from the preceding. The preparation is here done by a special staff of tributors who receive a fixed price of £3.15.0 per ton of ore enriched to about 65 per cent of lead.

The sketch does not extend to thi
floor which lies to the west between the road and the river; besides, the produce is not more than 1 percent of the whole ores sold.

The whole process comprises three divisions:

1. Operations before crushing, comprising:
   - the cleaning of the ore stuff,
   - the classification according to size, which separates the small ore from the blocks and lump fragments,
   - the bucking and sorting of the blocks, and handpicking the fragments, whence results refuse and good crushing stuff, and lastly the preparation of the small ore.

2. Treatment of the crushed ores: There are two pairs of rollers; the large rollers crush the sorted stuff rather coarse; the small rollers crush it finer, and receive the secondary products of preparation, whether small ore, or coarsely crushed stuff, or lastly the stuff requiring to be finely crushed.

3. Treatment of the finely crushed stuff and the slimes from the whole floors; the stamps are fed with the small and poor secondary matters (products from the work, the small ore, and the crushings), they yield sands and slimes; the sand is washed separately whilst the slimes flow into settling tanks with
all those from above; the settling are treated in
the lower dressing floor.

Notes on the Apparatus.