THE LEA LEAD SMELTER IN 1936

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Abstract: A contemporary description of lead smelting practice at the mill just before closure in 1936, together with photographs. It includes comment on prevention of lead poisoning amongst the men.

The Millclose Mine Company's smelting plant is situated at Lea at a distance of seven miles from the mine. Transport of concentrate from the mine is done by contractors using light motor lorries of the Morris Commercial or Bedford class, each load averaging about 3 tons.

This smelting plant is more than 60 years old and will soon be replaced by the modern smelter which is now being erected adjacent to the mine. The new plant embodies the latest type of Newnham hearth with mechanical ram stokers and 16 tuyeres per hearth, as compared with the hand-stoked Scotch Hearths with only one tuyere.

An analysis of the concentrate from the mine gives 82% Pb. as compared with 86.6% in chemically pure galena. The plant consists esentially of hearths, condensers and scrubbing towers followed by a considerable length of flue to settle the dust before the gases emerge into the atmosphere.

There are five Scotch Hearths and one Newnam Hearth*, the latter having been installed as a forerunner to the new smelter for the purpose of experimenting to discover the optimum charge and conditions for this type.

The Scotch Hearth is very suitable for rich ores such as that treated here, since it gives a quick flow of lead with a small fuel consumption. Poor ores have to be treated in a blast furnace.

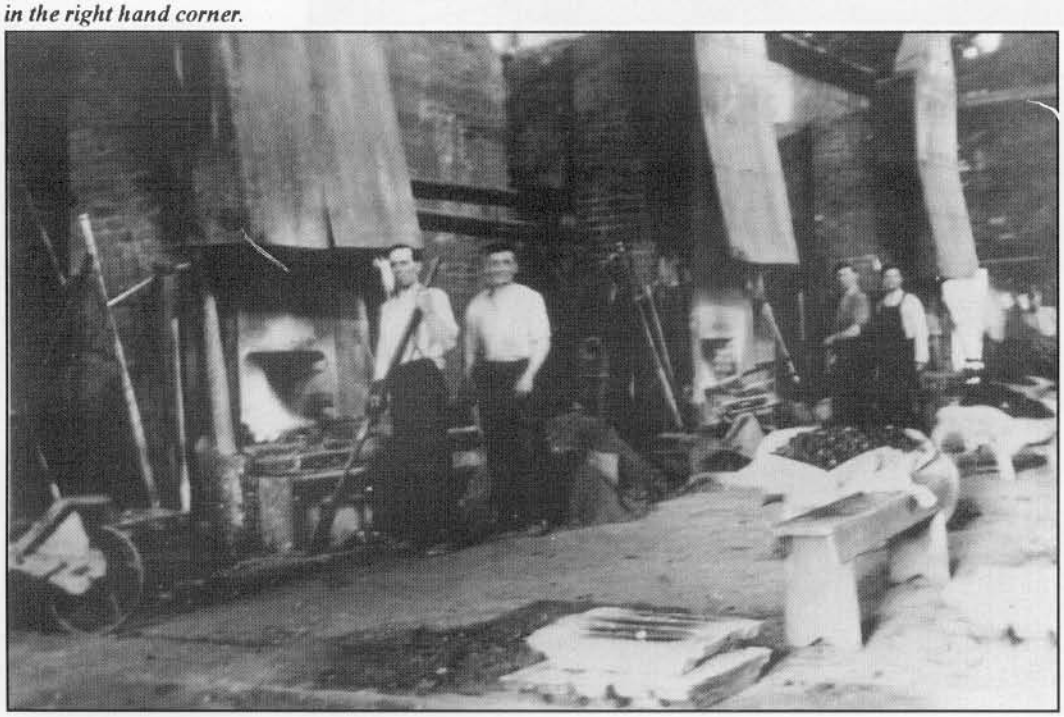
The flow of lead depends to a very great extent on the skill of the stokers. This is not a desirable state of affairs, hence the management are making careful studies to determine the best method of applying the charge so that all men may work on the same principles, and so raise the efficiency of the plant.

The 9 x 20 x 24 inches well of the hearth serves as a reservoir for the molten metal, on the surface of which floats the burning charge. The tuyere for the blast is 3 inches above the surface of the metal and therefore in the base of the charge. A normal charge is 48 cwts. of galena with 17 % of burnt soot, ie. 55 cwts. of charge per hearth per shift. Lead overflows from the hearth into a reservoir under which is kept a fire to maintain the metal in the molten state. At intervals, the metal is ladled out into moulds wherein are cast 1 cwt. pigs of lead.

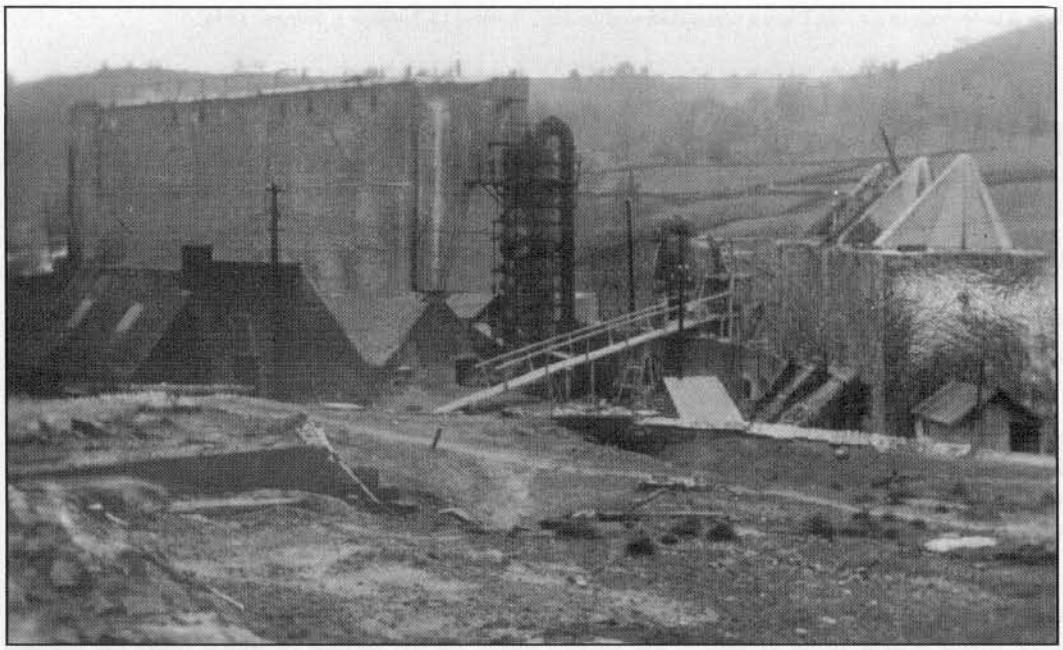
The iron "stones" of the hearths have hollow watercooled sides through which is is circulated a total of 300-400 gallons water per hour. Air for the blast is supplied by a Keith James Blackman fan giving 7 inches water gauge at the tuyeres.

Fuel - coal containing low quantities of alkali and iron, is added in the proportion of 8% of the charge. This figure is 4.4 cwts. per 55 cwts. of charge. At the rate of three shifts per day and seven days per week, the fuel amounts to 23 tons for 250 tons of concentrate. Coke breeze is being tried but difficulty is experienced in the blowing out of the fine fuel by the blast.

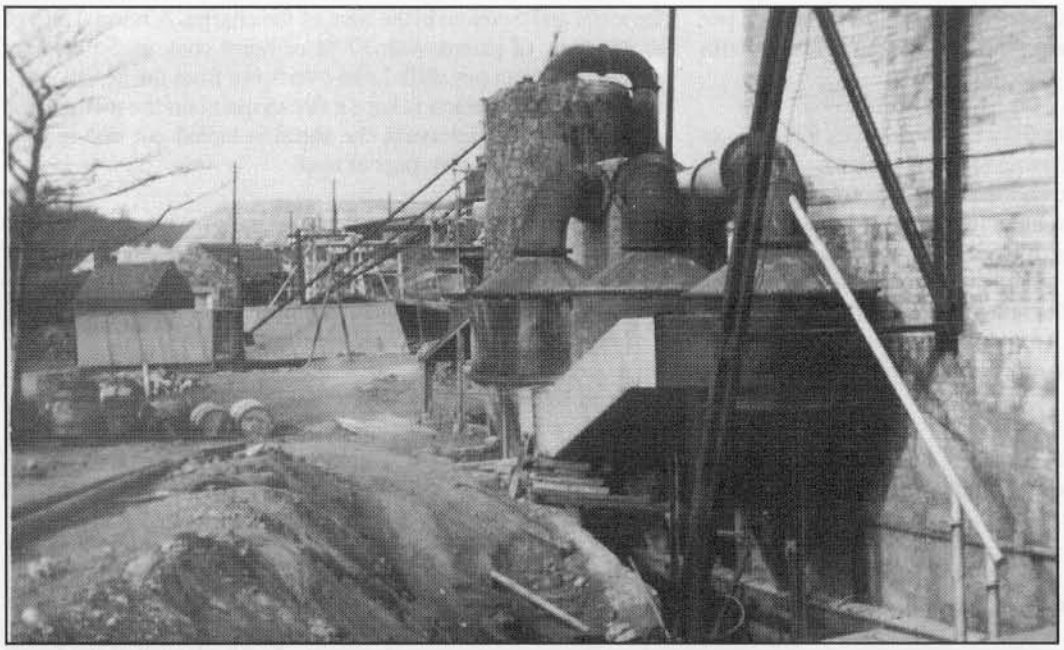
Three of the Scotch hearths at Lea Lead Works, each with a smelter and his labourer. Pig moulds are just visible in the right hand corner.



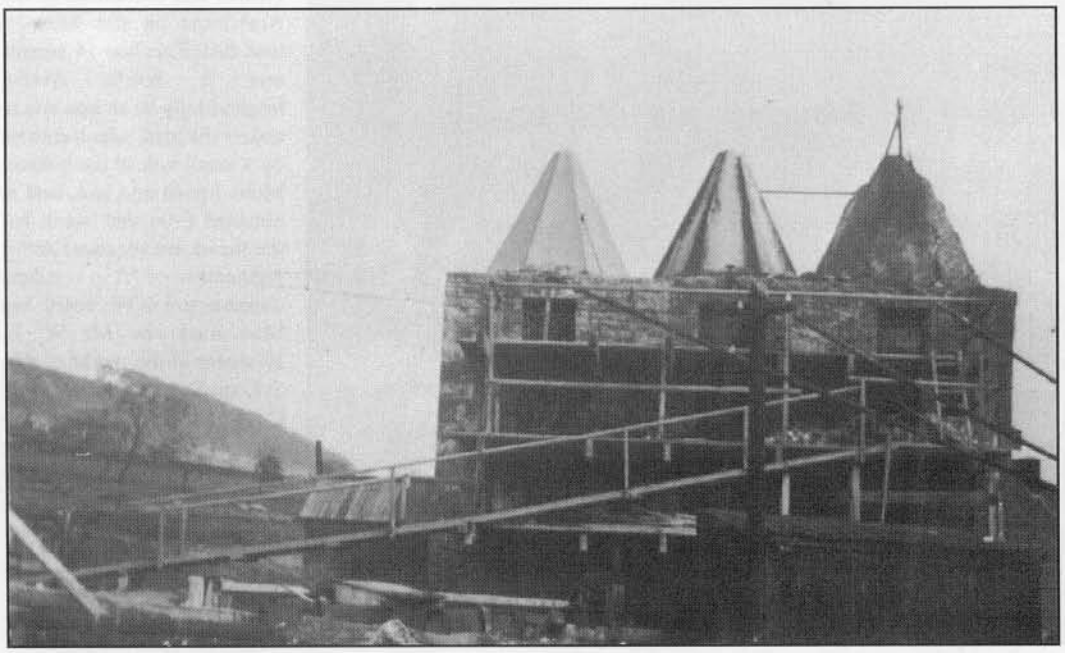
* An adaption of the Scotch Hearth was introduced by the Americans on the Missouri lead belt. This had 14 tuyeres and a hearth divided longitudinally by an iron box to collect the lead, which entered by a small hole at the bottom. More fumes and less lead is obtained from this hearth but the fumes are very suitable for pigments. "A radical improvement in this hearth has been made by Mr W. E. Newnam at the works of the St Louis Smeltingand Refining Co, at Collinsville, Illinois, in which mechanical rabbling replaces that formerly done by hand". (vide *Eng and Min Journal* October 1915. Abstract of paper by W.E. Newnam, *Bulletin A.I.M..E.*)



The large condenser (left) 90 by 30 feet by 50 feet high. Gases pass from the tower to three cyclones and then to four scrubbing towers - three together and a fourth just visible between the three and the steel tower. The steel tower was disused.



A blower for pumping flue gases at the side of the large condenser.

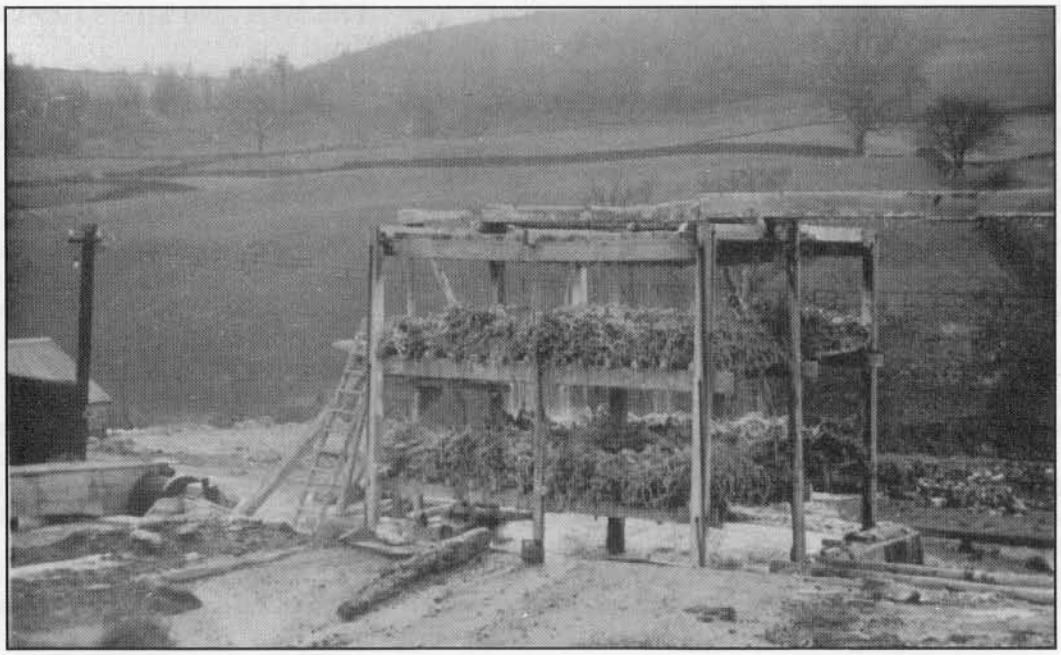


The group of three scrubbing towers. Water was pumped in at the top with the flue gases, absorbing sulphur dioxide. The towers were filled with ceramic pipes to give a large surface area.

The mixing tanks where the acid-water and lime- water reacted to produce calcium sulphate.

Settling ponds for the calcium sulphate slurry which was then pumped to a waste heap.

The faggot cooler for the purified water from the slime ponds, before it was returned to the system.



In the hearth a temperature of 1000°C is reached; this is just sufficient to melt the lead without causing too great a loss by volatilisation. The flue gases pass into a large main flue in which is deposited the heaviest of the soot.

From the main flues the gases pass into a large condensing tower shown to the left background of this photograph. In horizontal dimensions this tower is 90 x 30 feet, and in height 50 feet.

Within the condenser the gases take a very circuitous path and thereby are made to deposit most of their suspended soot. At intervals of a few months this soot is removed from the bottom of the condenser; it is then burnt to a stringy mass and resmelted with the charge. Chemically, the soot consists of PbO, PbS, and $PbSO_4$, with very little other impurity save perhaps a little zinc.

From the condenser the passage of the gases is to three Cyclone Dust Extractors and thence via a fan to four scrubbing towers. Dust is burnt and resmelted. Blackstone Slurry Pumpsare used for circulating the 8000 gallons of water per hour. These pumps are fitted with special bronze impellers which stand-up extremely well to the corrosive action of the SO_2.

The first tower is alone but the other three are built into a single bxick structure as shown in the photograph. The gases enter with the water spray at the top of the towers and descend through a packing of short lengths of 4 x 3 inches sanitary pipe. The towers and pumps are in series.

A fan exhausts from the base of the fourth tower and passes the gases into 670 yards of 6 x 3 feet section flue. Cleaning of this flue is undertaken once every ten years. Hence the flue gases eventually reach the atmosphere via the chimney.

The Factory Act limits the amount of SO_2 in chimneys to 6 grains per cubic foot of flue gas. The figure maintained here never exceeds 4 grains. On leaving the last tower the scrubbing water is well saturated with sulphur dioxide. In the past this wasallowed to flow into the river, rather to the detriment of the fish; but of recent years complaints have been made by local farmers and landowners of damage to property and crops. The reply to these is the neutralizing plant where the same water isagain made servicable for the extraction of sulphur dioxide. The acidulated water is now pumped to a lime mixer (a Chilian mill) wherein is ground I.C.I. (Buxton) lime. Fifty tons of lime are used every week, the proportion of lime to water being 0.085 lbs. per gallon of water. The lime is well ground and stirred until the emulsion is fine enough to escape through the mesh, and to pour into two long mixing troughs in series. The photographs show these troughs, the latter giving a close-up view of the paddles by means of which the liquid is stirred. The reaction between the gases and lime water is simple:

$$Ca(OH)_2 + SO_3 = CaSO_4 + H_2O.$$

The calcium sulphate settles in the settling ponds and is thence pumped as a slurry to the waste slime-heap (this is a truncated-conical structure found at the north east end of the site today).

From the settling ponds the.now purified water gravitates to, and over, a faggot cooler (made of sticks or blocks of wood in a frame) and thence to the reservoir for the first Blackstone pump.

Lead recovery is as follows:- 79 % of the Pb content of the concentrate is run off and cast into pigs, 3 to 4% goes into the slag, the remaining 17% passes off with the flue gas. 35 pigs, 35 cwts., of lead are cast per hearth per shift making a total of 184 tons of lead per week. Almost the whole of this quantity is sold to the Derby Cables Company.

The 3 to 4% of Pb remaining in the slag causes this to be of value. It analyses 40% Pb and is resmelted elsewhere in a blast furnace. A ready market is found for the soot in the main 18 x 5 feet flue, the whole of it being sold to a paint manufacturing works at Matlock.

There is no market for the calcium sulphate since it contains dirt and impurities and there are large natural reserves of it, occuring as gypsum and anhydrite, in England.

THE LABORATORY

The most important duty of the laboratory staff is to check and report on the SO_2 content of the flue gas. This is estimated and recorded in terms of grains of SO_3 per cubic foot of gas. A solution of 100 ccs. of water with 20 ccs. of hydrogen peroxide and a dash of methyl orange is put into a bellows; the nozzle is attached to a pipe passing into the chimney stack and four bellows full of gas are brought into contact with the solution. At each filling of the bellows the gas and solution are well shaken together to extract the SO_2 . At each filling of the bellowsthe gas and solution are well shaken together to extract the .

After this operation the solution is taken to the laboratory and titrated against standard sodium carbonate. Four bellows full equals one eighth of a cubic foot, hence SO_2 per cubic foot is soon evaluated and converted to terms of SO_3

Other estimations conducted in the Laboratory include the analysis of slags, this is being carefully studied to determine the effect of adding small quantities of lime to the charge. Fuels are checked for silica and iron content, the latter to have a maximum value of 16 % FeO in the fuel.

Wet lead assays are conducted on the concentrates, the galena being dissolved in H_2SO_4 and titrated against ammonium molybdate witb tannic acid indicator. Soot assays enable the hearth temperature to be adjusted so as to volatilize as little Pb as possible without falling below the fusion point of the metal.

The amount of zinc in soot is determined by wet assay with potassium ferrocyanide and uranium acetate indicator.

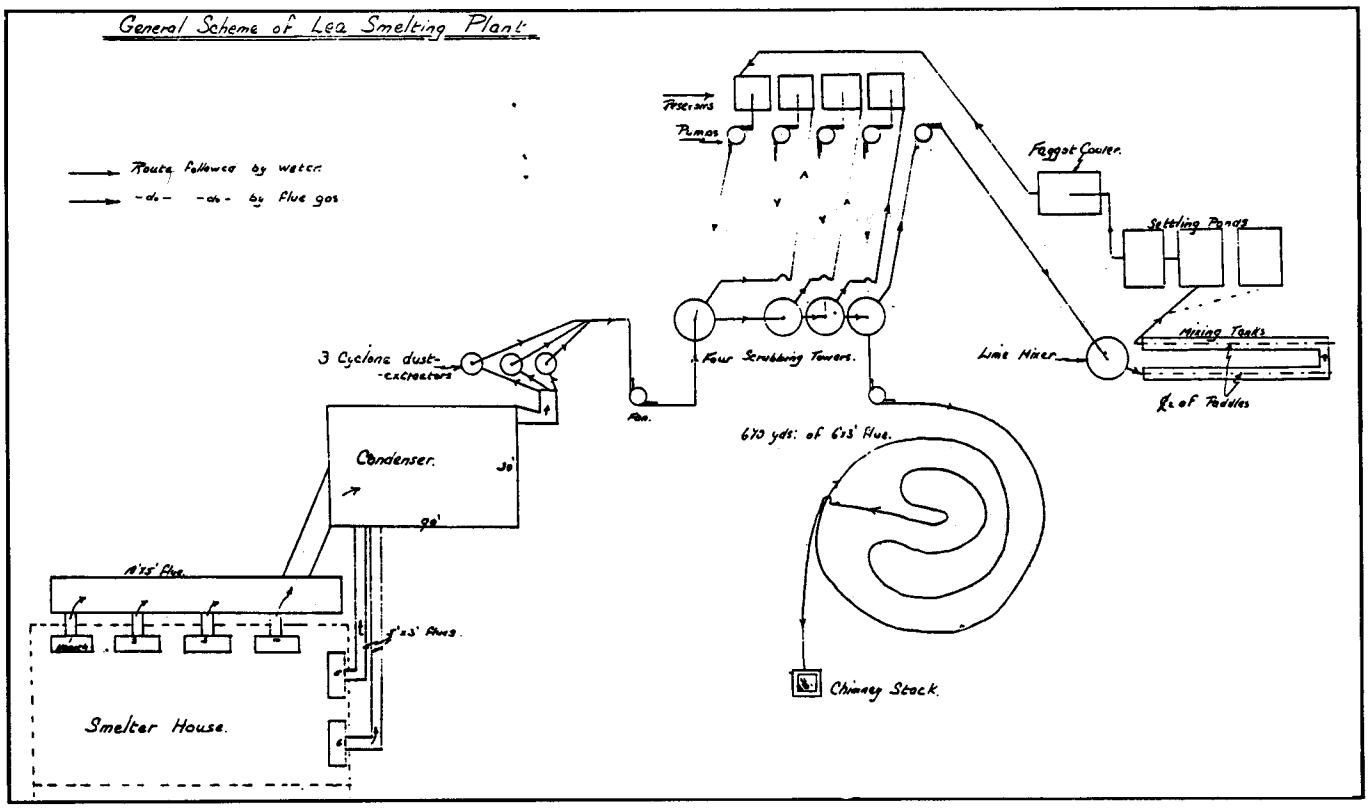
THE MEN AND THEIR HEALTH

The employees, totalling 65 men, are divided into four shifts. Working three eight-hour shifts per day on the plant it is possible for each of the men to have a twenty four hour rest between the end of one and the beginning of his next shift.

Medical examinations are frequently carried out on the men so that any cases of poisoning can be detected in the early stages. For cleaning out the flues, " sooting " as it is termed, respirators are worn. Similarily, for shovelling the concentrate into barrows whereby it is taken to the hearths, the men are supplied with masks.

The concentrate as it arrives from the mine iscomparatively harmless, very few cases of lead poisoning occur amongst the miners; but the soot is extremely injurious, especially as lead salts are not easily expelled from the system.

Milk, a good antidote against lead poisoning, is provided for the workers, the drinking of water is discouraged since it opens the



General layout of the Lea Lead Works plant in 1935.

pores and invites chills to those working in the heat of the hearths. Smoking is strictly forbidden since soot would most undoubtedly be passed into the mouth by the fingering of the cigarette. Lastly, it has been found by experience that an excess of alcohol weakens the resistance to poisoning and increases the retaining powers of lead in the system .

Regular habits, Epsom salts (magnesium sulphate - a then commonly used pugative) and plenty of exercise and fresh air are the best safeguards against trouble.

One extra point is worthy of note however, and it is this; there is a very noticeable difference between,the effect of this work on different men. Some, in spite of very careful precautions and an otherwise healthy constitution, fall early victims to poisoning, while others, even some careless in their habits, work for years without the slightest ill effect. By means of the frequent medical examination it is possible to separate these two classes of constitutions and recommend the unsuitable for work on other parts of the plant.

ACKNOWLEDGEMENTS

I am grateful for the facilities given to me by the former Millclose Mines in 1935 to examine the facilities at Lea. This report is part of an undergraduate dissertation produced whilst I was an undergraduate at the Royal School of Mines. The full dissertation on the Millclose Mines is now available at the Derbyshire Record Office (DRO.D4383/2) and I am pleased to thank them for their help in its preservation and facilitating its use here and for the permission of Derbyshire County Council to reproduce both written material and photographs from it.

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