taining a large amount of the oxides of iron, and also organic matter, which, by their mutual re-action, gave rise to a solution of bicarbonate of iron—that this solution percolated through the limestone, and, removing a large part of the carbonate of lime by solution, left in its place carbonate of iron; and not that the rock was formed as a simple deposit at the bottom of the sea.

ON THE PURIFICATION OF LEAD BY CRYSTALLIZATION. BY WILLIAM BAKER, ESQ., OF SHEFFIELD.

The following Paper is to shew chiefly that copper may be separated from lead by the process of crystallization introduced in 1833, by Hugh Lee Pattinson, for the purpose of desilverizing lead, which process is now very generally employed in England and on the continent.

Pattinson was led to this discovery by the accidental upsetting of a pot containing argentiferous lead, which had cooled down nearly to the point of solidification. Observing a portion more fluid than the rest; he found upon assaying both, that it contained the larger proportion of silver.

The principles of the process are these:—When lead containing a certain amount of silver is melted and then allowed to cool slowly, whilst it is constantly stirred, a crystallization of pure lead obtains at a temperature at which an alloy of silver and lead still remains fluid. The crystals of lead which sink towards the bottom of the vessel may be removed by means of a perforated ladle, leaving the rich lead, (that is lead containing an alloy of silver and lead,) to be further treated in a similar manner until the silver is concentrated sufficiently to be recovered by the old method of cupellation.

Formerly, lead containing less than 20 oz. of silver per ton would hardly bear the cost of extraction. By Pattinson's process, with a sufficiently extensive battery of pots, lead containing only 2½ to 3 oz. per ton, may be worked with
advantage, as the metal, during the process, becomes softer and finer in quality from the removal of other foreign matters.

As an example of the purification of lead by this method, the following is a description of the results of some experiments made with a battery of four pots. The pots contained about six tons of lead. The metal employed being at the commencement, of very fair quality, as the accompanying analysis will shew:

<table>
<thead>
<tr>
<th>No. 1</th>
<th>No. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>000.0066</td>
</tr>
<tr>
<td>Iron</td>
<td>000.0065</td>
</tr>
<tr>
<td>Silver</td>
<td>000.0046</td>
</tr>
<tr>
<td>Sulphur</td>
<td>Trace</td>
</tr>
</tbody>
</table>

The iron pots are set in brickwork, and rest upon a broad rim, the fire playing freely round the hemisphere. Dampers are provided to regulate the temperature, upon which the success of the process much depends. The lead is melted as rapidly as convenient, the temperature being far below red heat. Constant stirring facilitates the separation of impurities which rise to the surface, and are removed by skimming with the portion of oxidised lead. The impurities thus removed, will be the easily oxidisable metals when present, as iron, antimony, arsenic, together with sulphide of lead. After skimming, the fires are raked out and the lead allowed to cool. It is kept constantly stirred, and any portions which solidify round the edge of the pan are sliced off with the iron tool used in stirring, and thrust into the fluid metal. In about an hour-and-a-half or two hours time, small crystals of lead are formed, presenting a granular appearance in the melted mass. These are removed to the adjoining pot by means of a perforated ladle. The temperature then is carefully preserved at the same point until a sufficient fraction has been taken out; the bottoms, or enriched portion, is ladled into another pan.
We may assume that it is only the pure lead which possesses this tendency to crystallize, and that the silver or copper found in every sample of the crystals is really only contained in the fluid alloy, entangled, so to speak, amongst the crystals. This will be readily granted on consideration of the imperfect separation of the solid and fluid particles obtained by simple draining in a perforated ladle.

Pursuing the operation in this manner, we obtain on the one hand, crystals increasing in purity and freedom from foreign metals; on the other, lead increasing in richness of silver and (as will be shewn,) of copper.

The fracture and other physical qualities of such kinds of lead present marked differences. As the crystals are purer, they are darker in appearance; those from the rich pot being sometimes of a silvery whiteness.

Annexed is a tabular view of a series of analysis which will at once shew that a similar law regulates the separation of copper as of silver from lead; that is to say:—there is an alloy of copper and lead which remains fluid at a temperature at which crystals of pure lead are formed. Iron, it will be seen, cannot be removed by this method, but is chiefly separated by oxidation, and subsequent skimming the surface of melted metal:

<table>
<thead>
<tr>
<th>In 100 Parts.</th>
<th>Silver</th>
<th>Copper</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rich Pot.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Before Crystallizing</td>
<td>.0108</td>
<td>.0344</td>
<td>.0312</td>
</tr>
<tr>
<td>2 Crystals—25 parts</td>
<td>.0052</td>
<td>.0152</td>
<td>.0086</td>
</tr>
<tr>
<td>3 Fluid Lead—85 parts</td>
<td>.0140</td>
<td>.0476</td>
<td>.0122</td>
</tr>
<tr>
<td><strong>Second Pot.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Before Crystallizing</td>
<td>.0052</td>
<td>.0154</td>
<td>.0068</td>
</tr>
<tr>
<td>5 Crystals—95 parts</td>
<td>.0020</td>
<td>.0066</td>
<td>.0118</td>
</tr>
<tr>
<td>6 Fluid Lead—25 parts</td>
<td>.0128</td>
<td>.0286</td>
<td>.0140</td>
</tr>
<tr>
<td><strong>Third Pot.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Before Crystallizing</td>
<td>.0020</td>
<td>.0103</td>
<td>.0118</td>
</tr>
<tr>
<td>8 Crystals—70 parts</td>
<td>.0010</td>
<td>.0038</td>
<td>.0188</td>
</tr>
<tr>
<td>9 Fluid Lead—25 parts</td>
<td>.0100</td>
<td>.0240</td>
<td>.0082</td>
</tr>
<tr>
<td><strong>Fourth Pot.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 Refined Lead</td>
<td>.0014</td>
<td>.0054</td>
<td>.0112</td>
</tr>
</tbody>
</table>
By the first crystallization, from .0108 per cent. 3 oz. 10 dwts. 13 grs. per ton Silver, is reduced to .0052 per cent. 1 oz. 13 dwts. 23 grs. per ton in the crystals; and concentrated to .0140 per cent. 4 oz. 11 dwts. 11 grs. per ton in the fluid lead, left in the pot.

Copper, from 11 oz. 4 dwts. 16 grs. per ton, is reduced to 4 oz. 19 dwts. 7 grs. in, the crystals, and concentrated to 15 oz. 10 dwts. 23 grs. in the fluid lead.

In the second crystallization, the separation is still more apparent, as a larger proportion of crystals are removed than in the first. Ultimately, the Silver is reduced to only 9 dwts. 3 grs. per ton; Copper, 1 oz. 15 dwts. 6 grs. per ton in the refined lead.

It will be seen that the amount of foreign metals in the crystals should correspond to that in the metal of the next pot before crystallizing, and in most cases it is identical in others sufficiently near to prove the truth of the analysis.

Although iron appears in the first crystallization to be removed in a similar manner, yet, upon repeating the operation, it does not diminish in quantity in the crystals, nor become concentrated in the fluid lead, but rather the minimum seems to be in the samples of lead taken before crystallization, that is immediately after skimming. Contact with the iron vessels and ladles then supplies the increased per centage in the crystals.

It is probable that this method of purification succeeds best when the amount of impurities is not very considerable. For, in the instance of lead containing a large proportion of copper, when it is submitted to a regulated temperature just sufficient to melt the more fusible metal; it liquates, leaving a skeleton of copper. Upon this, a process is founded, called the liquation process, totally different from that described in this paper.

Thus, by melting at a regulated temperature, by skimming, and by crystallization, a lead may be obtained practically pure.