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Lixiviation of a silver ore by the Russell process

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THESIS

--FOR THE--

Degree of Bachelor of Science

--IN--

MINING ENGINEERING.

SUBJECT:

"Lixiviation of a Silver Ore by the
Russell Process."

J. L. PICKLES. E. A. MORTLAND.

MAY 1902.

LIXIVATION OF A SILVER ORE BY THE RUSSELL PROCESS.

The purpose of this investigation was to determine by a series of experiments, the action of the Russell solution on a particular ore; and to determine the best size to crush to, the strength of the solution to use, the temperature most suited, and the length of time for best extraction, and finally to come to a conclusion whether or not the ore was suited to this Process.

In an investigation of this nature the first thing to do, and a thing of the utmost importance, is to find a quick and accurate method for determining the result of each test.

In this work any one of the numerous methods for the determination of silver might have been used, but the one most suited to the purpose, and the quickest, was the one wanted.

The methods tried in this case were as follows:

The Ammonium Thiocyanate method.

In this method the silver in a nitric acid solution is titrated with the Ammonium Thiocyanate, using Ferric alum as an indicator.

This method works well for silver bullion but it was found that it could not be relied upon to give accurate results on the small amounts of silver extracted from the ore used. The end reaction in every case came too soon on account of the action of foreign substances in the solution, the removal of which involved a long and tedious separation, in the process of which a small amount of silver was almost certain to be lost.

This process was given up after a thorough trial.

The Iodide method of determining silver was next tried. In this method the silver is titrated in a neutral solution, using starch paste as an indicator. This method was found to give very much more accurate results but a great amount of preliminary work had to be done before the silver could be gotten into the proper shape to titrate. The silver was first precipitated with sodium sulphide but this also precipitated the copper which was extracted and also the unused copper of the copper sulphate in the extra solution. This copper had to be separated from the silver, and to do this the silver was dissolved in nitric acid. The silver precipitated as a bromide with potassium bromide. The silver bromide redissolved in sodium thio sulphite, then reprecipitated with sodium sulphide and the precipitate dissolved in nitric acid again.

After this the solution had to be made exactly neutral before it could be titrated . After finding there was no way around this tedious operation the method was given up and the fire assay method adopted as the surest and most expedient way to determine the results.

This method also necessitated the separation of the copper as explained above and cupelling the silver bromide direct as it was left on the filter paper by wrapping this up in lead foil.

The determination of the strength of the $Na_2S_2O_3$ used, was accomplished by means of the Iodometric Method.

This method is based upon the reaction

$$2\ Na_2S_2O_3 + 2I = 2\ NaI + Na_2S_4O_6$$

and the property of free iodine to turn the starch past blue.

Hence if to hyposulphate solution, containing starch, iodine is added the blue color will appear as soon as the $Na_2S_2O_3$ is changed into tetrathionate ($Na_2S_4O_6$)

The iodine solution was made up by dissolving 5.121 grams chemically pure iodine in a liter of water containing about seven grams potassium iodide.

The solution was then standardized with chemically pure $Na_2S_2O_3$ which has been finely pulverized and dryed in a desicator.

The starch solution is prepared by dissolving one part of starch,which has been mixed to a paste, in one hundred cc of boiling water.

The solution is allowedtto settle and then filtered.

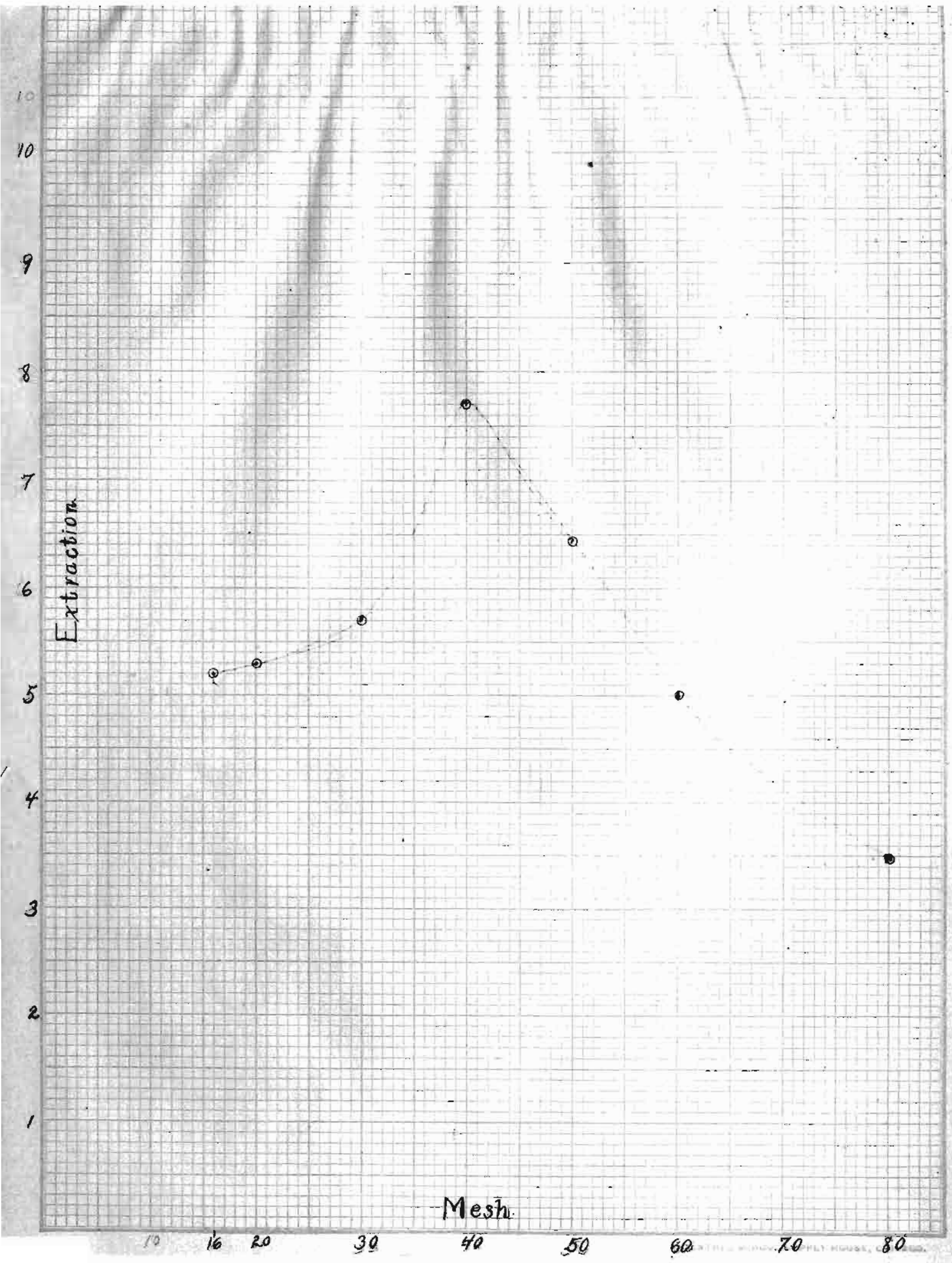
The $Na_2S_2O_3$used in the experiments was found to be one hundred percent pure

Making Up of Stock Solution.

The stock solutions were made at ratio of ten grams of $Na_2S_2O_3$ and of $CuSO_4$ respectively in one hundred cc. of water. This gave ten percent solutions and they could be diluted very easily to the one percent solution used,by diluting with water.

Apparatus.

No complicated apparatus was necessary in this investigation but simply the common things found in every laboratory,such as beakers holding about six hundred cc,beakers holding about one hundred cc.,pipetts,buretts,funnels,measuring cylinders,a long funnel stand,cupels and a cupelling furnace.

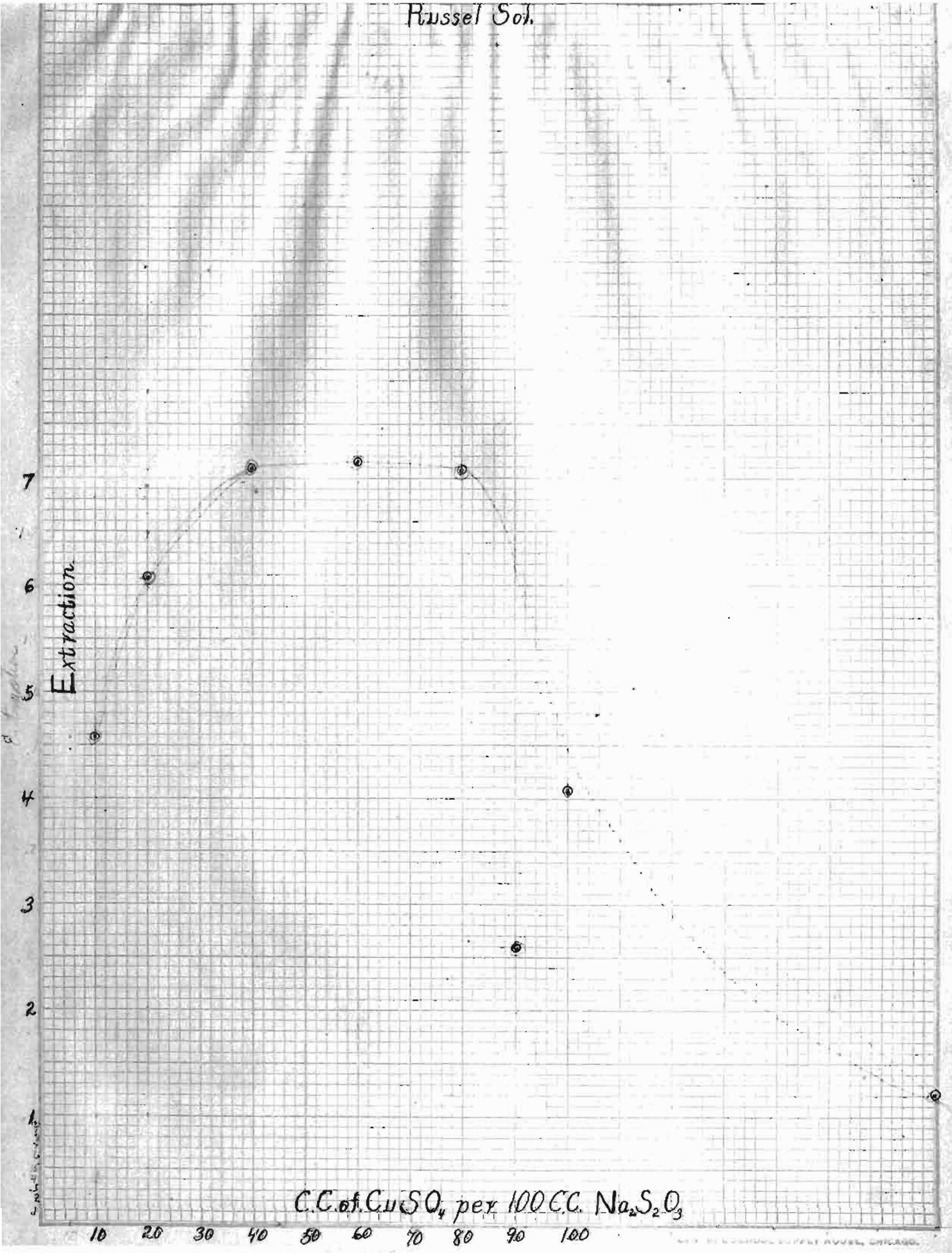

Extraction
10
10
9
8
7
6
5
4
3
2
1
Mesh
10
16
20
30
40
50
60
70
80

Operation

First Series of Experiments.

The first series of experiments were made to find the most advantageous size of ore to use. The ore was crushed and sized to various sizes as given in table below and two assay tons of each size weighed out, placed in a beaker containing two hundred cc. of one percent extra solution and allowed to stand twenty-four hours. The solution was then filtered off and the silver precipitated with a solution of sodium sulphide. The precipitate cupelled and results recorded. From the table below and from the curve plotted it is easily seen that the forty mesh ore gives the best extraction and accordingly all the ore was crushed to that size for the following series of experiments:

Table One.	Extraction.
Ore passing a 16 mesh sieve.	17.2%
" " " 20 " "	17.6"
" " " 30 " "	19.04%
" " " 40 " "	25.60"
" " " 50 " "	20.30"
" " " 60 " "	16.60"
" " " 80 " "	11.60"


Russel Sol.
Extraction
7
6
5
4
3
2
1
C.C. of CuSO4 per 100 C.C. Na2S2O3
10
20
30
40
50
60
70
80
90
100
% of Cu

Second Series of Experiments.

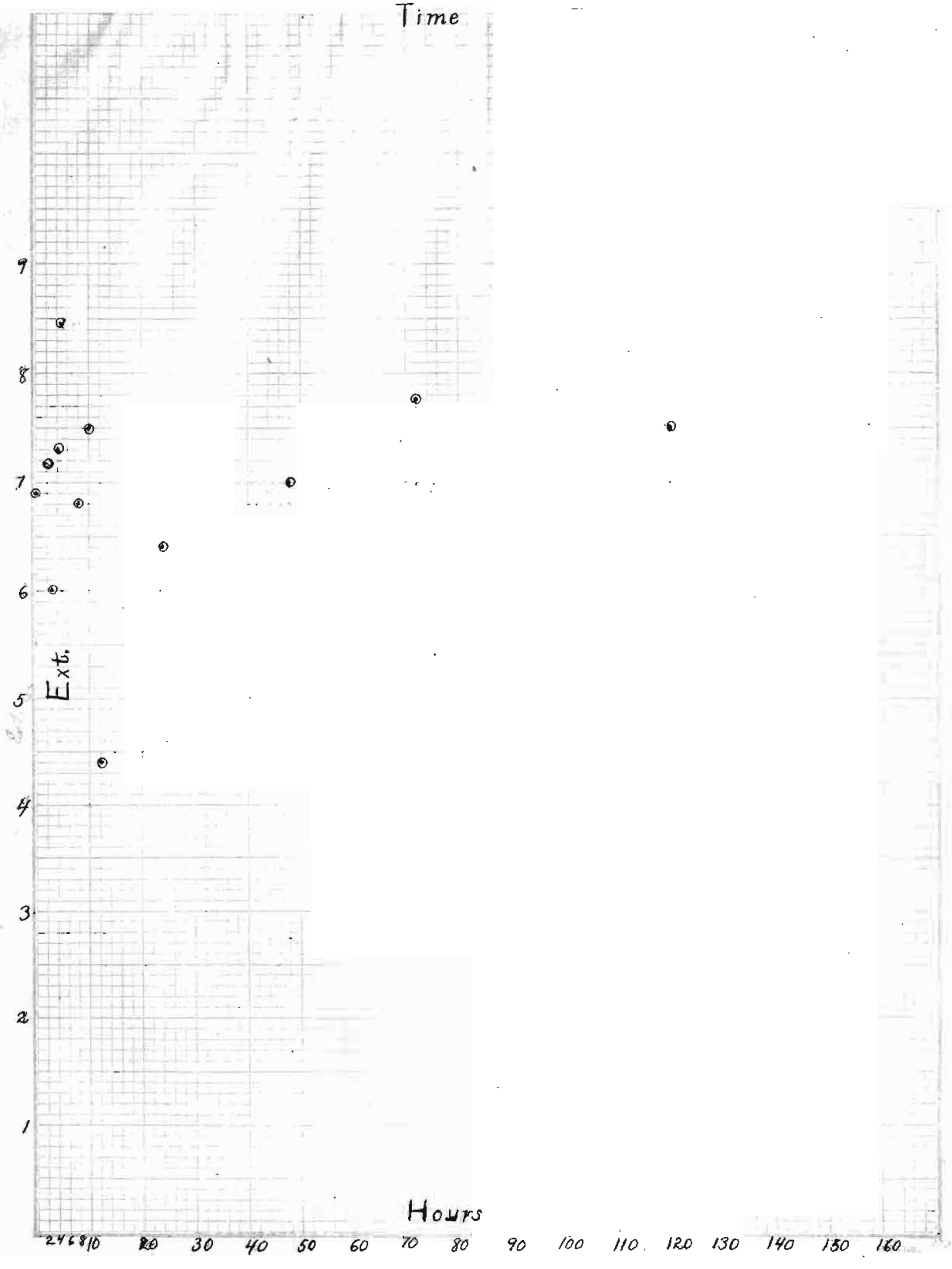
This set of experiments were made for the purpose of finding the proper proportion in which to mix the one percent $Na_2S_2O_3$ solution with the $CuSO_4$ solution.

Two assay tons of the 40 mesh ore was put in each beaker and ~~av~~varying amounts of the different solution added. After standing twenty-four hours the solution was filtered off, the silver precipitated and assayed.

Table No. 2, given below shows the proportions in which the solutions were mixed. From the table and the curve given it is found that an extra solution mixed in the proportion of one hundred cc. of $Na_2S_2O_3$ to sixty cc. of $CuSO_4$ solution give the best extractions and this solution was used in the following set of experiments with the forty mesh ore

Table No. 2.

One percent $Na_2S_2O_3$	:	one percent $CuSO_4$ Solution	Extraction.
100 cc	:	10 cc	15.2%
100 cc	:	20 cc	20.0"
100 cc	:	40 cc	23.4"
100 cc	:	60 cc	23.5"
100 cc	:	80 cc	23.3"
100 cc	:	90 cc	8.5"
100 cc	:	100 cc	1.3"
100 cc	:	200 cc	No extraction.


Time
Ext.
Hours
9
8
7
6
5
4
3
2
1
2 4 6 8 10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

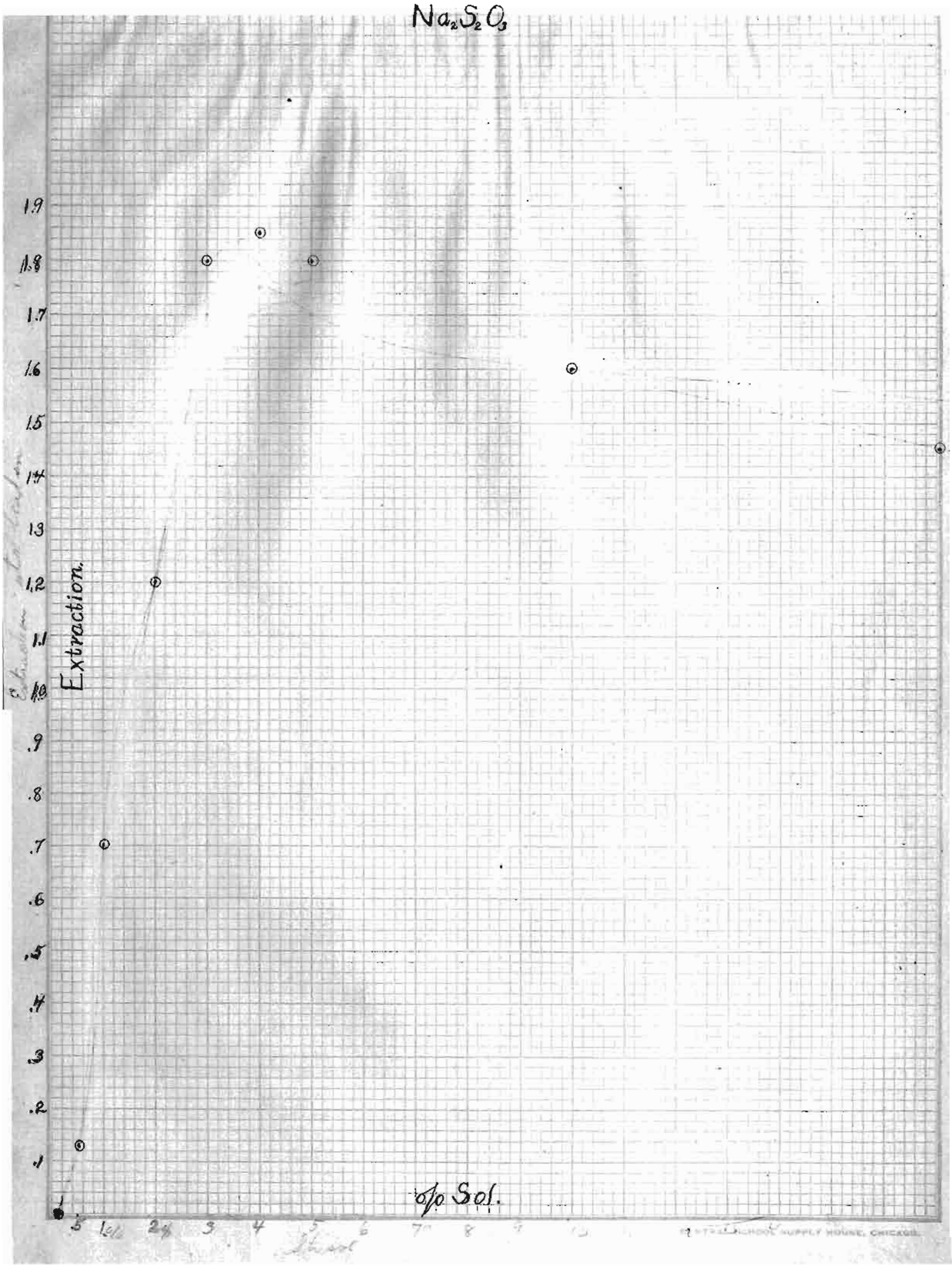
Third Series of Experiments.

This set of experiments were made for the purpose of determining the time required for the best extraction.

Two assay tons of ore was weighed out and two hundred cc. of the solution added and allowed to stand ,varying lengths of time as shown in table three. The conclusions derived ~~arrived at~~ from this set of experiments was,that no advantage was to be gained by allowing the solution to remain on the ore longer than five hours.

Table No. 3.

Time	Extraction.
Filtered right through	22.17 percent
1 hours	23.31 "
2 hours	23.80 "
3 "	19.90 "
4 "	24.30 "
5 "	29.00 "
8 "	22.64 "
10 "	24.98 "
12 "	14.65 "
24 "	21.31 "
2 days	22.88 "
3 "	23.80 "
5 "	24.98 "


$Na_2S_2O_3$
Extraction.
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
% Sol.
.5
1%
2%
3
4
5
6
7
8
9
10

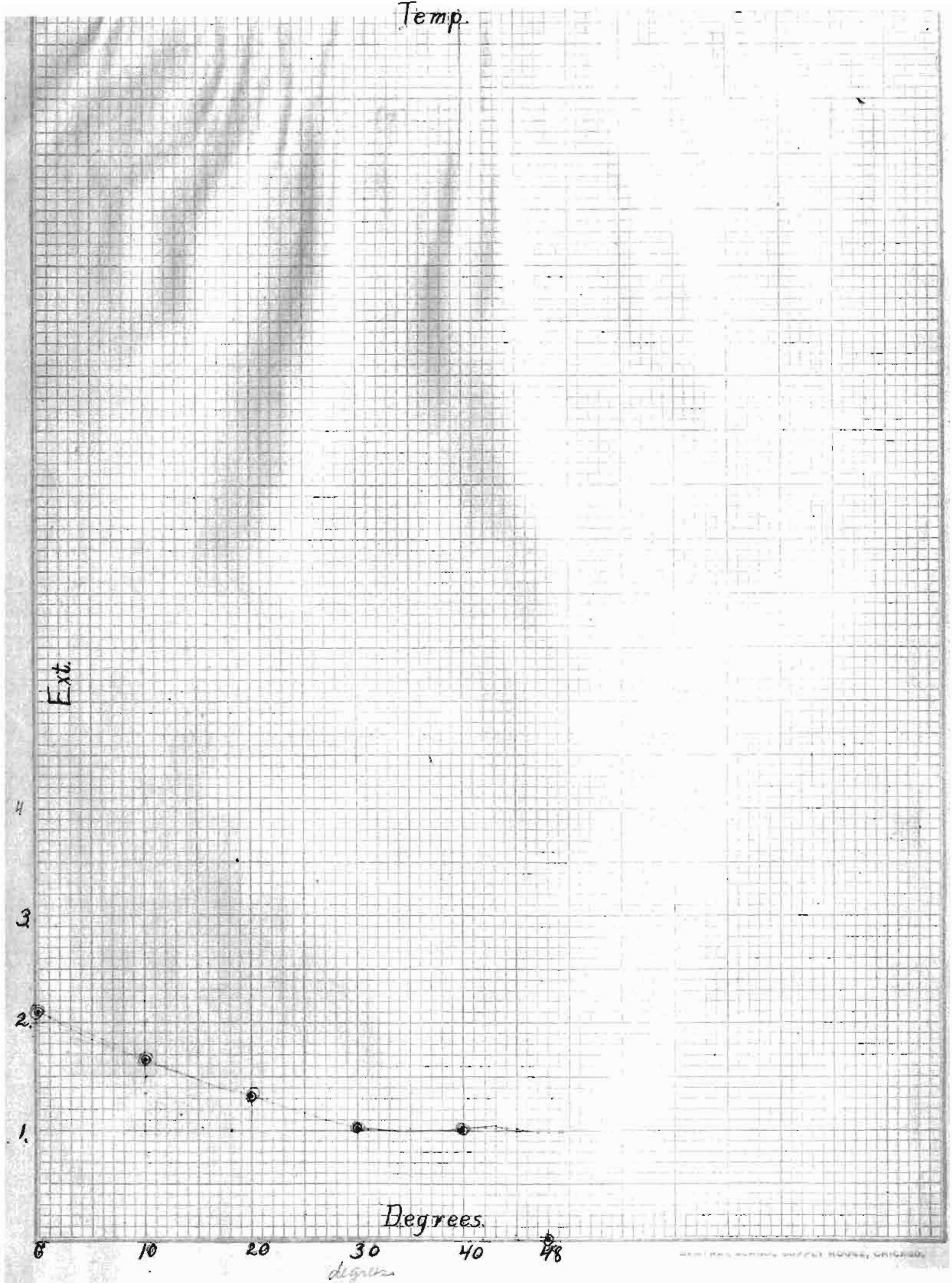
Fourth Series of Experiments.

This set of experiments were made to investigate the action of pure $Na_2S_2O_3$ solution of different strengths on the ore. Two hundred cc of the varying strengths of solution were placed on the ore, and allowed to stand twenty-four hours.

The strength of solution varied as shown in table four and the conclusions ~~arrived at~~ derived were that a four percent solution gave the best result.

Table No. 4.

Strength of Solution.	Extraction.
0.1 percent	No extraction
0.5 "	.43 percent
1.0 "	2.30 "
2.0 "	3.97 "
3.0 "	5.99 "
4.0 "	6.16 "
5.0 "	6.00 "
10.0 "	5.32 "
50.0 "	2.66 "


Temp.
Ext.
4
3
2.
1.
Degrees.
0
10
20
30
40
48
degrees

Fifth Series of Experiments.

This set of tests were made for the purpose of finding out whether or not the temperature had any effect on the extraction. It was arranged to make eleven tests on the ore at temperature varying from 0 degrees centegrade to 100 degrees centegrade,but it was found that at forty-eight degrees c. the extra solution decomposed and Cu_2S was precipitated and therefore no tests were made on the ore above this temperature.

The temperature varied as shown in table five and the conclusion arrived at was that the lower the temperature the higher the extraction. This of course does not hold good for temperatures below 0 degrees C.

Table No. 5.

Temperature	Extraction.
0 degrees C.	6.993 percent
10 " "	5.495 "
20 " "	4.429 "
30 " "	3.397 "
40 " "	3.463 "

Samples of ore were next roasted, part with salt and part without salt. Then treated with different solutions as shown for the unroasted ore but it was found that the extraction was not increased any so it was concluded that roasting did not help, but would only add to the expense and trouble of preparing the ore for leaching.

The percentage of the important consituents are as follows:

SiO_2	Cu.	$CaCO_3$	Pb	Fe_2O_3	S	Ag
25.27%	.37%	48.09%	16.78%	6.43%	3.02%	15 oz.

From the analysis it is very apparent that this ore would be an excellent one for the blast furnace process as it contains plenty of lead and would require very little fluxing to form a fusable slag.

Final Conclusion.

Taking into account the low extraction of Silver by the leaching process, size to which the ore would have to be crushed, and the trouble of extracting the lead in the lixivation process it is not likely that it would be at all economical to work it by this method. On the other hand, as stated above, it is primarily a blast furnace ore and should be treated by the Russell process, if it is possible to get the ore to a blast furnace.

The best extraction however would be obtained with a 4% solution in the proportion of 100 $Na_2S_2O_3$ to 60 $CuSO_4$ on a 40 mesh sieve, standing five hours and at as low a temperature ascan be conveniently obtained.