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Gold chlorination

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GOLD CHLORINATION.

In a process of gold chlorination recently introduced and apparently used with success in Southern Australia, potassium permanganate, common salt and sulphuric acid were used as the generators of the chlorine

A series of experiments was made to determine the efficiency of these reagents for developing chlorine as compared with other methods in use. For these tests Potasium Permanganate and Sulphuric acid and Manganese Dioxide, Sodium Chloride and Sulphuric acid were taken for comparison.

A sulphide ore carrying both gold and silver was used; and in all experiments the ore was "dead" roasted. The silver was not taken into account.

In each case 200 grams of Ore was used with just enough water to cover the whole.

A fire assay shows the ore to run two ounces to the ton, therefore there are .0125 grams of gold in 200 grams of Ore.

Working out the following equations we determine the amount of the various reagents needed.

$$3\ CaO\ Cl_2 + 3H_2SO_4 + 2Au = 2Au\ Cl_3 + 3\ Ca\ SO_4 + 3\ H_2O \quad \text{(1)}$$

$$3\ MnO_2 + 6\ H_2SO_4 + 6Na\ Cl + 2\ Au = 2\ Au\ Cl_3 + 3\ Mn\ SO_4 + 3Na_2SO_4 + 6H_2O \quad \text{(2)}$$

$$6KMnO_4 + 24\ H_2SO_4 + 30NaCl + 10Au = 6MnSO_4 + 15Na_2SO_4 + 3K_2SO_4 + 10AuCl_3 + 24H_2O \quad \text{(3)}$$

In working out (1) we find that we actually need .012 grams of Bleaching Powder and .0093 grams of Sulphuric Acid. The Bleaching Powder used contained but 33% of Bleaching Pwdr; therefore .037 grams of the Bleaching powder will be needed to furnish .012 grams of Bleaching Powder.

In (2) .0083 grams of Manganese Dioxide, .0187 grams of Sulphuric Acid and .0111 grams of Sodium Chloride are needed for the completion of the reaction.

In (3) .0060 grams of Potasium Permanganate, .0149 grams of Sulphuric Acid and .0111 grams of Sodium Chloride are needed.

To have plenty of the reagents, amounts quite in excess of the above were used. But the ratio was in all cases .012 grams of Bleaching Powder: .0083 grams of Manganese Dioxide: .0060 grams of Potasium Permanganate. This was done in order that the Chlorine generated should be the same for all changes in any series of tests.

The filtrate showed in some cases a red color due to incomplete decomposition of permanganate.

Ore.	Mesh	$CaO\ Cl_2$	MnO_2	$KMn\ O_4$	Salt	H_2SO_4	Time	Condition	Per cent of Extract.	Remarks
200 gr	20	4 gr.	-	-	-	.908g	2 hrs.	Standing	40	
200 gr	20	4 gr.	-	-	-	.908"	4 hrs.	Standing	52	
200 gr	20	-	.9 gr	-	1.22g	1.6 "	2 "	Standing	55	
200 gr	20	-	.9 gr	-	1.22"	1.6 "	4 "	Standing	22	
200 gr	20	-	-	.62gr.	1.2 "	1.5 "	2 "	Standing	48	Red Color.
200 gr	20	-	-	.62gr.	1.2 "	1.5 "	4 "	Standing	67	Red Color

200 grams of ore with the reagent and enough water to cover all were put in a fruit jar. The cover was then fastened on air-tight and the jar set away to stand. After the required time it was opened and the ore thrown on a filter paper and thoroughly washed. Then the tails were assayed and the percentage of extraction determined by the relation between the original assay and the assay of the tails.

In the first set of experiments the percentage of extraction is low in all. It was thought that possibly the ore caked on the bottom and action was thus hindered and made incomplete. So in all the following experiments the jars were kept revolving through the experiment.

Ore	Mesh	$CaOCL_2$	MnO_2	$KMnO_4$	Salt	H_2SO_4	Time	Condi dition	Percent of Extract.	
200gr.	20	4 gr.	-	-	-	.908g	2hrs.	Revolved	80	
200gr.	20	4 gr.	-	-	-	.908"	4 "	"	80	
200 "	20	-	.9 gr.	-	1.22	1.6 "	2 "	"	20	
200"	20	-	.9 "	-	1.22	1.6 "	4 "	"	45	
200"	20	-	-	.62 gr.	1.2	1.5 "	2 "	"	65	
200"	20	-	-	.62 "	1.2	1.5	4 "	"	77	

To verify the foregoing results the same conditions were maintained in another set of experiments with the following results:

Ore	Mesh	$CaOCl_2$	MnO_2	$KMnO_4$	Salt	H_2SO_4	Time	Condi- tions.	Percent Extract.	
200gr.	20	4 gr.	-	-	-	.908	2 hrs.	Revolved	80	
200 "	20	4 "	-	-	-	.908	4 "	"	80	
200 "	20	-	.9 gr.	-	1.22	1.6	2 "	"	25	
200 "	20	-	.9 "	-	1.22	1.6	4 "	"	40	
200 "	20	-	-	.62 gr	1.2	1.5	2 "	"	65	
200 "	20	-	-	.62 "	1.2	1.5	4 "	"	82.5	

Tests with increased quantities of reagents.

Ore	Mesh	$CaOCl_2$	MnO_4	$KMnO_4$	Salt	H_2SO_4	Time	Condi tions	Percent Extraxt.	
200gr.	20	6 gr.	-	-	-	1.36g	2 hrs.	Revolved	87	
200"	20	6 "	-	-	-	1.36"	4 "	"	89	
200"	20	-	1.35g	-	1.83g	2.4 "	2 "	"	78	
200"	20	-	1.35"	.-	1.83"	2.4 "	4 "	"	66	
200"	20	-	-	.93gr.	1.8"	2.25"	2 "	"	77	
200"	20	-	-	.93 "	1.8"	2.25"	4 "	"	77	
200"	20	8gr.	-	-	-	1.82g	2 hrs.	Revolved	59.4	
200"	20	8 gr.	-	-	-	1.82"	4 "	"	83.9	
200"	20	-	1.8gr.	-	2.44g	3.2"	2 "	"	29.8	
200"	20	-	1.8"	-	2.44"	3.2	4 "	"	29.8	Red
200"	20	-	-	.1.24g	2.4 "	3.	2 "	"	61.6	Color
200"	20	-	-	.1.24"	2.4 "	3.1	4 "	"	65.6	Red Color.

As shown from the table,an increase in the reagents did not raise the percentage of extraction. It was thought that possibly the ore should be finer. Up to this point ore which went through 20 mesh was used. This was somewhat coarse so different meshes were used,as shown by following tables:

Ore	Mesh	$CaOCl_2$	MnO_2	$KMnO_4$	Salt	H_2SO_4	Time	Condi tions.	Percent Extract.	
200G	30	4 gr.	"	"	"	.908	2hrs	Revolved	70	
200"	30	4 "	"	"	"	.908	4 "	"	70	
200"	30	"	.9gr.	"	1.22gr	1.6	2 "	"	52.5	
200"	30	"	.9 "	"	1.22"	1.6	4 "	"	50	
200"	30	"	"	.62gr.	1.2 "	1.5	2 "	"	50	
200"	30	"	"	.62 "	1.2 "	1.5	4 "	"	40	
200"	40	4 grs.	"	"	"	.908	2 hrs	Revolved	73	
200"	40	4 "	"	"	"	.908	4 "	"	80	
200"	40	"	.9gr.	"	1.22gr	1.6	2 "	"	34	
200"	40	"	.9"	"	1.22 "	1.6	4 "	"	45	
200"	40	"	"	.62gr.	1.2 "	1.5	2 "	"	57	
200"	40	"	"	.62 "	1.2"	1.5	4 "	"	51	
200"	50	4 gr.	"	"	"	.908	2hrs.	Revolved	87	
200"	50	4 gr.	"	"	"	.908	4 "	"	87	
200"	50	"	.9gr.	"	1.22gr	1.6	2 "	"	64	
200"	50	"	.9"	"	1.22"	1. 6	4 "	"	64	
200"	50	"	"	.62gr.	1.2 "	1.5	2 "	"	33	
200"	50	"	"	.62 "	1.2 "	1.5	4 "	"	64	

The last three sets of experiments showed no improvement in the amount of gold extracted over those when 20 mesh was used.

Here it was thought well to determine the amount of wash water needed or at least have some idea of the amount that would be sufficient.

The following table shows the results:

Ore	Mesh	$CaOCl_2$	H_2SO_4	Washwater	Time	Conditions	Percent of Extraction.
200G	50	6 grs.	1.36gr.	250 cc	2hrs.	Revolved	45
200 "	50	6 "	1.36"	500 "	2 "	"	53
200"	50	6 "	1.36	1000 "	2 "	"	53
200 "	50	6 "	1.36	2000 "	2 "	"	53

Evidently the gold chloride is readily soluble and 500 cubic centimeters of water are sufficient for washing purposes. Amounts in excess of this have been used in all the tests so far, so there is no error in the results due to the lack of wash water.

Next was tried six grams of Bleaching powder, 1.35 grams of Manganese Dioxide and .93 grams Potassium permanganate and the proportional amounts of the other reagents, with the ore through a 50 mesh.

Ore	Mesh	$CaOCl_2$	MnO_2	$KMnO_4$	Salt	H_2SO_4	Conditions	Percent of Extraction.
200gr	50	6 gr				1.36	Revolved	88%
200 "	50	6 gr.				1.36	"	89%
200 "	50		1.35g		1.83	2.4	"	44
200 "	50		1.35"		1.83	2.4	"	37
200 "	50			.93gr.	1.8	2.25	"	30
200 "	50			.93 "	1.8	2.25	"	30.

The extraction of the bleaching Powder was taken as the maximum which could be obtained and the next series of tests were to find how much more manganese and potassium permanganate were needed to raise the extraction in these cases up to what it was in the case when six grams of Bleaching Powder were used.

Ore	Mesh	MnO_2	$KMnO_4$	Salt	H_2SO_4	Conditions	Extraction	
200g	50	2 gr		2.7 g	3.55 g	Revolved	70 percent	
200"	50	3 "		4.05"	5.22	"	49 "	
200"	50	4 "		5.4"	7.1	"	80 "	
200"	50		2 gr.	3.87"	4.84	"	62 "	Red color
200"	50		3 "	5.79"	7.24	"	86 "	
200"	50		4 "	7.74"	9.69	"	87 "	

As indicated in table the ore in the above test went through 50 mesh. In the next text the ore was put through a 20 mesh and the same amount of reagent used.

Ore	Mesh	MnO_2	$KMnO_4$	Salt	H_2SO_4	Conditions	Extraction	
200g	20	2 gr		2.7g	3.55	Revolved	60 percent	
200"	20	3 "		4.05	5.22	"	61 "	
200"	20	4 "		5.4	7.1	"	lost	
200"	20		2 gr.	3.87	4.84	"	67 percent	Red color
200"	20		3 "	5.79	7.24	"	67 "	Red color
200"	20		4 "	7.74	9.69	"	78 "	Red color

The extraction is somewhat less with coarser material. The highest extraction obtained was 89 percent. This is a high enough extraction but the amounts of reagents used were excessive so it would not be profitable to use this method. The ore used is evidently not suited to the chlorination method of gold extraction.

However this was not the primary object of these tests. That was to compare the methods. In allcases-where the amounts of reagents were proportional, the bleaching powder gave the best results. The manganese dioxide gave very irregular results,which irregularity I cannot account for. The Potassium permanganate gave apparently regular results but the extraction was low and it took nearly three times as much of this

to give the same extraction as with Bleaching Powder.

One source of difference in the results was due to the Bleaching Powder loseing its strength. It was kept in a closed can but after a months opening and reopening it lost greatly in strength.

For example the tests with 4 grams of Bleaching Powder and ore through a 50 mesh were repeated with fresh material and much better extraction was obtained.