UNIVERSITY OF NEVADA

THE SAMPLING OF FREE GOLD ORES

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BY

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THE SAMPLING OF FREE GOLD ORES.

I.

INTRODUCTION.

Considerable difficulty has been experienced in obtaining a correct sample from ores that carry free gold. Much has been written in regard to the sampling of such ores and the summary below gives a brief outline of the contents of the principal articles dealing with this subject.

Brunton* fully discusses the theory of sampling and gives tables and curves showing the results of his experiments. He also gives the mesh to which an ore must be crushed to get an accurate sample of a given weight. This discussion is by far the most exhaustive and valuable of any yet written and anyone who is interested in the problem of ore sampling should not neglect to study it carefully as his time would be well repaid. The same author, in another article**, gives an excellent outline of the practice of ore sampling. There is included some interesting results on the sampling of ores in sampling works. Typical flow sheets, of modern sampling works are given and are discussed in detail.

White*** illustrates the difficulties involved in

* D. W. Brunton. "The Theory and Practice of Ore Sampling". Trans. A.I.M.E. Vol. XXV 1895.

** Ibid. "Modern Practice of Ore Sampling". Trans. A.I.M.E. Vol. XL 1909.

*** Franklin White. "Errors in Sampling and Assaying Ores Due to the Presence of Coarse Gold". Trans. I.M.& M. Vol XXll 1913.

in obtaining accurate results in sampling and assaying an ore in which free gold was present. There are also given some experiments which tend to illustrate the impossibility of obtaining a correct sample by the methods commonly used. His results, however, are inconclusive. Lass* furnishes an interesting article with an example of the variability of assays on an ore that contains free gold in a gangue that is practically barren. Locke** gives an example of the extreme case where the removal of but a single particle of gold from the origonal lot of ore vitally effected the assays on the samples taken afterward. In this case the gold occured in rather large nuggets. Brunton*** performed some experiments to determine the maximum sized particle that would pass a sieve of a given mesh. These tests were carried out with gold and silver filings and therefore were not representative of the particles that would be found in the sample prepared for assay by the usual methods.

In the articles mentioned, except the two just given, nothing deffinite has been stated in regard to the nature of the gold as it occurs either in the ore, or in the final samples taken for assay.

The experimental work presented in this paper was commenced with the object of determining the shape, size, and weight, of the largest particle that would pass a given mesh, hoping that this study would throw some light on the cause of the difficulty experienced in obtaining correct results from

*W. P. Lass. "Variations in Assaying at the Alaska Treadwell". Mining Magazine. Vol. 111 #1 Jan., 1913.
**C. E. Locke. "School Laboratory Work-Sampling an Ore Containing Coarse Gold". Trans. A.I.M.E. V01 XLV 1914.
***Loc. cit.

correct results from samples of free gold ores. Tables giving the results of these tests, with curves for comparison, have been prepared. Several assays were run to determine the results of the various samples taken.

These experiments were performed in the laboratories of the Mackay School of Mines during the college year of 1919-1920.

I wish to express my thanks to Professor F. C. Lincoln for continued encouragement during the work and for many helpful suggestions in the preparation of this paper. I am also indebted to Professors W. S. Palmer and J. C. Jones for their many valuable criticisms and a readiness to lend assistance when needed. Mr. A. A. Codd, Mr. Frank M. Manson, and Mr. Felix Borzynski, mining men of Reno, Nevada, rendered valuable assistance by furnishing ore samples for experimentation.

*D. W. Brunton. Loc. cit.

II

PRELIMINARY EXPERIMENTS.

The nature of the occurance of gold in ores is of the utmost importance in sampling. Whether it occurs in large pieces, or finely divided, etc., effect the care with which they must be sampled to insure accurate results.

The three cases as outlined below, represent the most usual conditions under which gold occurs in ores.

1. In very finely divided particles either in silicious, oxidized, or sulfide ores,

2. In spongy or cellular masses that, upon grinding, are readily reduced to a very large number of finely divided particles.

3. In fairly large pieces of homogeneous metal, either in a gangue that carries values or in one that is practically barren.

The first two cases present little or no particular difficulty in sampling. The first represents a practically ideal case, while the second becomes very like unto the first when it has been well ground. The last case however is the sort with which we are mostly concerned as it presents an interesting problem. It has been demonstrated* that the most difficult ore to sample correctly, is one in which there are particles of very rich material distributed thru a gangue

*D. W. Brunton. Loc. cit.

that is comparitåvely barren. The larger the rich particles, the higher their specific gravity as compared to that of the gangue, and the lower the grade of the ore, the more difficult becomes the problem of obtaining a correct sample. It was an ore, such as the last case mentioned, that was wanted upon which to experiment.

Much difficulty was experienced in securing an ore such as this, and the search for one revealed the fact that ores of this sort are rather rare. Upon investigation of various ores that promised to be of this kind, due to difficulty experienced by the Nevada State Ore Sampler in checking the sampling works on control samples, it was found that the cause of not checking was due, not so much to the nature of the ore, as to insufficient mixing of the sample before the control samples were quartered out. This experience leads to the belief that this is often the case where variations in assays occur, as these same ores presented no further trouble when they thoroly mixed before the final pulps were divided.

A sample of free gold ore, from Masonic, California, was experimented upon but proved to be unsuited for these tests as no gold was caught on the sieves until the ore had been groung to pass an eighty mesh sieve. The particles of gold in the ore were fairly large, but being of a spongy nature they readily ground up so as to pass the small meshed sieves. Similar results were obtained upon free gold ores from Rawhide, and Como, Nevada. Several other ores were examined with similar results. These investigations revealed the fact that ores carrying free gold, that is fairly coarse, are the exception rather than the rule. A lot of ore that fulfilled the conditions sought for, was finally obtained, from Allegheny, California, thru the courtesy of Mr. A. A. Codd. This ore consisted of a practically pure quartz gangue carrying fairly large particles, up to eight mesh, of gold in flakes and small grains, or nuggets. It also contained very small amounts of arsenopyrite, realgar, and orpiment.

This lot conforms to the conditions stated in class three in that we have fairly rich particles of material in a gangue that is practically barren. It also presents one of the most difficult cases in that we have a very high specific gravity for the gold, whereas that of the quartz is rather low.

Thruout these experiments the sieves used, were those of the Tyler Standard Screen Scale based upon an opening of 0.074 millimeters for the 200 mesh sieve. The meshes per inch and the diameter of the opening in millimeters, of the sieves used, are given in the following table;*

Mesh.	Millimeters.
14	1.168
28	0.589
48	0.295
100	0.147
150	0.104
200	0.074

* See catalog 36. The W. S. Tyler Company, Cleveland, Ohio.

III

PROCEDURE WITH ALLEGHENY ORE.

The Allegheny ore, weighing 822 grams, was crushed in a jaw crusher to pass a quarter inch sieve. It was then crushed on a buckingboard with a muller until practically all of the sample passed the 14 mesh sieve. The resulting metallics were now separated from the little gangue that remained. This was done with a needle mounted on a wood handle, a hand lens being used to better distinguish the smaller particles from the gangue material. These were then washed with dilute nitric acid to free them from adhering particles of foreign substances and give them a bright yellow solor. The purity of the gold was such that the strength of acid used did not dissolve it appreciably. The particles were now separated into three groups according to whether they were of cylindrical, irregular, or spherical in shape. Most of the irregular ones were either round or roughly square, in outline and rather thin. The groups were then weighed on an assay balance. The maximum, average, and minimum, sized particle in each group was then selected and the two greatest dimensions determined. Each of them was then weighed separately.

These metallics were now ground on the bucking board, pulp being added to furnish abrasive material, with alternate screening and grinding, until all passed the 14 mesh sieve. For the very last portion of the gold, it was found that an agate mortar was more effective for grinding and the chances of loss were thereby greatly reduced. Altho the disc pulverizer is now more generally used for grinding, it was deemed advisable to use the bucking board and muller so as to better observe the effect of the grinding of the metallics at various stages. The whole of the sample, including the metallics, was now thoroly mixed by prolonged rolling on a rubber surfaced cloth. A sample was cut out by passing the pulp thru a Jones riffle sampler. The pulp was well rolled after each passing thru the sampler so that it would be thotoly mixed.

The same procedure, as outlined above, was followed on the several sieves down to and including the 200 mesh. The metallics were however ground thru the 150 and 200 mesh sieves without sorting, weighing, etc., as was done on the meshes.

IV

METALLIC PARTICLES ON SIEVES.

The results of the preceeding tests are tabulated below. Measurements in table 1, and those of the length of cylindrical particles in table 2, were made with a hand scale. The others were made with a microscope, Dimensions are given in millimeters.

TABLE 1. METALLICS ON 14 MESH. (All of the ore)

Shape.	Number.	Weight mgms.	Avg. Wt. mgms.	Dimensions. Length	Width
Cylindrical	22	1176.00	53.45		
Maximum		180.15		8.8	1.5
Selected Avg.		69.38		4.9	1.0
Minimum		4.66		3.5	0.3
Irregular	32	757.10	23.69		
Maximum		73.74		6.8	3.2
Selected Avg.		25.85		4.0	2.5
Minimum		0.91		2.7	1.8
Spherical	0				
Total	54	1933.10	3.58		

TABLE 2. METALLICS ON 28 MESH. (0.875 of the ore)

Shape.	Number.	Weight. mgms.	Avg. Wt. mgms.	Dimensions. Length	Width.
Cylindrical	73	338.20	4.77		
Maximum		10.60		3.2	0.58
Selected Avg.		5.93		2.5	0.50
Minimum		1.52		2.0	0.45
Irregular	84	144.10	1.71		
Maximum		7,74		2.75	1.56
Selected Avg.		2.84		1.36	0.13
Minimum		0.26		0.77	0.45
Spherical	206	427.50	2.08		
Maximum		3.68		1.21	0.66
Selected Avg.		2.34		0.75	0.73
Minimum		1.12		0.81	0.66
Total	363	909.70	2.34		

TABLE 3. METALLICS ON 48 MESH. (From 0.657 of the ore)

Shape.	Number.	Weight mgms.	Avg. Wt. mgms.	Dimensions. Length	Width.
Cylindrical	208	96.76	0.465		
Maximum		1.04		2.06	0.26
Selected Avg.		0.48		1.16	0.22
Minimum		0.04		0.64	0.12
Irregular	289	98.78	0.342		
Maximum		1.78		1.73	0.69
Selected Avg.		0.40		1.17	0.71
Minimum		0.03		0.32	0.24
Spherical	7	1.25	0.178		
Maximum		0.21		0.37	0.32
Selected Avg.		0.18		0.37	0.26
Minimum		0.14		0.29	0.29
Total	504	196.79	0.390		

TABLE 4. METALLICS ON 100 MESH. (From 0.492 Of the ore)

Shape.	Number.	Weight mgms.	Avg. Wt. mgms.	Dimensions. Length	Width.
Cylindrical	1	0.06	0.060	0.28	0.11
Irregular	696	20.26	0.021		
Maximum		0.14		1.49	0.64
Selected Avg.		0.08		0.24	0.19
Minimum		0.01		0.22	0.22
Spherical	0				
Total	697	20.32	0.029		

The results in table 1, represent all of the origonal sample whereas the others do not as there was a portion cut out for assay after passing each screen. Therefor to get a comparison between them it will be nescessary to calculate what would have been their respective weights and number of different sizes had all of the ore been put thru each sized sieve. To this each quantity has been divided thru by the percent of the sample represented.

After these calculations we get the results as given in tables 5, 6, and 7. Table 1 would remain unchanged, while the quantities of all the others are raised.

TABLE 1. (In part) ON 14 MESH.

Shape.	Number.	Weight. mgms.
Cylindrical	22	1176.00
Irregular	32	757.10
Spherical	0	
Total	54	1933.10

TABLE 5. (Table 2, recalculated) ON 28 MESH.

Shape.	Number.	Weight. mgms.
Cylindrical	83	386.39
Irregular	96	164.57
Spherical	236	488.57
Total	415	1039.53

TABLE 6. (Table 3, recalculated) ON 48 MESH.

Shape.	Number.	Weight. mgms.
Cylindrical	317	147.28
Irregular	441	150.35
Spherical	11	1.91
Total	769	299.54

TABLE 7. (Table 4, recalculated) ON 100 MESH.

Shape.	Number.	Weight. mgms.
Cylindrical	2	0.12
Irregular	1415	41.18
Spherical	0	
Total	1417	41.30

These results are representative only of the special method of grinding used. The personal equation enters too largely into them for them to be comparable with other methods of grinding. The weight and motion given to the muller have much to do with the shape and size, while the point to which the grinding is carried before they are separated out influences both the total weight, and the number of them. An idea is obtained as to their variation in shape, size, mumber, and weight of the metallics at various stages of crushing. It will be noted that the number of particles to be expected on the various sieves increases as the size of the mesh decreases. The number on 28 is almost eight times the number on 14 mesh. The increase on the other sieves is however only about twice that of the preceeding sieve. As to the weight of the particles: the decrease is very rapid, about as follows 1/2, 1/3, 1/7. The decrease in weight is slower than the increase in number and so we will have a decrease in the average sized particle. This is bourne out in the experiment as the average weight decreases as follows; 3.58, 2.34, 0.390, and 0.029 or in these ratios: 1.53, 5.75, 13.45. This shows that the weight of the average particle decreases very rapidly as the finer meshes are approached. An interesting relation between the various shaped particles is revealed. The spherical and cylindrical ones decrease toward the finer meshes while the irregular ones increase.

These results indicate that a large number of particles are to be expected on the finer meshes, while on the coarses meshes will retain a considerable weight of them. Also it will be noted that as the irregular shaped particles increase very rapidly in number, so does the average weight of particles decrease, but much more rapidly. Their is also a rapid decrease in the ratio between the largest and smallest particle found on each mesh as follows; 198, 71, 59, and 14. In other words the variation in the size of the particles in gradually anproaching a minimum, hence the indication is that they would eventually become of the same size if the grinding were carried far enough.

V

METALLIC PARTICLES THRU SIEVES.

One half of an assay ton (14.583 grams) of pulp was weighed out from each of the samples taken at the different meshes and sized by screening thru the following sieves; 28, 48, 100, 150, and 200 mesh. The sieves were shaken by hand, shaking being continued until no further appreciable amount of pulp passed thru so as to insure as nearly complete sizing as possible. The screening was done dry. The resulting sizes, from each sample, were weighed. The largest metallic particle, passing each sieve, down to and including 100 mesh was selected and, after cleaning was weighed, measured, and returned to the pulp. The weights are given in milligrams and the dimensions in millimeters. Loss in weight, in screening, is assumed to be of -200 mesh material, and is added to the weight of the -200 mesh material actually found. The loss, in each case, is stated in each table. The results are tabulated below:

TABLE 8. SIZING OF -14 MESH MATERIAL.

Mesh.	Weight.	%	Cum. %	Wt. of particle		Dimensions Length	Width	Prevailing Shape
+ 28	4.240	29.1	29.1	8.56	cyl.	1.69	0.61	cylindrical
+ 48	3,353	23.0	52.1	1.88	cyl.	1.21	0.33	cylindrical
+100	2.230	15.3	67.4	0.60	irreg	0.71	0.67	irregular
+150	1.160	7.9	75.3	0.05	cyl.	0.56	0.09	irregular
+200	0.740	5.1	80.4					
-200	2.860	19.6						
Total	14.583	100.0						
Loss	0.200							

TABLE 9. SIZING OF -28 MESH MATERIAL.

Mesh.	Weight.	%	Cum. %	Wt. of particle	Dimensions. Length	Width	Prevailing Shape.
+ 48	4.470	30.6	30.6	2.17 cyl.	1.62	0.43	cylindrical
+100	2.935	20.1	50.7	1.00 cyl.	0.93	0.43	cylindrical
+150	1.425	9.8	60.5	0.05 cyl.	0.37	0.11	irregular and
+200	1.030	7.1	67.6				spheres
-200	4.723	32.4					
Total	14.583	100.0					
Loss	0.128						

TABLE 10. SIZING OF -48 MESH MATERIAL.

Mesh.	Weight.	%	Cum. %	Wt. of particle	Dimensions. Length	Width	Prevailing shape.
+100	2.620	18.0	18.0	0.40 cyl.	0.95	0.17	cylindrical
+150	2.070	14.2	32.2	0.10 cyl.	0.56	0.11	cylindrical
+200	1.345	9.2	41.4				with few
-200	8.548	56.8					spheres
Total	14.583	100.0					
Loss	0.198						

TABLE 11. SIZING OF -100 MESH MATERIAL.

Mesh.	Weight.	%	Cum. %	Wt. of particle	Dimensions. Length	Width	Prevailing shape.
+150	1.755	12.0	12.0	0.09 cyl.	0.69	0.09	cylindrical
+200	1.925	13.2	25.2				and irregular
-200	10.903	74.8					are about equal.
Total	14.583	100.0					Also a few spheres.
Loss	0.133						

TABLE 12. SIZING OF -150 MESH MATERIAL.

Mesh.	Weight.	%	Cum. %	Wt. of particle	Dimensions. Length	Width	Prevailing shape.
+200	1.730	11.2	11.2				
-200	12.853	88.8					
Total	14.583	100.0					
Less	0.048						

The prevailing shape is cylindrical. They are far in excess of the irregular ones, while the spherical particles are rather rare especially in the larger meshes. The ten particles selected as the largest on their respective meshes show nine cylindrical ones to one that is irregular. In the sample from which the largest particle was irregular, there were two irregular particles that were of the same weight and of the same dimensions. No large spherical particles were found.

Wherever the irregular particles were found to be in excess; there were also a good portion of cylindrical ones. The cylindrical ones however rapidly decreased toward the smalled meshes, while the irregular and spherical particles showed a corresponding increase.

These data indicate that with finer grinding the tendency is toward the formation of irregular and spherical shapes, the former predominating, but the latter form becoming more and more in evidence. A cylindrical particle that is of slightly less diameter than the opening in the sieve can readily pass thru tho it may be several times this dimension in length. This causes the spherical particles of considerable weight to pass. The spherical ones that will pass are limited to those that have a diameter slightly less than the opening; the largest sphere that can pass will therefore be of less weight than the largest cylindrical particle that can get thru. The irregular ones will be lighter yet as the heaviest particle that can pass will have as its greatest dimension the diameter of the mesh. Those examined have been found to be either of a rounded, or practically square, outline while their third dimension was very much less. They therefore would tend to be lighter than the spheres. This tendency toward the spherical, and especially the irregular shaped, particles would suggest that there would be a much better chance of getting good samples the finer the sample is ground. An interesting point brought out is that while the spherical particles show a decrease, among the metallics that remained on the sieves; they show an increasing proportion in the metallics that passed thru the sieves.

VI

ASSAYS.

One half assay ton samples, in triplicate, were run on the samples taken at various meshes as the ore was being ground. The following charge was used;

Litharge 35 grams.
Soda 35 grams.
Borax glass 5 grams, as a cover.
Charcoal to reduce a 20 gram button.

The pulps, from the sizing tests, were run with the same charge but enough ground glass was added to each of them to bring the weight of pulp up to a half assay ton. This charge gives a very clear, fluid, slag. The resulting buttons were hammered to remove the slag and cupelled. The furnace used for this work, was the low pressure burner, oil burning type. This type of furnace is fired from the front and over heats the rear of the muffle while the front is too cold. Because of this the cupellation must be carried on so far back in the muffle that insufficient oxygen reaches the cupels. Back p pressure from the fire box causes a reversal of the air current in the muffle and subjects them to sudden cooling. It is therefore nescessary to carry too high a temperature for proper cupellation and no doubt causes excessive cupellation losses.

After cupellation the resulting beads were weighed, four parts of silver to one of gold added, and recupelled with 6 to 8 grams of test lead.

The beads were now passed thru bullion rolls until they were quite thin, and rolled into cornets. The cornets were parted, at slightly below boiling, with 8 to 1 nitric acid for from fifteen to twenty minutes. The acid was decanted off, and hot concentrated nitric added, kept at near boiling temperature for about fifteen minutes, and then decanted. The parting was carried on in parting flasks. The flasks were now filled with hot distilled water and inverted over porcelain capsules to catch the gold. The gold was now washed three times with hot distilled water, dryed, ignited, cooled, and weighed.

These results are tabulated on page 19.

TABLE 13. ASSAYS ON SCREEN ANALYSES.

-14 MESH.

Assay No.	Size.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton
1	+28	46.22	39.92	7.30	274.4	50.2
2	+48	29.69	26.42	3.27	229.7	28.4
3	+100	15.05	13.26	1.79	173.5	23.4
4	+150	7.27	6.22	1.05	157.5	27.8
5	+200	3.38	2.89	0.49	113.3	19.2
6	-200	20.75	17.59	2.76	178.9	28.1
		122.36	106.30	16.66		
Ounces per ton.			212.60	33.32		

-28 MESH.

Assay No.	Size.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton
7	+ 48	50.42	44.39	6.03	290.1	39.4
8	+100	27.52	24.12	3.40	240.0	33.8
9	+150	9.86	8.50	1.36	173.5	27.7
10	+200	6.75	5.71	1.04	160.8	29.3
11	-200	34.29	29.80	4.49	183.9	27.7
		128.84	112.52	16.32		
Ounces per ton.			225.04	32.64		

-48 MESH.

Assay No.	Size.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton
12	+100	39.82	35.24	4.58	391.5	50.9
13	+150	22.73	19.80	2.93	278.9	41.3
14	+200	10.71	9.18	1.53	199.6	33.3
15	-200	62.30	54.30	8.00	185.3	27.3
		135.56	118.52	17.04		
Ounces per ton.			237.04	34.08		

-100 MESH.

Assay No.	Size.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton
16	+150	32.38	28.15	4.23	469.2	70.5
17	+200	22.27	18.93	3.34	286.8	50.6
18	-200	86.85	75.10	11.75	200.8	31.4
		141.50	122.18	19.32		
Ounces per ton.			244.36	38.64		

-150 MESH.

Assay No.	Size.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton
19	+200	21.00	18.15	2.85	324.1	50.9
20	-200	119.20	103.96	15.24	234.1	34.3
		140.20	122.11	18.09		
Ounces per ton.			244.22	36.18		

The results given in table 13, show that there is a marked similarity in the gradual decrease in the value per to, in both gold and silver, from the coarser sizes down to the finer sizes on all of the samples. It is alöo apparent that there is a wide range in values in the coarser sizes while in the finer sizes the difference becomes less until with the -2oo mesh material the variation, from,one sample to the other, is comparitively small. This brings out the fact that with the smaller sizes there is less variation in values than there is in the caarser ones. This would lead to the suggestion that the finer the grinding the closer would be the agreement between the various sizes on any one sample. The value of the coarsest mesh material of each sample was in each case the highest of all the sizes. The value of the -200 mesh material is a minimum in the -14 mesh sample but gradually increases up to nearly the value of the ore in the -150 mesh sample.

The summary and discussion as outlined above points to the conclusion that the finer the grinding the cloaser the agreement of the value of the various sizes in a sample, and hence we would expect to get a better sample.

The results of the assays on the ore samples taken at the several meshes are given in table 14.

TABLE 14. ASSAYS ON ORE SAMPLES.

Assay No.	Dore' mgm	Gold mgm	Silver mgm	Oz. Au. per ton	Oz. Ag. per ton	Variation* Avg.	Max.
			-14 MESH PULP.				
21	159.74	139.45	20.29	278.90	40.58	22.87	
22	145.34	125.88	19.46	251.76	38.92	4.27	40.48
23	136.22	119.21	17.01	238.42	24.02	17.61	
			Average	256.03	37.84	14,92	
			-28 MESH PULP.				
24	130.55	113.24	17.31	226.48	34.62	2.35	
25	133.47	116.37	17.10	232.74	34.20	3.91	6.26
26	130.99	113.64	17.36	227.28	34.72	1.55	
			Average	228.83	34.51	2.60	
			-48 MESH PULP.				
27	144.60	126.36	18.24	252.72	36.48	1.51	
28	145.16	126.21	18.95	252.42	37.90	1.21	4.22
29	141.94	124.25	17.69	248.50	35.38	2.71	
			Average	251.21	36.59	1.81	
			-100 MESH PULP.				
30	140.73	122.91	17.82	245.82	35.64	0.87	
31	141.59	123.51	18.08	247.02	36.16	0.33	1.40
32	141.60	123.61	17.99	247.22	35.98	0.53	
			Average	246.69	35.93	0.58	
			-150 MESH PULP.				
33	140.01	122.41	17.60	244.82	35.20	0.27	
34	141.22	123.57	17.65	247.14	35.30	2.05	3.84
35	139.17	121.65	17.52	243.30	35.04	1.79	
			Average	245.09	35.18	1.37	
			-200 MESH PULP.				
36	138.76	121.30	17.46	242.60	34.92	0.54	
37	139.10	121.63	17.47	243.26	35.94	0.12	0.96
38	139.17	121.78	17.39	243.56	34.78	0.42	
			Average	243.14	35.21	0.36	

* The variation as given is the variation from the average of the assays between the triplicate samples and is headed Avg. The variations given under Max., are the maximun differences between the three samples.

With the exception of the -28 material, the average assays show a gradual decrease in value from the -14 mesh to and including the -200 mesh. The reason for this decrease is not clear. These results however are not conclusive as there were too few assays to get a representative result for the avefage, With as few as three assays the effect of an erratic assay on the average is too great. It is probable that had fifteen or twenty been taken the agerage would represent very nearly the true value of the ore. They do indicate however that the average variation decreases toward the smaller meshes. The -150 mesh material gives a variation that appears to be too great for it is very much higher than the -100 mesh variation. This would indicate that -150 mesh would be a poor mesh to grind to, or that -100 mesh was fine enough. This in however, not likely to be the case; it is very probale that had sufficient assays been run on each of the various samples, to give a nearly true result, the average variation would have shown a gradual decrease. As it is the -200 mesh gives by far the smallest variation, which would indicate that the finer grinding would tend to give the better results. This is in keeping with the experiments carried out on the metallics as given in section five. The -14 mesh material gives the greatest variations in assays while the -200 mesh material gives the smallest.

VII

DISCUSSION.

Most authors, in discussing the theoretical side of sampling, assume that the maximum sized particle that can pass a sieve of a given mesh is a cube of the same dimensions as the opening in the sieve.* This assumption, however, is likely to lead to false reasoning, especially in the case of metallics, as the experiments given here show that the maximun sized particle to be expected is likely to be cylindrical. The particles are of somewhat less diameter than the opening in the sieve but many times as long, and therefore will weigh much more than the largest cube that could pass thru. They also show that the cubical particle of metallics in wholly absent or at least very rare, not one being found in hundreds of particles examined. It is very likely, had a disc pulverizer been used for grinding, that the majority of the particles would have been of different shape than those found in these experiments. They would likely have been largely spherical.

A more exact method of sampling would be to remove the metallics as they appear on the sieves and assay them separately and make a correction on the assay of the resulting pulp.

*D. W. Brunton. Loc. Cit.
W. P. Lass. Loc. cit.

This method would usually impractical to apply at sampling works where commercial sampling is done and several duplicate final samples must be prepared. This difficulty could likely be overcome as it has been at individual mills where metallics gave trouble in obtaining a correct assay of the ore.* It is also probable that the nature of the gangue has much to do with the grinding of ores containing metallics. Metallics by themselves prove very difficult to reduce to a fine state of division. The presence of a hard abrasive, such as quartz, aids materially is the grinding; with a soft gangue it is likely that considerable difficulty would be experienced in reducing the metallics. Experiments along this line, using gangues of different hardness, would , no doubt, produce some interesting results.

CONCLUSIONS.

This study has brought out many interesting points that will be briefly summarized as follows.

1. Ores that carry free gold in fairly large particles are of comparitively rare occurence.

2. Difficulty in obtaining check assays on pulps carrying free gold, is often due to improper mixing of the sample rather than to the free gold present.

3. In the final pulp, as prepared for assay, the larger gold particles are likely to be cylindrical in shape, in the coarser meshes, and spherical or irregular in the finer meshes.

4. The largest gold particle to pass a given mesh

* See article by C. C. Sample, E.& M.J. Vol., 82. page 362.

will probably be found to be cylindrical in shape.

5. The varistions in assays are least on the material crushed to the finer sizes. This is no doubt due to the shape of the metallic particles as well as to their finer state of division.

6. A good method for sampling ores containing metallics would be to remove the metallics as they appeared on the sieves and assay them separately; a correction for them to be applied to the assay of the resulting pulp. This would largely remove the influence of metallics on the irregularity in assays.

SUGGESTIONS FOR FUTURE WORK.

To anyone who wishes to continue along this line of investigation, I would like to suggest that experiments, similar to those above, be carried out using other means of grinding the ore. It would be interesting to see how they would check each other. The gangue in which the gold occurs may have a considerable influence on grinding; hence the experimentation on free gold ore with different gangues may produce results that would be instructive. Enough assays should be run on each sample that an average would tend to eliminate the effect of an occasional erratic one.

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