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DETERMINATION OF CRITICAL POINT OF CONCENTRATING TABLES ON ARIZONA COPPER ORE.

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THESIS.

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DETERMINATION OF CRITICAL POINT OF CONCENTRATING TABLES ON AN ARIZONA COPPER ORE.

In the concentration of an ore by means of concentrating tables, there is a critical point in sizing beyond which the valuable minerals can not be recovered. Theoretically, the lighter gangue is washed over the side of the table and the heavier mineral, reguardless of size, is recoverable at the end, these concentrates being graded from coarse to fine sizes up the slope of the table. In practice, however, the finer sizes of concentrates are found mixed with the middlings and tailings, as indicated by the arrows on the diagram of the concentrating table shown below. The problem is to determine the critical sizes where the divisions occur, or in other words, the finest size of the valuable mineral which it is possible to recover in table concentration.

The following experiments were made in an attempt to determine these critical sizes in the concentration of an Arizona copper ore. Twelve samples for this purpose were obtained from the mill of the Miami Copper Company, these samples consisting of heads, concentrates, middlings and tailings from three Deister No.2 concentrating tables. These tables handle material differing somewhat in size as shown by the screen analysis in the accompanying tables.

Each original sample was thoroughly mixed, and a small portion taken for chemical analysis. A screen analysis was then made on one kilogram of each sample, using a set of Tyler's Standard Screens, consisting of 35, 48, 65, 80, 100, 115, 150, 170 and 200 mesh screens. The use of these screens is recommended for screen analysis because the areas of the openings increase and decrease throughout the series in a fixed ratio and hence will divide the material in better proportion than a series of sieves which has no fixed relationship between the areas of the openings. Many industries have established 200 mesh screens as the minimun in screen sizing. TheBureau of Standards of the United States Government has taken as a standard 200 mesh sieve made from 0.0021 inch wire, and having an opening the linear dimension of which is 0.0029 inch. This sieve has been adopted as the base of the Tyler Standard Screen Scale. The 100 mesh sieve in this screen scale also comes within the specifications adopted by the Bureau of Standards. The diameters of the openings in the scale increase in the ratio of the fourth root of 2, or 1.189, the factor recommended by Professor Richards in his work on ore dressing. This gives a ratio of the square root of 2, or 1.414, between the areas of the openings in successive screens. This ratio applies to the finer sizes from 65 to 200 mesh. For the two coarser screens, the ratio between the diameters of the openings is the square root of 2, or 1.414, so that the area of each openings is double that of the opening in the next finer sieve.

The tailings, heads, middlings and concentrates were screened in the order named, to avoid any possible salting of the poorer samples, which might result if the richer samples were screened first. The product from each screen was weighed to the nearest gram, and analyzed for copper. All chemical analyses were made in duplicate.

The copper determinations were made by the potassium cyanide method, as follows; a standard solution of potassium cyanide was prepared by dissolving 21 grams of pure potassium cyanide in one liter of water. This solution was standardized in the following manner. Weighed accurately about 0.2 gram of pure copper foil and dissolved it in a beaker with 5 c.c. of nitric acid. Diluted with 25 c.c. of distilled water, and boiled to expel the nitrous fumes. Added 50 to 75 c.c. of cold distilled water and neutralized with ammonium hydroxide, adding about 10 c.c excess. Titrated slowly with the potassium cyanide solution. The weight of the copper foil used, divided by the number of cubic centimeters of the potassium cyanide solution required to reach the end point in titration, gives the copper equivalent of one cubic centimeter of the standard solution. This solution was standardized every week, as we were able to work on only two consecutive afternoons each week.

In running the copper analyses on the samples of the different table products, we used two grams of the heads and tailings, one gram of the middlings, and one half gram of the concentrates. Each sample was placed in a 250 c.c. beaker, and 15 c.c. of a saturated solution of potassium chlorate in nitric acid was added. This was boiled for ten minutes, and 5 c.c. of hydrochloric acid was added slowly from a dispensing burette. This mixture was boiled to expel the nitrous fumes, diluted to 100 c.c. with distilled water, and neutralized with ammonium hydroxide, adding about 10 c.c. in excess, but avoiding a large excess. This was then boiled for five minutes, and filtered into a 400 c.c. beaker, washing the precipitate with boiling water. The precipitate was then washed into the original beaker, dissolved again in hydrochloric acid, and re-precipitated with ammonium hydroxide, again avoiding a large excess. This operation was to remove the last traces of copper from the iron hydroxide. This mixture was then filtered into the 400 c.c. beaker, and the precipitate washed with boiling distilled water as before. The combined filtrate wehn cool was then titrated with the standard solution of potassium cyanide.

$$\frac{\text{No. c.c. K C N X Standard}}{\text{weight of sample}} \quad \% \text{ copper}$$

The results of the alanyses are to be found in the accompanying tables.

From the results of our experiments, we were unable to determine definitely the critical point for the particular ore upon which our tests were made. According to our screen analyses, the finer sizes in the tailings, and especially the material finer than 200 mesh, contained the higher percentages of copper in each case. This would seem to indicate that the critical point might be found somewhere below the 200 mesh.

The table products on which these tests were run came from a mill treating an ore in which copper occurs as a mixture of chalcocite and malachite. The latter, because of its lesser specific gravity and porosity is difficult to concentrate, and this factor must be taken into consideration in studying the results of our experiments. It seems reasonable to suppose that the copper losses in the coarser sizes are largely in the form of malachite. If this is true the losses of chalcocite are mainly in the finer sizes, and this again would indicate that the critical point might be found below the 200 mesh.

From the chemical analyses it is seen that the concentrating tables which furnished our samples were recovering from 71.4% to 83.5% of the copper content in the feed. This high a recovery, on feed containing only 2.25% to 3.25% copper, leaves very little to be lost in the tailings, and this adds to the difficulty of determining the critical point.

In conclusion, it appears that the critical sizes occur somewhere below 200 mesh, and it is probable that a series of exhaustive experiments on many different samples conducted with alaborate apparatus for separating the material passing a 200 mesh sieve into its different sizes, would discover more closely the critical point sought.

CLASSIFIER SPIGOT # 2 DEISTER TABLES # 3 & # 4

HEADS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 3.25 % Cu Content= 32.5 g.m.

Screen Analysis.				Chemical Analysis.	
Mesh		Opening in Inches	Weight Grams	Wet Assay per cent Cu	Cu Content Grams
Thru	On				
		Ratio=1.414			
	35	0.0164	337	1.19	4.00
35	48	0.0116	298	1.40	4.17
48	65	0.0082	185	2.56	4.73
		Ratio=1.189			
65	80	0.0069	57	4.70	2.68
80	100	0.0058	52	9.12	4.75
100	115	0.0049	19	13.85	2.63
115	150	0.0041	18	22.40	4.03
150	170	0.0035	7	26.30	1.84
170	200	0.0029	7	25.70	1.80
200			20	11.30	2.26

CLASSIFIER SPIGOT # 2 DEISTER TABLES # 3 & # 4

TAILS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 0.83 Cu Content= 8.3 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
	35	RATIO=1.414 0.0164	390	0.91	3.55
35	48	0.0116	338	0.71	2.40
48	65	0.0082	155	0.55	0.85
65	80	RATIO=1.189 0.0069	43	0.65	0.28
80	100	0.0058	33	0.68	0.22
100	115	0.0049	9	0.94	0.08
115	150	0.0041	7	1.53	0.11
150	170	0.0035	3	1.87	0.05
170	200	0.0029	3	1.87	0.05
200			19	1.90	0.36

CLASSIFIER SPIGOT # 2 DEISTER TABLES # 3 & # 4

MIDDLINGS

ORIGINAL SAMPLE.

Weight= 1,000 g.m. Wet Assay= 4.94 Cu Content= 49.4g.m.

Screen Analysis.				Chemical Analysis.	
Mesh		Opening in Inches	Weight Grams	Wet Assay Per Cent Cu	Cu Content Grams
Thru	On				
		RATIO=1.414			
	35	0.0164	74	10.30	7.63
35	48	0.0116	135	8.05	10.85
48	65	0.0082	221	4.25	9.40
		RATIO=1.189			
65	80	0.0069	132	2.60	3.43
80	100	0.0058	213	2.60	5.54
100	115	0.0049	66	3.80	2.51
115	150	0.0041	81	5.20	4.22
150	170	0.0035	26	5.93	1.54
170	200	0.0029	24	5.60	1.34
200			26	6.95	1.81

CLASSIFIER SPIGOT # 2 DEISTER TABLES # 3 & # 4

CONCENTRATES

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 47.1 % Cu Content= 471 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
		RATIO=1.414			
	35	0.0164	18	39.6	7.13
35	48	0.0116	63	42.6	26.85
48	65	0.0082	143	41.8	59.75
		RATIO=1.189			
65	80	0.0069	104	45.4	47.25
80	100	0.0058	230	45.6	105.00
100	115	0.0049	97	46.8	45.40
115	150	0.0041	160	48.2	77.00
150	170	0.0035	61	51.5	31.40
170	200	0.0029	63	54.00	34.00
200			66	58.1	38.30

CLASSIFIER SPIGOT # 3 DEISTER TABLES # 5 & 6

HEADS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 2.29 % Cu Content= 22.9 g.m.

Screen Analysis.				Chemical Analysis.	
Mesh		Opening in Inches	Weight Grams	Wet Assay Per Cent Cu	Cu Content Grams
Thru	On				
		RATIO=1.414			
	35	0.0164	121	0.685	0.83
35	48	0.0116	318	0.610	1.94
48	65	0.0082	307	0.76	2.38
		RATIO=1.189			
65	80	0.0069	97	1.37	1.33
80	100	0.0058	81	3.28	2.66
100	115	0.0049	20	9.50	1.90
115	150	0.0041	18	17.30	3.12
150	170	0.0035	7	28.60	2.00
170	200	0.0029	6	29.30	1.76
200			22	14.90	3.28

CLASSIFIER SPIGOT # 3 DEISTER TABLES # 5 & # 6

TAILS

ORIGINAL SAMPLE.

Weight= 1000g.m. Wet Assay= 0.655 % Cu Content= 6.55g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
		RATIO=1.414			
	35	0.0164	145	0.57	0.82
35	48	0.0116	396	0.62	2.46
48	65	0.0082	296	0.595	1.76
		RATIO=1.189			
65	80	0.0069	74	0.62	0.46
80	100	0.0058	48	0.735	0.35
100	115	0.0049	10	1.02	0.10
115	150	0.0041	8	1.76	0.14
150	170	0.0035	3	2.90	0.08
170	200	0.0029	3	3.52	0.10
200			17	4.28	0.73

CLASSIFIER SPIGOT # 3 DEISTER TABLES # 5 & # 6

MIDDLINGS

ORIGINAL SAMPLE.

Weight= 1000g.m. Wet Assay= 3.1 % Cu Content= 31.0g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT	WET ASSAY PER CENT Cu	Cu CONTENT
THRU	ON		GRAMS		GRAMS
		RATIO=1.414			
	35	0.0164	- -	- -	- -
35	48	0.0116	100	3.28	3.28
48	65	0.0082	273	2.92	7.97
		RATIO=1.189			
65	80	0.0069	198	2.82	5.58
80	100	0.0058	252	2.92	7.36
100	115	0.0049	69	3.45	2.38
115	150	0.0041	64	3.79	2.42
150	170	0.0035	17	4.18	0.71
170	200	0.0029	11	4.24	0.47
200			16	5.32	0.85

CLASSIFIER SPIGOT # 3 DEISTER TABLES # 5 & # 6

CONCENTRATES

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 47.2 % Cu Content= 472 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
		RATIO=1.414			
	35	0.0164	--	--	--
35	48	0.0116	--	--	--
48	65	0.0082	60	37.2	22.32
		RATIO=1.189			
65	80	0.0069	83	35.5	29.45
80	100	0.0058	211	40.2	84.90
100	115	0.0049	111	43.7	48.50
115	150	0.0041	221	49.1	108.75
150	170	0.0035	88	53.0	46.70
170	200	0.0029	117	56.5	66.10
200			111	57.5	64.00

CLASSIFIER SPIGOT # 4 DEISTER TABLES # 7 & # 8

HEADS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 2.26 Cu Content= 22.6 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
		RATIO=1.414			
	35	0.0164	- -	- -	- -
35	48	0.0116	69	0.495	0.34
48	65	0.0082	251	0.396	0.99
		RATIO=1.189			
65	80	0.0069	173	0.467	0.81
80	100	0.0058	260	0.576	1.50
100	115	0.0049	84	1.21	1.02
115	150	0.0041	70	2.94	2.06
150	170	0.0035	27	8.40	2.27
170	200	0.0029	22	15.20	3.04
200			41	18.40	7.55

CLASSIFIER SPIGOT # 4 DEISTER TABLES # 7 & #8

TAILS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 0.372 % Cu Content= 3.72 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON		GRAMS		
	35	RATIO=1.414 0.0164	- -	- -	- -
35	48	0.0116	126	0.52	0.65
48	65	0.0082	326	0.47	1.53
65	80	RATIO=1.189 0.0069	185	0.37	0.68
80	100	0.0058	188	0.34	0.64
100	115	0.0049	69	0.38	0.03
115	150	0.0041	55	0.40	0.02
150	170	0.0035	16	0.51	0.08
170	200	0.0029	11	0.51	0.05
200			21	1.28	0.27

CLASSIFIER SPIGOT # 4 DEISTER TABLES # 7 & # 8

MIDDLINGS

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 0.863 Content= 8.63 g.m.

Screen Analysis.				Chemical Analysis.	
Mesh Thru	Mesh On	Opening in Inches	Weight Grams	Wet Assay per cent Cu	Cu Content Grams
		RATIO=1.414			
	35	0.0164	--	--	--
35	48	0.0116	24	0.74	0.17
48	65	0.0082	163	0.74	1.21
		RATIO=1.189			
65	80	0.0069	170	0.96	1.63
80	100	0.0058	316	0.90	2.84
100	115	0.0049	92	0.90	0.83
115	150	0.0041	113	0.90	1.02
150	170	0.0035	41	0.90	0.37
170	200	0.0029	42	0.85	0.36
200			49	1.41	0.69

CLASSIFIER SPIGOT # 4 DEISTER TABLES # 7 & # 8

CONCENTRATES

ORIGINAL SAMPLE.

Weight= 1000 g.m. Wet Assay= 41.7 % Cu. Content= 417 g.m.

SCREEN ANALYSIS.				CHEMICAL ANALYSIS.	
MESH		OPENING IN INCHES	WEIGHT GRAMS	WET ASSAY PER CENT Cu	Cu CONTENT GRAMS
THRU	ON				
		RATIO=1.414			
	35	0.0164	- -	- -	- -
35	48	0.0116	- -	- -	- -
48	65	0.0082	- -	- -	- -
		RATIO=1.189			
65	80	0.0069	22	18.1	3.98
80	100	0.0058	96	22.6	21.70
100	115	0.0049	72	28.3	21.00
115	150	0.0041	202	37.6	76.00
150	170	0.0035	112	43.2	48.30
170	200	0.0029	198	44.8	88.80
200			302	54.0	163.00

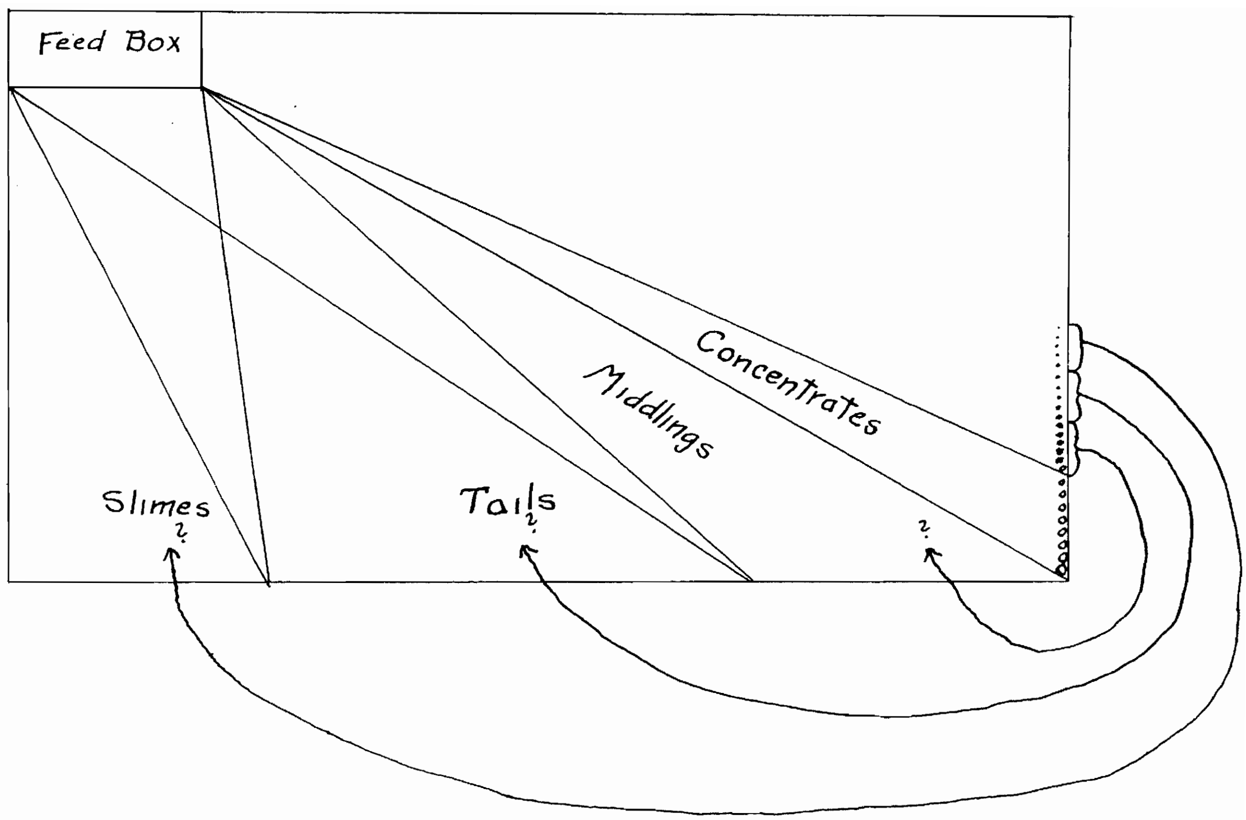

Diagram of Wilfley Table Separation