SAMPLING METHODS FOR IMPOUNDED TAILINGS

by

Robert W. Ageton

A Thesis

submitted to the faculty of the

Department of Mining Engineering and Metallurgy

in partial fulfillment of

the requirements for the degree of

Master of Science

in the Graduate College

University of Arizona

1945

Approved: H C Krumlauf, Director of Thesis, Dec 19, 1945, Date

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Illustrations

ACKNOWLEDGMENT

The writer gives grateful acknowledgment to Prof. J. B. Cunningham for his supervision of this work; to Dr. T. G. Chapman for his kind, keen, critical comments and suggestions; to Prof. H. E. Krumlauf for his assistance with the field work and the preparation of the thesis; and to George Roseveare (Metallurgist, Arizona Bureau of Mines) for his advice and suggestions.

The writer wishes to acknowledge the assistance given him with the field work and the continuous 300-pound metallurgical test by his fellow students, Messrs. Robert G. High, Peter M. Mosier, and Richard L. Flagg.

Chapter I - INTRODUCTION

Advances made in the treatment of ores and changing economic factors often permit the consideration of the re-treatment of impounded tailings. The first considerations in determining the economic feasibility of such treatment are (a) the size of the impounded deposit, and (b) the contained metal values. The experimental work described herein deals with the determination of the metal values in an impounded tailing deposit.

Some Factors Governing the Treatment of Tailing Deposits

Since the tailing deposit selected for the experimental work described herein originated from the treatment of gold ore many years ago, a statement of the factors which permits consideration of its retreatment is desirable. Important advances in the treatment of gold ores during the past fifty-five years include the introduction of the cyanide process during the period 1887 to 1893 and the application of the flotation process to the treatment of gold ores about 1928. A more recent development is the charcoal - cyanidation process still in the experimental pilot plant stage.[1] In addition to advances made in metallurgical processes, many mechanical equipment improve-

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[1] Chapman, T. G.: Cyanide Process based on the Simultaneous Dissolution and Adsorption of Gold. A.I.M.E., Milling Methods, vol. 134, 1939, p. 207.

ments in grinding, classifying, thickening, and agitating have been effected which have permitted simplification of treatment methods which in turn has resulted in decreasing the initial cost of plant and operating costs for the retreatment of tailing deposits. Furthermore, developments for the transportation of large tonnages of material at low cost which have been introduced during the past twenty-five years might provide added incentive for the retreatment of tailing deposits. Particularly, the use of trucks, tractors, conveyor belts, and scrapers for economical haulage has been widely acclaimed.

Price of metals is an important factor in the consideration of retreating tailing deposits. Selecting gold as an example, J. J. Croston[2] stated that the price of gold increased four-fold during the period 1344 to 1717. In 1717 the price was pegged at the equivalent of $20.67 per troy ounce and this price remained unchanged until April 20, 1933, when in a period of nine months the price of gold increased to $35.00 per troy ounce which is its current price. The increase in the price of gold in 1933 provided and still provides an incentive for the consideration of retreating tailing deposits containing

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2 Croston, J. J.: Effect of Revaluation on the Gold-Mining Industry. A.I.M.E. Trans., vol. 126, 1937, p. 302.

gold values.

Available Methods of Sampling Tailing Deposits

As previously mentioned, the experimental work described herein deals with only one phase of the problem of retreating tailing deposits; namely, the determination of the average metal value of the deposit. The determination of gross metal value includes obtaining samples of the deposit, which samples, although comprising a very small proportion of the entire deposit yet must be representative of the deposit with respect to metal content and physical characteristics. These samples are used for quantitative assays and analyses and for metallurgical process investigations.

In the past the methods which have been employed to obtain representative samples of tailing deposits include (1) Drive pipe, (2) Trenching, (c) Test pits, and (4) Auger drills.

The "drive pipe" method of sampling consists in driving a hollow steel pipe into the deposit and withdrawing a section of the deposit through which the pipe has traversed. The difficulties which have been encountered with this method are (1) it is difficult to retain granular material upon withdrawing the pipe, and (2) the depth to be sampled is limited to probably not over six feet.

Trenching comprises excavating comparatively narrow ditches and thereby exposing cross-sections of the deposit

for channel sampling. This method is not practical for impounded tailing, for the material of such deposits usually caves, and if a trench is broader at the top than at the bottom to prevent caving, relatively more material is taken from the top for the sample. The assay value of the material is certain to be in error unless the material of the dump is absolutely uniform. Further, the method presents a hazard to operators if the trenching is carried to appreciable depths.

Sampling by test pits consists in sinking pits to the bottom of the deposit thus exposing cross-sections for channel sampling. It is the most accurate method of sampling a tailing deposit, but it is usually too expensive to use. This method is used chiefly to confirm the results of auger sampling.

Auger drills used for sampling tailing deposits are similar to wood augers. They obtain a sample by boring a vertical hole to the desired depth and on being withdrawn bring to the surface a portion of the deposit through which the drill penetrated. These drills are considered as being the most satisfactory as well as the most economical method of sampling tailing deposits.

Review of the Literature

Baxter and Parks [3] state:

> "The sampling of stockpiles usually presents a special problem because of the segregation of the coarse and fine material which occurs when a body of mixed mined material is dumped from an overhead point."

Truscott [4] states:

> "It may be at once said that samples taken from the dump surface would be unreliable, since concentration or impoverishment may have resulted from the action of wind or rain. Moreover, the material at the surface need have no sort of relation to what lies at the bottom; the material there may be the richer residues of an earlier and less efficient equipment, or it may be scrap containing no material at all."

In addition to the mechanical segregations described by Baxter, Parks, and Truscott it is well recognized that segregation of soluble gold cyanide salts occur on the surface of a tailing deposit of former cyanide operations. The segregation is explained by the migration of the soluble salts to the surface of the deposit by capillarity. This segregation is so serious that approximately the top 18 inches of the tailing deposit should be sampled separately.

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[3] Baxter, C. H.; Parks, R. D.: Mine Examination and Valuation. Published by authors, Houghton, Michigan, 1939, p. 24.

[4] Truscott, J. J.: Mine Economics. Mining Publications, Ltd., Salisbury House, London, S. C. Z., 1937, p. 137.

The Ohio Copper Company [5] in 1928 sampled copper bearing mill tailing with 5-inch post auger holes to a maximum depth of 55 feet. The material within the limit of the drill holes was estimated at about five million tons with an average content of 0.42 per cent copper. Subsequent concentrator operations in treating this material showed a calculated mill head for 114,550 tons of 0.41 per cent copper which would indicate that drill hole sampling with 5-inch post hole augers was reliable with this material.

Attempts to sample tailings produced in the old Ophir Hill gravity concentrator Ophir Canyon, Tooele County, Utah,[6] with different types of the "conventional" auger drills were unsuccessful. Therefore, an auger was designed which consisted of a flat circular disk of three-eighths inch boiler plate 6½ inches in diameter, through the center of which a hole was cut to allow welding to a short length of three-fourths inch pipe. A 3-inch screw auger was welded to the pipe below the disk. The disk had two cutting edges on opposite sides. The auger had a core barrel one foot long and 6 inches in diameter. The metal contents of the deposit

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5 Milliken, F. R., and Goodwin, R.: Ohio Copper Company Tailings Retreatment Plant. A.I.M.E. Tech. Pub. No. 1221, (Min. Tech., July, 1940), pp. 1 and 2.

6 Thompson, Rip. V., and Peterson, E. C.: Reclamation and Treatment of the Ophir Hill Tailing Deposit. A.I.M.E. Tech. Pub. No. 1239, (Min. Tech., Nov., 1940), pp. 1-9.

were calculated from the composite of the cores. The tabulation which follows gives the metal content of the deposit as determined by drilling, and also the metal content of 222,140 tons which were subsequently treated.

Comparison of Sampling Results with Subsequent Calculated Mill Heads

	Drill Sampling	Calculated Mill Heads
Copper, per cent	0.65	0.71
Lead, per cent	2.20	2.00
Zinc, per cent	2.10	2.06
Iron, per cent	3.07	3.61
Silver, oz. per ton	2.60	2.79
Gold, oz. per ton	0.005	0.005

George J. Young [7] states that tailing deposits are preferably sampled by augers.

Lorain and Mihelich [8] report the use of a 3-inch Iwan Auger (see page 11) as a rapid, cheap method of sampling to

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[7] Young, George J.: Elements of Mining, 3d edition, McGraw-Hill Book Company, Inc., 1932, p. 679.

[8] Lorain, S. H., and Mihelich, M.: Hand Auger Rapid, Cheap to 140-ft. Depth in Clay. Eng. & Min. Jour., vol. 145, September, 1944, p. 78.

a depth of 140 feet in clay.

G. Austin Schroter [9] used a 1-3/4-inch Iwan-type auger to drill to depths of 30 feet through poorly cemented sandstone.

At the Yellow Aster Mine,[10] Randsburg, California, impounded amalgamation mill tailings were sampled by drilling by hand with ship augers and post-hole augers. The ship augers worked well in the dump slime, and the post-hole augers worked well in the sands.

Methods of Sampling Selected for Experimental Work

The writer selected auger drills for the experimental work of sampling as past experience of others indicated that this method of sampling would yield the best results. It was decided that the types of augers available at the College of Mines be used to sample a portion of a tailing deposit for the purpose of comparing mechanical suitability and analytical results of the various types. The results of the auger samples are to be compared with the values obtained from material excavated from a 3 by 5 by 6 foot pit; the channel samples of the pit walls; and with the calculated composite heads of a mill test employing the excavated material.

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9 Schroter, G. A.: Bleaching Clays Find Increasing Use. Eng. & Min. Jour., vol. 140, Nov., 1939, p. 38.

10 Sabin, A. B.: Sampling Yellow Aster Tailings, Eng. & Min. Jour., vol. 136, September, 1935, p. 444.

Chapter II.- TAILING DEPOSIT SELECTED FOR SAMPLING AND DISCUSSION OF SAMPLING EQUIPMENT

The material selected for the experimental sampling work was the impounded tailing of the Bonanza mill located eight miles south of Salome, Yuma County, Arizona.[11] The tailing is a product of the treatment of gold ore by amalgamation in a 20-stamp mill erected in May, 1891, followed by the cyanidation of the amalgamation tailing in a 150-ton capacity cyanide plant erected in 1895. The amalgamation treatment was operated by the Bonanza Mining Company and the cyanide operation by the Harqua Hala Gold Mining Company, Ltd. The latter company purchased the property in 1893. The treatment of the accumulated amalgamation tailing by cyanide was completed in 1897. Minor metallurgical operations were conducted intermittently since 1897. The gross value of gold produced from the property from 1891 to 1929 amounted to $2,510,700.

Preliminary Examination of the Deposit

The writer made a preliminary examination of the deposit on October 22, 1944 employing a Brunton Compass and pacing distances. The plan of the deposit approximates the figure of a parallogram, the longer side being about 230 feet, and

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[11] Wilson, E. D., Cunningham, J. B., and Butler, G.M.: Arizona Lode Gold Mines and Gold Mining; Ariz. Bur. of Mines Bull. 137 (1934), p. 128.

the shorter side being about 150 feet. The front of the deposit, one of the longer sides, bears about N 40° E, and the bearing of the shorter sides is about S 30° E. Two shafts are located in the south half of the dump; one has the dimensions 3 by 5 by 25 feet deep, and the other is 3 by 5 by 15 feet deep. A portion of the deposit measuring 6 by 8 feet was selected for sampling.

Description of Auger Drills Available for Experimental Work

Four types of auger drills were available for sampling and a description of each type follows:

Screw Auger: This drill is a common wood type two inches in diameter with double flutes 8 inches long, having a spiral pitch of 3½ inches. Six 3-foot lengths of slip joint extension rods were available which permitted drilling to a maximum depth of 20 feet. This auger was not equipped with casing.

Screw Auger with Casing: A casing was constructed for the drill described above comprising a 2-inch diameter pipe, 15 inches long, and 3/16 inch in thickeners. The cutting end was built with two cutting points to match the two points of the auger drill. The casing was secured to the auger shank by two set screws at the top end of the casing.

Iwan Auger: This auger consists of two rigid curved blades 8 inches long, each with a cutting edge on the side, and four cutting points at the lower end. Two of the cutting points are riveted together. These blades are rigidly fastened to a cast iron yoke to which lengths of three-fourths inch

diameter pipe with standard threads may be attached. This auger cuts a hole 4 inches in diameter. Plate I shows a view of the auger.

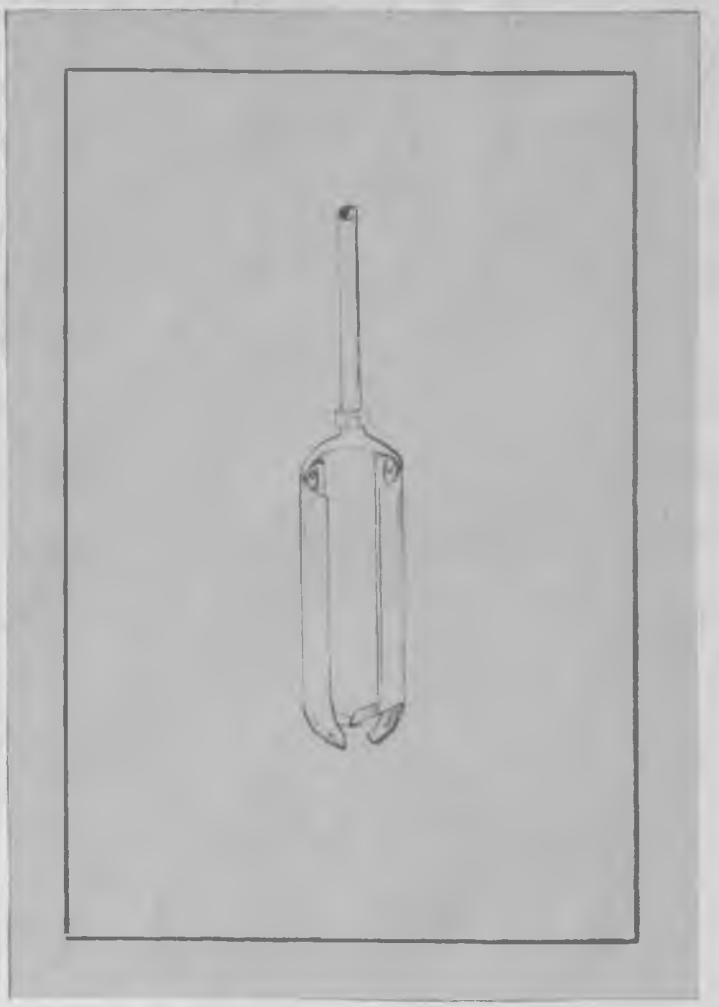
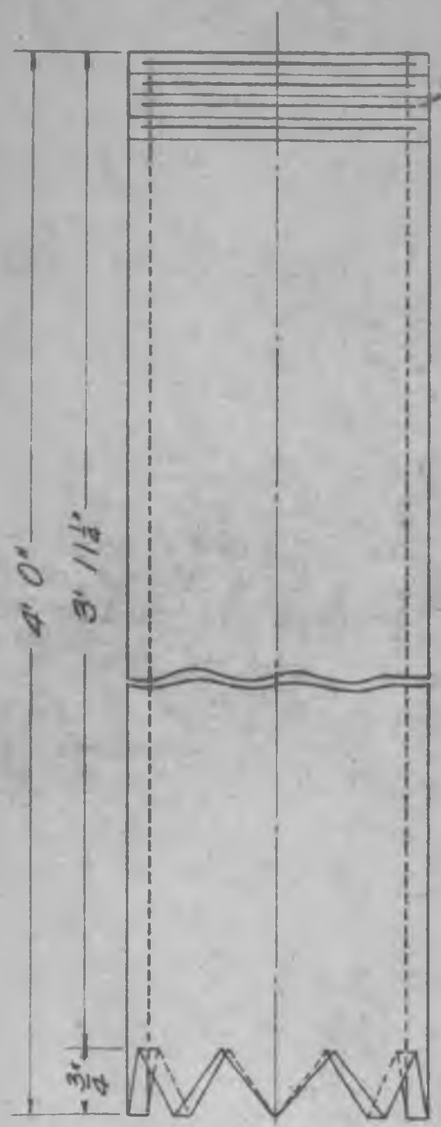


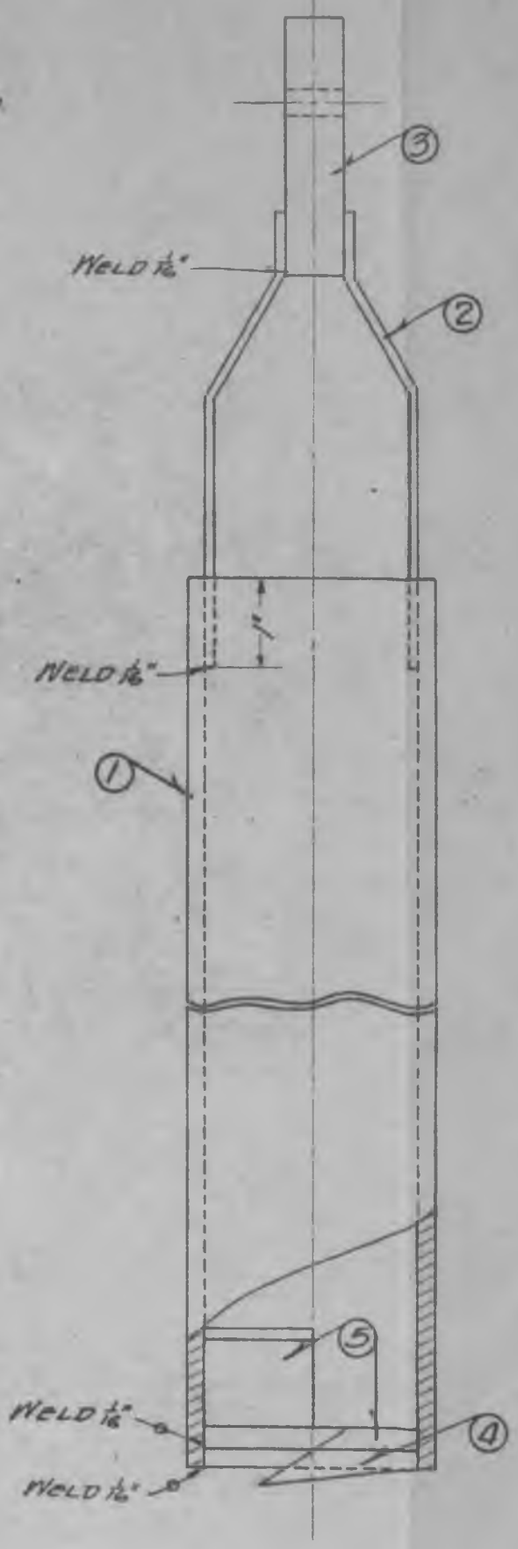
Plate 1. - Iwan Auger.

Designed Auger: Referring to Plate 2, this auger consisted of a 3-inch diameter pipe casing and a 2½-inch inside diameter auger. The pipe casing had a cutter four feet in length. This casing cutter was equipped with eight teeth at the lower end which were bent toward the outside of the pipe so that the diameter of the hole cut by the cutter was slightly larger than the outside diameter of the casing. Additional lengths of casing could be attached to the cutter with standard pipe couplings which permitted drilling to a maximum depth of 12 feet. The auger drill was made from standard 2½-inch pipe, and had a core barrel, a cutting bit, and a cutting bit cover. A yoke welded to the top of the core barrel comprised two flat steel braces and a short length of 11/16 inch diameter steel rod.

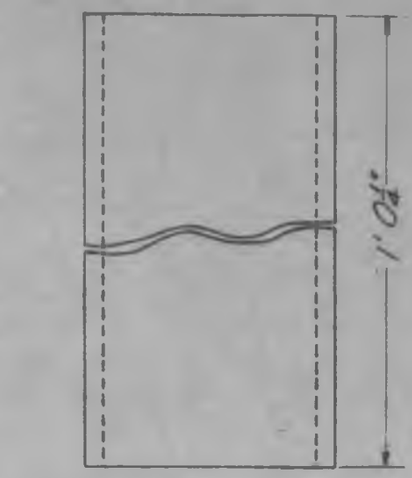
Plate 2



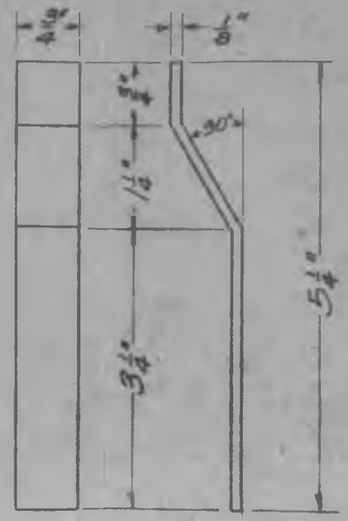
CASING CUTTER
3" Std. Pipe 1-Reqd.



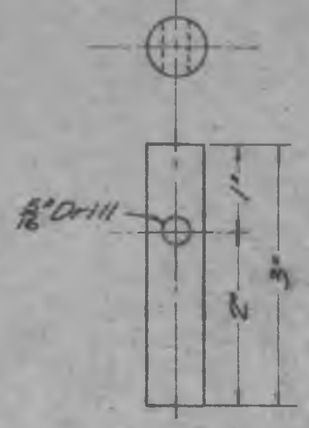
AUGER DRILL



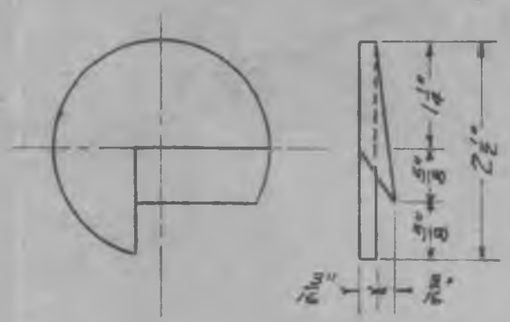
① CORE BARREL
2½" Std. Pipe 1-Reqd.

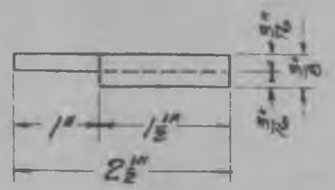


② BRACE
Strap Steel 2-Reqd.

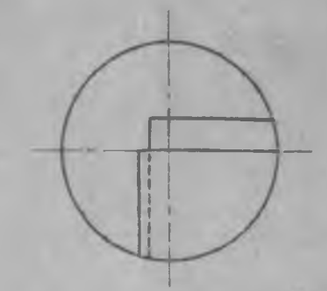


③ STEEL ROD
⅝" ϕ 1-Reqd.

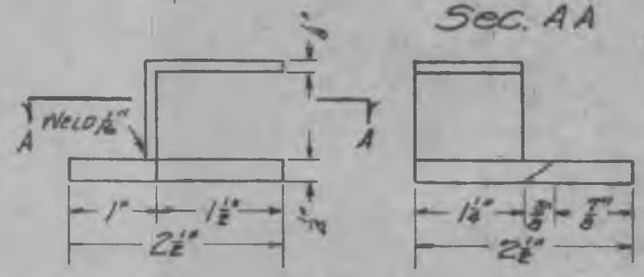




④ BIT
Steel 1-Reqd.



Sec. A A



⑤ BIT COVER
Steel 1-Reqd.

AUGER DRILL AND CASING

SCALE ½" - 1"

Designed By - R. W. Ageton
Date - February 7, 1945

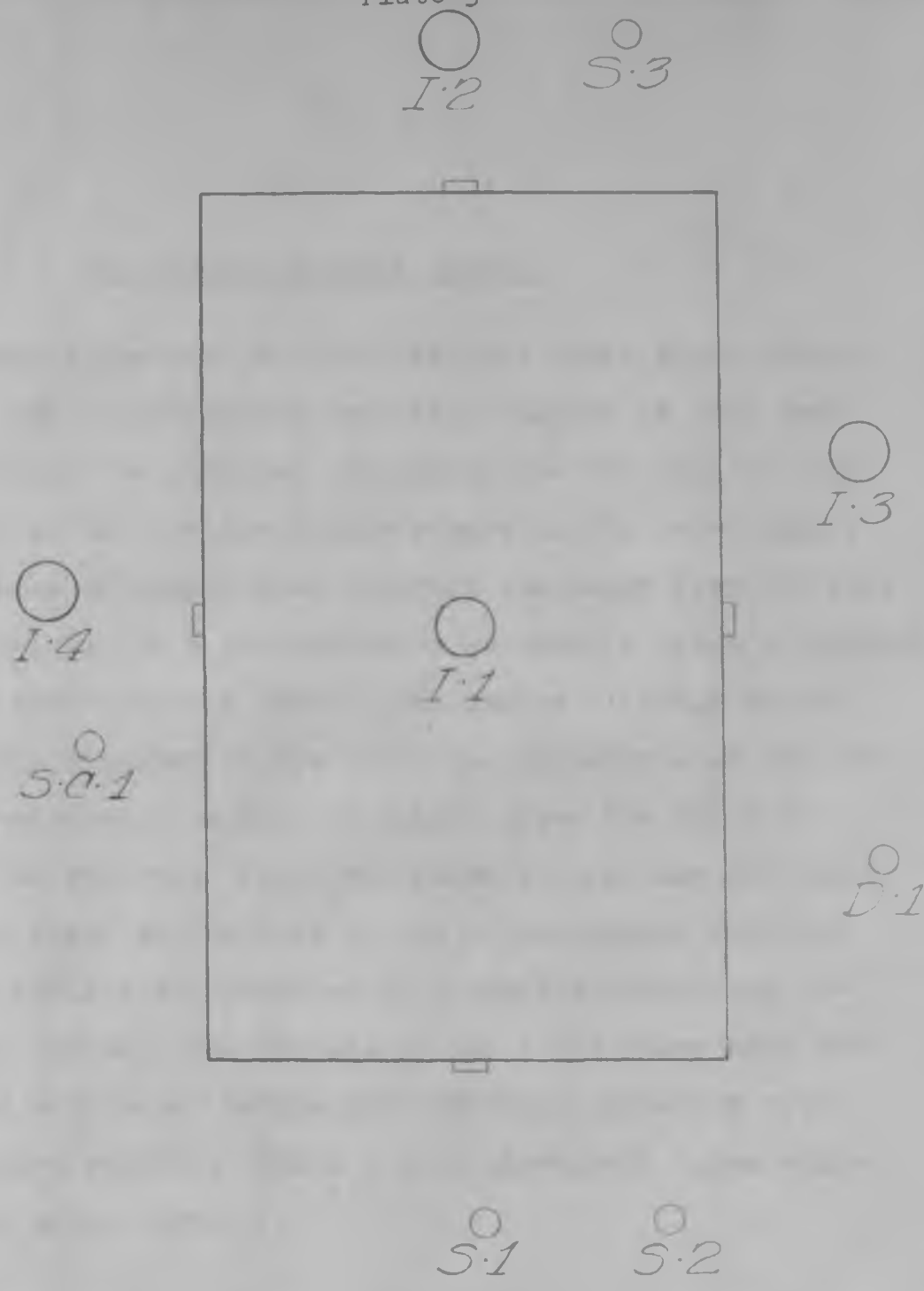
Chapter III - EXPERIMENTAL WORK

The sampling of the portion of the tailing deposit previously mentioned was done March 10 and 11, 1945 by five men and required two full days.

The top 36 to 40 inches of the portion of deposit selected had been removed for experimental metallurgical work by the Eagle Picher Mining and Smelting Company about March, 1944 and therefore it was necessary to remove only a few inches of the surface to avoid segregation of soluble gold salts by capillarity.

Plate 3 gives a plan showing the locations of the drill holes and shaft excavation. The locations for the drill holes were staked about one foot from the boundary of the proposed shaft. By locating the drill holes as closely as possible to the shaft, it would not be necessary to "weight" the holes in order to compare average drill hole assay values with that of the pit sample, the average of the channel samples, or the calculated mill heads. Separate samples were sacked for each 2-foot advance of the auger drill.

Plate 3



HOLE LAYOUT OF SHAFT SAMPLING

KEY

I — Iwan Auger
S C-Screw Auger with Casing
S — Screw Auger
D — Designed Auger
⊔ Channel Cut

N

Date: Feb. 7, 1945
Scale: 1" = 1' 0"
By: R.W. Ageton

Screw Auger Without Casing

Three holes were drilled with the Screw Auger without Casing. One objectionable operating feature of this type of drill from the sampling standpoint was the loss of core. The material did not completely adhere to the screw auger, and the loss of sample when removing the auger from the hole was excessive. As a precautionary measure, a piece of canvas one foot square with a hole in the center slightly larger than 2-inch diameter of the drill was centered over the hole and prevented serious loss of sample after the drill had reached the surface. Water was added to one hole drilled by the screw auger at the rate of one to two ounces for each 4 inches drilled and resulted in a greater percentage recovery of sample. The threads of the screw auger were also moistened with water before each drilling operation with satisfactory results. Plate 4 is a photograph taken while using the screw auger.

Plate 4

Screw Auger without Casing

Table I gives the drilling speeds of the screw auger.

Table I

Drilling Speeds of the Screw Auger

No.	Minutes 0 to 2 ft.	Minutes 2 to 4 ft.	Minutes 4 to 6 ft.	Totals for 6 ft.	Average Advance per core pull, ft.
1	9	19	15	43	0.27
2	8	12	15	35	0.25
3	15	11	14	40	0.25
Aver.	10.7	14.0	14.7	39.3	0.26

Screw Auger with Casing

Drilling with screw auger with casing was confined to one hole since operation of this drill was extremely difficult due to the packing of material in the opening to the core barrel, thus tending to prevent the downward movement of the screw. Furthermore, the sample that was finally forced into the core barrel was packed, and difficult to remove. The 2-inch pipe casing was held in place by two set screws which were readily

removed, but it was believed that time could be saved by tapping lightly on the core barrel rather than removing the casing each time the drill was pulled.

Plate 5 is a photograph taken while operating the auger drill with casing.

Iwan Auger

Five holes were drilled using the Iwan Auger. This drill is readily operated; there is little loss of the sample when withdrawing the drill from the hole; and the drill does not bind in the hole.

The speed of drilling holes with the Iwan Auger are given in Table 2.

Table 2 - Drilling Speeds of the Iwan Auger

Hole No. (1)	Minutes, 0 to 2 ft.	Minutes, 2 to 4 ft.	Minutes, 4 to 6 ft.	Totals Minutes, 6 ft.	Average advance per core pull, ft.
1	11	19	13	43	0.30
2	14	10	15	39	0.25
3	15	16	16	47	0.25
Aver.	13.3	15.0	14.7	43	0.27

(1) One hole was drilled without timing.
One hole, 16 feet deep, is not included in Table 2.

Plate 5.

(a) Screw Auger with casing.
(b) Iwan Auger.

One hole was drilled with the Iwan Auger to determine the drilling time for a hole 16 feet deep. The material from this hole was not used as a sample. The time periods required to drill from 6 to 16 feet are given in Table 3.

Table 3

Iwan Auger Drill - Drilling Speeds between 6 and 16 feet

Interval, ft.	6 to 8	8 to 10	10 to 12	12 to 14	14 to 16
Minutes	11	14	17	15	17

Referring to Table 3, the results of this test indicate that the Iwan Auger can be effectively operated to a depth of 16 feet, and because the average time of drilling did not show much increase up to a depth of 16 feet, it would indicate that this drill can probably be effectively used at a greater depth. Catlett [12] states that auger drills can be used up to 35 feet without the use of a tripod.

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12 Catlett, Charles: The Hand Auger and Hand Drill in Prospecting Work. A.I.M.E. Trans., vol. 27, 1898, p.123.

Sampling with Designed Auger

The designed auger functioned very unsatisfactorily when it was used to sample the Bonanza tailing. The difficulty was no doubt due partly to the nature of the material, a mixture of sandy quartz with argillaceous slime. The casing cutter could not be driven, nor could it be revolved as rapidly or as readily as anticipated; the core-cutter and barrel arrangement did not function, since its action was dependent upon the proper operation of the casing cutter. Further, the clayey material lodged firmly in the 1-inch opening, preventing movement of material up the core barrel.

The difficulties encountered in sampling the Ophir Hill mill tailing as described by Thompson and Peterson [13] when ordinary augers were used, were no doubt similar to the difficulties the writer encountered when using the so-called designed auger. The writer is of the opinion that if a short length of screw auger had been attached below the cutting bit of the auger in a manner similar to the one designed by Thompson and Peterson when they successfully sampled the Ophir Tailing, the results of the designed auger would have been more successful.

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[13] Thompson, R. V., and Peterson, E. C.: op. cit., p. 2.

Summary of the Drilling Operations

The Designed Auger and the Screw Auger with casing were found to be unsuitable for the sampling of the Bonanza Tailing deposit. It is possible, however, that these drills would operate satisfactorily on less compact deposits with lower clayey contents. The review of the literature revealed that no one drill was universally acceptable for the sampling of all tailing deposits; hence, the writer believes that additional work with the so-called designed auger on different deposits would be justified.

The Iwan Auger and the Screw Auger are very readily operated drills. Referring to Tables 1 and 2, a comparison of the drilling results of these augers indicates that the Screw Auger is a slightly faster boring drill and that the average advance per core pull of the two drills is almost the same. Since one very important objectionable quality of the Screw Auger is the loss of core the writer believes that the Iwan Auger is the better drill to use for the sampling of any tailing deposit containing granular material.

Shaft Sampling

Upon the completion of the drilling program the previously located pit was excavated. This pit when completed

was 3 by 5 by 6 feet deep with vertical sides. As the material was excavated it was shoveled on to 5 by 5 foot canvas mixing cloths and then transferred to iron plates for standard coning and quartering samples. About one-sixteenth of all the pit material removed, approximately 500 pounds, was taken to the University of Arizona for further sampling and metallurgical testing. A photograph of the excavated pit and equipment for sampling excavated material is shown as Plate 6.

Channel Sampling

After the pit had been excavated, channels 1 inch deep by 3 inches wide were cut down the center of each wall of the shaft. By cutting the channel down the shaft the cut would be at right angles to the sand and slime layers, the correct procedure for this method [14] of sampling.

Preparation of Samples

All of the auger samples and channel samples were sampled with a Jones sampler, sacked, labeled, and taken to the University of Arizona. They were then dried, further sampled and assayed in duplicate. Table 4 shows the results

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[14] Louis, Henry: Mineral Valuation, Charles Griffin & Company, Ltd., London, 1923, p. 139.

of the analysis for their gold content.

Plate 6

Sampling Pit Material

Table 4

Assay Results of Field Sampling

Depth, ft.	Gold, ozs. per ton: Channel Samples of Shaft Walls: N Wall	S Wall	E Wall	W Wall	Screw Auger with Casing	Screw Auger Without Casing: Hole No. 1	2	3	4-in. Iwan Auger: Hole No. 1	2	3	4
0 to 2	0.025	0.030	0.030	0.030	0.027	0.025	0.023	0.045	0.023	0.023	0.027	0.025
2 to 4	0.035	0.030	0.030	0.045*	0.028	0.030	0.030	0.040	0.033	0.025	0.045	0.030
4 to 6	0.025	0.025	0.025	0.050*	0.025	0.028	0.025*	0.035	0.030	0.025	0.020*	0.020
Average	0.028	0.028	0.028	0.042	0.027	0.028	0.026	0.040	0.029	0.024	0.031	0.025
Average Assay by Each Method		0.031			0.027		0.031			0.027		

Weighted average = 0.0293 oz. gold per ton

* These assays were rechecked.

Referring to Table 4, the average assay of the samples obtained by the Screw Auger Without Casing, namely 0.031 ounces gold per ton, agrees with the result obtained by Channel Sampling which, as previously stated, is its most accurate method of sampling a tailing deposit. Comparisons of sampling methods will be given after discussion of results obtained on the heads of a 300-pound metallurgical test.

Metallurgical Test of Shaft Sample

As previously mentioned about 500 pounds of the Bonanza tailing, being the one sixteenth cut from the material excavated from the pit was sampled in University of Arizona laboratories in order to obtain a head sample, a sample for a batch charcoal-cyanide test, and also a 300-pound sample for a continuous treatment test.

Screen Analysis of Bonanza Tailing

Mesh	Weight, Per cent	Cum. Weight, Per cent
+ 65	19.8	19.8
+ 100	14.0	33.8
+ 150	14.1	47.9
+ 200	15.7	63.6
- 200	36.4	36.4

Three moisture determinations of the Bonanza tailing were made and showed an average moisture content of 4.8 per cent.

Batch Charcoal-Cyanidation Test of Shaft Sample

A sample of 500 grams was ground minus 100-mesh and revolved in open bottle with 1.2 lbs. caustic soda, 0.60 lb. sodium cyanide and 4.0 lbs. of activated charcoal per ton of tailing for 18 hours. The pulp was then transferred to a 500-gram capacity Denver flotation machine and the charcoal floated with fuel oil and pine oil. The concentrate was removed for 5 minutes and a middling followed for 15 minutes.

The rougher concentrate and middling were not cleaned.

The cyanide and alkali consumptions amounted to 0.4 and 1.0 lb. per ton of tailing, respectively. The results of this test are given in Table 5.

Table 5. Results of batch charcoal-cyanide test

	Weight, grams	Tons per 100 tons heads	Assays, oz. gold per ton	Units oz. gold	Distribution, per cent
Heads (by assay)	-	-	0.030	-	-
Heads (by products)	-	-	0.031	-	-
Concentrate	2.41	0.48	3.26	1.565	49.8
Middling	6.33	1.27	0.069	0.088	2.8
Tailing	491.26	98.25	0.015	1.474	47.4
Totals	500.00	100.00	-	3.127	100.0

Referring to Table 5, the heads by assay amounted to 0.030 ounce gold per ton compared to a products assay of 0.031 ounce gold per ton. The extraction of the gold in charcoal concentrate was 49.8 per cent.

Continuous Charcoal-Cyanide Test of Shaft Sample

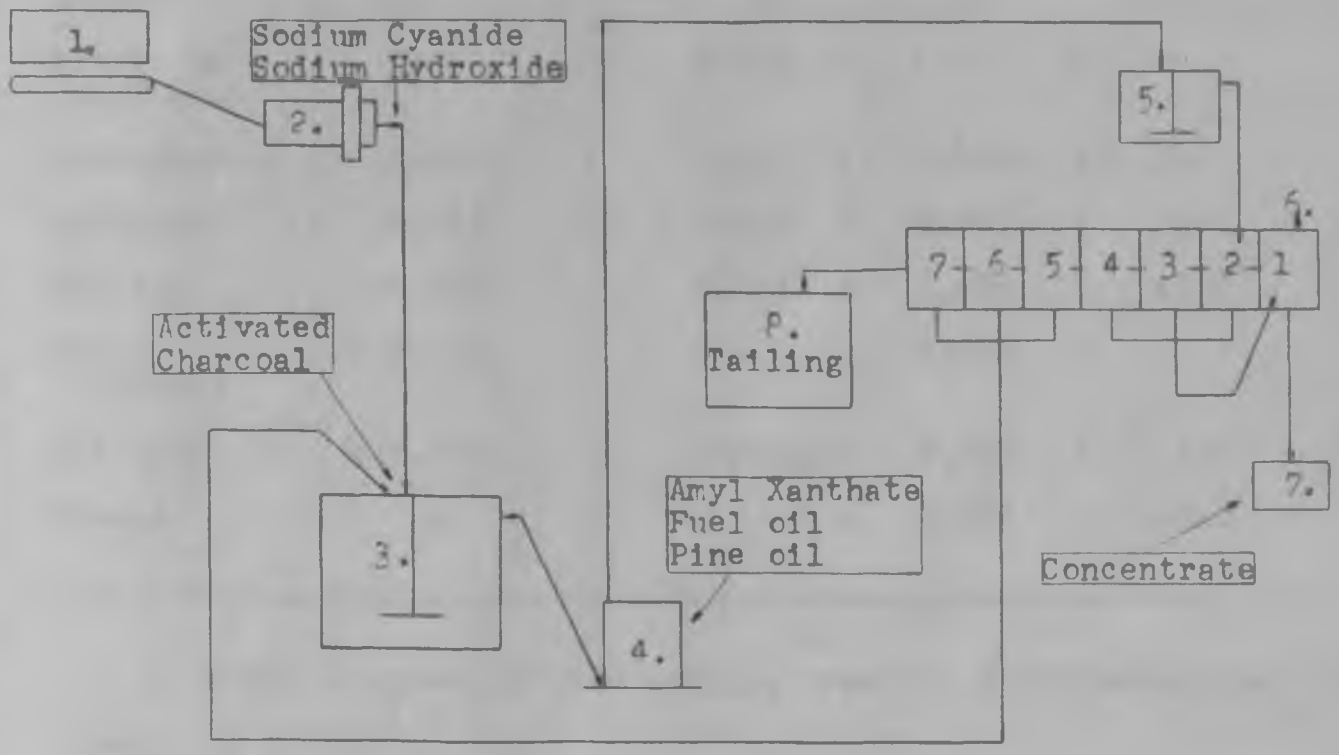
Referring to Plate 7, tailing was fed to a ball mill by a conveyor ore feeder at the rate of one pound per minute. The ball mill pulp containing 71 per cent solids was treated in Denver agitator with 0.58 lb. sodium cyanide, 1.1 lbs. caustic soda and 4.3 lbs. activated charcoal per ton of tailing. The detention time of the ore pulp in the agitator was 76 minutes. The agitator overflow was conditioned with 0.10 lb. of fuel oil, 0.10 lb. of pine oil and 0.10 lb. of amyl xanthate per ton of tailing. The conditioned pulp was treated in a 7-cell No. 5 Denver flotation machine with one stage of cleaning as shown on Plate 7.

The consumption of cyanide and caustic soda was 0.4 and 1.0 lb. per ton of tailing respectively.

The results of this test are given in Table 6.

Plate 7

TEST MILL FLOWSHEET AND LEGEND



LEGEND

1. Conveyor Ore Feeder: 3.2 cu. ft. hopper.
2. Ball Mill: 16 by 32-in.
3. Denver Conditioner, 18 by 24-in.: 3.28 cu. ft.
4. Denver Vertical Sand Pump.
5. Denver Conditioner: 12 by 18-in.: 1.10 cu. ft. capacity.
6. Denver No. 5 "Sub-A" Laboratory Flotation Machine - 7 cells.
7. Concentrate settling tank.
8. Tailing settling tank.

Table 6. Results of continuous charcoal-cyanide test

	Tons per 100 tons of heads	Assays, ozs. gold per ton	Units oz. gold	Distribution, per cent
Heads (by assay)	-	0.030	-	-
Heads (by products)	-	0.031	-	-
Concentrates	1.017	1.166	1.186	38.3
Middling	0.427	0.015	0.006	0.2
Tailing	98.556	0.015	1.487	47.7
Totals (solids)	100.000	-	2.670	-
Solution	285.810	0.0015	0.429	13.8
Totals	-	-	3.099	100.0

A screen analysis of the tailing from the above metallurgical test follows:

Screen Analysis of Mill Tailing

Mesh	Weight, per cent	Cum. Weight, per cent
+ 65	0.8	
+ 100	3.8	4.6
+ 150	7.5	12.1
+ 200	27.3	39.4
- 200	60.6	60.6

Referring to Table 6, the heads by assay amounted to 0.030 ounce gold per ton compared to a products assay of 0.031 ounce gold per ton. The extraction of the gold in cleaner flotation concentrate was 38.3 per cent.

Table 7 presents a comparison of the results obtained from six methods of sampling the Bonanza Tailing.

Table 7. Comparison of Sampling and of Assay Results.

	Gold, ounces per ton
Channel Sampling	0.031
Screw Auger with Casing	0.027
Screw Auger without Casing	0.031
Iwan Auger	0.027
Mill Heads of Continuous Test by Assay	0.030
Products Heads of Continuous Test	0.031

Chapter IV - CONCLUSIONS

1. The assumption is made that the product heads of the continuous 300-pound metallurgical test gives an accurate assay of the gold content of the portion of the Bonanza tailing selected for the experimental sampling work. Referring to Table 6, the metallurgical tests showed an assay value of 0.031 ounce gold per ton.

2. Referring to Table 7, the Channel sampling and the Screw Auger without Casing gave identical results as a 300-pound metallurgical test, namely, 0.031 ounce gold per ton. It is concluded, therefore, that these two methods of sampling yielded the most satisfactory results.

3. Referring to Table 7, the Screw Auger with Casing and the Iwan Auger each showed an assay value of 0.027 ounce gold per ton. Only one hole was drilled with the Screw Auger with Casing. It is believed that the accuracy of assaying justifies the statement that the Iwan Auger method of sampling yielded a result approximately 13 per cent lower than Channel sampling and Screw Auger sampling without casing.

4. The Designed Auger proved to be unsatisfactory for sampling the Bonanza Mill tailing.

5. From an operating standpoint the Iwan Auger proved to be the most satisfactory drill.

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