The Use of Falcon Concentrator to Determine the Gravity Recoverable Gold (GRG) Content in Gold Ores

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Abstract

This study presents the results of the application of the laboratory gravity-recoverable-gold (GRG) determination procedure on a Turkish gold ore using a Falcon concentrator. The study had two major goals; as investigating the compatibility of Falcon concentrator for GRG procedure (which was originally developed for Knelson concentrator); and finding out the gravity recoverable gold content in Gümüşhane/Mastra gold ore. It was seen that a concentrate enriched in Au content could be successfully achieved: After the first stage a product with an Au grade of 41.09 mgAu/tonne at %10.95 fractional gold recovery at the first stage of the procedure. Au content in the concentrate increased to 98.84 mg after the second stage and finally 59.74 mg Au was obtained by the third stage. As a result of the application, it was found that the GRG content of Gümüşhane/Mastra gold was 48.28%, corresponding to a significant potential for obtaining an Au-enriched preconcentrate.

Keywords: gravity recoverable gold, centrifugal gravity concentrator, preconcentration, Falcon concentrator

Introduction

High specific gravity of gold enables its separation from other minerals within the ore utilizing the density difference (Wills, 1997). In the gravity concentration process, gold grains should preferably be free and at coarse size to be able to perform an efficient separation (Adams, 2005). The use of gravity concentration methods to obtain a preconcentrate offers several advantages such as, shorter leaching time due to the removal of free coarse values, reduction in the consumption of leaching reagents and activated carbon in the CIP process (Vincent, 1997, Tanrıverdi, 1997). Potential removal of coarse and free valuable minerals prior to flotation also aids in improving the overall capacity and efficiency of the circuit.

Conventional gravity concentration equipments including jigs, shaking tables and spiralsare not sufficiently capable to recover high density minerals from relatively low-density gangue on accounts of the serious decline in the grade and liberation size. New generation, centrifugal gravity concentrators such as Mozley multi-gravity separator, Kelsey jig, Knelson concentratorand Falcon concentrator, developed in recent years brought a significant solution to this problem. The solution with these equipments relies on the working principle of such concentrators where the effects of centrifuging and gravity are combined. High centrifugal acceleration enables density separation at relatively finer sizes as compared to conventional gravity concentration units (Klein et al., 2010). These concentrators have been successfully used for the recovery of finely liberated particles of valuable minerals and their tailings as well as recovery of value-including-middlings after coarser grinding (Venkatraman et al., 2000; Bradley et al., 2000; Klein et al., 2010).

The Falcon concentrator was developed by the Falcon Concentrator Company of Vancouver, British Columbia in 1983. Falcon is basically an centrifugal gravity concentrator with similar features of Knelson concentrator. The concentration is achived in a fast spinning bowl. The device is fed from its bottom and employs centrifugal force to drain the slurry as a thin flowing film at its wall (Fonseca, 1995). The heavier particles are retained inside the bowl while the lighter minerals flow out with the fluid.

Many researchers have applied centrifugal concentrators for concentration of gold ores and a specifically dedicated procedure was developed to determine the amount of gravity recoverable gold content by centrifugal concentrators (Woodcock and Laplante, 1993, Laplante et al., 1996a; Laplante et al., 1996b). In this study, the gravity recoverable gold (GRG) determination procedure that was primarily developed by Andre R. Laplante's and became a standard labscale procedure was applied to determine the GRG content of the Gümüşhane/Mastra gold ore using a Falcon concentrator. The aim was to investigate the applicability of this procedure with a Falcon as well as to

Tab. 1. First Stage of the GRG Test Using Falcon (*Au assays of fractions were found based on the total head assay)

Tab. 1. Pierwszy etap tesu GRG dla wzbogacalnika Falcon zawartość Au oznaczono jako zawartośc całkowitą

Particle Size (µm)	Feed Au (mg)	Concentrate		Tailing		Fractional Recovery (%)	
		W (%)	Au (mg)	W (%)	Au (mg)	Conc.	Tail.
-1000+600	18.17	4.03	0.16	2.53	18.01	0.89	99.11
-600+355	124.12	47.96	1.63	30.13	122.49	1.32	98.68
-355+180	27.97	13.92	0.28	6.51	27.69	1.01	98.99
-180+106	66.90	19.95	1.05	21.95	65.85	1.57	98.43
-106+75	20.27	6.14	2.32	6.90	17.94	11.45	88.55
-75+53	16.75	3.90	3.88	5.64	12.87	23.17	76.83
-53	100.00	4.09	31.76	26.34	68.24	31.76	68.24
Total	374.18	100.00	41.09	100.00	333.08	10.98	89.02

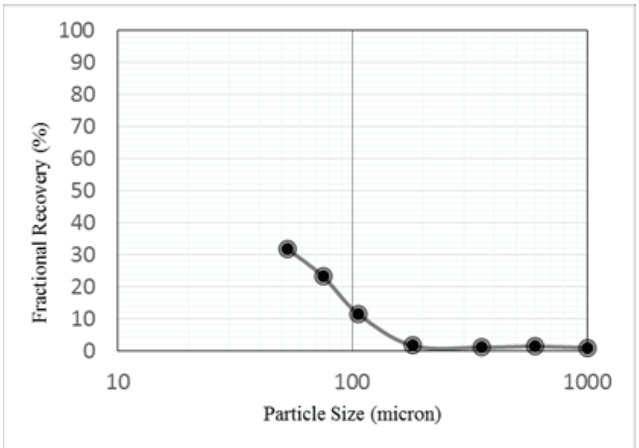

Fig. 1. Fractional gold recovery after first stage

Rys. 1. Uzysk złota po pierwszym etapie

seek the opportunity of obtaining an Au-enriched preconcentrate using centrifugal gravity concentration prior to finer grinding and further processing of the ore.

Material and Methods

Test Sample

For the test work gold ore from Gumushane-Mastra gold mine was used . The ore is a vein type and characterized as low sulphite epithermal deposit with gold and silver as major values. Galena, sphalerite chalcopyrite, arsenopyrite, pyrite, quartz, calcite minerals occur as accessory minerals in the ore (Tüysüz et al., 1995). It was reported that the ore contains gold entities with a mean diameter of 30 microns and 47.2% of the gold can be potentially be recovered by centrifugal gravity concentration using a Knelson concentrator at a P80 size of 75 µm (Celep et al., 2006).

Methods

For the assessment of the applicability of gravity-recoverable-gold (GRG) procedure using a Falcon type concentrator, a Falcon L40 laboratory scale concentrator was used . The original GRG test procedure involves the treatment of 50 kg ore sample using a batch laboratory type Knelson-Concentrator, mainly a MD3. The procedure includes three treatment stages in total. The first stage is conducted using the ore sample ground to a P100 size of - 850 micron. The subsequent two runs are performed using the tailings of the preceding phases as the feed. Second stage is performed on approximately 24 kg of 45–55 % -75 micron feed, and the last stage is performed on 18 to 21 kg feed with a size of 75–80% -75 microns (Laplante et al., 1996a).

Representative samples from the products of each stage were filtered, dried at 105 C^0 and ground to -106 micron for chemical analysis and

Tab. 2. Second Stage of the GRG Test Using Falcon (*Au assays of fractions were found based on the total head assay)

Tab. 2. Drugi etap tesu GRG za pomoca wzbogacalnika Falcona (Au oznaczono jako zawartość całkowitą)

Particle Size (µm)	Feed Au (mg)	Concentrate		Tailing		Fractional Recovery (%)	
		W (%)	Au (mg)	W (%)	Au (mg)	Conc.	Tail.
-1000+600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-600+355	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-355+180	30.53	9.05	0.84	5.13	29.69	2.76	97.24
-180+106	122.05	38.74	2.95	31.65	119.10	2.42	97.58
-106+75	38.08	17.85	2.52	12.06	35.55	6.63	93.37
-75+53	11.75	12.60	3.23	8.17	8.53	27.46	72.54
-53	179.46	21.75	89.29	42.99	90.17	49.76	50.24
Total	381.87	100.00	98.84	100.00	283.03	25.88	74.12

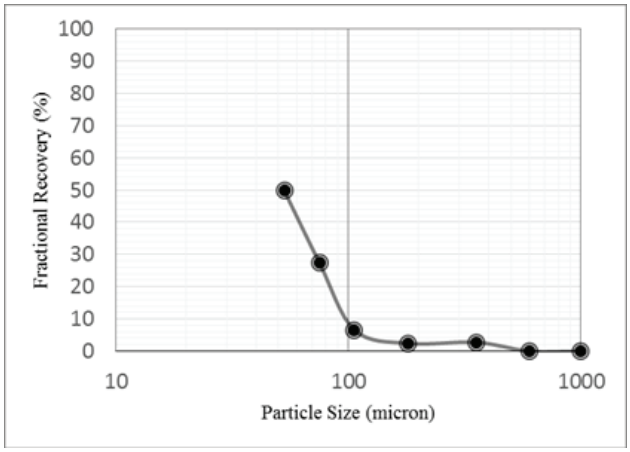

Fig. 2. Fractional gold recovery after second stage

Rys. 2. Uzysk złota po drugim etapie

characterization. Aqua regia mixture was used to dissolve gold. Gold assays were determined by AAS using a Perkin–Elmer Atomic Absorption Spectrophotometer.

Results and Discussion

The first stage of the test was performed using 123 G centrifugal force, 15 l/min wash water and at a feed rate of 1000 g/min. The results are given in Table 1 and Figure 1.

The highest fractional recovery was obtained as 31.76% at -53 µm fraction. As seen in Figure 1, fractional gold recovery tends to increase with decreasing particle size. Overall gold recovery was determined as 10.98% at this stage.

The tailing of the first stage concentration test was ground to 55% -75 µm to be used as feed for the second stage. 24 kg of feed was subjected to Falcon concentration at 123 G centrifugal force, 13.5 l/min wash water and at a feed rate of 500 g/min . The results of the second stage are presented in Table 2 and Figure 2.

Overall gold recovery increased to 25.88% at the end of the second stage. The highest fractional recovery was obtained at -53 µm similar to the first stage. Figure 2 indicates a similar trend to that seen in Figure 1, revealing the reduction in fractional recovery with increasing particle size.

The last stage of the GRG procedure was performed using the tailing of the second stage after grinding to a P80 size of 75 µm. 20 kg feed was used for this stage at 400 g/min.feed rate, 123 G centrifugal force and 10.5 l/min wash water rate. The results are presented in Table 3 and Figure 3.

Total calculated gold content of the feed decreased to 273.64 mg after two concentration steps. Falcon concentrator produced a concentrate containing 59.74 mg of Au at 21.83% recovery. The highest Au grade was identified in the finest fraction again. As can seen in Figure 3, the same

Tab. 3. Third Stage of the GRG Test Using Falcon (*Au assays of fractions were found based on the total head assay)

Tab. 3. Trzeci etap tesu GRG za pomoca wzbogacalnika Falcona (Au oznaczono jako zawartość całkowitą)

Particle Size (micron)	Feed Au (mg)	Concentrate		Tailing		Fractional Recovery (%)	
		W (%)	Au (mg)	W (%)	Au (mg)	Conc.	Tail.
-1000+600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-600+355	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-355+180	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-180+106	13.38	9.36	0.28	2.32	13.09	2.11	97.89
-106+75	61.78	33.08	2.09	16.68	59.69	3.39	96.61
-75+53	50.52	25.48	1.40	18.32	49.13	2.77	97.23
-53	147.96	32.07	55.97	62.69	91.99	37.83	62.17
Total	273.64	100.00	59.74	100.00	213.90	21.83	78.17

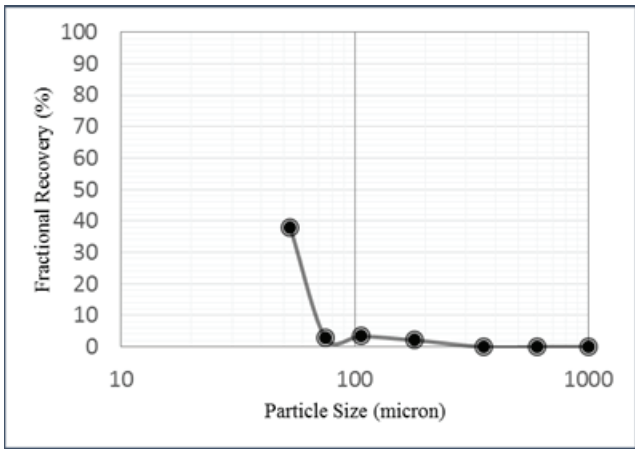

Fig. 3. Fractional gold recovery after third stage

Rys. 3. Uzysk złota po trzecim etapie

Tab. 4. Cumulative calculated recoveries of the individual stages

Tab. 4. Wyliczone uzyski skumulowane w kolejnych stadiach

Particle Size (µm)	Cumulative Calculated Recovery (%)		
	1st Stage	1st & 2nd Stages	All Stages
-1000+600	0.04	0.04	0.04
-600+355	0.43	0.43	0.43
-355+180	0.50	0.71	0.71
-180+106	0.76	1.67	1.74
-106+75	1.32	2.85	3.42
-75+53	2.26	4.56	5.48
-53	9.94	33.84	48.28

Tab. 5. Overall Metallurgical Result of the Falcon Based GRG test

Tab. 5. Ocena wyników hutniczych na podstawie testu GRS Falcon

Product	Weight %	Grade g/t	Recovery %
Concentrate	0.85	469.64	48.28
Tailing	99.15	4.31	51.72
Feed	100.00	8.27	100.00

fractional recovery profile with the previous stages was found at this last stage.

After completing all stages, cumulative recoveries were calculated to evaluate the efficiency of the process with respect to gold beneficiation (Table 4). Total Au grade of the feed was calculated based on the products' metallurgical results at the individual stages so as to determine the overall GRG potential of Mastra ore.

As seen in these figures (1,2&3) , GRG values are increase by decreasing particle size. The highest recovery values were obtained at 53 µm fraction for all thhreee stages, implying that the liberaiton of free gold entities occur below 53 µm.

At the end of the tests a gold concentrate containing 469.64 g/t Au was produced at 48.28 % recovery.The overall metallurgical performance of the GRG test with the Falcon concentrator is presented in Table 5.

Conclusion

As a result of this study, Falcon concentrator was successfully employed in the determination of the GRG potential of Mastra gold ore. The highest gold recoveries were attained for the -53 µm fraction at all stages. This suggests a liberation size of -53 µm for the free gold entities. The overall GRG value for this ore was found as 48.28%. Producing a pre-concentrate by gravity concentration from this ore would be promising and such an application would cyanidation related costs for the remaining values in the ore. The economic evaluation considering these aspects is a subject of a different study.

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Zastosowanie wzbogacalnika typu Falcon do określenia zawartości złota w produkcie ze wzbogacania grawitacyjnego (test GRG) dla rud złota

Artykuł przedstawia wyniki zastosowania procedury laboratoryjnego testu GRG (wzbogacania grawitacyjnego) dla tureckich rud złota za pomocą wzbogacalnika typu Falcon. Badania miały dwa główne cele: zbadanie przydatności wzbogacalnika typu Falcon do testu GRG (który został opracowany oryginalnie dla wzbogacalnika typu Knelson) oraz określenie zawartości złota w produkcie ze wzbogacania grawitacyjnego dla rudy złota ze złoża Gümüşhane/Mastra. Stwierdzono, że produkt o dużej zawartości Au może zostać osiągnięty. Po pierwszym etapie otrzymano produkt o zawartości Au równej 41,09 mg przy uzysku frakcjonowanym złota równym 10,95% przy pierwszym stadium testu. Zawartość Au w koncentracie wzrosła do 98,84 mg po drugim etapie a finalnie otrzymano zawartość Au równą 59,74 mg po etapie trzecim. W wyniku zastosowania eksperymentu stwierdzono, że zawartość GRG złota ze złoża Gümüşhane/Mastra wyniosła 48,28% a ponadto stwierdzono wysoki potencjał do otrzymania wstępnych koncentratów bogatych w Au.

Słowa kluczowe: test GRG (gravity recoverable gold), wirówka, wstępne wzbogacanie, wzbogacalnik typu Falcon