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Analysis Percent Extraction Main Ridge Quarter 4 Ore with Bottle Roll Test Method at PT J Resources Bolaang Mongondow

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Abstract

One of the leaching methods used for oxide-type ores is heap leaching. The company that performs this method is J Resources Bolaang Mongondow. At J Resources Bolaang Mongondow there are several parameters for the heap leaching process carried out, such as ore size, NaCN and lime consumption, and basemetal content. This study aims to analyze the effect of grain size on the percent extraction and reagent consumption and analyze the effect of basemetal content on the percent extraction of gold through the bottle roll test method. The study used oxide gold ore of sizes +12, +6, and -6 mm. From the results of the experiments carried out, it was found that the highest extraction percent was produced in the -6 mm size of 97% which also had the highest lime and NaCN consumption of 5.89 kg/ton and 0.71 kg/ton. From these results, it is found that ore size greatly affects the percent extraction produced as well as the consumption of lime and NaCN used. In addition, the leaching process is influenced by the basemetal content contained in the ore.

Keywords: Gold, Bottle Roll, Leaching, Extractive Metallurgy

Introduction

Gold cyanidation in field scale is mainly conducted through heap leaching and tank leaching methods (Azizitorghabeh et al., 2023). The choice between alternatives depend on several factors including grade of precious metals in the ore, size of the reserve, etc (Kasaini et al., 2008). Regardless of the method selection, the liability of the Au-bearing ore to cyanidation is the most critical aspect (Solihin et al., 2025). In other words, the extraction possibility of gold from the given ore should be justified to consider any leaching method for field scale operation (Yilmaz et al., 2020). Testing a given ore in laboratory scale is essential to accurately identify its liability to cyanidation, leaching behaviour and kinetics as well as its tendency to consume cyanide (CELEP et al., 2009) (Li et al., 2013).

For laboratory testing and determination of cyanide leaching behaviour of Au-bearing ores, several methods have been proposed (Cappuyns et al., 2014). Yet, bench-scale bottle roll testing has become a well-established procedure to gain preliminary insight about the leachability of a particular Au-bearing ore (Azizitorghabeh et al., 2021)

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(Altinkaya et al., 2020). The procedure seems straightforward, relatively easy to apply and is percepted to provide reliable and fast data that would form the basis for further assessment of a particular ore with respect to a prospective leaching process and scaling-up of leaching methods (Han et al., 2020).

Based on these advantages, bottle roll tests were used in a vast number of previous work to estimate extent of Au-extraction and process design parameters, to evaluate performance of on-going leaching operations, to optimize leaching processes or to apply innovative approaches that would contribute to enhance conventional leaching procedures (Blanc et al., 2012). This study aims to determine the effect of grain size on the percent of gold extraction, NaCN and lime consumption on grain size, and basemetal content on the percent of gold extraction (Wang et al., 2021).

Research Methods

This research was carried out by testing gold ore samples from Pit Main Ridge J Resources Bolaang Mongondow. This test was carried out using the bottle roller method with sample preparation previously carried out to obtain a particle distribution size of up +12, +6, and -6 mm. The leaching process parameters using the bottle roller test can be seen in table 1 as follows.

Table 1. Operations Data for the running Bottle Roll Test

Feed Weight	1000 gram
Water	1500 gram
%solid	40%
Rate NaCN	500 ppm
pH	10.5 – 11
Time	48 hours (checking pH in 0, 2, 4, 8, 12, 36, and 48 hours)

After the test was completed, the pregnant leach solution (PLS) were analyzed by AAS while the tailings were subjected to fire assay analysis to determine the content of valuable metals and impurities in them. Following the completion of the AAS dan fire assay analysis process, assay data is acquired. Subsequently an assessment of the percent extraction value was conducted (Gan et al., 2024).

Result and Discussion

Analysis of Gold Extraction.

Based on figure 1, the highest percent of Au extraction at grain size +12 mm was 91% at MRD 1641 (11 -15) and the lowest percent extraction was 29% at MRD 1358 (67.3 -72). At +6 mm grain size, the highest extraction percent was 94% at MRD 1641 (11-15) and the lowest extraction percent was 87% at MRD 1641 (19- 20). At a grain size of -6 mm, the highest extraction percent was obtained at 97% at MRD 1491 (79 - 82) and

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the lowest extraction percent was 84% at MRD 1358 (67.3 -72).

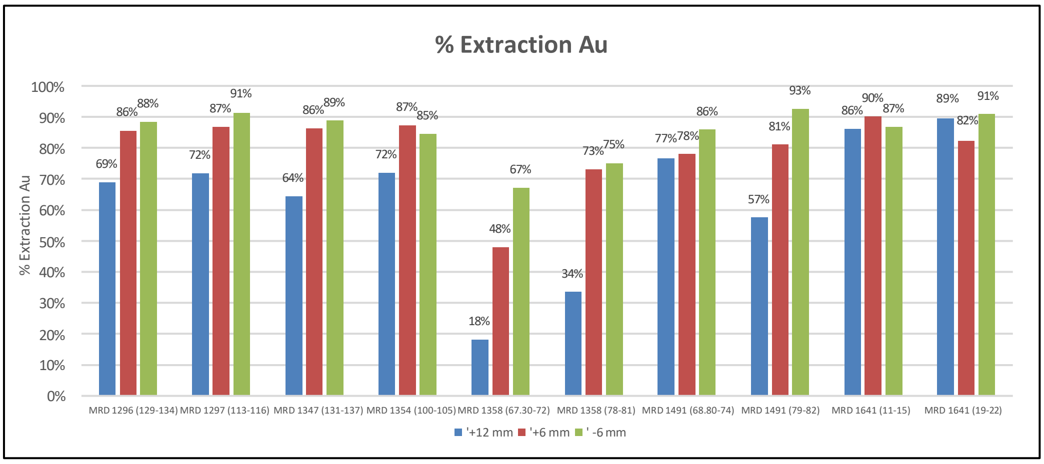

Figure 1. Percentage of Gold Extraction

Amanida's research (2019), on the effect of grain size on the percent of gold extraction also resulted in an increasing percent of gold extraction as the grain size fineness increased by 79.9% at grain size P80 +75 µ, 84.3% at size P80 +106 µ, and 84.8% at grain size P80 +150 µ with the same NaCN concentration for each sample of 500 ppm. Increasing grain size fineness provides a larger contact surface area during the leaching process and also reduces the penetration distance required for cyanide to dissolve gold resulting in a high percent gold extraction.

The percent gold extraction is also categorized based on the standards set by the company to classify the gold ore samples taken for heap leaching. In Table 2 are the extraction categories used.

Table 2. Extraction Category

Parameter	**Extraction Category**		
	High	Medium	Low
Predictive Extraction on Actual Cell	**92-95%**	**85-90%**	**<85%**
+12 mm	>70%	<50%	<50%
+6 mm	>70%	>70%	<50%
-6 mm	>95%	>95%	<90%

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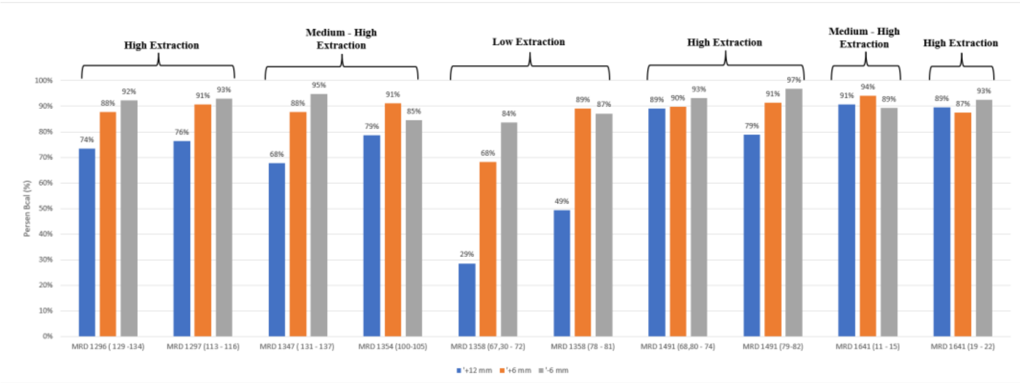

Figure 2. Extraction Category obtained

The percent Au extraction results can be categorized as follows. Samples MRD 1296 (129 - 134), MRD 1297 (113 - 116), MRD 1491 (68.80 - 74), MRD 1641 (19 - 22) and MRD 1491 (79 -82) include high extraction because they have a percent extraction of +12 mm >70%, +6 mm >70%, and -6 mm >95%. MRD 1358

(67.30 - 72) and MRD 1358 (78 - 81) samples include low extraction because they have a percent Au extraction of +12 mm <50%, +6 mm <50%, and -6 mm <90%. MRD 1347 (131 - 137), MRD 1354 (100 -105), and MRD 1641 (11 - 15) arenmedium-high extraction because they have Au extraction percent values of +12 mm <50%, +6 mm >70%, and -6 mm >95%.

1. Analysis of Grain Size against NaCN and lime consumption.

   Based on Figure 2, the -6 mm grain size consumes more cyanide than the +12 and +6 mm grain sizes. This is because the small grain size has a high surface area, so that the reaction of cyanide with gold particles will be more than the larger grain size. The highest NaCN consumption was produced by sample MRD 1358 (67.30- 72) grain size -6 mm at 0.71 kg/ton, while the lowest NaCN consumption was produced by sample MRD 1641 (19-22) grain size +12 mm at 0.08 kg/ton.

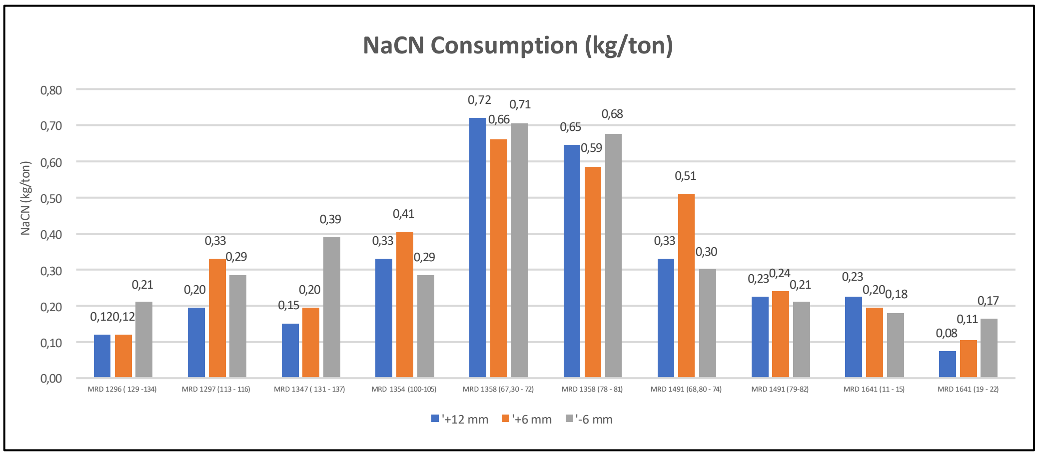

Figure 3. Percentage of NaCN Consumption

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In the research of Asghar Azizi (2015), the optimum conditions were achieved with NaCN consumption of 729.56 ppm with a particle size of 37.52 µm resulting in a percent gold extraction of 91.5% while at NaCN consumption of 730 ppm with a particle size of 37 µm resulting in a percent gold extraction of 91.25%. This results in NaCN consumption increasing with increasing grain size.

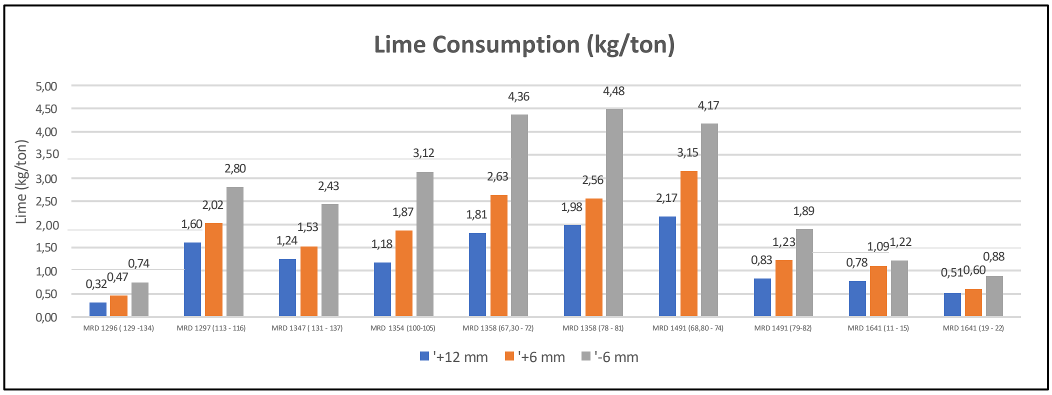

Figure 4. Percentage of Lime Consumption

In Figure 3, the lime consumption of sample MRD 1358 (94-98) has the highest gain of the other samples. Sample MRD 1358 (94-98) has consecutive lime consumption values at sizes +12, +6, and -6 mm of 2.24 kg/ton, 3.76 kg/ton, and
5.89 kg/ton. The -6 mm grain size consumes more lime than the +12 and +6 mm grain sizes. High lime consumption is influenced by the initial pH of the gold ore used. The lower the initial pH, the more lime is needed to reach the target leaching pH. The acidic initial pH of gold ore has a tendency for high basemetal density as well. Basemetal can cause gold ore to be acidic so that additional lime is needed to achieve optimum leaching conditions.

2. Analysis of Basemetal.

Gold ore contains basemetals that can be dissolved during the leaching process. Basemetals in the analyzed gold ore include Ag and Cu.

In Figure 4, samples MRD 1358 (78 - 81) grain size +12 and +6 mm have a fairly high percentage of Ag extraction with 50% and 49% respectively. The fineness of the grain size also affects the solubility of the Ag element in the gold ore, so the finer the grain size, the higher the % extraction of Ag. The finer the grain size, the higher the percent of Ag extraction. However, this increase in Ag extraction percent needs to be analyzed because it may affect the Au extraction percent.

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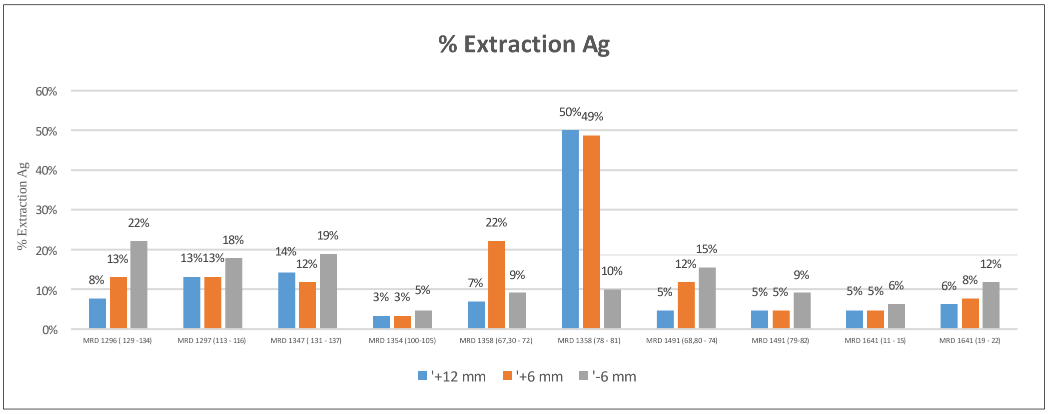

Figure 5. Percentage of Ag Extraction

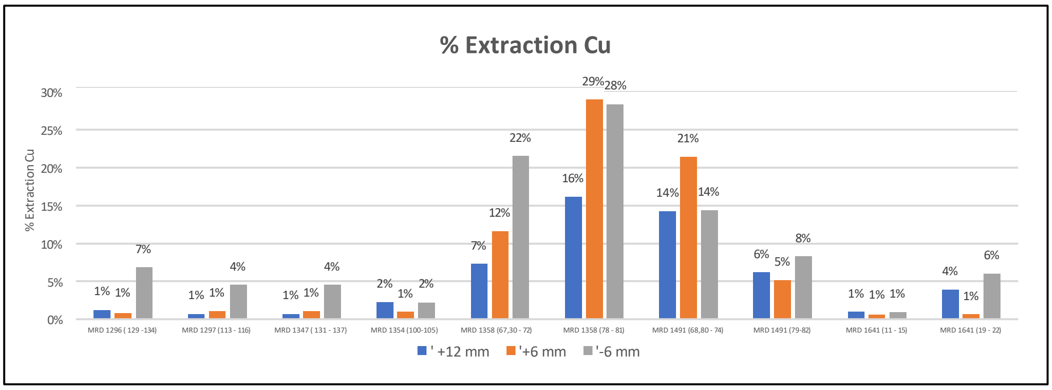

Figure 6. Percentage of Cu Extraction

In Figure 5, the percentage of Cu extraction is still below 30%. The samples that have a fairly high percent of Cu extraction are samples MRD 1358 (67.30 -72), MRD 1358 (78-81), and MRD 1491 (68.80 -74). From both Ag and Cu extraction percentages, the ore with high basemetal solubility was found in MRD 1358 (67.30-72). When looking at the percent gold extraction in Figure 1, the sample falls into the low extraction category. Therefore, it can be concluded that the low percent extraction of gold can be influenced by the basemetal content. Research on basemetal has been carried out previously by Hakim, A.R (2023) where the results of % gold extraction at sample size -6 mm are smaller than sample size +6mm. The involvement of basemetal in significant amounts allows 2 main things to happen, namely the formation of a passive layer of metal cyanide on the gold surface and the binding of cyanide to form complex compounds. In the case of cyanide passivation, basemetal promotes the onset of oxidation reactions in cyanide which results in cyanide becoming inactive in dissolving gold. Meanwhile, the formation of complex compounds with cyanide tends to be in a stable phase that makes cyanide unable to react with gold, thus reducing the percentage of extraction that occurs.

Conclusions

From the research conducted, it can be concluded that grain size affects the percent of gold extraction, where the smaller the grain size results in a higher percent of gold extraction. Percentage of gold extraction in sample MRD 1491 (79 - 82) grain size - 6 mm is 97%, while in sample MRD 1358 (67.3 -72) grain size +12 mm is 12.47%. The consumption of lime and NaCN increases as the grain size gets smaller. Basemetal content affects the percent of gold extraction, where the higher the basemetal content has a tendency to obtain a low percent of gold extraction.

References

Altinkaya, P., Wang, Z., Korolev, I., Hamuyuni, J., Haapalainen, M., Kolehmainen, E., Yliniemi, K., & Lundström, M. (2020). Leaching and recovery of gold from ore in cyanide-free glycine media. *Minerals Engineering*, *158*. https://doi.org/10.1016/j.mineng.2020.106610

Azizitorghabeh, A., Mahandra, H., Ramsay, J., & Ghahreman, A. (2023). Selective gold recovery from pregnant thiocyanate leach solution using ion exchange resins. *Hydrometallurgy*, *218*, 106055. https://doi.org/10.1016/J.HYDROMET.2023.106055

Azizitorghabeh, A., Wang, J., Ramsay, J. A., & Ghahreman, A. (2021). A review of thiocyanate gold leaching – Chemistry, thermodynamics, kinetics and processing. *Minerals Engineering*, *160*. https://doi.org/10.1016/j.mineng.2020.106689

Blanc, P., Lassin, A., Piantone, P., Azaroual, M., Jacquemet, N., Fabbri, A., & Gaucher, E. C. (2012). Thermoddem: A geochemical database focused on low temperature water/rock interactions and waste materials. *Applied Geochemistry*, *27*(10), 2107–2116. https://doi.org/10.1016/j.apgeochem.2012.06.002

Cappuyns, V., Alian, V., Vassilieva, E., & Swennen, R. (2014). PH dependent leaching behavior of Zn, Cd, Pb, Cu and As from mining wastes and slags: Kinetics and mineralogical control. *Waste and Biomass Valorization*, *5*(3), 355–368. https://doi.org/10.1007/S12649-013-9274-3

CELEP, O., ALP, I., DEVECI, H., & VICIL, M. (2009). Characterization of refractory behaviour of complex gold/silver ore by diagnostic leaching. *Transactions of Nonferrous Metals Society of China*, *19*(3), 707–713. https://doi.org/10.1016/S1003-6326(08)60337-4

Gan, M., Li, J., Ji, Z., Fan, X., Yu, D., Liu, L., & Sun, Z. (2024). Preparation of high-quality biomass char and gas as fuels for ferrous metallurgy by integrated water leaching and pyrolysis: A case study using maize straw. *Biomass and Bioenergy*, *184*, 107200. https://doi.org/10.1016/J.BIOMBIOE.2024.107200

Han, Y., Yi, X., Wang, R., Huang, J., Chen, M., Sun, Z., Sun, S., & Shu, J. (2020). Copper extraction from waste printed circuit boards by glycine. *Separation and Purification Technology*, *253*. https://doi.org/10.1016/j.seppur.2020.117463

Kasaini, H., Kasongo, K., Naude, N., & Katabua, J. (2008). Enhanced leachability of gold and silver in cyanide media: Effect of alkaline pre-treatment of jarosite minerals. *Minerals Engineering*, *21*(15), 1075–1082. https://doi.org/10.1016/J.MINENG.2007.12.005

Li, J., Bunney, K., Watling, H. R., & Robinson, D. J. (2013). Thermal pre-treatment of refractory limonite ores to enhance the extraction of nickel and cobalt under heap leaching conditions. *Minerals Engineering*, *41*, 71–78. https://doi.org/10.1016/J.MINENG.2012.11.002

Solihin, Syafri, I., Rosana, M. F., Hirnawan, R. F., Guntoro, D., Nurrochman, A., & Purwanto, A. (2025). Assessment Of The Optimal Gold Recovery Rate Through Heap Leach Extraction Process From Hydrothermal Alteration Zone Ore. *Journal of Applied Science and Engineering*, *28*(2), 305–317. https://doi.org/10.6180/JASE.202502_28(2).0010

Wang, J., Faraji, F., Ramsay, J., & Ghahreman, A. (2021). A review of biocyanidation as a sustainable route for gold recovery from primary and secondary low-grade resources. *Journal of Cleaner Production*, *296*. https://doi.org/10.1016/j.jclepro.2021.126457

Yilmaz, S., Sirkeci, A. A., Bilen, M., & Kizgut, S. (2020). Increasing the heap leach efficiency of Uşak Kışladağ gold ore using nut shell as permeability aid. *Hydrometallurgy*, *198*, 105520. https://doi.org/10.1016/J.HYDROMET.2020.105520