USE OF GOOD TABLE ("WILFLEY TABLE" TECHNIQUE) AS A BENEFICIATION OF GOLD CARRIER MINERALS

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ABSTRACT

Increasing the level of an extract into a marketable and valuable mineral or beneficiation process can be carried out in various ways, one of which is a table technique ("Wilfley table"). Beneficiation begins with knowing the character of ore through XRD characterization, mineragraphy, SEM-EDS and Fire Assy. Then, the ore is smoothed to a range of ~200 mesh and concentrated with rocking table gravity by varying the size of rock fraction, table slope and water discharge. Based on the comparison of XRD characters, mineragraphy, SEM-EDS and fire Assy from the initial seeds and recovery, the results obtained is found to be within the optimum conditions at fraction ~200 mesh size, 3° elongation table, and water discharge of 14 liters / minute and with gold recovery of 84.48% or increase gold content from 1.32 g / ton to 18.75 g / ton. Based on the optimization, the finer the size of the particles , the higher the level of gold recovery. Nevertheless, the increase in the slope of the table and water discharge can reduce the recovery of gold.

Keywords: Gold seeds, Beneficiation of gold, Rocking Table, Variable process, Increased gold content, Beneficiation gold seed / Gold seeds, Beneficiation, Wilfley Table, Variable processes, Increased gold content, Benefid gold seeds

INTRODUCTION

Indonesia is a country with a tremendous mineral resources of various types of minerals, for instance: chromite [1], kaolin [2], and other minerals that can be used as raw materials for the synthesis of inorganic materials. Synthesized inorganic materials can be used as textile dye adsorbents [3], catalysts [4,5,6] or photocatalysts [7,8] for drying materials depending on their chemical and physical properties.

Until now, gold is still the most eligible for metallurgical mining business, as its price has soared to the level of US $ 700 / oz and over. One of the golden ore mining locations in the city of Batu Hijau mining area, Indonesia has a fairly low gold content [9,10,11].

Gold minerals are usually associated with sulfide minerals [12,13], which have been oxidized such as pyrite minerals, chalcopyrite, magnetite, sphalerite, galena and kovellite [14,15]. The gold usually has low mineral content. Therefore, further processing is needed to transform it into usable products and meet the next process criteria [16].

In general, the technology of processing gold ore is cyanidation and amalgamation. However, if the gold content is lower or lesser then the required specification, then processing through the aforementioned technology is highly likely unprofitable. In addition, extra technology is needed to increase gold content (beneficiation of ore) in an effort to prepare gold concentrates that are ready for further processing known as the concentration process. Concentration is essentially one of the important processeses in a series of gold processing. Gravity (gravity) and flotation concentrations are widely used in gold processing [17,18,19].

In this study, gravity construction was carried out with a wilfley table type rocking table. Rocking table is a relatively simple process, but it can be effective well if the parameters are in accordance with the type and character of rocks both physically and chemically [20]. Therefore, it is imperative to have the right optimization in order to obtain the fraction of results with high beneficiation with the wilfley table type rocking table.

METODOLOGY

Gold ore samples originating from PT AMNT’s BatuHijau mining. The preparational process was carried out and the initial characterization is set up in the form of XRD characterization, mineragraphy, SEM-EDS and Fire Assy. Then the sample is smoothed and the particle size fraction is carried out with the size of the rock fraction +60, ~ 60-100, ~ 100 + 150, ~ 150 + 200, ~ 200 mesh. After that, the separation process with the rocking table for each particle size fraction and doing separation optimization performed rocking table operating table with a table slope of 20, 30, 40 and changes in water discharge variations of 12, 14 and 16 liters / minute.

The results of the separation from each fraction were analyzed in the form of XRD characterization, mineragraphy, SEM-EDS and Fire Assy. Recovery from results can be calculated by calculation:


\[ R = \frac{(C \cdot c)}{(F \cdot f)} \times 100\% \]

Where:
- \( R \): Recovery (%)
- \( F \): Feed weight (gr)
- \( C \): Concentrate weight (gr)
- \( f \): Content of feed (g / ton)
- \( c \): concentrate content (g / ton)

RESULTS AND DISCUSSION

a. XRD Analysis

XRD analysis is used to determine the mineral phase contained in rock samples. The results of the analysis are shown in Figure 1.

![Graph of Diffractogram XRD Raw Material](image1)

Figure 1. Graph of Diffractogram XRD Raw Material

Figure 1 is then compared with JPDF data from minerals so that the results obtained in the form of minerals contained in the sample as listed in Table 1.

<table>
<thead>
<tr>
<th>Komposisi Mineral</th>
<th>Rumus Kimia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>SiO₂</td>
</tr>
<tr>
<td>Chlorite-Serpent</td>
<td>(Mg, Al) 6(Si, Al) 4O₁₀(OH)₈</td>
</tr>
<tr>
<td>Albite</td>
<td>Na(Si₃Al)O₆</td>
</tr>
<tr>
<td>Calcite</td>
<td>CaCO₃</td>
</tr>
<tr>
<td>Hornblende</td>
<td>(Ca, Na₂)(Fe₂, Mg)₅(Si, Al) 8O₂₂(OH)₂</td>
</tr>
<tr>
<td>Illite</td>
<td>(K₂H₂O)Al₃Si₃AlO₁₀(OH)₂</td>
</tr>
<tr>
<td>Pyrite</td>
<td>FeS₂</td>
</tr>
</tbody>
</table>

Table 1. Results of XRD Raw Material Analysis

Figure 1 shows there are mineral phases namely quartz, chlorite-serpent, albite, calcite, hornblende, illite, and pyrite. Quartz minerals, chlorite-serpent, albite, calcite, hornblende, illite are altered minerals while the mineralization is pyrite. The results are in accordance with Garwin's research on BatuHijau mining [3]. The mineral pyrite phase is one of the minerals associated with gold. Therefore, the results of this analysis need to be supported by the results of other analyzes.

b. Mineragraphy Analysis

Mineragraphy analysis was conducted to determine the types of metal minerals contained in rock samples, the degree of liberation, and mineral content. This analysis was carried out on five polishing incisions of rock fractions, namely the size of +60, -60 + 100, -100 + 150, -150 + 200, -200 mesh using a polarizing microscope. Photomicrograph results of mineragraphy analysis using polarization microscopy are shown in Figure 2 (-100 + 150 mesh), Figure 3 (-150 + 200 mesh) and Figure 4 (-200 mesh).

![Fotomikrograf fraksi ~100+150 mesh](image2)

Figure 2. Fotomikrograf fraksi ~100+150 mesh

![Fotomikrograf fraksi ~150+200 mesh](image3)

Figure 3. Fotomikrograf fraksi ~150+200 mesh

![Fotomikrograf ~200 mesh](image4)

Figure 4. Fotomikrograf ~200 mesh

Figures 2, 3 and 4 show the minerals found in rock samples are pyrite, chalcopyrite, bornite, chalocyt, covellite, magnetite, galena, and spalerit. Furthermore, the minerals are analyzed based on their physical properties (mineral color). Pale creamy pyrite, yellow chalcopyrite, bright brownish magnetite, brownish red bornite and white galena.

Minerals with fine fraction sizes are usually found in single grains or free particles. The finer the size of the rock fraction increases the degree of liberation of each mineral, as listed in Table 2. The
pyrite in the size of the +60 mesh fraction has a degree of liberation of 91.91%, at a size of -100 + 150, -150 + 200, and -200 mesh sequentially liberated the pyrite to 92.28%, 93.41% and 96.44%. Similarly, magnetite has a degree of liberation that increases with the smooth fraction size ranging from 87.34% - 95.07% and for copper minerals such as chalcopyrite, bornite, chalcocyte, and kovelit having degrees of liberation ranging from 77.19% - 96 79%. In this analysis no gold grains were found. This is because gold is included in metal sulphide minerals so that the gold content in rock samples is low, making it difficult to detect by polarizing microscopy.

### Table 2.
Degree of Mineral Liberation for Each Rock Fraction

<table>
<thead>
<tr>
<th>Ukuran Fraksi</th>
<th>FeS₂</th>
<th>FeO₃</th>
<th>Mineral Cu</th>
<th>PbO</th>
<th>ZnO</th>
</tr>
</thead>
<tbody>
<tr>
<td>+60</td>
<td>91.91</td>
<td>87.34</td>
<td>77.19</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-60+100</td>
<td>92.10</td>
<td>91.28</td>
<td>90.70</td>
<td>83.33</td>
<td>-</td>
</tr>
<tr>
<td>-100+150</td>
<td>92.28</td>
<td>91.97</td>
<td>92.83</td>
<td>91.60</td>
<td>67.41</td>
</tr>
<tr>
<td>-150+200</td>
<td>93.41</td>
<td>93.46</td>
<td>93.20</td>
<td>93.02</td>
<td>70.17</td>
</tr>
<tr>
<td>-200</td>
<td>96.44</td>
<td>95.07</td>
<td>96.79</td>
<td>93.46</td>
<td>75.47</td>
</tr>
</tbody>
</table>

Information Mineral Cu: Kalkopirit, kalkosit, bornit, kovelit, Pirit (FeS₂), Magnetit (FeO₃), galena (PbO), Spalerit (ZnO).

In addition, the finer the size of the rock fraction also increases the mineral content of each rock fraction as shown in Table 3. Metal mineralization of rock samples originating from BatuHijau is dominated by pyrite, chalcopyrite and magnetite minerals which are usually associated with gold

### Table 3.
Mineral content of each rock fraction.

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Berat Jenis (gr/cc)</th>
<th>Ikatan Mineral</th>
<th>KK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetit</td>
<td>5.17</td>
<td>Emas-Magnetit</td>
<td>4.39</td>
</tr>
<tr>
<td>Pirit</td>
<td>5.01</td>
<td>Emas-Pirit</td>
<td>4.56</td>
</tr>
<tr>
<td>Kalkopirit</td>
<td>4.30</td>
<td>Emas-Kalkopirit</td>
<td>5.55</td>
</tr>
<tr>
<td>Bornit</td>
<td>5.30</td>
<td>Emas-Bornit</td>
<td>4.26</td>
</tr>
<tr>
<td>Kalkosit</td>
<td>5.77</td>
<td>Emas-Kalkosit</td>
<td>3.84</td>
</tr>
<tr>
<td>Kovelit</td>
<td>4.68</td>
<td>Emas-Kovelit</td>
<td>4.97</td>
</tr>
<tr>
<td>Spalerit</td>
<td>4.10</td>
<td>Emas-Spalerit</td>
<td>5.90</td>
</tr>
<tr>
<td>Galena</td>
<td>7.58</td>
<td>Emas-Galena</td>
<td>2.78</td>
</tr>
</tbody>
</table>

Description: Gold Specific Gravity 19.3 gr / cc

e. **SEM-EDS Analysis**

Analysis was carried out on one of the concentrates resulting from separation with a rocking table. Figure 5 shows the presence of flat granules of gold of the size of each grain, which is 2.25 µm and 2.0 µm - which attaches to copper sulphide minerals. The results of SEM micrographs were supported by the EDS analysis summarized in Table 5. Samples containing gold were 1.24%, silver was 3.78%, copper was 26.35%, iron was 28.73%, tellurium was 25.48% , and sulfur is 14.42%. The graph in Figure 8 shows that gold (Au) has a peak that is parallel to tellurium (Te) which is detected at 2,121 keV for gold and 2,267 keV. This allows the gold bearing mineral in the sample to be calaverit (AuTe2) which is classified as gold telluride.
f. Effect of Table Slope on Recovery Au

The effect of the slope of the table on recovery of gold is shown in Figure 6. Gold recovery increases at a slope of 2 ° to a slope of 3 °. At a slope of 3 °, gold recovery appears stable. This is due to the slope of 3 ° not too sloping and not too steep so that the process of stratification and the spread of mineral granules are evenly distributed. Gold recovery decreases at a slope of 4 °. This is due to the gravitational force and the increasing velocity of fluid resulting in valuable minerals not being distributed evenly so that impurity minerals will be carried away towards concentrate side, and also valuable minerals such as heavy and fine minerals into the tailing side that affect the recovery of gold.

<table>
<thead>
<tr>
<th>Unsur</th>
<th>Elektron (keV)</th>
<th>Volt (%)</th>
<th>Massa (%)</th>
<th>Atom (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>2,307</td>
<td>14,42</td>
<td>14,42</td>
<td>29,11</td>
</tr>
<tr>
<td>Fe</td>
<td>6,398</td>
<td>28,73</td>
<td>28,73</td>
<td>33,30</td>
</tr>
<tr>
<td>Cu</td>
<td>8,040</td>
<td>26,35</td>
<td>26,35</td>
<td>26,85</td>
</tr>
<tr>
<td>Ag</td>
<td>2,983</td>
<td>3,78</td>
<td>3,78</td>
<td>2,27</td>
</tr>
<tr>
<td>Au</td>
<td>2,121</td>
<td>1,24</td>
<td>1,24</td>
<td>0,41</td>
</tr>
<tr>
<td>Te</td>
<td>2,267</td>
<td>25,48</td>
<td>25,48</td>
<td>8,07</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>100,00</td>
<td>100,00</td>
<td></td>
</tr>
</tbody>
</table>

Table 5. EDS Quantitative Analysis Results

Water Velocity 12 Liter/Menit

Figure 6. Graph of the effect of table slope on recovery of Au in each water discharge

Analysis of the effect of the size of rock fraction on recovery of gold is shown in Figure 7. Recovery of gold increases with the finer size of the rock fraction in each water discharge. When compared to the effect of the size of the rock fraction on each slope of the table, recovery of gold at a slope of 3 ° results in better recovery than slopes of 20 and 40. This is due to the slope of 3 ° distribution of heavy minerals and smooth evenly on the table surface shake, influenced by forces acting during the separation process, heavy and fine minerals will enter concentrate side so that it affects the recovery of gold. Gold recovery on slope 40 produces the lowest recovery which is equal to 48.51% for rock fraction -100 + 150 mesh, and the highest gold recovery is produced at 30 slopes with recovery ranging from 58 - 84%.
**Figure 7.** Graph of the effect of size of rock fraction on recovery of Au in each water discharge

**h. Effect of Water Debit on Recovery Au**

Analysis of the effect of water discharge on gold recovery can be seen in Figure 8. The more water flow increases, recovery of gold at each table slope has decreased. This is because the increased water discharge results in a greater fluid velocity so that valuable minerals such as heavy and fine minerals will be pushed into the tailing side and middling side that affect the recovery of gold. Besides that, it is also influenced by the gravitational force that is getting bigger as the table slope increases so that the distribution of minerals is not evenly distributed in the separation process with the shake table. The highest gold recovery is obtained at 84.48% at 14 liters / minute water discharge. This is because at this water discharge produces fluid velocities that are not too large or small so that the fine and heavy minerals will be stratified well and the separation process takes place smoothly which results in a good recovery of gold.

**CONCLUSION**

From the results of the study can provide several conclusions, namely:
1. Based on the initial characterization of rock samples, it gives an idea of the types of minerals contained, the initial gold content in rock samples is 1.32 g / ton. The presence of gold in rock samples is included in metal sulfide minerals. The gravity concentration method on the rocking table can be done based on the Concentration Criteria which has a value of > 2.5 which states that separation in gravitational concentration can be done for all rock particle sizes.
2. Increasing deck slope in the rocking table method increases gold content and decreases gold recovery. The biggest gold recovery at a slope of 3° with the size of rock fraction -200 mesh, and at a water discharge of 14 liters / minute.
3. In general, the experiment with rocking table gives the most optimum results in producing gold recovery to approximately 84.48% with the condition of the table operating variable...
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