STRIPPING AND ELECTROWINNING OPTIMIZATION IN GOLD AND SILVER PROCESS

By

Göksel Kaygisiz Şendur

Zenit Madencilik San. Ve Tic. A.Ş, Turkey

Presenter and Corresponding author

Göksel Kaygisiz Şendur
g.kaygisiz@zenitmadencilik.com

ABSTRACT

Since the commissioning of the CIL Processing Plant in 2017, Zenit Madencilik has been carrying out surveys in the stripping and electrowinning unit in order to increase the overall Au-Ag recovery, stripping and electrowinning efficiency and reduce the operating cost. For this purpose, the optimization studies on the stripping and electrowinning unit were commenced in 2019, and the outcomes were evaluated after the adequate database was generated.

Since the commissioning of the stripping and electrowinning unit, data collection was started. The barren and pregnant solution samples were collected hourly from the heat exchanger, stripping column and electrowinning cells. During the stripping stage the loaded and barren carbon were sampled and analyzed for Au and Ag.

According to the data collected between 2017-2019, the operating time of the stripping unit was longer and the electrowinning efficiency was lower. Therefore, it was decided that the optimization in the stripping and electrowinning was essential.

The parameters such as operating time, solution flow rate, caustic and cyanide concentrations, stripping vessel pressure and temperature, distance between anode-cathode plates in the electrowinning cells and the cleaning period of the heat exchanger were investigated individually. In consequence, the operating time for stripping was reduced by approximately 33% and the stripping efficiency was increased by 3%.

Key words: *Elution, Stripping, Electrowinning, Optimization, Au-Ag Recovery.*

INTRODUCTION

Stripping of gold and silver from carbon is affected by means of two main processes (AARL and ZADRA). The main rate-enhancing parameter in the stripping of gold and silver is temperature. A secondary rate-enhancing parameter is ionic strength. (1) Stripping is usually conducted within a solution containing sodium cyanide (0.1 – 0.5%) and caustic (1 – 3%) (J.C. Monette, E. J. Fuller, 1992).

Besides these, research on the effect of the process parameters of the Zadra elution process is being conducted in order to optimize the process parameters to minimize energy consumption and lower the operating and design costs of the elution process. Such a move will advance the efficiency of the Zadra elution process (Van Deventer et al., 2003).

Since gold loading on carbon is an equilibrium-driven response, the more effective the stripping, the better the recovery from solution. Maximizing recovery from the activated charcoal is essential to the maximum recovery in the absorption circuit (Michael Drozd, Annual Canadian Mineral Processors Conference, 2008).

Effective stripping depends on optimizing the stripping conditions and maximizing the recovery in electrowinning. Since stripping is an equilibrium response just like loading, less gold is removed as the result grade returning from electrowinning goes up (Michael Drozd, Annual Canadian Mineral Processors Conference, 2008).

In stripping processes, the voltage of the electrolysis cells should be between 2.2 and 2.4 for gold and silver metal. At voltage values above this, other metals in the ore also cling to the cathode plates, causing pollution in the casting (Urbanic, J.E., Jula, R.J., Faulkner, W.D., 1985).

MATERIAL AND METHODS

Material

In the Kızıltepe gold and silver mine owned by Zenit Madencilik, gold and silver recovery is carried out by loading activated carbon. A series of stripping processes related to the efficiency of gold and silver recovery loaded on activated carbon were followed and many parameters were examined.

Method

From the initial examination due to the accumulation of deposits between the heater resistances, there was no solution transfer between the resistances and overheating was detected in the heater tubes. Therefore, the actual temperatures could not be increased. The heaters were disassembled, cleaned between the resistances and reassembled.

Limit temperatures and actual temperatures were provided to read the same values. In this way, the stripping temperature was increased up to the design value of 148°C. In order for the stripping efficiency to be high, the unloaded solution temperature entering the stripping column should be at the maximum level, according to the studies. The accumulation of deposits on the probes of the temperature clocks was largely prevented, and the optimum temperature for stripping was determined. The solution temperature entering the stripping column was increased from 120°C to 135- 140°C by following the temperatures of the heaters.

In the Kızıltepe gold and silver mine, a solution of 12000ppm cyanide and 2-3% caustic was prepared in the unloaded solution tank. The water used while preparing the stripping solution was provided as fresh water. However, the presence of dissolved minerals such as Ca, Mg, Cl in the fresh water used in the field has a corrosive effect on the electrolysis cell plates. The water in which the stripping solution will be prepared has a conductivity degree close to the properties of filtered and pure water, and its corrosive effects on the cell plates will be reduced.

It is thought that the electrical charges on the anode and cathode plates are not constant in terms of not being able to discharge the metal charge. When a load of around 4 volts is given into the cell, only 2.2-2.4 volts current is generated on the plates. Coating the inner surface of the cells to provide insulation will bring a solution.

RESULTS AND DISCUSSION

This study is about increasing the efficiency of the stripping unit in gold and silver mines. In the studies carried out in Balıkesir Kızıltepe gold and silver mine, research was carried out on all active points during stripping.

In the optimization of the stripping unit, firstly, studies related to temperature were carried out, and the graphic related to these studies is given below.

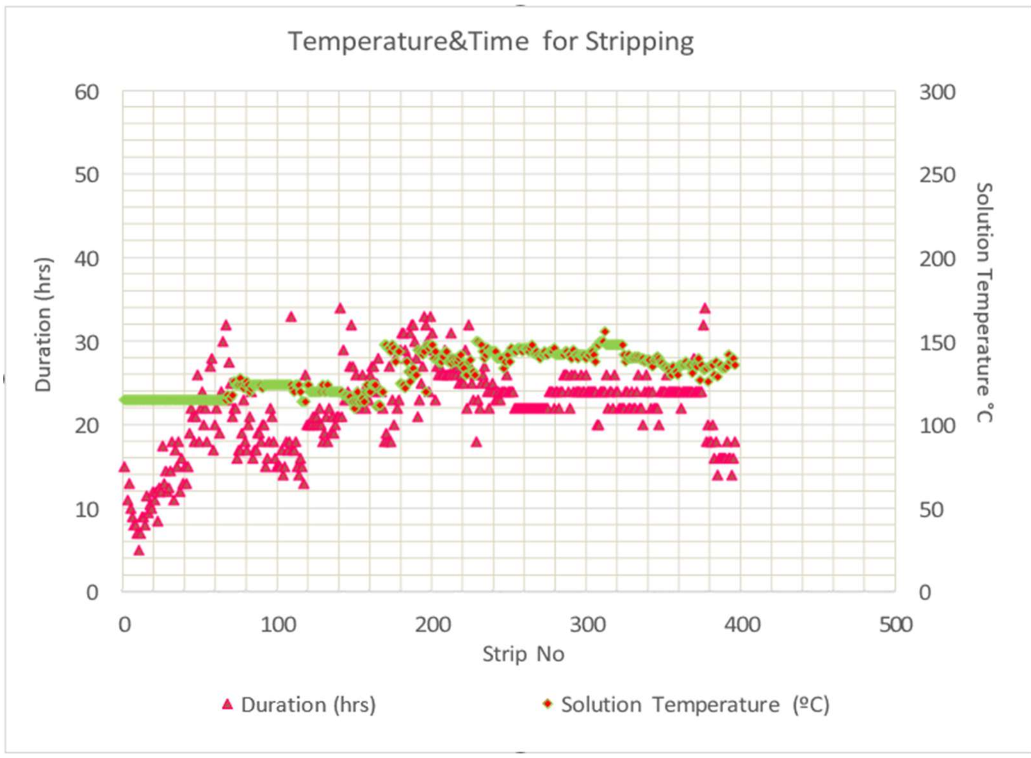

Figure 1 Stripping Duration and Temperature

In Figure 1, the stripping time shortens with the increase in the temperature of the solution entering the pressurized stripping column. First of all, studies were carried out to shorten the stripping time by optimizing this parameter, and the stripping time was shortened.

For each stripping process, a solution of 12000ppm cyanide and 2-3% caustic was prepared in the unloaded solution tank. In the first stripping processes, it was ensured that the cyanide concentration was not reduced below 1000ppm throughout the process. This led to an increase in cyanide consumption. After optimizing the temperature and pressure, studies were started to determine the cyanide consumption, and during the stripping period, cyanide was not added to the unloaded solution tank when the cyanide concentration fell below 1000ppm. Thus, the cyanide consumption in the stripping process is reduced. In addition, the low cyanide concentration throughout the process did not cause any negative effects on metal recovery efficiency or stripping time.

After optimizing the temperature and chemical concentrations, the effects of gold and silver recovery were investigated by performing low voltage electrolysis. The voltage value read on the plates in the cells is measured between 2.2-2.4 V. In this study, the electrolysis cell rectifier voltage was reduced to 2.0 V and the voltage values of the cells were followed during the stripping time. Reducing the EW cell voltage did not have a positive effect on the stripping time or metal recovery efficiency, and when the stripping results were examined, it was seen that the empty carbon results were high. Therefore, the electrolysis cell voltage should be between 2.2 and 2.4 V for gold and silver ore. The results are shown in Table 1.

Table 1 Electrolysis Cell Voltage During Stripping

Time (hrs)	Electrowinning Cell-1 Voltage		Electrowinning Cell-2 Voltage		EW-1 Au(ppm)	EW-2 Ag(ppm)	EW-1 Au(ppm)	EW-2 Ag(ppm)
	Entrance	Exit	Entrance	Exit	Entrance		Exit	
1.00	1.5	1.5	1.5	1.4	77	1130	71	1570
2.00	1.5	1.5	1.5	1.5	70	845	51	592
3.00	1.4	1.1	1.5	1.5	49	240	32	73
4.00	1.4	1.4	1.5	1.5	72	98	13	26
5.00	1.3	1.3	1.5	1.4	32	37	12	17
6.00	1.4	1.5	1.4	1.2	20	18	10	6
7.00	1.1	1.0	1.3	1.1	18	6.8	8.8	5.4
8.00	1.2	1.2	1.1	1.2	16	1.6	8.4	2.2
9.00	1.1	1.2	1.2	1.3	14	1.1	8.1	1.8
10.00	1.1	1.2	1.5	1.6	9.8	0.4	6.9	0.6
11.00	1.7	1.7	1.7	1.7	7.4	0.1	5.8	0.4

Loaded Carbon Au (ppm)	Loaded Carbon Ag (ppm)	Barren Carbon Au (ppm)	Barren Carbon Ag (ppm)
1050	12100	205	3250

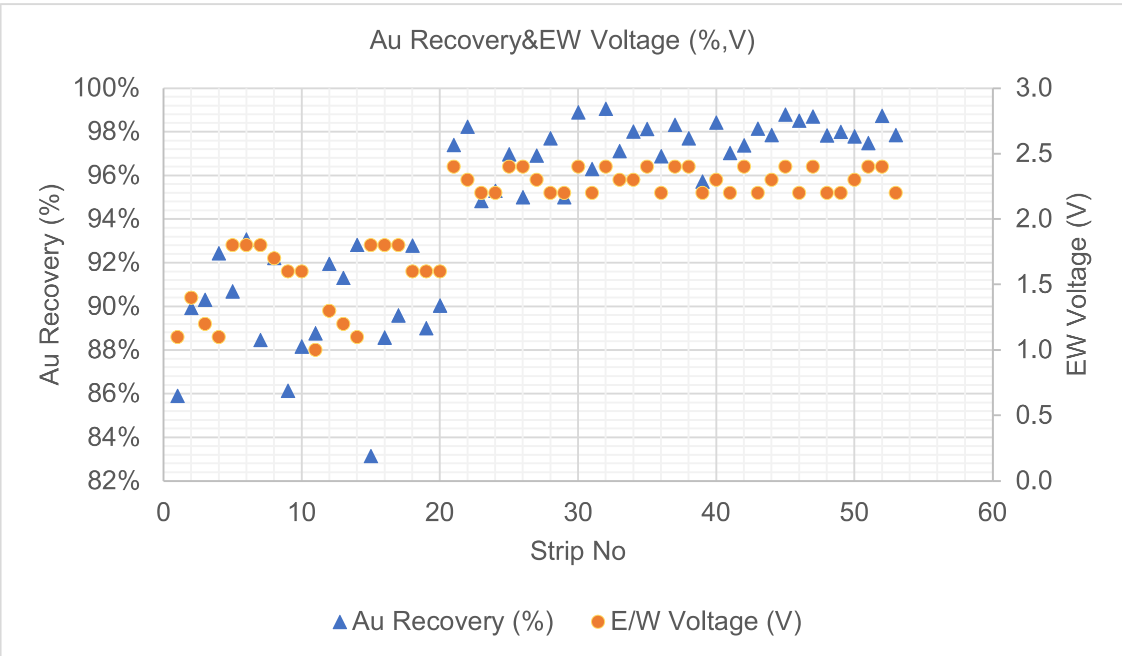

Figure 2 Au Recovery and EW Voltage

When looking at the figure 2, relationship between voltage and gold recovery, the gold recovery decreases as the EW voltage value decreases.

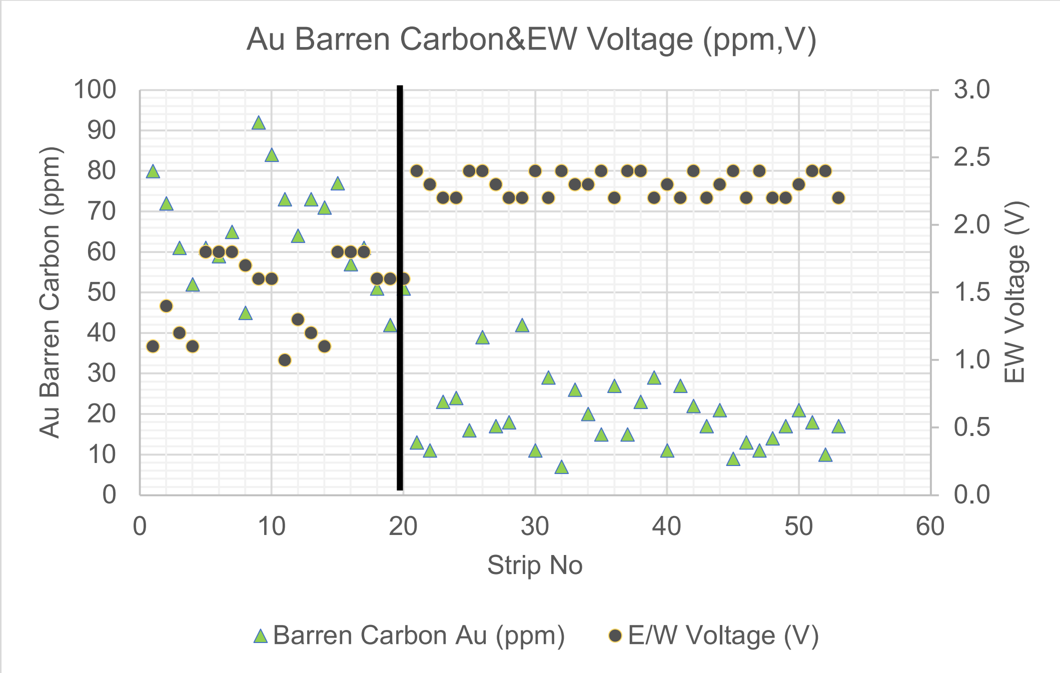

Figure 3 Au Barren Carbon and EW Voltage

When looking at the figure 3, relationship between voltage and Au barren carbon, the EW voltage value decreases, barren carbon for Au increases.

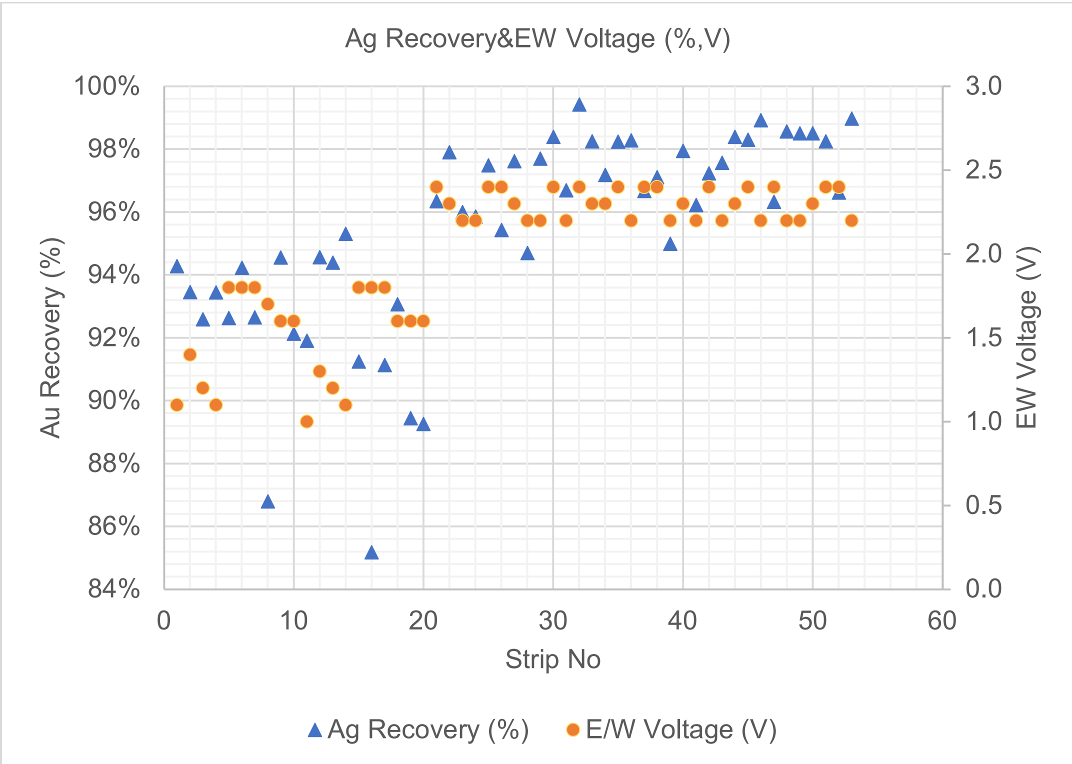

Figure 4 Ag Recovery and EW Voltage

When looking at the figure 4, relationship between voltage and silver recovery, the silver recovery decreases as the EW voltage value decreases.

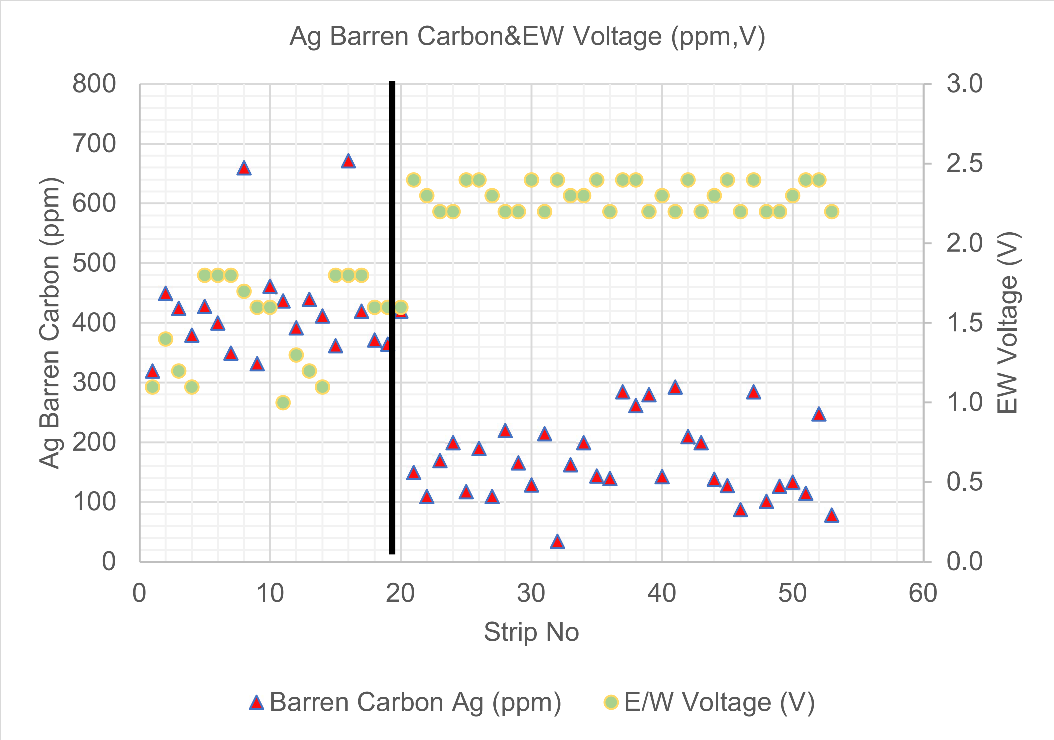

Figure 5 Ag Carbon and EW Voltage

When looking at the figure 5, relationship between voltage and Ag barren carbon, the EW voltage value decreases, barren carbon for Ag increases.

CONCLUSION

Many different tests were carried out by changing one variable determined in the stripping process and keeping other variables constant. As a result of these tests, it has been clearly revealed that all parameters (temperature, flow rate, solution concentration, electrolysis voltage etc.) in the stripping unit have an effect on stripping. When all variables and parameters are examined, the shortening of the stripping time;

- Decreased stripping duration and decreased power consumption.
  Equipment operating times (pump, heaters..) decreased from 24-26 hours to 14-16 hours.
- Decreased chemical consumption, reduced blockage/accumulation in the unit
  The cleaning times of the unit decreased as the precipitation material decreased with the reduction of the caustic concentration.
- Initial stripping solution concentrations should be prepared as 12000ppm NaCN and 2-3% NaOH
- Decreased chemical consumption, increased lifetime of the spares.
  The operation life of the anode cathode is extended.
- Decreased chemical consumption, decreased the operation cost
  Cyanide consumption decreased by approximately 50%.
  Caustic consumption decreased by approximately 40%.
- The temperature of the stripping solution entering the pressure tank should be 135-140°C.
- In cases where the difference between the limit temperatures and the actual temperatures of the heaters exceeds 10 degrees, the heaters should be immediately taken into the cleaning operation without being damaged.
- Electrolysis cells depend on the volt value between the plates being between 2.2-2.4V.

The detailed table of the results is given below.

Table 2 Stripping Optimization Results

Test No	Stripping Duration (hrs)	Loaded Carbon Au (ppm)	Loaded Carbon Ag (ppm)	Barren Carbon Au (ppm)	Barren Carbon Ag (ppm)	Au Recovery (%)	Ag Recovery (%)	Solution Temperature (ºC)	EW Voltage (V)
1	16	900	12600	30	830	93.30%	93.40%	134	2.2
2	14	1095	13000	32	500	94.50%	96.20%	126	2.2
3	16	1185	13350	25	550	88.40%	94.80%	135	2.3
4	16	940	13300	42	475	95.50%	96.40%	136	2.3
5	14	1005	13600	51	866	94.90%	93.60%	136	2.2
6	16	975	13250	31	525	92.60%	94.30%	130	2.2
7	16	870	10600	41	475	95.30%	95.50%	138	2.3
8	14	1030	12600	26	430	89.60%	92.60%	129	2.3
9	16	1310	12900	25	400	94,00%	93.90%	136	2.2
10	16	1250	12100	30	420	83.80%	91.70%	136	2.2
11	16	1603	12715	20	272	97.90%	98.20%	134	2.3
12	16	1123	12490	15	350	79.70%	91.50%	134	2.4
13	16	1147	13160	28	520	82.80%	92.70%	134	2.2
14	16	1400	13600	27	443	98.10%	96.70%	135	2.2
15	16	686	11575	15	1060	97.80%	90.80%	142	2.2
16	16	820	12700	39	534	95.20%	95.80%	138	2.2
17	14	738	11025	32	600	93.60%	90.50%	140	2.3
18	16	965	13250	15	410	98.40%	93.10%	140	2.2
19	16	1065	11900	21	470	98.00%	96.10%	136	2.2
20	16	1093	12500	15	480	98.60%	96.20%	146	2.2
21	16	1200	13300	25	380	92.70%	94.90%	146	2.3
22	16	1180	11350	18	445	98.50%	96.10%	146	2.3

REFERENCES

1. J.C. Monette, E. J. Fuller, SME Annual Meeting (1992) “Plant experiences with the use of a novel chemistry to strip gold and silver from carbon”,

2. Van Deventer, J. S. J., & Liebenberg, S. P. (2003). “The role of cyanide in the multicomponent elution of cyanide complexes from activated carbon. The European Journal of Mineral Processing and Environmental Protection”, 3(3), 1303-1868.

3. Michael Drozd, Annual Canadian Mineral Processors Conference, (2008) “Activated carbon’s use in gold adsorption and recovery”, 491-493.

4. Michael Drozd, Annual Canadian Mineral Processors Conference, (2008) “Activated carbon’s use in gold adsorption and recovery”, 491-493.

5. Urbanic, J.E., Jula, R.J., Faulkner, W.D., 1985. Regeneration of activated carbon used for recovery of gold. Miner. Metall. Process., November, 193 – 198.