

RECOVERY OF PLACER GOLD USING THE KNELSON CONCENTRATOR

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ABSTRACT

The recovery of alluvial gold was studied using 3 and 7.5 inch Knelson concentrators applied to four kinds of sands coming from Bajo Cauca and El Bagre, Antioquia, Colombia. Gold recoveries of over 98-99% were obtained from the three-stage tests under the following operating conditions: pulp dilution, 3: 1; particle size range, -10+20, -20+65 and -65 Tyler mesh; and a water pressure of 3 to 5 psi with an average of 4 psi.

INTRODUCTION

The recovery of placer gold in Colombia is carried out in gravity concentrators, such as, sluice boxes and jigs which yield coarse gold recoveries of between 40% and 70%. The losses of fine gold are very high. The Knelson Concentrator is widely known as an efficient equipment for the recovery of fine gold [Harris, 1984] Hence, the objective of this work was to determine the optimum operating conditions of the Knelson Concentrator to obtain maximum recovery of fine gold from the alluvial placers of El Bajo Cauca and El Bagre in Antioquia, Colombia, S.A.

EQUIPMENT AND MATERIALS

Knelson Concentrator

The Knelson Concentrator is a centrifugal bowl-type concentrator developed by Lee Mar Industries, Inc., of Bumaby, B.C., Canada [Silva, 1986]. The unit is essentially a high speed, ribbed rotating cone with a drive unit. Figure 1 shows a schematic of the Knelson Concentrator with its main mechanical parts.

The ore slurry containing 25% to 35% solids is fed into the top of the unit. The concentrates are retained in the cone until clean-up while tailings are continually washed out from the side of the unit.

There are currently five models of Knelson Concentrators available, ranging in size, from 3 inches to 30 inches (as measured by the diameter of the cone). The technical and operating parameters are given in Table 1.

The Knelson Concentrator utilizes the principle of hindered settling classification in a centrifugal force field. A central perforated cone containing horizontal ribs welded along the inside wall is rotated at 400 rpm, at which speed it generates a force of 60 times the gravitational force. Heavy particles are forced out against the walls and trapped between the ribs while the lighter particles are carried away by the water flowing out. The cone is surrounded by a pressurized water jacket that forces water through holes in the cone to keep the bed of heavy particles fluidized. The force of the water acts against the centrifugal force of the rotating cone. This counter force is strong enough to inhibit severe compaction of the

collected concentrate. As a result, the mineral grains remain mobile, allowing the heavy particles to penetrate. As processing continues, lighter particles in the mobile bed are replaced by incoming heavier ores, until only the heavier particles in the feed are retained. Clean-up is accomplished by stopping the cone, opening a drain at the bottom, and flushing out the concentrate. This is usually done at the end of a shift.

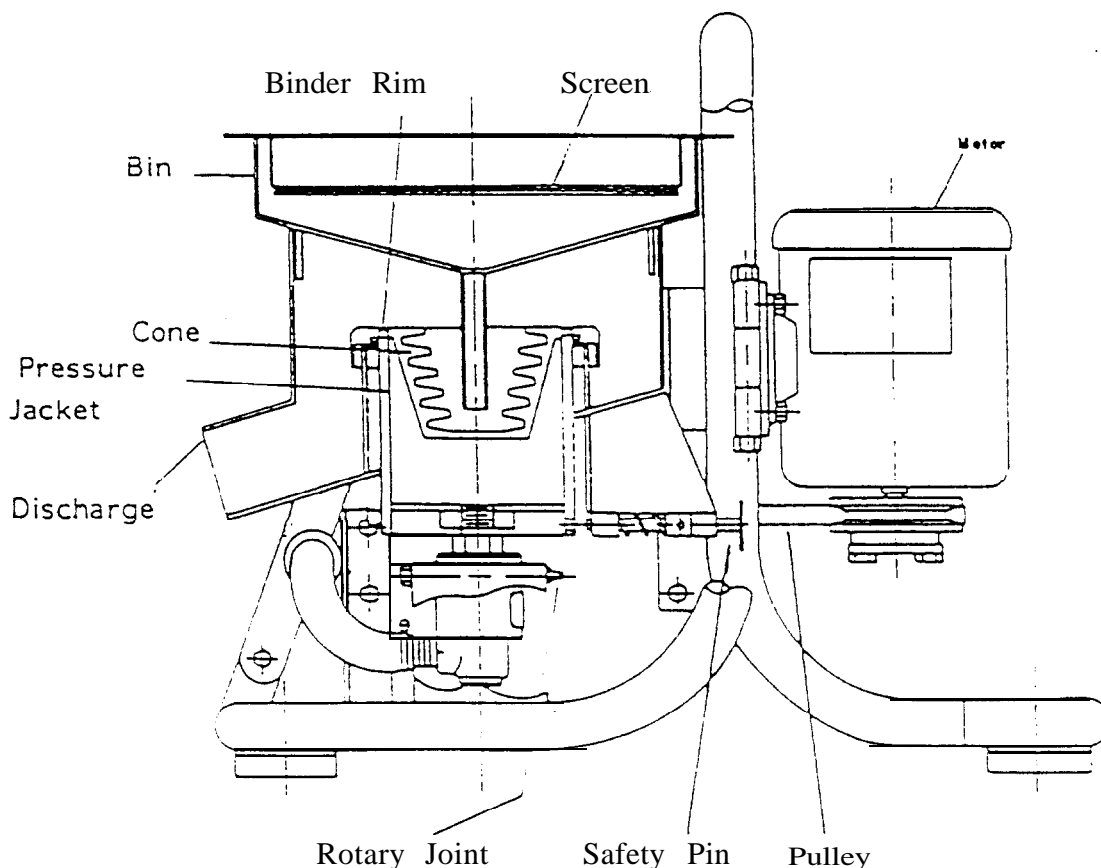


Figure 1 Cross section of 3 inch Knelson Concentrator

Table 1 Technical and operating parameters of the Knelson Concentrators

Model (D, in.)	P (Kwatt)	Vr (rpm)	Cap. (t/h)	WW (L/min)	Ap (L/min)	C (Kg)	d (mm)
3		1200	0.065	2	13	0.08-0.11	2
7.5	0.37	800	0.25	20	30	2.3	4
12	0.75	600	3-4	120	80	10-20	6
20	3.75	460	12-15	400	250	30-40	6
30	7.15	400	30-40	1200	600	60-70	6

Nominal pulp dilution: 35% of solids

D = Cone diameter in inches

VI = Rotational speed of the cone

WW = Wash Water

C = Concentrate weight

P = Motor Power

Cap. = Capacity (tph)

Ap = Pressure Water

d = Maximum particle size in the feed

MATERIALS

The placer sands used for the research came from alluvial deposits of Bajo Cauca, Mine "Los Colonos" and Mines "Las Malvinas" and "Mineros de Antioquia", Province of Antioquia, Colombia, S.A. The placer sands were identified as: type A, B, C and D. Table 2 shows physical and chemical characteristics of the sands.

Table 2 Physical and chemical characteristics of the different types of alluvial sands

Type	Density Wcm3)	Particle size (Tyler mesh)	Au grade (n&n31	Associated Minerals	
				SiO ₂ (%)	HM (%)
A	2.9	- 20	1400	80	20
B	2.8	- 28	500-2250	88	12
C	2.8	- 20	300	88	12
D	2.9	- 14	30098-93466	81	19

HM: Heavy Minerals (especially Magnetite and Ilmenite)

The type A are black sands from sluice boxes. The type B are fresh sands from alluvial deposits, while the type C are tailings from sluice boxes. The type D are sands from overflows of primary jigs in Drag - 8 belonging to Mineros de Antioquia.

EXPERIMENTAL PROCEDURE

The concentration experiments were carried out in the Knelson Concentrator in three steps as follows:

- Stage 1: The mineral pulp is fed into the Knelson Concentrator under the selected operating conditions. The material retained in the cone is called Concentrate 1 (C1) and the sands flowing out is known as Tailings 1 (T1).
- Stage 2: The Tailings 1 is fed again into the concentrator obtaining Concentrate 2 (C2) and the material flowing out Tailings 2 (T2)
- Stage 3: The Tailings 2 is fed again into the concentrator obtaining Concentrate 3 (C3) and final Tailings 3 (T3).

The concentrates C1, C2 and C3 are taken out from the cone at the end of each stage. The gold is recovered by amalgamation.

The final tailings (T3) are concentrated in pan and the gold is also evaluated by amalgamation.

RESULTS AND DISCUSSION

Effect of water pressure

In order to determine the effect of water pressure on the cumulative recovery during the three stages of concentration, experiments were carried out employing water pressures in the range of 3 to 7 psi, while keeping the other operating parameters constant according to the type of sand. The type A, type B and type C sands were concentrated only using the 3 inch Knelson Concentrator while the type D sands were processed using the 3 and 7.5 inch Knelson concentrators.

Type A sands. The operating conditions were: pulp dilution, 3:1; particle size, -20 Tyler mesh; average grade, 1400 mg/m³; and feed flowrate, 0.02 m³/hr. The cumulative recovery was evaluated for the pressure range of 4 to 6 psi. The results obtained are shown in Figure 2. The best cumulative recovery of gold was 98.5% at a water pressure of 4 psi.

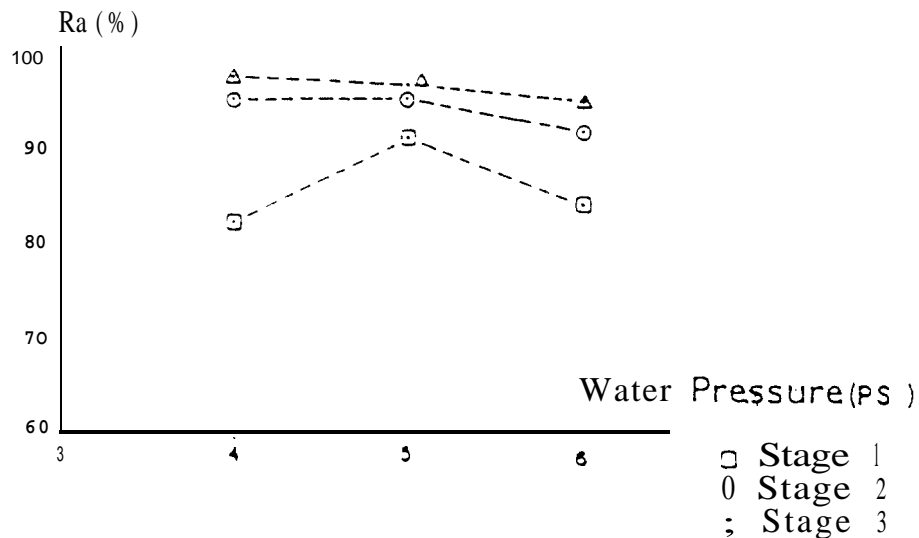


Figure 2 Recovery vs. water pressure, type A sands [-20+65 Tyler mesh]

Type B sands. This material was studied under the following operating conditions: pulp dilution, 3:1; particle size, -20+65 Tyler mesh; average grade, 2250 mg/m³; feed flowrate, 0.02 m³/hr; and the water pressure was changed from 3 to 7 psi. The results obtained are shown in Figure 3.

Stages 1 and 2 show an abnormal behaviour for gold recovery, while the stage 3 presents stability at the pressure range studied. The best gold recovery was 99.5% at 3 psi.

To determinate the effect of water pressure on fine material (-65 Tyler mesh), tests were carried out using water pressures in the range of 2 to 5 psi and with an average grade of 500 mg/m³. The results obtained are shown in Figure 4. The maximum gold recovery is obtained at a water pressure of 3 psi. It is important to keep in mind that high water pressures are not suitable for the recovery of fine gold particles.

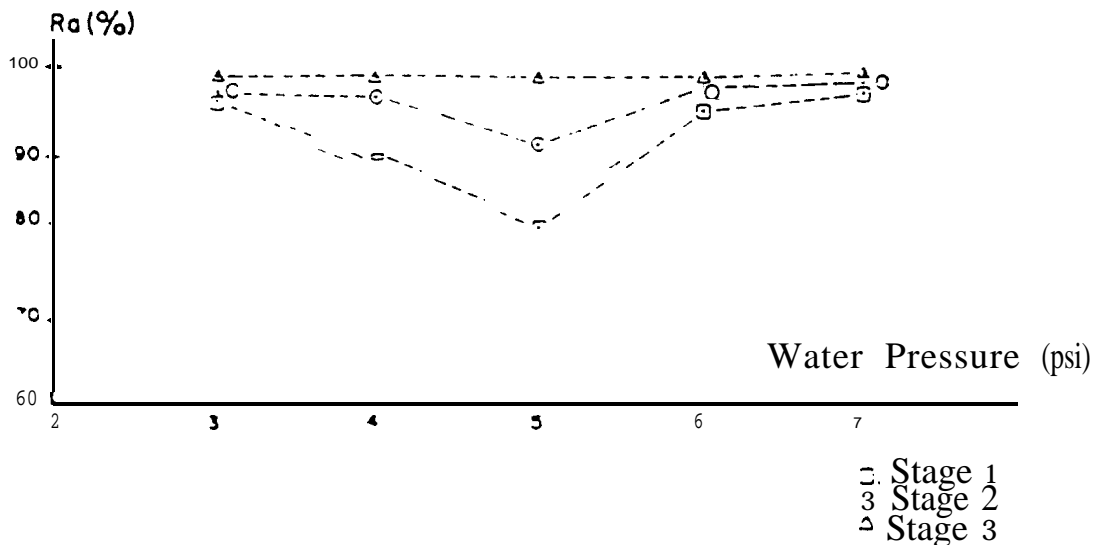


Figure 3 Recovery vs. water pressure, type B sands [-20+65 Tyler mesh]

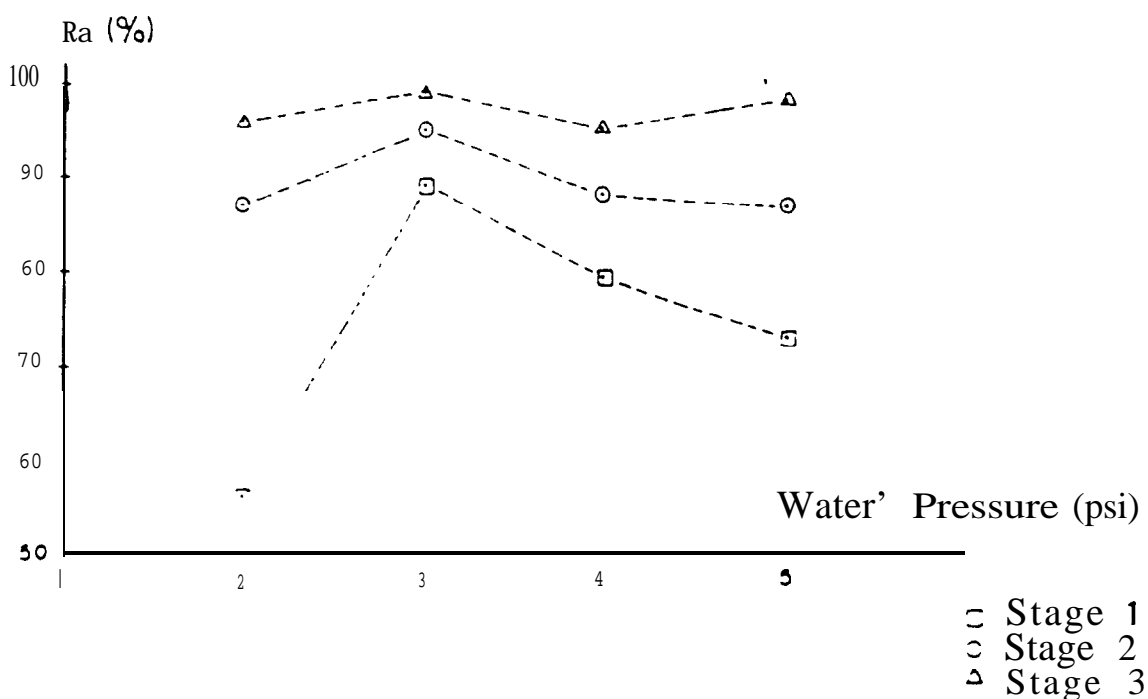


Figure 4 Recovery vs. water pressure, type B sands [-65 Tyler mesh]

Type C sands. This material was studied under the following operating conditions: pulp dilution, 3: 1; particle size, -20 Tyler mesh; average grade, 300 mg/m³; and the feed flowrate, 0.02 m³/hr. The cumulative recovery was evaluated for the pressure range of 3 to 7 psi. The results are presented in Figure 5. It is noted that the recovery of gold does not show great variations in the water pressure range studied. The pressure selected was 5 psi due to the wide size range of particles. The gold recovery was 98%.

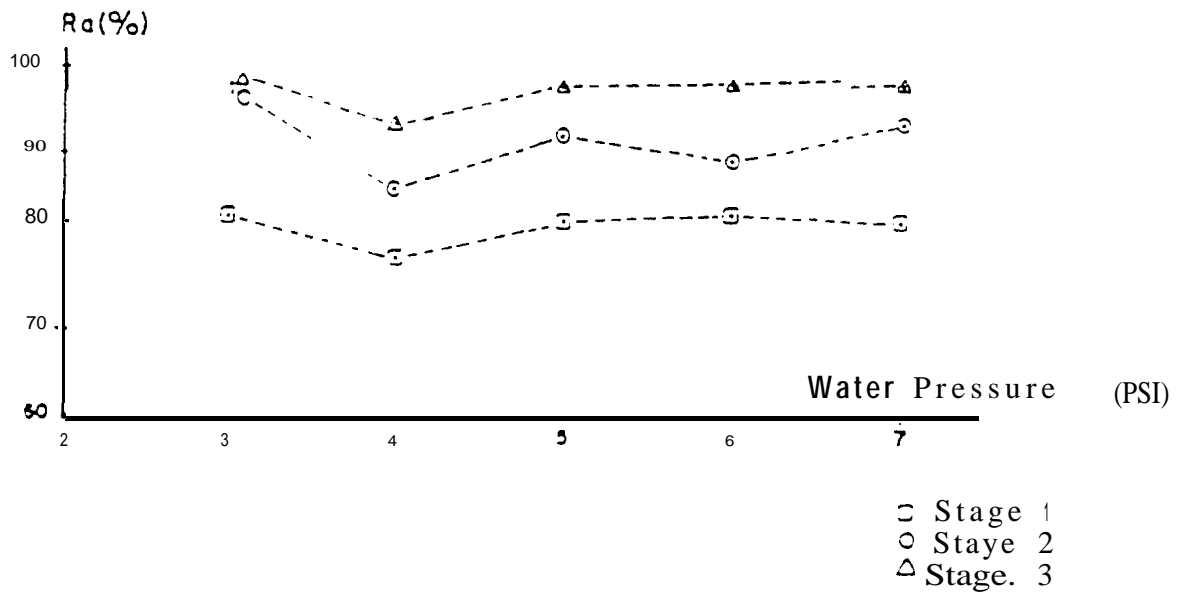


Figure 5 Recovery vs. water pressure, type C sands [-20 Tyler mesh]

Type D sands. This material was processed using the 3 inch and 7.5 inch Knelson Concentrators. The tests with the 3 inch Knelson Concentrator were carried out under the following operating conditions: pulp dilution, 3: 1; particle size, - 10 Tyler mesh; grade, different for each test (44973 - 93467 mg/m³); the feed flowrate, 0.02 m³/hr; and water pressure, in the range of 4 to 6 psi. Figure 6 shows the results obtained. The best gold recovery was 99.9% at 5 psi of water pressure.

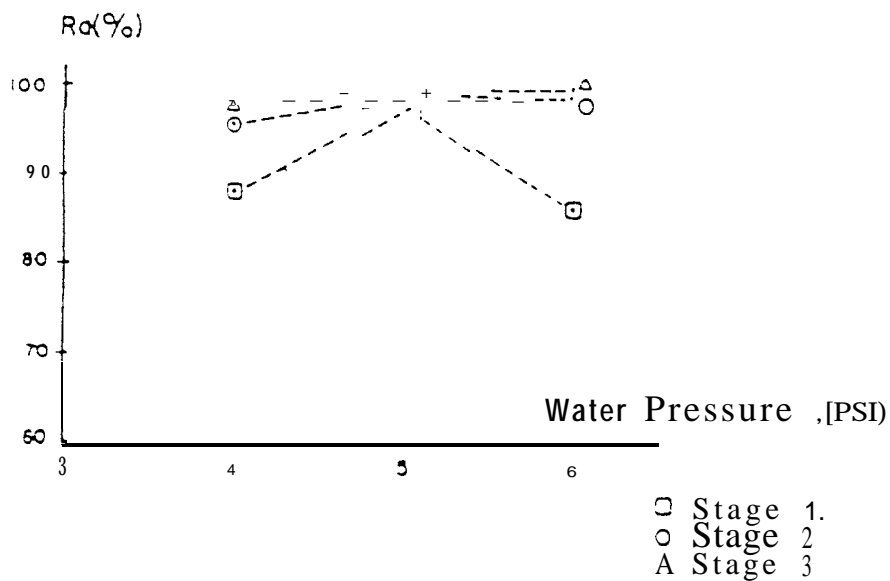


Figure 6 Recovery vs. water pressure, type D sands, 3 inch Knelson Concentrator

The tests with the 7.5 inch Knelson Concentrator were carried out under the following operating conditions: pulp dilution, 3 : 1; particle size, -10 Tyler mesh; grade, different for each test (30099-96326 mg/m³); the feed flowrate, 0.22 m³/hr; and water pressure, in the range of 4 to 6 psi. The results are shown in Figure 7. The gold recovery was 99.9% at a water pressure of 5 psi.

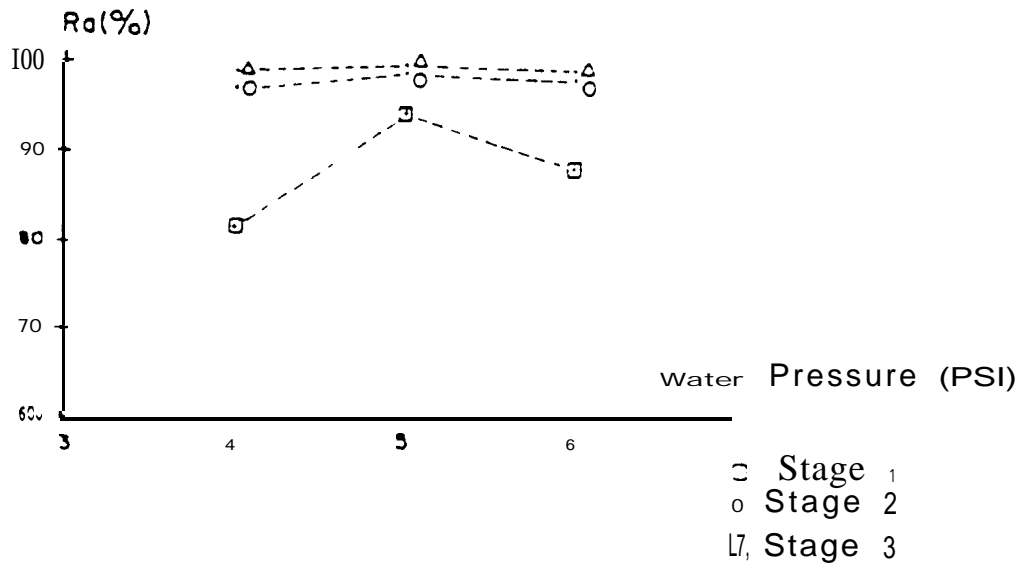


Figure 7 Recovery vs. water pressure, type D sands, 7.5 inch Knelson Concentrator

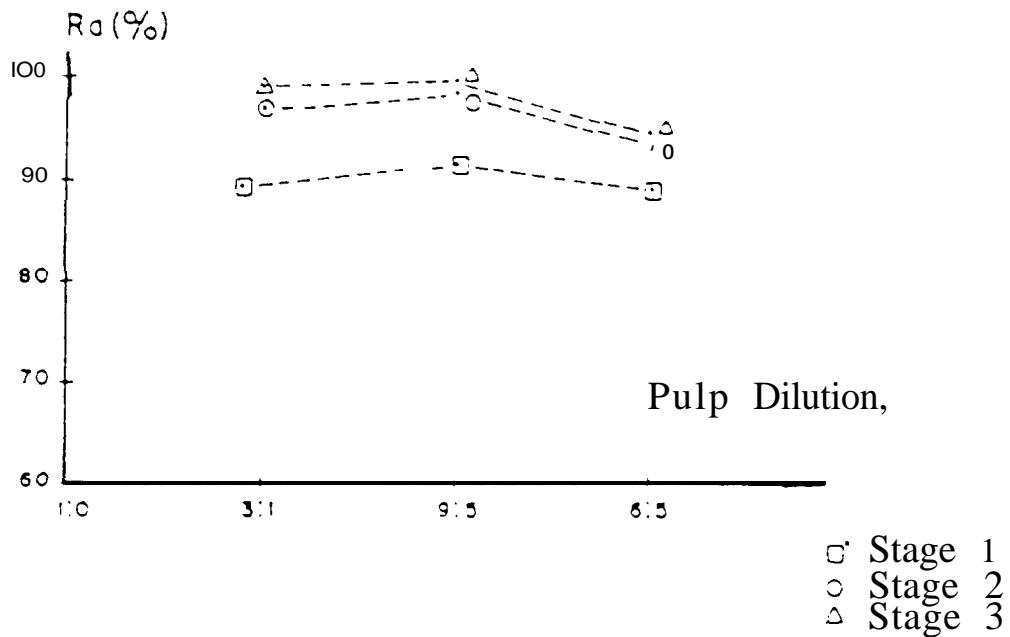


Figure 8 Recovery vs. pulp dilution, type B sands [-20+65 Tyler mesh]

Effect of pulp dilution

The pulp dilution was studied for the type B, type C and type D sands. The pulp dilutions examined were 3: 1, 9:5 and 6:5, with the other parameters being fixed. Figures 8, 9, 10 and 11 show the results obtained. The recovery of gold does not change significantly with different pulp dilutions. The Gold recovery is 97 to 99% for a dilution of 3:1

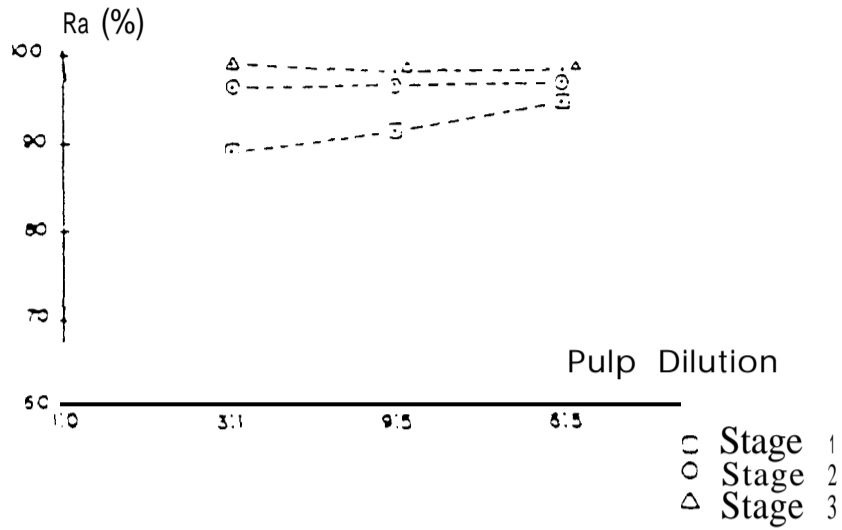


Figure 9 Recovery vs. pulp dilution, type B sands [-65 Tyler mesh]

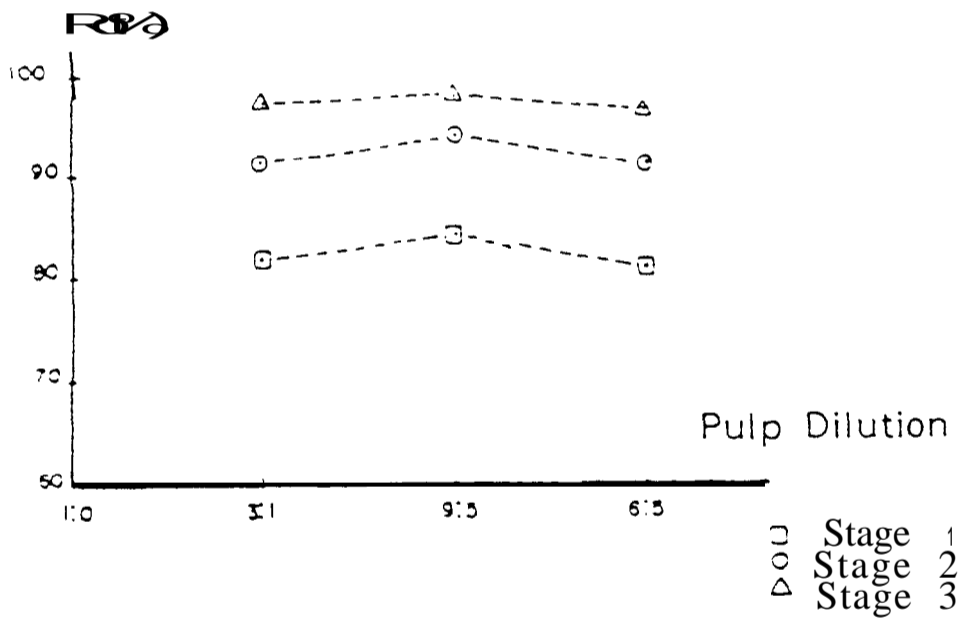


Figure 10 Recovery vs. pulp dilution, type C sands [1-20 Tyler mesh]

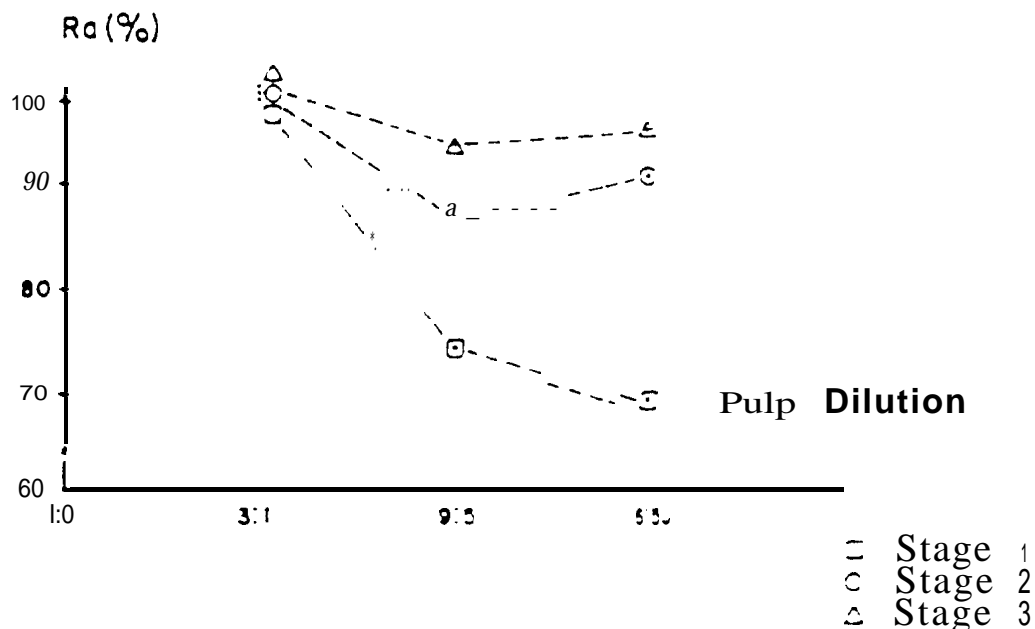


Figure 11 Recovery vs. pulp dilution, type D sands [-20 mesh],
3 inch Knelson Concentrator

CONCLUSIONS

From the results of this study on the recovery of alluvial fine gold using the Knelson Concentrator, the following observations were made:

The Knelson Concentrator proved to be an efficient equipment for recovering free gold in all particle size ranges, specially for the recovery of fine gold which is lost during the operation of the other gravitational concentrators (sluice boxes and jigs).

The water pressure showed to be the most important variable to obtain high gold recoveries while the pulp dilution did not have a significant effect. The suitable water pressure was less than 3 psi for fine particles.

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