ASPECTOS PRINCIPALES DE LA FLOTACION DE CALCINAS PROVENIENTES DEL PROCESO DE SEGREGACION

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1.- INTRODUCCION

Algunos minerales oxidados de Cu (malaquita, crisocola), es posible sulfidizarlos y luego recuperarlos por flotación directa, pero cuando la crisocola es muy abundante este método tiene baja eficiencia más aún cuando existen minerales arcillosos como ganga tal como sucede con el mineral de Berenguela, el cual es un mineral de cobre oxidado con alta ley de plata, en una matris de manganeso amorfo en la cual la Ag y el Cu se encuentran finamente diceminados y en solución sólido acompañada con una ganga de calcitas y otros carbonatos lo que haría sumamente costosa una lixiviación con ácido sulfúrico.

Por esa razón se decidio aplicar métodos no convencionales más eficientes y adecuados como por ejemplo el de segregación, tal como se muestra en la Tabla # 1, que muestra los principales métodos para el tratamiento de minerales oxidados de Cu y Ag, lo cual fué confirmado posteriormente durante las pruebas de Laboratorio y Planta Piloto en las que se obtuvo recuperaciones de más de 90% para el Cu y más de 70% para la Ag aplicando la segregación.

TABLA # 1 METODO PARA EL TRATAMIENTO DE DIFERENTES MINERALES

MINERAL	Principales Minerales de Cu		GANGA	METODO DE RECUPERACION						OBSERVACION.
				FLOTACION		SEGREGACION		LIXIVIACION		
				Recup. Cu	Recup. Cu y Ag	Recup. Cu	Recup. Cu y Ag	Recup. Cu	Recup.Cu y Ag	
Sulfuro	Primario Secunda. Secunda.	Calcopirita Cobre Calcopirita	Silicato	◎	○	△	△	x		Porphing Cupper
	Secunda.	Cobre	Carbnt.	◎	○	△	△	x		
Mineral Oxidado	Carbnt.	Malaquita	Sulfato Carbnt.	○ ○	○ ○	◎ ◎	◎ ◎	◎ x		
	Silicato	Crisocola	Sulfato Carbnt.	x x	x x	◎ ◎	◎ ◎	◎ x		Min. Tintaya Min. Katanga
	Sulfuro	Proshantite	Sulfato Carbnt.	x x	x x	◎ ◎	◎ ◎	○ x		Mi. C. Verde
	Oxidado	Cuprita	Sulfato Carbnt.	○ ○	○ ○	◎ ◎	◎ ◎	◎ x		
Otros	Amorfo		Sulfato Carbnt.	x x	x x	◎ ◎	◎ ◎	? x		Berenguela
	Metal	Cobre Natur.	Sulfato Carbnt.	○ ○	○ ○	◎ ◎	◎ ◎	○ x		

NOTA : ◎ Buena recuperación
○ Aplicable (Resultado variable)
△ Difícil aplicación
x No aplicable directamente, requiere tratamienro aparte

2.- PRUEBAS DE FLOTACION

2-1) Pruebas a nivel de Laboratorio

Estas pruebas fueron realizadas según el Flow-Sheet que se muestra en el esquema # 1.

El cobre y la plata se segregan en estado metálico formando una aleación sobre la superficie del coke y su flotación no resiste mayores problemas por su alta flotabilidad, tal como se puede observar en su curva cinética en los Gráficos # 1 y 2.

Para el proceso usamos un colector fuerte como el xantato amílico de potasio (AERO -350) y un espumante energico como el aceite de pino. En la etapa scavengher se usa con colector de coke fino el kerosene y el Z-200 para mejorar la recuperación de Ag y Cu finos. Los resultados se muestran en la siguiente tabla.

Tabla # 2

	LEY QUIMICA		RECUPERACION		CONDICION DE FLOTACION	CONDICION DE SEGREGACION
	Cu%	Ag g/t	Cu	Ag		
Cabeza	1.38	438	100.0	100.0	KAX :200 g/t A. Pino :100 g/t	Tempe.:800°C
Concen.	10.2	2,620	92.9	75.0	Z-200 :100 g/t Kerosene: 50 g/t Tiempo :10 min.	NaCl :0.5% Coke : 5% Tiempo: 30min
Relave	0.15	163	7.1	25.0		

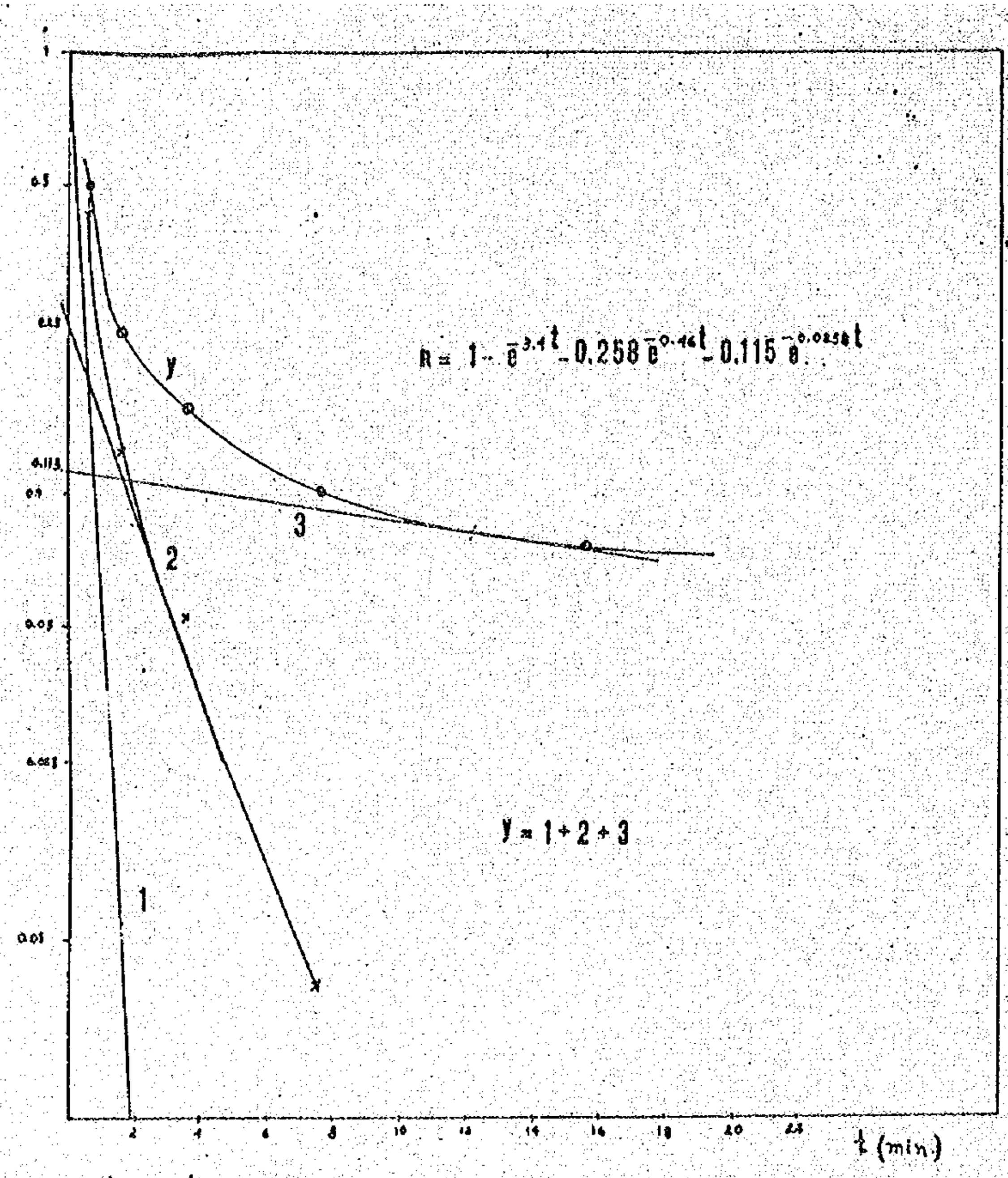
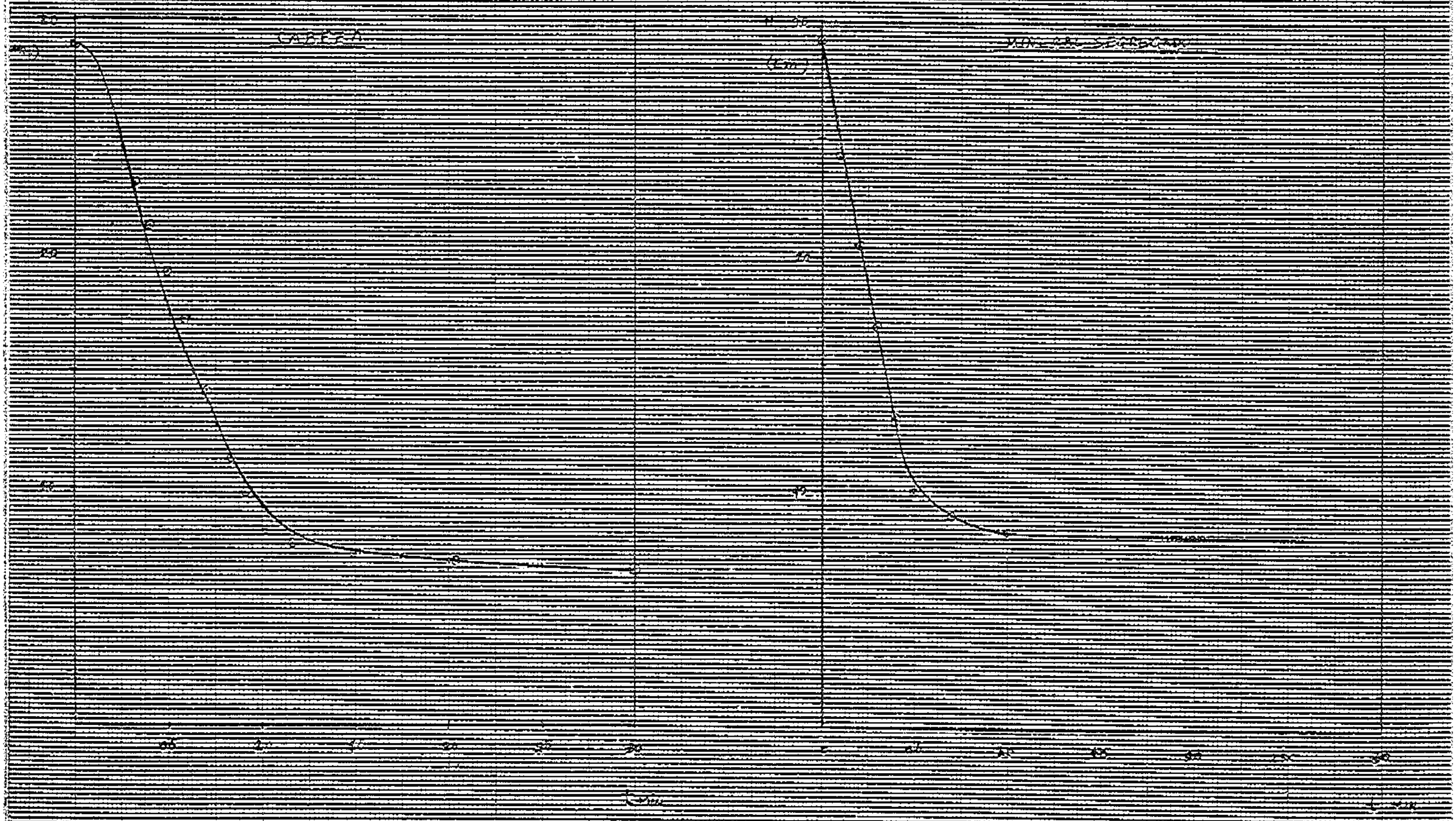
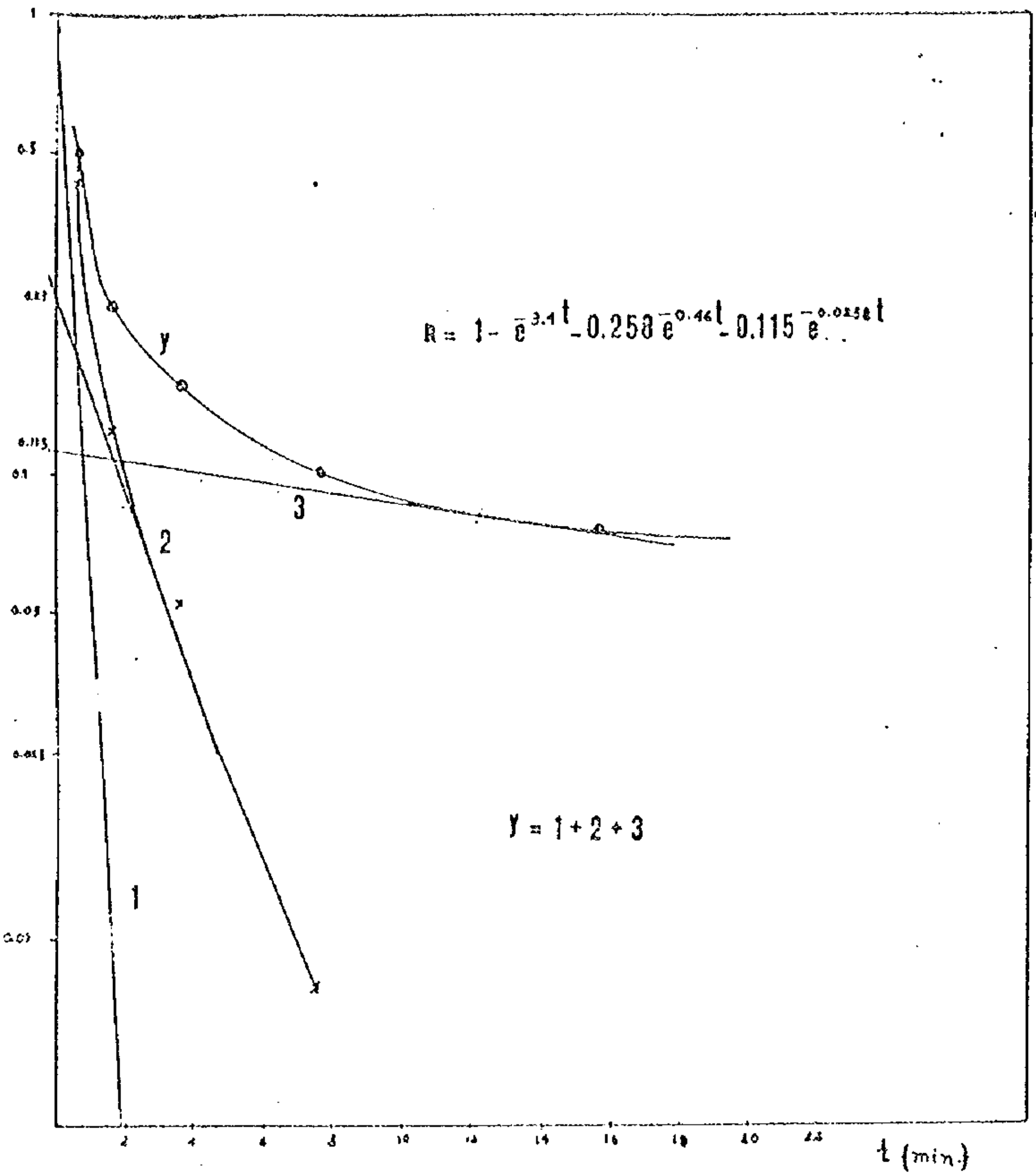


grafico nº 1 ecuacion de la cinetica de flotacion

CURVAS DE SEDIMENTACION





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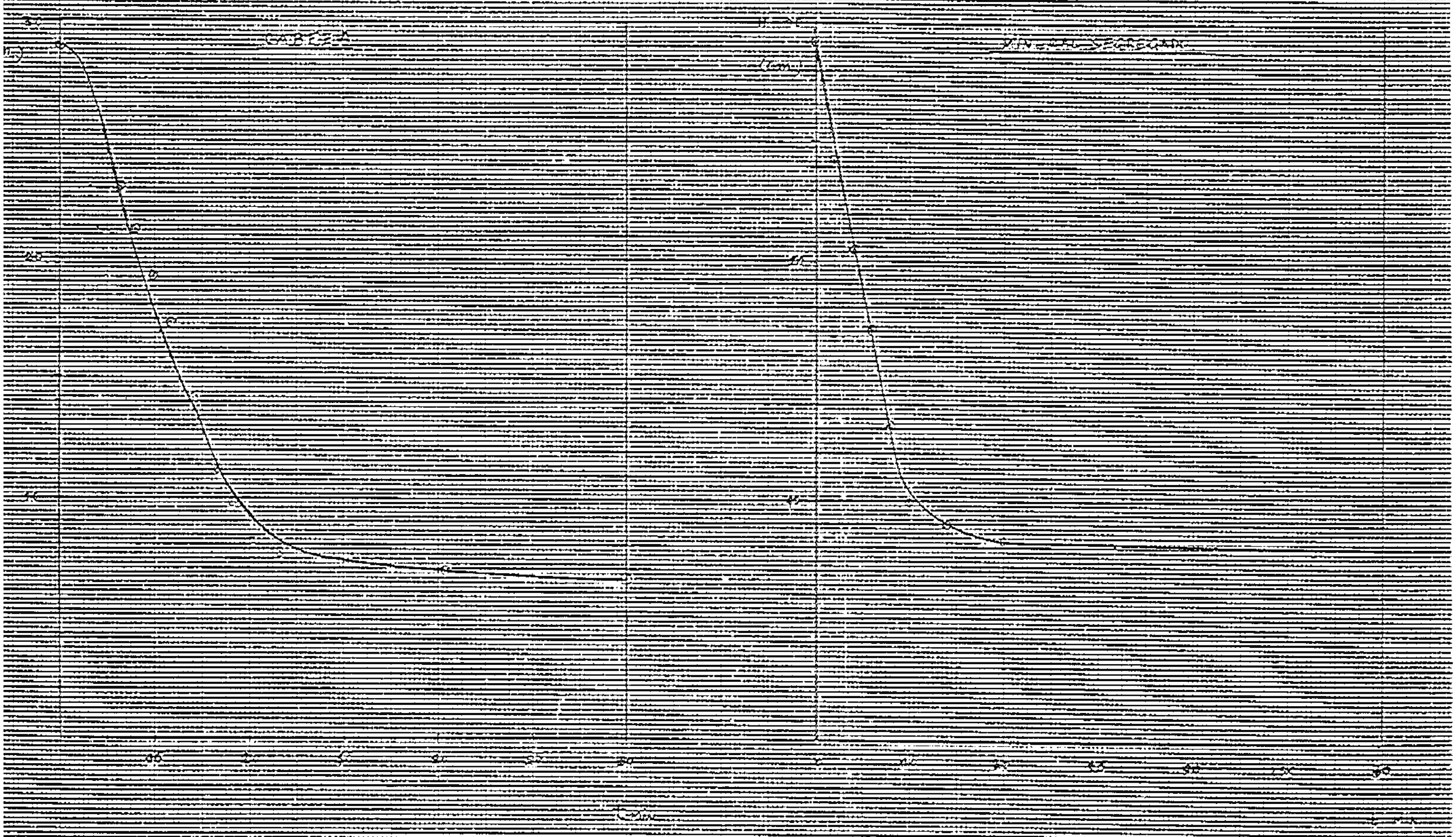
CURVAS DE SEDIMENTACION



2-2) Pruebas a nivel de Planta Piloto

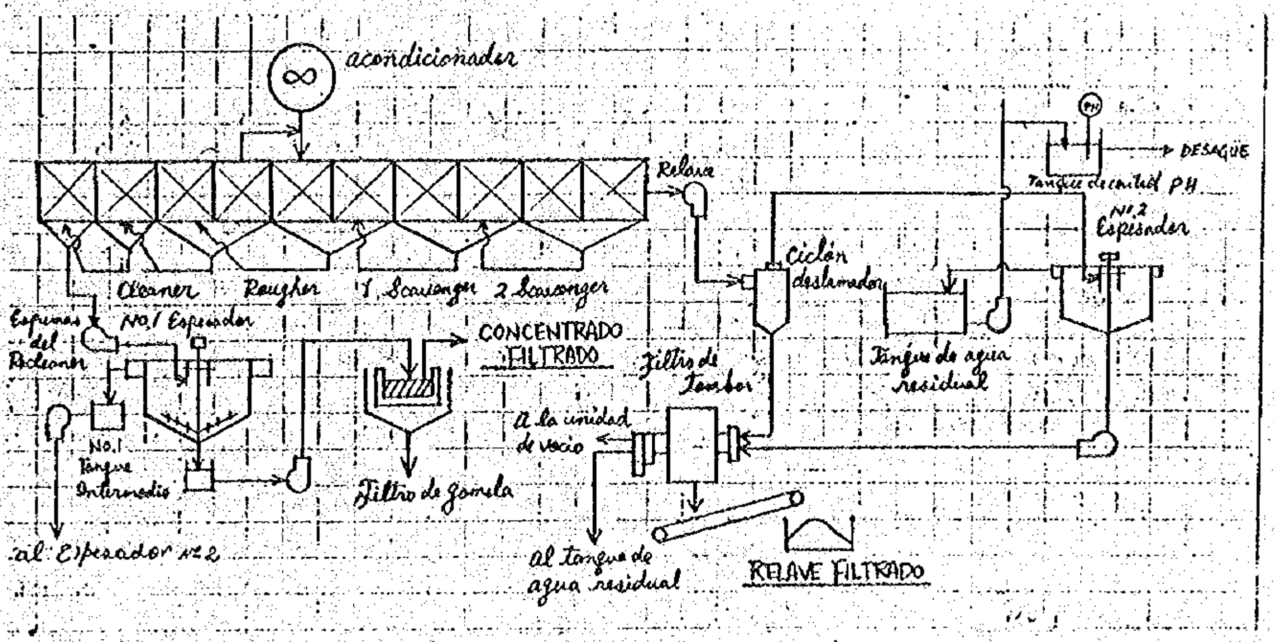
Como hemos mencionado anteriormente la flotación de calcinas de segregación no tiene diferencias muy grandes respecto a la flotación convencional de sulfuros, por lo cual se diseño a nivel piloto un circuito de flotación como se muestra en el esquema # 2.

Una de las particularidades más importantes que se puede mencionar es que al encontrarse el Cu y Ag como aleación la pulpa tiene una gran tendencia a sedimentarse por lo que las celdas deben de tener características especiales, otra particularidad es la existencia de ganga carbonócea que ocasiona incrustaciones en las celdas y ductos lo cual provoca atoros contínuos debiendo hacerse mantenimiento cuidadoso periódicamente.

El proceso de flotación a nivel piloto cuenta con 6 celdas de flotación Rougher tipo FW-8 divididas en 3 etapas de 2 celdas cada una también 4 celdas de limpieza tipo FW N° 7 divididos en 3 etapas. El concentrado bulk Cu-Ag que se obtiene es espesado y luego se bombea para ser filtrado en filtros tipo panel pues debido al alto peso específico de los mismos y a su granulometría son fácilmente filtrables.

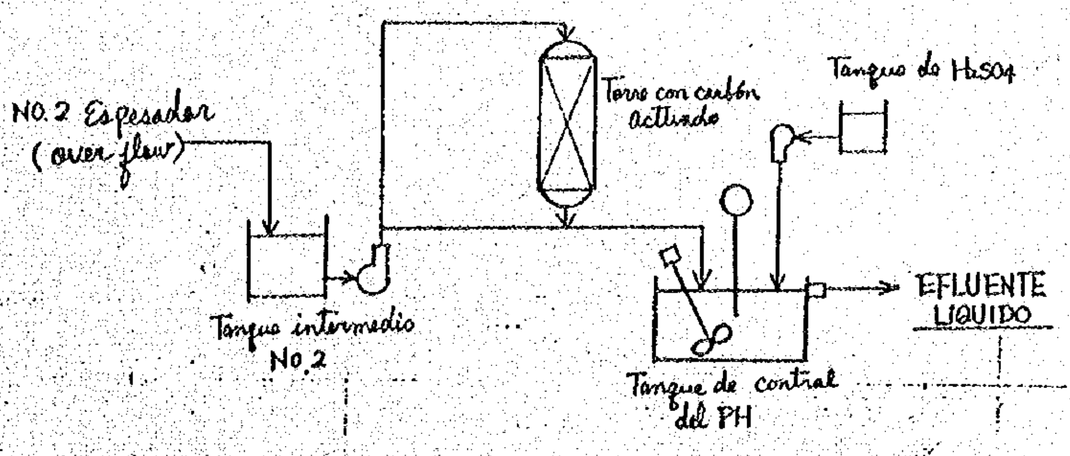
ESQUEMA Nº 2

CIRCUITO DE FLOTACION DE LA PLANTA PILOTO DE SEGREGACION



ESQUEMA Nº 3

SISTEMA DE TRATAMIENTO DE AGUA



En cuanto al relave se bombea primero a un ciclón desaguador, de donde el Under Flow gruesos se envía en un filtro de tambor (OLIVER) y el Over Flow (finos) se envía a un espesador # 2 cuyo over flow a su vez se lleva para tratamiento de aguas residuales en una columna de carbón activado que absorve los reactivos y luego pasa a un tanque de pH en el que neutraliza con H_2SO_4 antes de enviarlo al desagüe.

3).- Características de la máquinarias para flotación

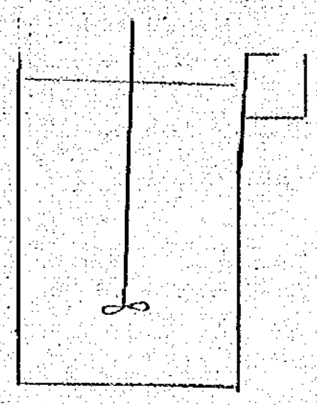
3-1 Celdas de flotación

La elección de las celdas de flotación debe de ser cuidadosa ya que el Cu y la Ag segregados sobre la superficie del coke le da una gravedad específica muy alta a estas partículas aumentando considerablemente su velocidad de sedimentación, por eso las espumas de concentrado deben ser retiradas lo más rápido posible y el borde de las celdas debe ser lo más corto posible ó nulo como se muestra en la Fig. # 1.

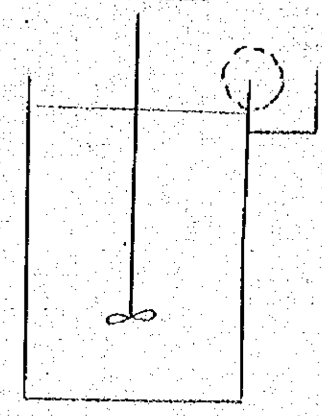
Además la velocidad del impulsor de la celda debe ser mayor de lo normal para evitar la sedimentación y el arenamiento (948 r.p.m. en el rougher y 1180 r.p.m. cleaner).

Otro aspecto importante a tener en cuenta en el diseño de los bancos de flotación es mantener un adecuado tiempo de retención por lo que es recomendable no usar bancos de tipo flujo libre sino dividido en compartimientos. Observar Fig. # 2.

CARACTERISTICAS DE LAS CELDAS

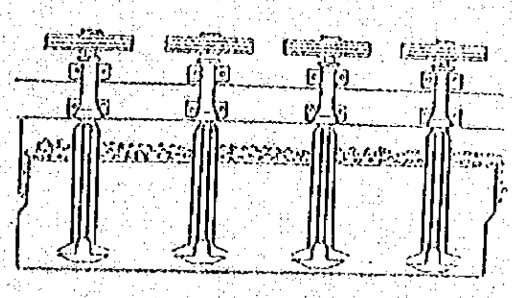


CON BORDES

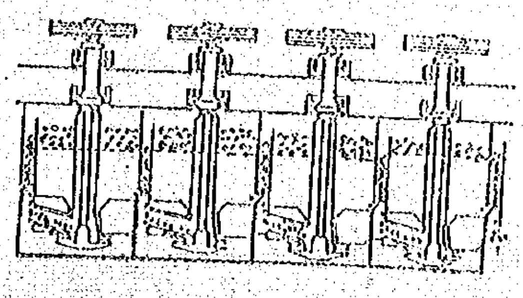


SIN BORDES

FLUJO LIBRE O ABIERTO



BANCO DIVIDIDO EN COMPARTIMIENTOS



El mejoramiento de la recuperación de Cu y la ley del concentrado bulk requiere de remolienda para liberar el Cu y Ag, segregados sobre las partículas gruesas de coke pues como se puede observar en la Tabla# 3. El relave contiene mayor cantidad de valiosos en las mallas más gruesas no liberadas por ejemplo +65 m = 2.2% Cu, mientras que las mallas finas tienen menor ley. Sin embargo en el concentrado observamos que las mallas de menor ley son las gruesas (+65m 25.8% Cu) en tanto que las mallas finas tienen muy alta ley (m-325-68.2% Cu).

3-2 Filtrado

Para el diseño de los equipos de filtrado debe tenerse en cuenta también la alta velocidad de sedimentación lo cual hace inadecuado el uso de filtros tipo tambor o disco debido a las frecuentes arenamientos en la batea de estos equipos por esta razón se utiliza filtros tipo panel cuya estructura es muy simple y se muestra en la Fig. # 3.; Puesto que los concentrados son fácilmente filtrables se pueden filtrar en forma natural ó se puede ayudar la operación haciendo un vacío.

3-3 Tratamiento de agua

Un aspecto muy importante es el tratamiento de los efluentes líquidos de flotación los cuales contienen reactivos residuales (xantatos, espumantes) y cobre soluble, con un pH básico.

La Planta Piloto cuenta con un sistema de tratamiento de agua (Ver esquema# 3). En el cual los reactivos y el Cu se adsorven en una torre con carbón activado y luego se pasa a un tanque donde se controla el pH automáticamente y se neutraliza con H_2SO_4 .

TABLA # 3 BALANCE METALURGICO DE LA PLANTA PILOTO DE SEGREGACION

NOMBRE	LEY QUIMICA		RECUPERACION		CONDICION DE FLOTACION	CONDICION DE SEGREGACION
	Cu%	Ag%	Cu%	Ag%		
Cabeza	1.64	543	100.0	100.0	KAX : 300g/T	Feed : 150Kg/h
Conc.	26.9	6700	91.9	70.0	A. Pino : 100g/T	Sal : 0.5%
Relave	0.14	170	8.1	30.0	Z-200 : 100g/T	Coke : 3.0% en
					Kerósene: 50g/T	cabeza

En posteriores pruebas se pondrá en operación y se determinará la apli cabilidad y eficiencia del sistema.

4).- Sulfidización de menas oxidadas de cobre

El estudio mineragráfico del mineral de Berenguela indica que las espe cies oxidadas de cobre son malaquita ($CuCO_3$. $Cu(OH)_2$) y crisocola ($Cu\ SiO_3$ $2H_2O$) acompañado de sulfuros de cobre y plata como Covelita CuS y Argentita Ag_2S principalmente, en una matriz de manganeso oxidado amorfo.

Este mineral fué tratado por sulfidización con sulfuro de sodio Na_2S y hidrósulfito de sodio Na HS, luego flotado con xantato obteniéndose para el cobre una recuperación de 38% solamente y 26% para la plata.

La malaquita ($Cu\ CO_3\ Cu(OH)_2$) responde bien a este proceso de sulfidi zación tal como se aplicaba en la mina Katanga donde se recuperaba por flotación hasta el 89% esta especie para lo cual se dosificaba el NaHS y NaS de manera continua es decir que se añadía poco a poco en diferentes partes del Banco de flotación.

La eficiencia de la sulfidización depende mucho de la superficie del mineral por eso se hace una limpieza previa de la superficie con H_2SO_4 diluído en el acondicionador y luego se dosifica NaHS y NaS en no menos de 4 puntos en la flotación del Rougher y 2 puntos de aplicación en el Scanveghe

La razón de este método, de dosificación lenta y continua es que la superficie sulfidizada se destruye rápidamente por la agitación dentro de la celda y por la oxidación que provoca en ella el oxígeno del aire disuelto dentro de la pulpa, lo cual disminuye la flotabilidad del mineral.

Además el exceso de reactivos sulfidizantes NaS y NaHS disminuye la eficiencia del xantato, también en Berenguela el estudio por Rayos-X demostró la existencia de abundante dolomita y calcita como ganga acompañante. Lo cual produce lamas que interfieren la formación de la superficie sulfidizada, por ello fué conveniente la adición de un reactivo dispersante como LA POLIACRILAMIDA.

DISTRIBUCION GRANULOMETRICA DE PRODUCTOS DE FLOTACION

1.- RELAVE

MALLA	PESO (%)	ENSAYE Cu%	DISTRBUCION %
+65	3.1	2.20	12.7
+100	10.4	0.59	11.4
+200	26.9	0.27	13.5
+325	12.4	0.26	6.1
-325	47.2	0.64	56.3
TOTAL	100.0	0.54	100.0

2).- CONCENTRADO

MALLA	PESO %	ENSAYO Cu%	DISTRIBUCION %
+65	12.6	25.8	6.2
+100	14.3	36.2	9.8
+200	30.9	52.2	30.7
+325	11.0	61.6	12.9
-325	31.2	68.2	40.4
TOTAL	100.0	52.6	100.0

R E P O R T

T R A I N I N G O F P E R U V I A N C O U N T E R P A R T

SEPTEMBER 2 , 1984 - OCTOBER 2, 1984

ENG. ELEUTERIO LEON R.

LIST OF CONTENT

SUMMARY AND RECOMMENDATIONS

In accordance with the Agreement on Technical Cooperation between the Peruvian and Japanese Government for the Project on the Recovery of valuable minerals from comples oxide ores and according with Annual work Plan from April 84 for the Project before mentioned, in the country of Japan was develop the training of Eng. E. León and Eng. S. Cardenas (INGEMMET - Peruvian Counterpart Personnel) on September 2, 1984 to October 2, 1984. The purpose of the training was to provide practical and theoretical training for the Peruvian Counterpart Personnel on the Segregation process and other technologies and consequently contributing to the better utilization of the mineral resources in the Republic of Perú. The training was initiated and Eng. E. León received the request from Japan International Cooperation Agency (JICA-TOKIO) of the attend the briefing Session which it was held at Tokyo International Center on 3 September. Before that Eng. Eleuterio León assisting a meeting with members of Japanese Consultation Team, headed by Eng. Taira Sunami. The purpose of this meeting was to confirm the activities acomplished for the project in the period July 84 to August 84.
The present report covers a visit to Tamano Smelter. Kushikino mine, Central Laboratory, Tokyo University, Geological Survey, NRIPR, Waseda University, Kamioka mine & Smelter, Hachinohe Smelter, Otsuka iron works and Nittetsu Mining Co. Ltd. Research and Development Department. A list of participants is included in the first part of this report.
Because of the limited time available (one month) had to be made according the program of training prepared by JICA but in relation with interest of the Segregation Project.
The main objetive has been to get a deeper insight into Process Equipment, operational Technologies and research activities Segregation process is of the vital interest to Perú.
It is recommended that the Technical Cooperation continues the support to INGEMMET. In relation with this main objective I think was reached successfully

The start of research activities in Aero fall mill segregation and flotation has strong interest in Peru (Minero Peru INGEMMET, Banco Minero MEM). There is a further need for training and candidates exist in November 1985 there will be a Special Metallurgy Conference in Trujillo it is recommended that JICA bears the costs for a Japanese Metallurgical Scientist and Enginners to visit Peru during the conference. In such a way it will be possible to review the plan of thechnical assistance in a greater detail.
I wish to say thank you in name of INGEMMET for this opportunity for visit many industries institutes and universities and to know its Programs, Activities and Projects.
This opportunity was very important for us because we have been a friendly dialogue aimed at the clarification of doubts and to receive suggestions. The results stemming from this dialogue will no doubt be very useful to us since they will help in the improvement and widening of our points of view, contributing thus, to the achievement of our project.

OBJETIVES

Provide practical and theoretical training for the Peruvian counterpart Perssonnnel on the Segregation Process and other technologies. Contributing to the better utilization of the mineral resources in the Republic of Peru.
The goals and purposes previously stated led a thorough analysis of needs and means available and concluded in the formulation of Agreement on Technical Cooperation and Annual work plan from April 84 to March 85. This activity (training) is one of the main activity in the Annual work plan for our project.

DURATION

A one month plan, September 2th - October 2 th.

NAMES OF RESEARCH INSTITUTES AND OTHERS

JAPAN

- Japan International Cooperation Agency
- Mitsui Mining & Smelting Co. Ltd. Hibi Kyodo Smelting Co. Ltd. Tamano Smelter.
- Mitsui Kushikino Mining Co. Ltd.
- Central Research Laboratory of Mitsui Mining & Smelting. Co. Ltd.
- Department of Mineral Development Engineering, Faculty of Engineering. The University of Tokyo.
- Geological Survey of Japan.
- National Research Institute for Pollution and Resource of Japan.
- Department of Mineral Enginnering Faculty of Science and Engineering . Waseda University.
- Kamioka Mine & Smelter of Mitsui Mining & Smelting Co. Ltd.
- Otsuka iron works.
- Nittetsu Mining Company Limited Research and Development Department.

PERU

- Geological Mining and Metallurgical Institute (INGEMMET).

NAMES OF PARTICIPANTS

PERU

- Eleuterio León : General Director of Metallurgical Direction of INGEMMET.
- Saúl Cárdenas : Head of Special Metallurgical Division Extractive Metallurgy Department.

JAPAN

- Nobuo Matsui : General Manager, Metallurgist Engineering.
- Promotion Office Mitsui Mining & Smelting Co. Ltd.
- N. Kayoshima : Third Training Division Training Affairs Department JICA.
- Taira Sunami : Leader Japanese Consultation Team (JICA)
- Takashi Sano : Project Coordinator (JICA).
- K. Kawarabata : General Manager Int. Operations Office
- Mitsui Mining & Smelting Co. Ltd.
- N. Yoshida : International Operation Office M.M.S.
- Y. Hashimoto : International Operation Office M.M.S.
- H. Hanai : International Operation Office M.M.S.
- T. Atsuka : General Manager MMS- Hibi Kyodo Smelting - Co.
- Hibi Smelter - Tamano Smelter.
- T . Shibata : Deputy General Manager MMS Hibi Kyodo - Co. Ltd. Hibi Smelter - Tamano Smelter.
- H. Yamamoto : President Mitsui Kushikino Mining Co. - Ltd.
- H. Yoshitome : General Manager Mitsui Kushikino Mining Co. Ltd.
- T. Hosooka : Mining Engineer (Head of Metallurgical - plants) Mitsui Kushikino Mining Co. Ltd.
- K. OR : Mining Engineer (Head of Mine) Mitsui Kushikino Mining Co. Ltd.

- T. Memura : Geologist Mitsui Kushikino Mining Co. Ltd.
- K. Fukusako : Geologist Mitsui Kushikino Mining Co. Ltd.
- Hajime Hashizume : Assistant General Manager Central Research Laboratory MMS.
- K. Simoukura : Senior Research of Metallurgy Division (Segregation Process) Central Research Laboratory MMS.
- Yoshikatsu Shirokura : Manager Senior Mineral Processing.
- Engineer Mineral and Energy Resources Headquarters MMS.
- Toshio Ynoue : Professor Dept. of Mineral Development.
- Engineering Faculty of Engineering. The University of Tokyo.
- Ryokichi Shimpo : Research Associate (Cooper) Department of Metallurgy. Faculty of Engineering University of Tokyo.
- Ake Holmstrom : Research Metallurgist (Boliden Metall Sweden) Department of Metallurgy Faculty of Engineering University of Tokyo.
- Noriyuki Fuju : Director Overseas Geology Office.
- Geological Survey of Japan.
- Hideo Takeda : Mineral Deposit Department Geological Survey of Japan.
- Yahiyuki Takei : Geofisic Geological Survery of Japan.
- Y. Kanazawa : Mineralogist (Cristalografia) Geological Survey of Japan.
- Michi Ichijo : Director of Mineral Processing.
- Department National Research Institute for Pollution and Resources of Japan.
- Hiroshi Matsubara : Metallurgist Senior N.R.I.P.R.

- Research Officer of Mineralogy and Mineral Dressing Division N.R.I.P.R.
- Kotaro Susuki : Metallurgist, Research Officer of Mineralogy and Mineral Dressing Division N.R.I.P.R.
- Mikio Kobayashi : Metallurgist, Research Officer of Mineralogy and Mineral Dressing Division N.R.I.P.R.
- Taneomi Harada : Profesor of Mineral Processing - Faculty of Science & Engineering Waseda University.
- Shuji Owada : Instructor Department of Mineral Engineering School of Science & Engineering Waseda - University.
- Atsushi Yoshida : Assistant General Manager.
- Kamioka Mine and Smelter MMS.
- Tomoharu Jogo : Head of Explotation Department Kamioka Mine and Smelter MMS.
- T. Sato : Assistant Superintedent Concentrator Shikama Kamioka Mine and Smelter MMS.
- Kazuo Takahashi : Assistant Superintendent Lead - Plant Kamiola Mine & Smelter MMS.
- K. Marita : Assistant Superintendent Zinc Plant Kamioka Mining & Smelter MMS.
- Plant Kamioka Mining & Smelter MMS.
- Etsuji Nomura : Director General Manager Hachimohe works Hachimohe Smelting Co. Ltd. Subsidiary of Mitsui Mining & Smelting Co. Ltd.
- Yuji Nishimura : Superintendent Sinter Acid Plant, Smelting & Refinery Hachimohe Smelter.
- Junio Shimada : Director Factory Manager Otsuka - Iron Works Ltd.
- K. Matakawa : Mineral Processing Engineer Project Supervisor Nittetsu Mining Co. Ltd.

ACTIVITIES

MITSUI MINING & SMELTING CO. LTD. HIBI KYODO SMELTING CO. LTD. TAMANO SMELTER

This company is a new investment of Mitsui Mining & Smelting Co. Ltd. (63.51%) and Nittetsu Mining Co. Ltd. (20.27%) and Furukawa Co. Ltd. (16.22%) it is a Toll System Smelter and Refining facilities . "Tamano Smelter" was constructed with a designed monthly capacity of 7,000 tons of electrolytic copper (1972) . But the current capacity is 11,600 tons/month (1984).

Concentrates consigned by the shareholders are processed into anodes and slags through the smelting process (Flash Smelting). Bedding drying, Flash Smelting with Furnace Electrodes, Converting Furnace, Refining Furnace, Casting Wheel off gases are sent to the acid plant and converted into sulfuric acid.

Converter slags are transported to the concentrator and separated into iron concentrates (tailings) and recovered slag concentrates.

Anodes sent from the smelter are electrorefined into copper cathodes with a grade of 99.99% .

Anodes slimes containing gold and silver are shipped to and treated at the Takehara Refinery of Mitsui Mining and Smelting Co. Ltd.

The Products are Electrolytic Copper, crude nickel sulphate leached slime, sulfuric acid, gypsum, iron concentrates, slag concentrates, granulated slag.

This plant was designed to realize and extremely high sulfur recovery ratio by utilizing the F.S.F.E. (Flash Smelting Furnace with Furnace Electrodes) process, a double contact acid plant and a desulfurization plant. Thus combined technology attains not only a pollution free operation but also and economical one.

This plant has high productivity level, through over all -

enlargemment, mechanization, automation and the installment of measuring instruments, they perform to minimize labour requirements this plant was designed to improve in productivity and to reduce copper invertories by use of periodic current reversal.
Tamano Smelter has waste heat boilers attached to the F.S. F.E. and coverters which generate enough steam to drive the generator the supplements power to the plant.
Tamano Smelter is a organization which devotes high per - cent of the total budget to quality control and research.
It is a very automized plant.

MITSUI KUSHIKINO MINING CO. LTD.

Kushikino is one of the largest gold-silver mines in Japan. The mine is composed of two mines Kushikino mine and Iwato mine.
In 1914 when all-slime Cynadation process was first established in Japan, the plant started to treat 150 tons of the crude ore per day. In 1968 the production was 600 per day. But after them it was inevitable to decrease the production by reason of the limited minable ore reserve.
The crude ore is feed to a hopper and crushed to under 70 mm. by two Blake Crushers (610 x 360 mm) . The crushed ore in washed to separate slime from metallic minerals, and the waste materials are afterwards rejected by handpicking. The ore is crushed again more finely by means of secondary crushing which is composed of cone crushers (1200 MM Ø) and vibrating screens.
The material under the screens is feed to storage bins and the oversize material is recycled to the cone crushers.
The washed slime is directly sent to the grinding process.
Lime is added to the pulp in this process for the purpose of settling the ore as well as increasing and stabilizing

CN. The ore from the storage bins is feed to conical ball mills (2400 x 900 mm) with cyanide solution, and the over- size pulp is recycled to the ball mills to be perfectly - ground to minus 48 mesh. The milled ore is feed to bowl - classifiers to be classified by 200 mesh and the oversize slurry is ground again by tube mills as secondary grinding. The pulp is condensed to 1.4 gr/t/cm^3 by thickners. The - overflow from the thincknērs is recycled to the crushing - and grinding process. After Na CN and small amount or Pb NO_3 are added to the tickened pulp, the pulp is condition- ed in agitator thanks for four days.

In this process, gold and silver in the ore are disolved - into the solution. After the dissolution of Gold and Sil - ver, the pulp is sent to Moor filters. The filtrate is -- clasified in settling tanks. Disolved oxygen in the filtra te is removed by Merril Crowe Method and Zinc dust is - added. As a result, gold and silver ore precipited as very fine black powders. This precipitate is treated in refine ry . After a series of treating processes of roasting, mel ting and refining, dore metal is produced.

This dore metal is sent to Takehara Refinery of Mitsui Min ing & Smelting Co. Ltd. to be separated into gold and sil- ver by electrowining.

Filler and Keiseki concrete are produced from the washed - cake of Moor filters, Filler cycloned and kilned cake, is very usefull for road povement Keisekiconcrete, the mixtu- re of cement and the washed cake, is used for reclamation. 160 ton crude ore of all, with a silica grade of 95% is - daily sent to Hibi Cooper Smelter of Mitsui Mining and - Smelting Co. Ltd. as a silica flux for copper smelting pro cess.

This plant is very particular because there are not tail - ings disposal, all the tailings are treated and produced - by products ; Silica (15%) sand (35%) and Keiseki concrete (50%) ton/day of tailings.

CENTRAL RESEARCH LABORATORY OF MITSUI MINING AND SMELTER CO. LTD.

One of the very active research laboratories in Japan is - the Central Research Laboratory (M.M.S.) It was founded in 1949. An important fact to the development of the laboratory is the general interest Mitsui has to Geological, Mining and metallurgical activites including domestic and overseas. This has implied that Mitsui had performed research activites in order to development in shophisticated equipment. The laboratoty has also performed contract services with other companies. The Scientific and Administrative personnel reach 210 people. They are working mainly in three fields:

A) MINERAL RESEARCH : Includes mineral research group, magnetic separation, metallographics studies, observations with microscopes, X-Ray analysis, Studies on characteristic of the ore samples, amenability studies on mineral dressing. Quantitative analysis for manganese nodules, Rocks Mechanics and other studies, chemical analysis.

B) METALLURGY : There are several groups Mineral Processing Hidrometallurgy Pirometallurgy, Electrometallurgy plus such specialities as Solvent Extraction , Segregation. High Gradient Magnetic Separation, Cynadation and Others.

The laboratory perform important research project not only for Japan, but for others overseas countries such as Chile, Brazil Perú and others including examination of the mineral Processing for several minerals and treatment for no Sulphur minerals.

Basic research for treatment to the by products in the - Smelter process, Gold and Silver Mineral Processing, Stu - dies Mineral Dressing of low grades ultrafines particles, studies and development for new technologies.
'The laboratory's organization is rational and has apart a small administration office. It has two Directions - Departments.

a) Research Department
b) Development of Mineral Resources. The building area is 23,180 m^2.

The main equipment is Aerofall mill, High Gradient Magne - tic Separator, Electric furnace for Segregation, Flotation Cells, poolished and cuting machine, Microscopic , FRX - equipment A/A equipment, Gas Cromatographer, Iron Cromato- grapher, Equipment for gas's analysis Inductively coupled plasma quanto recorder, X-Ray Difractometer. Scanning Elec tron Microscopic, Electron Probe microanalyzer combine Sca nning & X-Ray , 2M Emision Spectographic.
In accordance with the training program was prepared by - JICA, Mr. Saúl Cárdenas is going to remain in this central laboratory, one month on Oct. 02 to Nov. 02 1984. His work plan includes; Review atomic absortion analysis (Mn, Ag, - Au, Cu, Fe and Others) and Segregation test.
(Laboratory - batch) and review of technical Litterature related.

DEPARTMENT OF MINERAL DEVELOPMENT ENGINNERING FACULTY OF ENGINEERING THE UNIVERSITY OF TOKYO

The activity is oriented towards the developments of process control tools using innovative software technology, this has connection with the idea of the metallurgical control sys - tems in concentrations plants helping this in the optimiza - tion of metallurgical results and, consequently , in the im- provement of economic benefits.
Alike most fields of computer applications use of small com- puters for the automatic control of mineral processing plan- ts is faced at the difficulty in the flexible adaptation of the software to the plant operations. To overcame the diffi- culty it is urgently requiered that the programming language itself showed be optimal. This activity is related with the feature of FORTH, a non-conventional language developed by C.H. Moore, in particular reference to its explotation for automatic control associated with real-time multi-task envi- ronment. This work show that the distinguished extensively of the language is a powerful basis for the design and the realization of the software system for automatic control ame nable to later modifications and further developments and - portable to various computer system and applications.

NATIONAL RESEARCH INSTITUTE FOR POLLUTION AND RESOURCES OF - JAPAN

Sky and rivers in Japan have been clarified in the last ten years, but there are still many pollution problems to be sol ved, such us nutrification of lakes and lagoons, exhaust emi ssions from diesel engines, noise from factories, disposal - of industrial wastes and increase of carbon dioxide in glo -

bal atmosphere.
The National Research Institute for Pollution and Resources under the Agency of Industrial Science and Technology is - carring out the research and development on the following important fields:

1.- Developments and utilization of new energy and resources.
2.- Pollution control and environmental assessment.
3.- Safety in mines and factories.

About 355 people are employed by N.R.I.P.R. which has an - annual budget of around 4,222 million yen (General expenses 5% ; personnel expenses 45.9%) . The main research and development parts are the Special Research (32.2% of Total Budget) :

- Special Research & Development 9 items.
- Energy Development Project 7 items.
- Large-Scale Project 2 items
- Pollution Control Project 18 items.
- Others 3 items.

With a great emphasis upon the current policy to utilize as much domestic mineral resources as possible. The Institute has conducted the studies on development of new mining techniques such as drilling, strata control, ground supports - fracturing of rocks and rock mechanics. Further attention has recently been paid to sea-botton mineral resources and the Institute has promoted the studies on explotation and exploration techniques for sea-botton minerals since 1969. Several studies are being undertaken to establish the most suitable flotation methods can be used in the mineral dressing process of inused low grade complex ores.

As for the international cooperative research project, two project were carried out on five years program respectively, between the Institute and two Institutes, of developing countries (Peru and Philippines).
In the Peruvian case the objetives of research project was to investigate the most adequate techniques that can be used in the mineral dressing process of low-grade complex ores from Peru in order to improve mill operations technologically and economically.

Two ores was selected.

1.- Cu-Su ore from San Rafael Mine
2.- Ag-Cu-Pb are from Julcani Mine.

The following steps were undertaken in this program :

(1) Studies on characteristics of the ore samples.
(2) Amenability studies on mineral dressing
(3) Establishment of the flow sheets and its optimum condition on each ore.

The agreement between the two participating Institutes included exchange of researches ; a Japanese research would be dispatched to Peru and a Peruvian researcher would be invited to Japan every year.
The research project finished on March 31, 1983 succesfull. The INGEMMET has given advice, based on the results of this project, to the San Rafael Mine about the construction of tin flotation plant.
Also the results of research on Julcani Ag-Cu-Pb ore will be applied to the mineral dressing process of this ore and other same types ores from Peru for improvement of the mill operation.

GEOLOGICAL SURVEY OF JAPAN

One of the very active organizations in Japan is the Geological survey. It has a long tradition and the first activities started around 1882. The expansion of the field of the Geological survey's activities in recent years can be ilustrated by the following few examples. The economic growth of the country has brought about the necessity for scientific research related to mineral and energy resources; the social development gave rise to the needs for geocientific investigation in conservation of environment, and prediction and mitigation of natural hazards ; the progress of science and technology has enabled us to study the geology and resources beneath the ocean floors ; international scientific and technical cooperation have become an integral part of the operations of the Geological Surverys of the world and global perspective is now necessary for all phases of geoscientific undertaking the present work of the geological survey can be largely grouped into the following fields.

1. Basic geoscientific investigation of the country and the surrounding marine areas.
2. Evaluation of energy and mineral resources.
3. Conservation of geologic environment and prediction and mitigation of geologic hazards.
4. International scientific co-operation, and technical cooperation in the field of geosciences and mineral resources.
5. Acquisition and dissemination of geoscientific information.

After the main discussion Mr. Takeda outlined the present status of the activities in mineralogy of Berenguela's ore

this research activities was geated to the clasification of the process where materials was transported from the original matter and precipitated as mineral deposit and clarifying the physicochemical nature of minerals (Silver Manganese, Copper Iron).
Emphasis was laid on crystal structure analysis of mine-- rals (thermogravimetric) X-Ray Diffraction and of course X-Ray Diffraction and of course X-Ray fluorescence) In the next time Mr. Takeda is going to send his report.

DEPARTMENT OF METALLURGY FACULTY OF ENGINEERING UNIVERSITY OF TOKIO

Research activities are performed in several fields:

1. A study on the equilibrium between copper matte and - slagsolubilities of cooper and sulfur in slag.
2. Behaviour of impurities on copper-slag equilibria-Bi - As and Sb.
3. Measurement of activities of B and Ni in B-Ni alloy.
4. The production Sn-Co alloy by reduction diffusion me-- thod.
5. Recovery of each element from the scrap of Sn-Co mag- net by solvent extraction method.
6. Recovery of valuable elements from poor ores by the se gregation method or roasting manganese nodule, sludge from acid cleaning.
7. Application of equilibrium calculation by a computer - to the various smelting systems.

This department is very well equipped. This opportunity was also useful for the opening of a friendly dialogue - aimed at the clarification of doubts. The results from - this dialogue I think be very useful to us since they will help in the improvement and widening of our points of view, contributing thus, to the achievement our Institucional purposes.

DEPARTMENT OF MINERAL ENGINEERING FACULTY OF SCIENCE & ENGINEERING WASEDA UNIVERSITY

The research subjects in Raw Materials Engineering Laboratory in Waseda University during 1984.

1. Fundamental studies on the flotation properties of pyrite.
2. Studies on the grindability of manganese nodule in relation to their petrographical properties.
3. Studies on the oxidation rates of sulfide minerals.
4. Studies on the grindability of minerals for the ceramic industry in relation to their hardness.
5. Studies on the grindability of sulfide minerals in relation to their hadness.
6. Desulfurization of coal by bacterial leaching.
7. Effect of surface property on the flotation order of pyrities in some flotation plants.

This department is very well equipped Most of the activities are centred around Prof. Harada, Prof. Matsui and instructor Owada and their group of ten students. After of the presentation of seven items before mentionated. Eng. León gave some technical comments in relation with the general design and operating criterion for mineral grinding/classification circuits.
Since the generalized introduction of hidrocyclon classifiers in mineral grinding circuits strong arguments have developed regarding the conditions at which these circuits showed be operated. Such discussiones have normally been centered around the most desirable dilution of

the solids in the cyclone feed ; recognized to be an important control variable for optimun classification efficiency.

In the current, Eng. León proposes a general design and operating criterion which basically states that the optimun cyclone feed dilution is that which necessarily arises from operating at the maximum circulating load the installations permits, the minimum percent solids in the cyclone overflow acceptable for downstream subprocess and also, the minimum water content in the apex discharge, taking care the classifier does not operate under roping conditions. Most commonly when grinding is carried out with the main purpose of improving mineral species liberation prior to flotation, the optimum cyclone feed percent solids exceeds 60% by weight, leading to the rather suprising conclusion that classification effienciency is antagonistic to overall circuit efficiency, when the latter is associated to maximum circuit throughput.

KAMIOKA MINE & SMELTER OF MITSUI MINING AND SMELTING CO. LTD.

Kamioka is one of the largest zinc mines in Japan. The Mine is composed of three groups of ore bodies : Mozumi, Maruyama and Tachibora.

Kamioka has two mines : Tachibora and Mozumi the distance in between is 12 km.

KAMIOKA ANNUAL PRODUCTION

MINE	ANNUAL PRODUCTION OF CRUDE ORE (Crude ore tonnage)	GRADE Ag (g/t)	Pb%	Zn%
Tachibora	953,600 Ton.	18	0.24	4.15
Mozumi	357,600 Ton.	21	0.83	7.90
TOTAL	1'311,200 Ton.	19	0.40	5.17

In this opportunity I had a friendly dialogue aimed at the clarification of doubts. But we was visited only Tachibora mine.

1.- PROVEN RESERVES

ORE BODY	RESERVE DILUTION (Mil tons)	GRADE Ag grs/ton	Pb%	Zn%
Tachibora	20,811	26	0.38	3.9
Masuyama	6,266	14	0.11	4.7
TOTAL	27,077	23	0.32	4.1

2.- MINING PRODUCTION

DEPARTMENT	PRODUCTION /DAY	TON/MAN	OPERATION COST US$/ton	CONC Pb	CON Zn
Mining Labour	200	Contract	37		
Tachibora Sup	400	22	30		
Tachibora Inf	1,700	31	23		
Maruyama	900	26	19		
TOTAL	3,200 Ton/day	27	22	4,000	63,000

3.- EXPLORATION

GALLERY 2,000 mt/year

BORING 1,500 mt/year

Ore obtained by exploration with gallery 85 ton/meter

Ore obtained annual by exploration with gallery 300,000 tons.

4.- MINING

a) Development

Quantity 7,000 meters/years

Trackless System 4.2m x 3.08m Slope 0°- 12°

b) Explotation Equipment & Materials

Drilling : Crowler Drill (Jumbo)

Explosives: AN - FO

c) Methods

Sub - level stoping	(20%)
Induced Block caving	(22%)
Cut & Fill	(39%)
Open pit	(5%)
Others	(14%)

5.- TRANSPORTATION

Mining operations → (Payloader) → Main chute → Locomotora 11 ton (2)

Ore bin → Crushers → Coveyor belt → Mill operations.

6.- FILL

- Materials of very low grade and waste materials.

7.- VENTILATION

- Natural (Summery & Winter)
- Blower Ventilation (other seasons)

8.- COMMPRESSED AIR

- Pressure 8.5 Kg/cm^2
- Three compresor 600 HP.

9.- WORKERS

- Explotation	137
- Eng. & Safety	21
- Maintenance	30
- Administration	11
- TOTAL	233

Kamioka mine has three mills plants:

- Tachibora mill.
- Shikama mill (with subway crushers)
- Mozumi mill

The Shikama concentrator was: Bulk, flotation and after that differential flotation. The products are; Lead con-- centrate and Zinc concentrate.

All the concentrates came from Kamioka mine and the other mines inside and outside to Japan is going to processing in the Smelter and Refinery facilities that Kamioka main-- teined in this place.
The sinter machine is a Dwight Lloyd type S-DL with up --- draft Fan. The calcine with coke is put in Blast Furnace in order to get Crude Lead. The crude Lead is refined using the electrolitic method (Betts Method) in order to get:
Bi (99.99%); Ag (99.999%); Au (99.2%); Pb (99.999%).
The slag of the blast furnace is conveyed to the slag fu-- ming furnace in this furnace the zinc is condensed and af ter that through Holding furnace and casting machine ob - tain Zinc (PW) 98.8%. The copper matte with copper con -- tent is sent to Hibi smelter.
The rosting furnace in zinc circuit is Lurgi type Fluo-So- lid Roaster, with the outlet gas is doing sulfuric acid - (New Monsanto Type).
The zinc refinery is a conventional plant and includes the electrolite purification stages and the cadmium production (Cd - pensil). In aditional to the zinc refined produc -- tion this plant produce several zinc alloys: ZAS, ZAC, - with variable contents in Zn, Al, Mg, Cu.
Some figure of production here after:

- Electro zinc	5,000 T/M
- Electro lead	2,225 T/M
- Electro silver	8,000 Kg/M
- Electro Bi	17,000 Kg/M
- Destiled zinc	300 T/M
- Cadmium	25,000 T/M
- Crude gold	23,000 Kg/M
- Sulfuric acid	10,000 Ton/M

HACHINOHE SMELTER - HACHINOHE SMELTING COMPANY LIMITED

Established on 1, February 1967 As a joint toll system smelter:

- Mitsui Mining and Smelting Company Limited	50%
- Dewa Mining Company Limited	20%
- Nippon Mining Company Limited	10%
- Mitsubishi Metal Corporation	10%
- Toho zinc Company Limited	5%
- Nisso Smelting Company Limited	5%

This smelter take advantage of the imperial smelting pro-cess to treat mised and complex ores, especially some con-centrates from "blackore" in Tohoku district of Japan and several concentrates from Perú; Huanzala, Chungar, Perú Bar.

The Smelter complex consists of sinter plant, acid plant cadmium plant, furnace (ISF) plant and zinc refinery.

The smelter is built on land reclaimed from the Pacific Ocean using sand dredged from the sea during the extension of the local govermmental port facilities. Plant site area is 271,000 m^2 in which 185,000 m^2 is occupied by the whole facilities. The plant was put into operation on 2 February 1969 and has been operating in the production ra-te such as:

YEAR	ZINC (METRIC-TON)			LEAD(METRIC-TON)
	PW	SH 6	TOTAL	Bullion
1980	37,109	21,923	59,032	24,012
1981	30,301	24,261	54,562	25,876
1982	34,989	25,211	60,200	27,809
1983	39,953	20,635	60,588	27,155

1.- MATERIAL STORAGE

Concentrate storage house	19,000 m^3
Coke storage house	4,400 m^3
Open storage yard	17,000 m^2

2.- SINTER PLANT

- Lurgi type sintering machine 1 2.5 mW x 36 m L
- Ignition wind box 1 3.5 m^2
- Updraft wind bow 12 90 m^2
- Crushing plant
- Sinter screen

TYPICAL SINTER MACHINE FEED

Concentrate and others	Production t/d	Zn %	Pb %	S %	Cu %
- Zinc concentrates	360	47.0	5.0	30.2	1.3
- Lead concentrates	140	8.5	54.0	21.6	1.9
- Dross & blue powder from ISF	50	27.0	36.6	1.2	0.2
- Oxide (Secondaries	48	28.1	29.3	5.5	3.3
- Recycle (secondaries)	44	18.9	3.0	5.3	0.4
- Return sinter	Variable				
- Sinter	588	38.6	20.2	0.5	1.56

3.- TYPICAL ANALYSIS OF SINTER (%)

- Zn	38.6%
- Pb	20.2%
- Cu	1.2%
- S	0.5%
- Fe	9.7%
- Ca O	2.6%
- $Si\ O_2$	2.4%
- $CaO/Si\ O_2$	1.05 - 1.15

4.- ISF Plant

4.1 CHARGE PREPARATION

- Cold coke storage bunker cap 120 t x 2.
- Insulated coke storage bunker 300 t x 2
- Addition bunker 20 t x 2
- Coke preheater 100 t carbon/d

The charge preparation is automatically controlled by using process computer; typical charge proportioning is:

- Hot coke 1,300 Kg
- Sinter 3,600 Kg
- Cao/Si O_2 in slag 0.8

4.2 AIR PREHEATER

- Blower capacity	600 Nm^3/min, 6000 mm W6 (Max)
- Cowper Stove	External combustion type 600 Nm^3/min.x 1000 C (Max) 5.4 max 26.5 mH x 2 stoves.
- Fuel	L.C.V. gas from ISF (Co 23%)
- Operating data	Hot blast to tuyere 550 Nm^3/min Topair 10 Mm^3/min Blast temperature 900°C Blast pressure 4000 - 5000 m/mH_2O

4.3 FURNACE

- Shaft area	m^2 17.2
- n. of tuyeres	16
- tuyere bore	mm 121
- tuyerepenetration	mm 463 (1-8) ; 413 (9-16)

- tuyere spasing mm 705
- end tuyere to casing mm 720
- nose to nose mm 1707
- nose to nose area m^2 10.6
- casing height mm 3215
- casing angle to vertical 5°
- Hearth area m^2 14.9
- hearth width 2490
- Torehearth Botton tapping type
- slag disposal Bucket elevator after water granulation.
- furnace off-take temperature 1036°C

5.- ISF OPERATING DATA

- Zinc production (crude zinc) 215 t/d
- Bullion 120 t/d
- Carbon burning rate 190 t/d
- LCV gas CO_2= 12% CO = 23%

	Zn	Pb	Cu	S	CaO	SiO_2	FeO	Al_2O_3
- Crude zinc	98.7	1.1						
- Lead bullion		91	8					
- Slag	6	0.9	0.7	2.5	13	16	43	7

6.- ZINC REFINING PLANT

(1) Refluxing

- Zinc holding bath cap 50 t
- Lead column x 2 56 trays
- Tray size 54" x 30"
- Capacity 35t SHG/d x 2

- Combustion chamber temp 1200 C
- Cadmium colum x 1 75 trays
- Capacity 70t SHG/d
- Combustion cham temp 1.130 - 1.160 C
- Fuel Butane - LCV gas mixture

(2) Casting

- Liquation and reheat bath cap 66,5 t
- temp 420° C and 500°C
- Melting and casting bath cap. 80t temp 530°
- Autocasting machine
- SHG 10 t/h x 1
- PW 11 t/h x 1
- Fuel Butane - LCV gas mixture

TYPICAL ANALYSIS (%)

PRODUCTS	Zn	Pb	Fe	Cd
- PW zinc	98.7	1.15	0.02	0.01
- SHG zinc	99.997	0.002	0.0005	0.0015
- Run-off zinc	98.7	1.15	0.024	0.0002

OTSUKA IRON WORKS LTD.

Otsuka Iron Works, Ltd. is Japan's most experienced manufacturer of mining and associated machinery with a brilliant history of over 70 years since its foundation in 1901. They have grown with the world's mining industry by solving the complex technical problems of today and tomorrow by offering quality and reliable products which are the offspring of his highly efficient research and development system.

The manufacturing facility consists :

- Space 30,135 square meters
- Equipment 74 machine tools
  8 lumber and woodworking machines
  19 cranes (2-30t)
  20 test run motors
  1 high-pressure test run facility
  22 laboratory testing machine
- Employee
  100 (Head Office)
  250 (Factory)
- Main Products
- Crushers (Jaw crushees, gyratory crushers, cone crushees, Roll crushers, Hammer pulverizers, cage mills).
- Grinding Mills (Conical Ball Mills, Tube Ball Mills, Comp arment Tube Mills, Grate Ball Mill, Rod Mills, Aerofall - Mills).
- Classifiers (Rake classifiers, Spiral classifiers)
- Screens (Vibrating Screens, Revolving screens).
- Concentrators (Flotation Machines)
- Dewaterers (Thickeners, Clasifiers, Vacuum Filters, Drum Washers).
- Feeders (Crizzly Feeders, Apron Feeders, Reciprocating , Plate Feeders).
- Laboratory Equipment (Role Jaw Crushers, Sample Grinders, Disc grinders, Samplers , etc.).
- Plants (Portable Mills, Aggregate Crushing and Screening Plants).
- Briquetting Machines (Briquetting Machines , Compacting Machines).

To ensure that Otsuka Iron Works can continue to supply - highly productive machines at low initial cost and minimal maintenance needs to satisfy the diversifying demands of -

the consumer industries they have kept innovating your exist ing capabilities whenever needed.
Technical license agreements with such world leaders of mill manufacturing as Stedman Foundry and Machine Company Inc. of USA and Newell Dunford Engineering Ltd. of England have contributed to the increased variety of yours product lines.
Special mention is doing to Osuka Aerofall Mill, licence of Newell Dunford Engineering Ltd. of England. The Aerofall - mill , unique autogenous and the only single stage type of comminution equipment capable of the combined actions of cru shing grinding and classifying has been manufactured since 1966. The Aerofall mill consists of a drum of large diameter with a set of flights on the inner cylindrical surface of - the drum.
As the drum rotates the flights carry materials up towards the top, and it then falls freely, crushed by impact with - others at the base of the drum into a finished fine product.
For favourable autogenous crushing and grinding, the characteristics of the mill feed play and important role.
Generally, primary crushed products of runs of mines is fed directly into a drum at the mill. An thus, it can eliminate or simplily the crushing and screening equipment which are necessary for ordinary mill feed. The ground product of the Aerofall mill is carried out of the drum by controlled air current and conveyed to a collec tion system.

NITTETSU MINING CO. LTD. RESEARCH AND DEVELOPMENT DEPARTMENT

This company is located in Mitaka city our visit is related with the interest for to know some details of high Gradient Magnetic Separator. This Company conducts several studies - with this appanutus it is aims to recover the clean of caolin

and remove the impurites by high gradient magnetic separa - tion HGMS which can capture paramagnetic microfines.
In this visit the researchers of the Nittetsu Mining was - doing experiments with suspension of CuO & $Al_2 O_3$ using HG- MS for trapped magnetic part and passed the non magnetic - parts.
In this opportunity I was looking the experiment with Beren quella's sample. In this case the ore sample (-80 mesh) 65 grs is joint with 1200 cc (water) and Sodium Hexametaphos - phate (as dispersant) 10% solution 0.1 cc (150 gr/t) adn 5. 1 % WT density. This suspension is passed in a SALA-HGMS Field 4.2 KGAUSS (Flow velocity 102 m/Hr.) and after that is possible to get the separation magnetic 80% wt and non - magnetic 20% wt. The magnetic suceptibility of Manganese - oxidized.

- $Mn\ O$ 75.9×10^{-6} cm/g.
- Mn_2O_3 69.0×10^{-6} cm/g.
- Mn_3O_4 55.9×10^{-6} cm/g.
- $Mn\ O_2$ 38.4×10^{-6} cm/g.

The operation variables are :

- Liberation
- Dispertion
- HGMS Conditions (Matrix (Filter) Magnetic field, and Flow Velocity).

FINAL REMARKS

Training Program, the part Eng. E. León was envolved fini - shed on October 2, 1984 sucessfull. By virtue of the extensi bility the well - oriented style and the variability, the -

training program permits review the main technologies inclu ded in the Segregation Project.
Peru has great investment opportunities in Small , Medium - and Large - Scale Mining Project - Berenguella Deposit have preliminary estimation of Reserves and in accordance with the preliminary Laboratory Metallurgical test, the Segregation Process, could be interesting.
I Kindly recommend to JICA continues the support to INGEM - MET, and accepting a new Training Program (Period 1985) for the Segregation Project.

ACKNOWLEDGEMENTS

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I Thank you in name of the INGEMMET for this opportunity to visit many mining and metallurgical companies and several - research institutes.
Eng. León is grateful in particular to his colleague Messrs Nobuo Matsui, Hideo Takeda and Taira Sunami for their helpful discussion and suggestions.

TOKIO -JAPAN
Oct. 2-1984

ELR/lps.

INFORME SOBRE EL STAGE REALIZADO EN EL JAPON

Octubre-Noviembre 1985

Ing. Félix Cárdenas.

I. INTRODUCCION.

Dentro de los muchos aspectos de Cooperación Técnica Internacional entre el Perú y el Japón a través de la Japan International Cooperation Agency (JICA) es seguro que uno de los más importantes es el Proyecto de "Segregación de Minerales Oxidados Refractarios de Cobre y Elementos Asociados" encargado por el Gobierno del Perú al Instituto Geológico Minero y Metalúrgico. Este Proyecto que se inició en octubre de 1983, tendría una duración de cinco años.

El principal objetivo del Proyecto es realizar la transferencia tecnológica del proceso de segregación, tecnología aplicada a minerales refractarios; objetivo que involucra actividades claves como :

- Capacitar al personal técnico peruano, en las diferentes especialidades de la tecnología minero-metalúrgica.

- Destacamiento de personal técnico japonés al Perú para la supervisión y desarrollo del Proyecto.

- Donación e instalación de equipo de laboratorio de segregación para los estudios fundamentales.

- Donación e instalación de equipo de la Planta Piloto de Segregación..

La transferencia tecnológica fundamentalmente se sustenta en la aplicabilidad de determinados procesos tecnológicos como alternativa potencial a un problema metalúrgico que viene a ser en este caso el yacimiento de Berenguela. Berenguela, está constituído por minerales oxidados de cobre y plata, óxidos e hidróxidos de manganeso y ganga de dolomita, calcita y cuarzo. Esta composición y la estructura mineralógica nos muestra la evidencia del carácter refractario de los minerales de Berenguela; que como es sabido a pesar de sus contenidos en cobre y plata y del volumen que representa, no ha entrado en producción a la falta de una respuesta metalúrgica para la recuperación de sus valores. Circunstancias que convierten al Proyecto "Segregación de Minerales Oxidados Refractarios de Cobre y Elementos Asociados" en objetivo de dimensión nacional : plantear y establecer bases de alternativa tecnológica para el desarrollo minero del yacimiento de Berenguela.

Como parte del programa de capacitación, una Delegación de INGEMMET viajó al Japón entre el 17 de octubre al 10 de noviembre de 1985; esta Delegación, multiespecial (Geología, Química Analítica y Metalurgia) tenía por objeto, además de conocer de cerca las instalaciones de investigación e industrias mineras, realizar estudios de caracterización mineralógica y metalúrgica de cuatro muestras del yacimiento de Berenguela.

En el presente documento el suscrito, integrante de la Delegación como Metalurgista, informa sobre el programa desarrollado durante el viaje en mención y en especial las pruebas metalúrgicas efectuadas.

PROGRAMA DESARROLLADO EN EL JAPON

FECHA	LOCALIDAD	ACTIVIDADES
17/10		Llegada a Japón.
18/10	Tokyo	-Entrevista y orientacion en JICA. -Viaje a la ciudad de Ageo.
19/10	Ageo	-Entrevista con ejecutivos - Central Research Laboratory de la MITSUI. -Preparación de muestras del Yacimiento Berenguela llevadas por el Ing.F.Cárdenas.
21/10	Ageo	-Pruebas preliminares de Segregación y flotación en reactor de 100 gramos.
25/10	Ageo	-Estudio de variables de Segregación : Temperatura, tiempo y once pruebas de segregación seguidas de flotación.
26/10	Ageo-Kyoto	Viaje a Kyoto
27/10	Kyoto	Turismo (día domingo)
28/10	Kyoto-Okayama	Viaje y visita a la Refinería de Tamano. Viaje a Okayama.
29/10	Okayama-Kamioka	Viaje a Kamioka
30/10	Kamioka	Visita a la Mina Kamioka Mina Tochibora, Planta Concentradora Refinería de Plomo Refinería de Zinc
31/10	Kamioka	Viaje de regreso a Ageo,vía Takayama, Nagoya y Tokyo.

FECHA	LOCALIDAD	ACTIVIDADES
01 al 09/11	Ageo	Central Research Laboratory de la Mitsui. -Estudio de segregación, variables de cantidad de coke y temperatura. -Estudio de segregación en reactor de 1 kg. de muestra. -Análisis químico de las muestras. -Análisis microscópico. -Análisis EPMA (Electros Probe X-Ray Microanalyzer). -Análisis por difracción de Rayos X. -Visita a los Laboratorios de control. -Visita a la sala de muestreo de productos en investigación -Evaluación de resultados.
09/11	Tokyo	Entrevista en JICA. Entrega del Reporte Final.
10/11		Salida de Japón.

EL PROCESO DE SEGREGACION

Los minerales de cobre se presentan en la naturaleza bajo dos formas principales : sulfuros y óxidos.

El tratamiento de los sulfuros es práctica conocida a través del enriquecimiento por flotación para después ser sometido a procesos de alta temperatura y refinación electrolítica para la recuperación del cobre metálico. Los óxidos de cobre también pueden ser enriquecidos por flotación, pero su tratamiento en la industria se efectúa por medio de la lixiviación ácida.

El mineral de Berenguela se encuentra al estado oxidado y con la desventaja de que los valores de cobre y plata se encuentran dentro de los óxidos e hidróxidos de manganeso, carbonato de calcio, etc., aplicar el proceso de lixiviación presenta las desventajas de un alto consumo de ácido sulfúrico y la pérdida en la recuperación de plata.

El proceso de segregación es un método alternativo para el tratamiento de minerales oxidados refractarios como es el caso de los minerales de Berenguela. En este proceso el mineral es sometido a alta temperatura (700-800°C) conjuntamente con pequeñas cantidades de cloruro de sodio ($<$ 1.0%) y coke (1.0-1.5%) para formar el cloruro de cobre que simultáneamente va precipitándose en forma metálica sobre las partículas de coke, los cuales son concentrados y recuperados por flotación. El proceso además de obtener mejores recuperaciones y leyes, contribuye en la recuperación del oro y la plata presentes en el mineral.

TEORIA DE LA SEGREGACION DEL COBRE.

Rey (1935) identifica que la segregación se desarrola en tres etapas :

1. La generación de los gases clorurantes.

   Cuando la temperatura alcanza más alla de 650°C el cloruro de sodio (NaCl) reacciona con los minerales arcillosos hidratados, tales como la montmorillonita y caolinita, liberando el ácido hidroclórico.

$$4NaCl+Al_2O_3.2SiO_2.2H_2O = 4HCl + Na_4Al_2O_3.2SiO_3 \quad (1)$$

$$2NaCl + SiO_2+H_2O = 2HCl + Na_2SiO_3 \quad (2)$$

2. Volatilización del cloruro de cobre.

   El ácido hidroclórico liberado en las reacciones anteriores atacan a los minerales oxidados de cobre para formar los cloruros cúprico y cuproso volátiles, de acuerdo con las siguientes reacciones :

$$CuO + 2HCl = CuCl_2 + H_2O \quad (3)$$

$$2CuO + 4HCl = Cu_2Cl_2 + 2H_2O + Cl_2 \quad (4)$$

El cloruro cúprico es inestable a temperaturas elevadas y se descompone en cloruro cuproso y es probable que el principal producto de la reacción es el cloruro cuproso. En el caso de un mineral de crisocola, la reacción será :

$$2CuSiO_3.2H_2O+4HCl = Cu_2Cl_2 + 6H_2O + Cl_2 + 2SiO_2 \quad (5)$$

El cloro formado, a su vez se difundirá por los gramos del mineral atacando a los minerales de cobre para formar más cloruros volátiles de acuerdo a la reacción (6).

$$2CuSiO_3.2H_2O + Cl_2 = Cl_2Cu_2 + 4H_2O + 2SiO_2 + O_2 \quad (6)$$

3. Precipitación del cobre

Los estudios han demostrado que la condición ideal para la segregación es que la atmósfera sea ligeramente reductora que contenga principalmente el dióxido de carbono. Bajo estas condiciones los cloruros de cobre volátil son reducidos a cobre metálico sobre las partículas de carbón.

Siendo las reacciones de reducción las siguientes :

$$Cu_2Cl + C + H_2O = 2Cu + 2HCl + CO \quad (7)$$

$$2Cu_2Cl_2 + C + 2H_2O = 4Cu + 4HCl + CO_2 \quad (8)$$

$$CuCl_2 + C+ H_2O = Cu + 2HCl + CO \quad (9)$$

$$2CuCl_2 + C + 2H_2O = 2Cu + 4HCl + CO_2 \quad (10)$$

De estas parece ser que la reacción principal es la reacción (8).

El cobre segregado usualmente se encuentra en la forma de granos discretos y a una granulometría menor de 65 mallas. El producto segregado es recuperado por flotación obteniéndose un concentrado de alta ley de cobre.

TRABAJO EXPERIMENTAL

Las pruebas de segregación-flotación fueron efectuadas, con las muestras llevadas del yacimiento de Berenguela, en los laboratorios de procesamiento de minerales del Central Research Laboratory de la Mitsui Ming & Smelting Co., Ltd.

La muestra del mineral de Berenguela.

Las muestras llevadas fueron las siguientes :

Nombre/clave	Peso, kg	Leyes (Perú) Cu %	Ag oz/T	Leyes (Japón) Cu%	Ag oz/T
1. Esmeralda Lado Norte	3.500	3.30	230		
2. Esmeralda Lado Sur	3.000	2.20	306	1.65	350
3. Punto 11	3.000	2.10	304		
4. Punto 4	1.000	3.06	1188	3.25	1270

En base a los análisis químicos efectuados en los laboratorios de INGEMMET, para efectos de realizar pruebas metalúrgicas de segregación-flotación, se optó por compositar las muestras 1,2 y 3 (nivel de Ag similares) que da las siguientes leyes calculadas : Cu : 2.57%; Ag : 277.4 g/t.

Analizado el compósito en los Laboratorios de la Mitsui dan : Cu 1.65% y Ag 350 g/t que difieren del calculado.

METODOLOGIA

Las pruebas experimentales se desarrollaron a nivel de laboratorio en sistema batch de acuerdo con el flow sheet de la figura N°1.

Para las pruebas de segregación se emplearon 2 tipos de hornos de inducción eléctrica :

HORNO ELECTRICO	PESO MUESTRA UTILIZADA	REACTOR Fig. N°
1. TUBULAR ESTATICO	100 g	2
2. TUBULAR CON MECANISMO DE ROTACION	1000 g	3

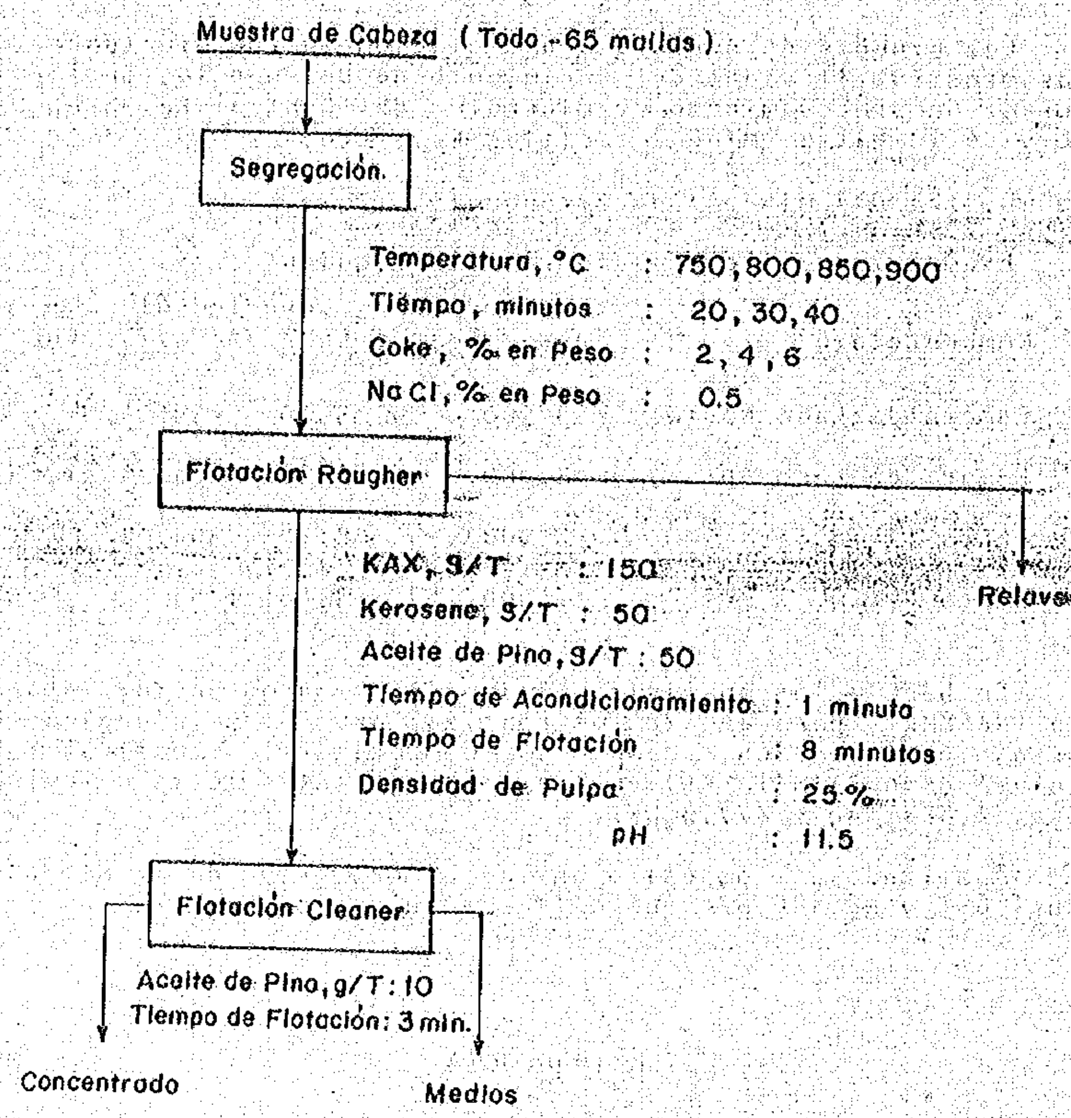


Fig. 1.- FLOWSHEET Y CONDICIONES

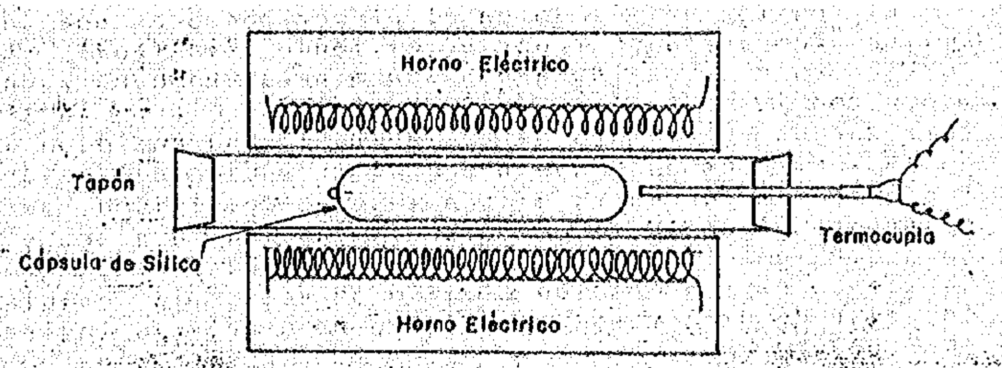


Fig. 2.- REACTOR PARA MUESTRA DE 100 g

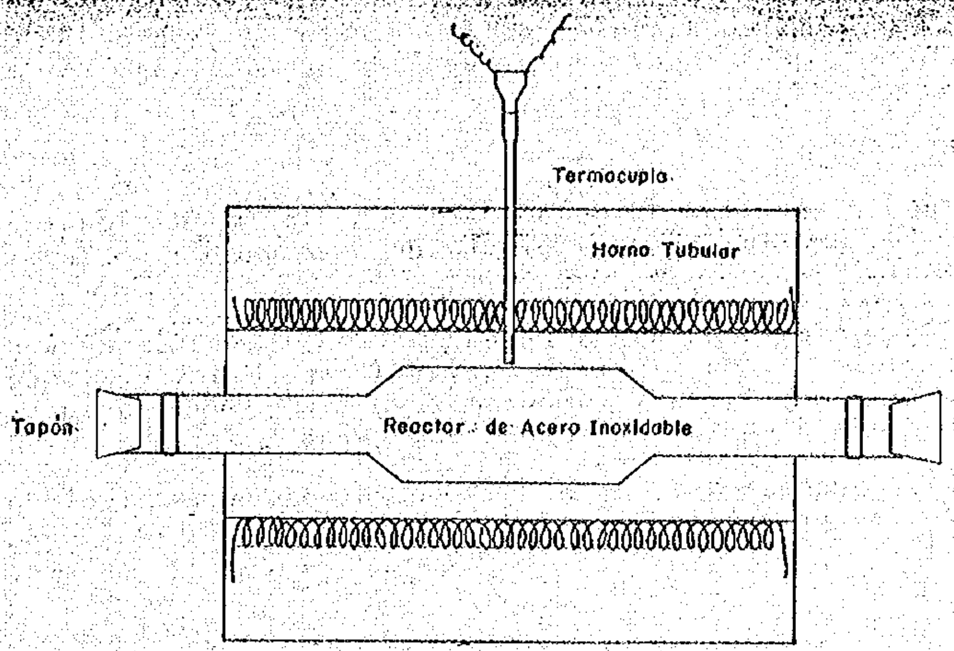


Fig. 3.- REACTOR PARA MUESTRA DE 1000 g

El reactor utilizado en el primer horno es una cápsula de sílica (compuesta de 2 partes el fondo y la tapa). La cápsula es cargada con los 100 gramos de mineral homogenizada conjuntamente con los reactivos (sal y coke), se cierra la tapa y es introducida en el tubo de sílice hasta una posición intermedia de los extremos para una buena distribución del calor, luego los extremos son cerrados con tapones de silicón, permitiendo solamente el conducto para la eliminación de gases y la entrada de la temperatura para el control. Después de transcurrido el tiempo de segregación elegido se retira la cápsula hacia el interior de otro tubo de sílica para enfriarlo indirectamente con agua.

El material del reactor utilizado en el horno con mecanismo de rotación es de acero inoxidable. En este caso 1000 gramos de mineral se homogenizaron con el correspondiente de sal y coke y fue introducido dentro del reactor. Luego el reactor es instalado en el horno, cerradas las entradas con tapas de acero y se deja en movimiento durante la prueba de segregación. Después del tiempo de segregación, el reactor es retirado manualmente y enfriado con la ayuda de un ventilador.

Las pruebas de flotación se ejecutan seguidamente después de las pruebas de segregación en celdas de acuerdo al tamaño de muestra. Las condiciones de las pruebas de flotación fueron las mismas para todas las pruebas de segregación. Ver Fig.N°1.

RESULTADOS :

Los resultados obtenidos así como las condiciones en que han sido efectuadas cada prueba de segregación se muestra en la Tabla N°2.

Los resultados de las pruebas N°2 a la 10 se encuentran graficadas en dos tipos de curvas (temperatura y tiempo de segregación vs. leyes y temperatura y tiempo de segregación vs. recuperación de valores) en las figuras 4 á 7.

Las pruebas N°13 a la N°15 corresponden al nivel de 1000 gramos y sus gráficos están representados en las figuras N° 8 a N°11.

TABLA N°2

CONDICIONES Y RESULTADOS DE LAS PRUEBAS DE SEGREGACION-FLOTACION CON MINERAL DE BERENGUELA

PRUEBA N°	TEMP. °C	TIEMPO (')	COKE g	NaCl (g)	LEY CONCENTRADO		RECUPERACION %	
					Cu %	Ag g/T	Cu	Ag
5	750	20	2	0.5	1.90	3006	2.9	18.1
6	750	30	2	0.5	7.11	5959	15.0	59.6
7	750	40	2	0.5	10.83	4360	34.8	66.0
3	800	20	2	0.5	4.68	5180	7.4	38.5
2	800	30	2	0.5	29.75	10354	58.9	87.2
4	800	40	2	0.5	22.05	6336	65.5	88.7
9	850	20	2	0.5	13.64	5292	42.2	77.2
8	850	30	2	0.5	24.57	6921	69.9	93.0
10	850	40	2	0.5	26.22	6871	81.0	100.1
13	900	40	2	0.5	60.06	14479	96.8	103.4
14	850	40	4	0.5	38.16	8559	97.2	102.7
15	850	40	6	0.5	27.74	6010	95.8	97.9

DISCUSION

Las fotomicrografías de las láminas 1,2 y 3 nos muestran al mineral a 46, 115 y 230X aumentes. En las que se observa claramente el cobre difundido en forma de silicatos. La lamina 3 hace presumir la presencia de psilomelano (granos de color blanco). La coloración amarilla en los bordes de los granos blancos dan a entender la presencia de Hollandita.

En la lámina 4 se muestran fotomicrografías de un concentrado de flotación, en el que se observa la presencia de coke recubierto con una película delgada de cobre metálico. La lámina 5 corresponde al relave donde se nota que quedaron aún algunas partículas de cobre segregado que no flotaron. Las vistas anteriores evidencian la efectividad del proceso de segregación y la separación del cobre-plata segregado por flotación dando concentrados de alta ley.

De las variables estudiadas (temperatura y tiempo de segregación) los resultados indican que la temperatura como el tiempo mejoran el nivel de recuperación tanto con el cobre como con la plata. En todo los casos la recuperación de la plata es mayor que la plata.

Las leyes tienen mejores resultados cuando se trabaja a 800°C y 30 minutos de segregación, al incrementar estas variables las leyes decaen.

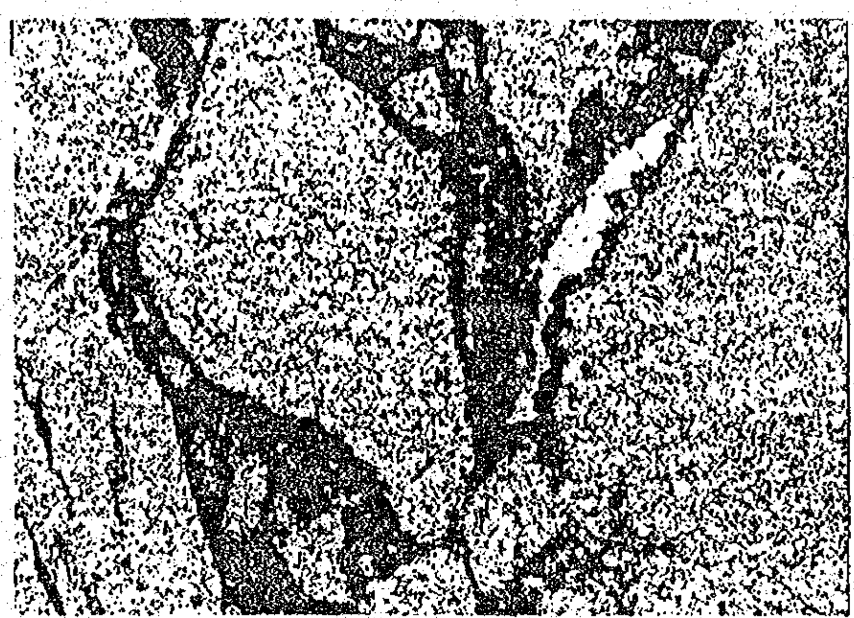
En las pruebas a mayor escala (1000 gramos) la recuperación del cobre se incrementa con la temperatura, que confirma lo anteriormente dicho, sin embargo, la plata tiende a mantenerse constante (Fig.N°9). En cambio en lo que se refiere a las leyes, se tienen datos contradictorios ya que estas elevan su nivel con el tiempo y la temperatura. En todo caso es necesario realizar más pruebas ya que como se observa en los balances en las pruebas 13 y 14 se sobrepasa el 100% las recuperaciones de plata.

Otro objetivo de las pruebas 13, 14 y 15 fue evaluar el reductor (coke) en la recuperación de los valores y la calidad del concentrado. Las fig. 10 y 11 muestran que 4% de coke es el más ventajoso.

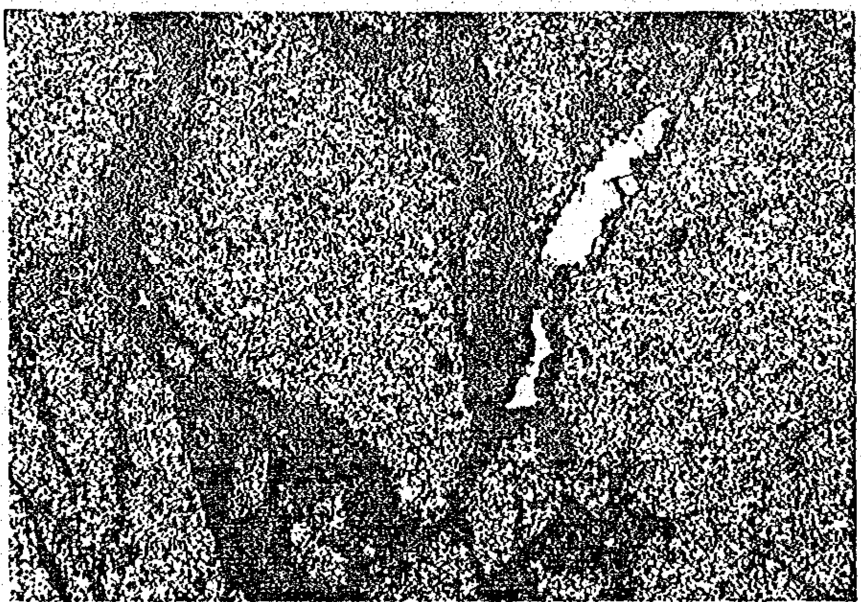
Adicionalmente se ha probado realizar la segregación con coke de granulometrías gruesas (28 M ~ 35M) y luego separar el cobre segregado por malla en lugar de la flotación. Los resultados mostrados en los balances de las pruebas 11 y 12 dan si bien es cierto de bajas recuperaciones, resultados interesantes ya que invitan a seguir estudiando esta alternativa que sería más barata que la flotación.

Prueba	Leyes		Recuperación		Coke
N°	Cu	Ag	Cu	Ag	usado
11	6.60	10728	4.4	33.7	2%
12	11.01	6589	23.4	65.9	4%

顕微鏡写真(透過光)



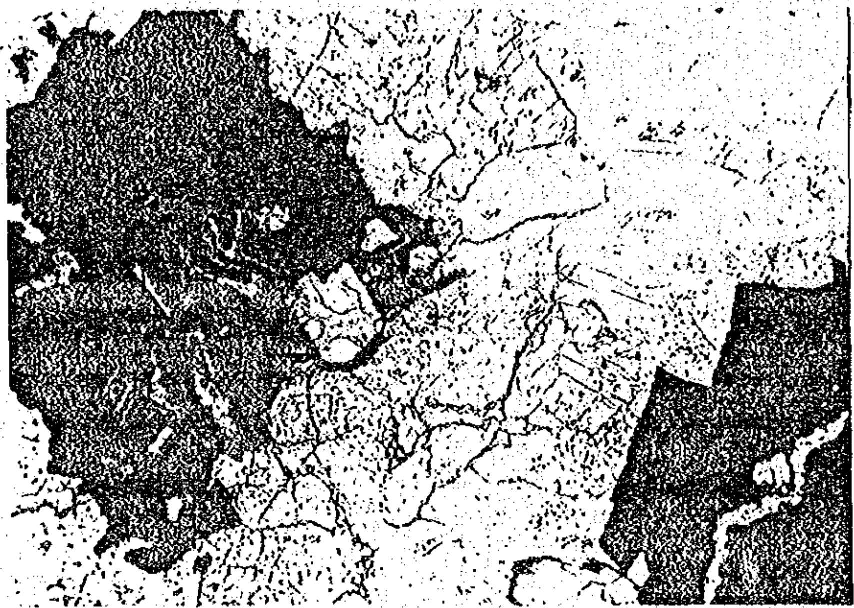
open nicol　　0　0.5mm



crossed nicols　　0　0.5mm

lamina 1

顕微鏡写真(反射光)



open nicol

0 0.2mm

crossed nicols

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Lamina 2

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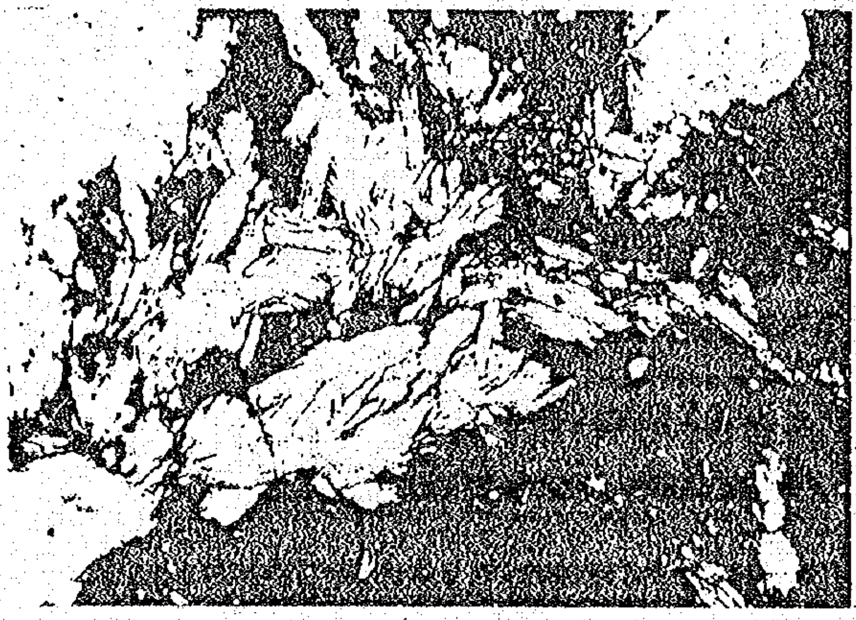
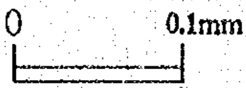
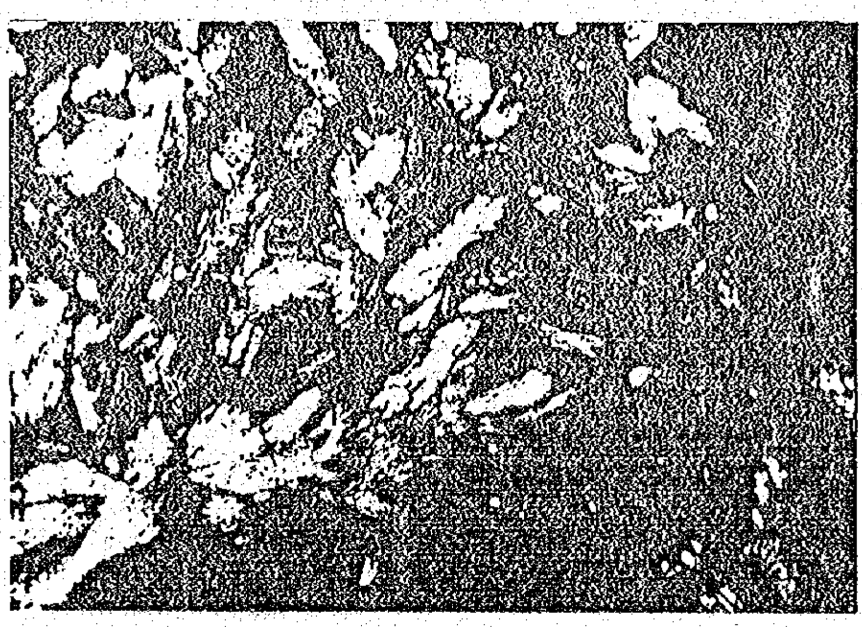
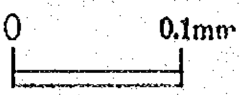


open nicol





crossed nicols



Lamina 3

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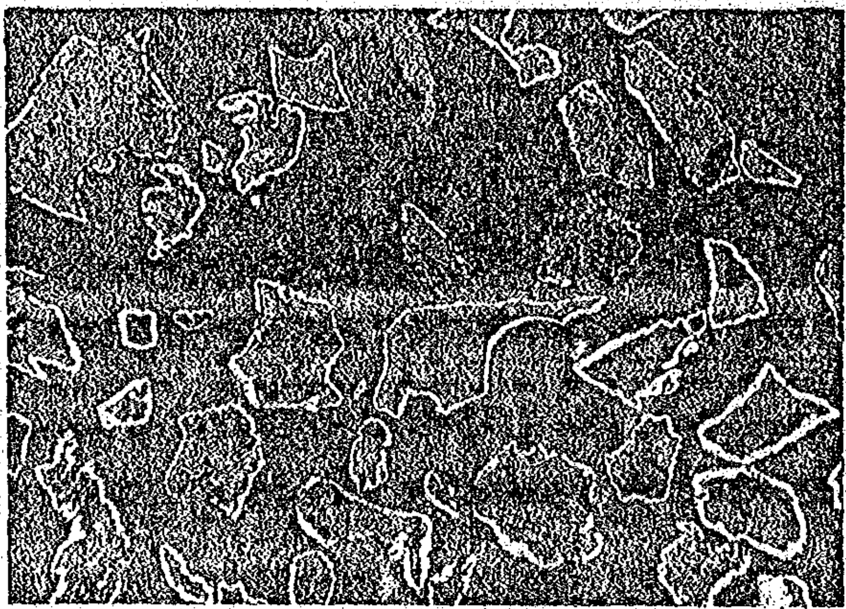

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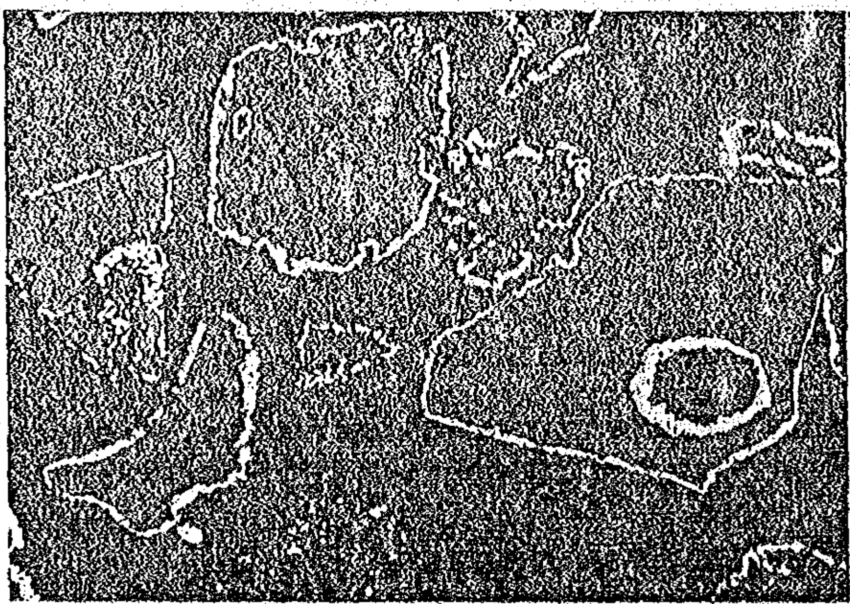

0　0.1mm

Lamina 4

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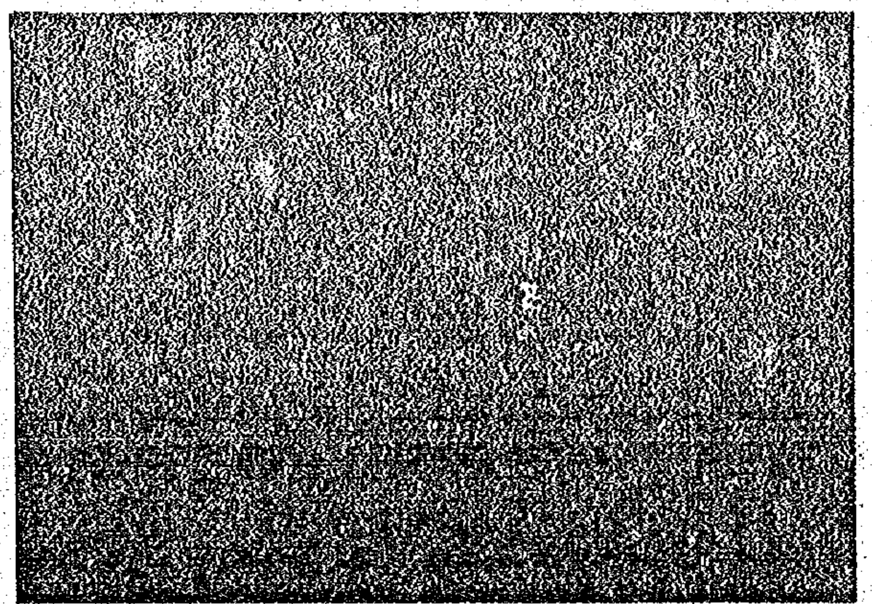

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Lamina 5

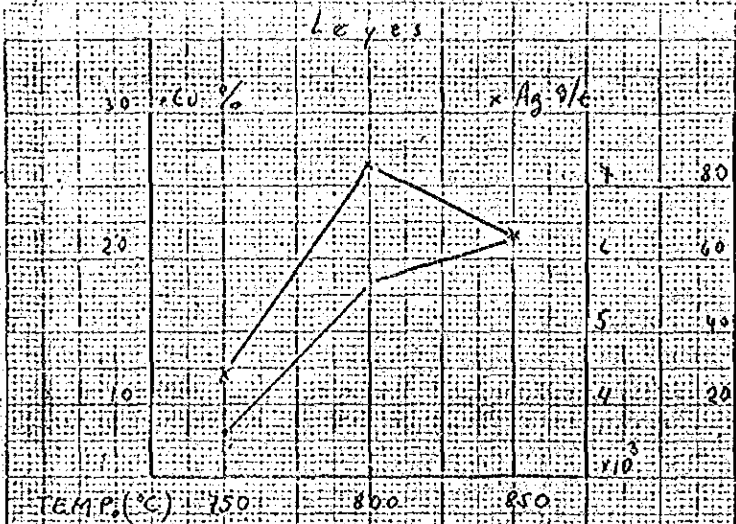

Fig. 4

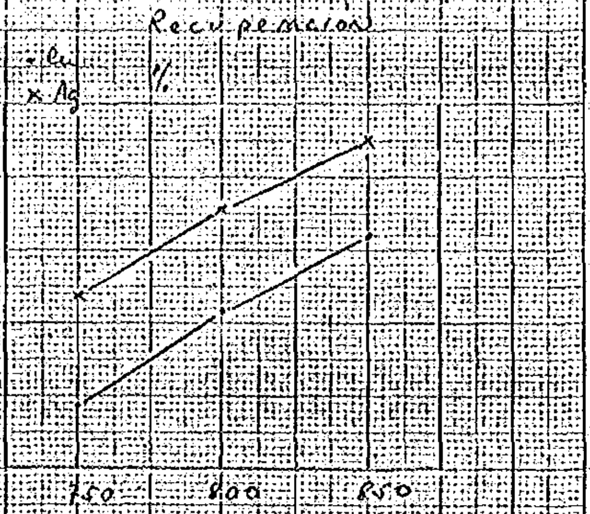

Fig. 5

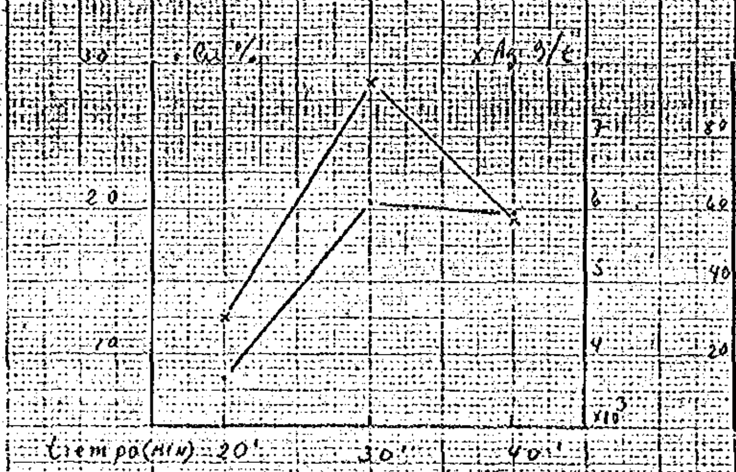

Fig. 6

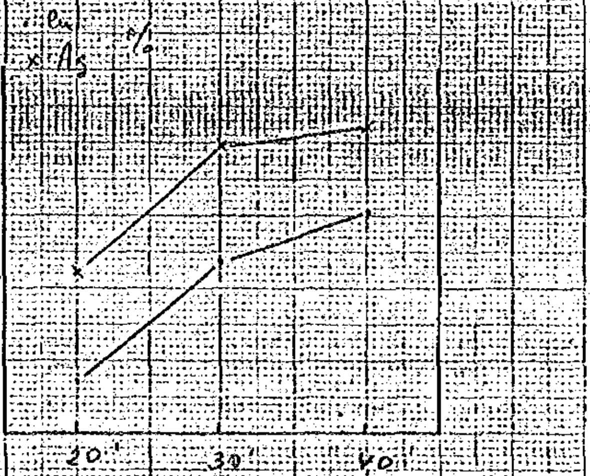

Fig. 7

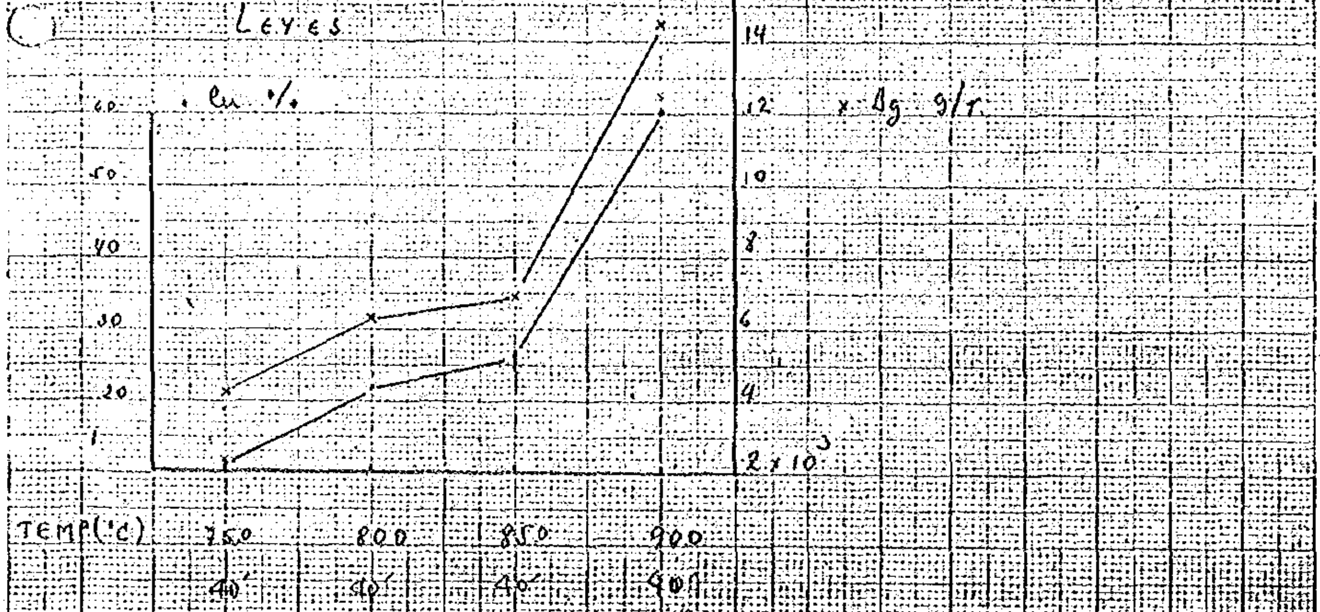

Fig. 8

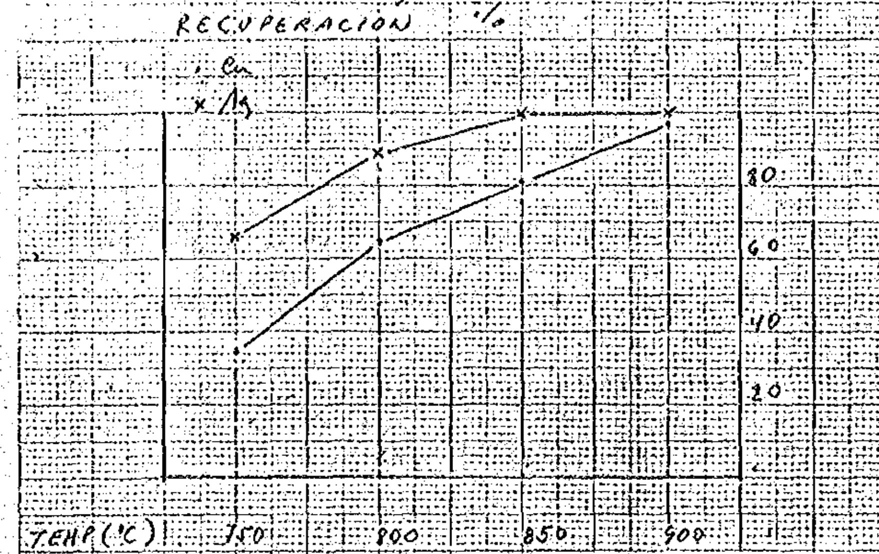

Fig. 9

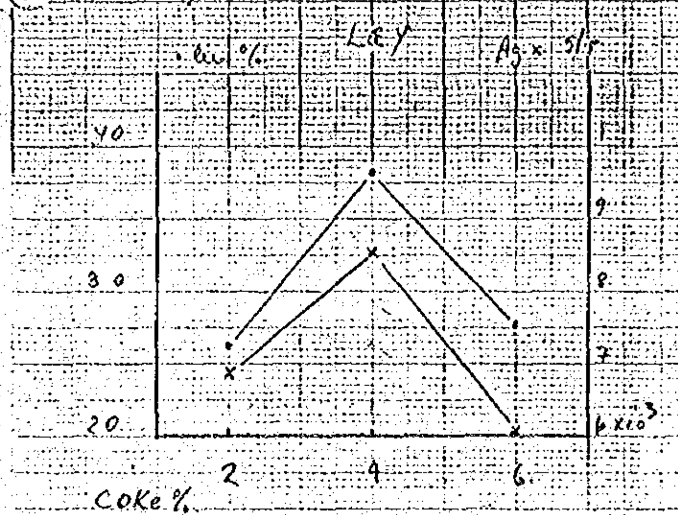

Fig. 10

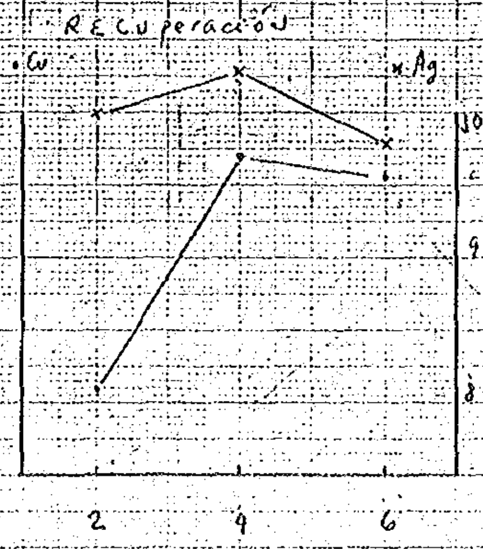

Fig. 11

CONCLUSIONES

- Los objetivos del stage han sido alcanzados; ya que nos permitirá conocer experiencias de centros de investigación sumamente desarrollados, la industria minera y la idiosincrasia del pueblo japonés que es altamente loable.

- El proceso de segregación es técnicamente factible para la recuperación de valores metálicos de minerales refractarios. Los resultados indican las mejores condiciones :

Temperatura	800-850°C
Tiempo	40 minutos
Coke	4 %
Sal	0.5 %

Las recuperaciones para tales condiciones están en :

Cu	84.88 ± 14.85 %
Ag	97.30 ± 6.00 %

AGRADECIMIENTO

A los Directivos y funcionarios del INGEMMET
A los Directivos de JICA
A los Directivos y funcionarios, investigadores e ingenieros de la Mitsui Mining & Smelting Co. Ltd.

FC/mc.

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鉱　　　　　　　　　　　　　　　　　　昭和　　年　　月　　日

Test No	鉱種	鉱量 g	鉱量 %	品位 (%) Cu	品位 (%) Ag			含有量 Cu	含有量 Ag			採収率 (%) Cu	採収率 (%) Ag			試験条件
#1	Feed	100.0						165 (166.318)	39000 (34309.1)			100.0	100.0			800°C – 30′
	(R)	3.0		27.97	10290			83.918	30870			50.8	88.2			cokes 2g
	C	1.7		48.27	17947			82.059	30509.9			49.7	87.2			NaCl 0.5g
	M	1.3		1.43	277			1.859	360.1			1.1	1.0			
	T	80.0		1.03	43			82.400	3440.0			49.9	9.8			
	(LOSS)							+ 1.318	– 690							
								(166.318	34310)			(100.7	98.0)			
#2	Feed	100.0						165 (160.411)	(32808.4)			100.0	100.0			800°C – 30′
	(R)	2.8		29.75	10354			83.296	28992.4			58.9	87.2			cokes 2g
	C	1.6		51.10	18013			81.760	28820.8			49.6	82.3			NaCl 0.5g
	M	1.2		1.28	143			1.536	171.6			9.3	4.9			
	T	79.5		0.97	48			77.115	3816.0			46.7	10.9			
	(LOSS)							– 4.589	– 2191.6							
								(160.411	32808.4)			(105.6	98.1)			
#3	Feed	100.0		1.65	350			165.000	35000.0			100.0	100.0			800°C – 20′
	(R)	2.6		4.68	5180			12.165	13467			7.4	38.5			cokes 2g
	C	0.9		9.89	14064			8.901	12658			5.4	36.2			NaCl 0.5g
	M	1.7		1.92	476			3.264	809			2.0	2.3			
	T	84.0		1.75	154			147.000	12936			89.1	37.0			
	(LOSS)															

(159.165 – 24443)　　　　(91.5 – 75.5)

鉱 昭和 年 月 日

Test No	鉱種	鉱量 g	%	品位 (%) Cu	Ag			含有量 Cu	Ag			採収率 (%) Cu	Ag			試験条件
#4	Feed	100.0						165 (162.21)								800°C – 40′
	(R)	4.9		22.05	6336			108.030	31 047			65.5	55.7			cokes 2g
	C	1.9		55.50	16225			105.450	30828			63.9	88.1			NaCl 0.5g
	M	3.0		0.86	73			2,580	219			1.6	0.6			
	T	77.4		0.70	40			54.180	3096			32.8	8.8			
	(LOSS)							- 2.79	- 857							
								(162.21	31143)			(93.3	97.5)			
#5	Feed	100.0		1.65	350			165.000	350 00			100.0	100.0			750°C – 20′
	(R)	2.1		1.90	3006			3.989	6313			2.9	18.1			cokes 2g
	C	0.4		1.94	13548			0.776	5419			0.5	15.5			NaCl 0.5g
	M	1.7		1.89	526			3.213	894			1.9	2.6			
	T	85.6		1.84	205			157.504	17548			95.5	50.1			
	(LOSS)							- 3.507	- 11139	c/o						
								(161.493	23 861)			(97.9	68.2)			
#6	Feed	100.0		1.65	350			165.000	35 000							750°C – 30′
	(R)	3.5		7.11	5959			24.893	20855			15.0	59.6			cokes 2g
	C	1.1		18.07	17742			19.877	19516.2			12.0	55.8			NaCl 0.5g
	M	2.4		2.09	558			5.016	1339.2			3.0	3.8			
	T	82.0		1.60	81			31.302	6642.0			80.0	20.0			
	(LOSS)							- 8.907	[illegible]							
								(156.093	27 497.4)			(95.0	79.6)			

鉱( )　　　　　　　　　　　　　　　　　昭和　　年　　月　　日

Test No	鉱種	鉱量 g	鉱量 %	品位(%) Cu	品位(%) Ag	含有量 Cu	含有量 Ag	採収率(%) Cu	採収率(%) Ag	試験条件
#7	Feed	100.0		1.65	350	165.000	35000	100.0	100.0	
	(R)	5.3		10.83	4360	57.423	23107	34.8	66.0	750℃ − 40′
	C	1.3		39.31	17285	51.103	22471	31.0	64.2	cokes 2g
	M	4.0		1.58	159	6.320	636	3.8	1.8	NaCl 0.5g
	T	78.7		1.28	57	100.736	4486	61.1	12.8	
	(LOSS)					- 6.841	- 7407			
						(158.159	27593)	(95.9	78.8)	
#8	Feed	100.0		1.65	350	165.000	35000	100.0	100.0	850℃ − 30′
	(R)	4.7		24.57	6921	115.472	32528	69.9	93.0	cokes 2g
	C	2.0		56.71	16129	113.420	32258	68.7	92.2	NaCl 0.5g
	M	2.7		0.76	100	2.052	270	1.2	0.8	
	T	76.5		06.0	48	45.900	3672	27.8	10.5	
	(LOSS)					- 3.628	+ 1200			
						(161.372	36200)	(97.7	103.5)	
#9	Feed	100.0		1.65	350	165.000	35000	100.0	100.0	850℃ − 20′
	(R)	5.1		13.64	5292	69.58	26991	42.2	77.2	cokes 2g
	C	1.5		43.46	17677	65.19	26516	39.5	75.8	NaCl 0.5g
	M	3.6		1.22	132	4.39	475	2.7	1.4	
	T	77.3		1.10	66	85.03	5102	51.5	14.6	
	(LOSS)					- 10.39	- 2907			
						([illegible]	32093)	(93.7	91.8)	

鉱（　　）　　　　　　　　　　（　　）昭和　　年　　月　　日

Test No	鉱種	鉱量 g	鉱量 %	品位(%) Cu	品位(%) Ag	含有量 Cu	含有量 Ag	採収率(%) Cu	採収率(%) Ag	試験条件
#10	Feed	100.0		1.65	350	165.00	35000	100.0	100.0	850°C – 40′
	(R)	5.1		26.22	6871	133.719	35044	81.0	100.1	cokes 2g
	C	2.1		62.89	16556	132.069	34768	80.0	99.3	NaCl 0.5g
	M	3.0		0.55	92	1.650	276	1.0	0.8	
	T	75.7		0.36	30	27.252	2271	16.5	6.5	
	(LOSS)					– 4.029	+ 2315			
						(160.971	37315)	(97.6	106.6)	
#11	Feed	100.0		1.65	350	165.00	35000	100.0	100.0	800°C – 30′
	C	1.1		6.60	10728	7.260	11801	4.4	33.7	cokes 2g
	T	83.0		1.84	204	152.720	16932	92.6	48.4	(28M～35M)
	(LOSS)					– 5.02	– 6267			NaCl 0.5g
						(159.98	28733)	(97.0	42.1)	
#12	Feed	100.0		1.65	350	165.000	35000			800°C – 30′
	C	3.5		11.01	6589	38.535	23062	23.4	65.9	cokes 4g
	T	82.0		1.53	130	125.460	10660	76.0	30.5	(28M～35M)
	(LOSS)					– 1.005	– 1278			NaCl 0.5g
						(163.995	33722)	(99.4	96.4)	

Test No	鉱種	鉱量 g	鉱量 %	品位(%) Cu	品位(%) Ag	含有量 Cu	含有量 Ag	採収率(%) Cu	採収率(%) Ag	試験条件
#13	Feed	100.0		1.65	350	165	35000	100	100	900°C – 40′
	(R)	2.5		60.06	14479	150.14	36197	96.8	103.4	cokes 2g
	C	1.9		78.45	18903	149.06	35916	90.3	102.6	NaCl 0.5g
	M	0.6		1.80	468	1.08	281	6.5	0.8	
	T	78.0		0.19	26	14.82	2028	9.0	5.8	
	(LOSS)									
						(164.96)	(38225)	(105.8	109.2)	
#14	Feed	100.0		1.65	350	165	35000	100	100	850°C – 40′
	(R)	4.2		38.16	8559	160.29	35948	97.2	102.7	cokes 4g
	C	3.5		45.58	10194	159.53	35679	96.7	101.9	NaCl 0.5g
	M	0.7		1.08	384	0.76	269	0.5	0.8	
	T	77.0		0.07	18	5.39	1386	3.2	4.0	
	(LOSS)					–	–			
	cc					(165.68)	(37334)	(100.4	106.7)	
#15	Feed	100.0		1.65	350	165	35000	100	100	850°C – 40′
	(R)	5.7		27.74	6010	158.11	34259	95.8	97.9	cokes 6g
	C	5.0		31.10	6742	155.50	33710	94.2	96.3	NaCl 0.5g
	M	0.7		3.73	784	2.61	549	1.6	1.6	
	T	76.0		0.09	28	6.84	2128	4.1	6.1	
	(LOSS)					– 0.10				
						([illegible])		[illegible]	[illegible]	