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EXPERT GROUP MEETING ON PROMOTION OF ENVIRONMENTALLY SOUND TECHNOLOGIES IN MINING AND ORE PROCESSING FOR SELECTED DEVELOPING COUNTRIES

Beijing, China

25-29 June 1996

An International Workshop
Organized by

- *United Nations Industrial Development Organization (UNIDO)*
- *China International Centre for Economic and Technical Exchanges (CICETE)*
- *Beijing General Research Institute of Mining and Metallurgy (BGRIMM)*

Contents

Paper to
UNIDO & BGRIMM Co-organized
Expert Group Meeting
25-29 June 1996, Beijing

BGRIMM EMULSION EXPLOSIVES AND THEIR APPLICATION

Xiong Daiyu
Beijing General Research Institute of Mining & Metallurgy

1. A Brief Introduction of BGRIMM Emulsion Explosive

BGRIMM emulsion explosive is a new type water proof industrial explosive which was successfully developed in 70's by Beijing General Research Institute of Mining & Metallurgy (BGRIMM). It is produced with such common raw materials as $(NH_4)NO_3$, water, oil, wax and emulsifier by emulsification technology. It has special internal physical structure of "water in oil" (W/O) and a series of unique features superior over other industrial explosives available, and is regarded as one of the best modern industrial explosives.

BGRIMM emulsion explosive was awarded a Unica gold medal in the 35th World Invention fair, Brussels, and several series of BGRIMM emulsion explosives were awarded rewards in China. For example, EL series emulsion explosives were awarded 2nd grade national invention reward in 1982; CLH series emulsion explosives got second grade national reward for science & technology progress in 1986; SB and BME series emulsion explosives were awarded 2nd grade national rewards for science & technology progress in 1991.

2. Types, Properties and Features of BGRIMM Emulsion Explosives

BGRIMM emulsion explosives are divided into 8 series with over 30 types according to the different blasting engineering needs. Besides the ordinary EL series, there are elastoplastic, non-sticky SB series designed for open and underground deep hole blasting; spherical CHL series emulsion explosives of high density, high detonation speed and high strength applicable for V.C.R mining method; low cost BME series granular emulsion explosives suitable for mechanical loading in open and underground mines, combining such merits as good detonation properties of emulsion explosives and low cost of ANFO explosive; high safety 3rd class permissible BY-2 type suitable for coal mines which are exposed to the explosion risk due to the underground gases and coal dusts; and BSE series emulsion seismic focus column suitable for seismic exploration of such mineral resources as petroleum, etc. The main properties of the 8 series emulsion explosives are shown in the Table attached.

BGRIMM emulsion explosives have the following technical characteristic features:

1) excellent water- proofness and good detonation performance;
2) reliable safety;
3) adjustable energy density;
4) good stability for storing;
5) wide adaptability to various blasting operations;
6) wide availability of raw materials and low production cost;
7) simple and easily mastered production technology and equipment, free of environment pollution;
8) little amount of harmful gases formed after explosion.

3. Production Technology and Application of BGRIMM Emulsion Explosive

There are two main technologies for manufacturing BGRIMM emulsion explosives:

3.1 Batch production technology: suitable for middle and small size mines or commercial plants with limited sales. The plant capacity is 1000-3000 t/y, featuring batch flexible production according to requirement. Usually ϕ32-40 mm small diameter cartridges are manufactured with good performance and long storage term. Large diameter non-cap-sensitive products can also be produced with this technology.

3.2 Continuous production technology: suitable for large size mine or specialized plant, featured with large output, high speed, high efficiency and low cost. It is suitable for open mine blasting, with output 8-12 t/h. The explosive can be put into bags, or directly fill in the borehole at site through mixing-loading machine; after adjustment it can also produce small diameter cap-sensitive products.

BGRIMM emulsion explosives are widely used in various blasting operations such as mining and stripping, rock excavation, road building, airport and port construction, water conservancy and hydroelectric engineering, petroleum and geological prospecting, military and civil engineering blasting.

Till now, there are over 30 BGRIMM emulsion explosives plants built in China. In addition, BGRIMM has successively transferred technology to or built plants in Sweden, Mongolia, Kazakhstan, etc. winning a good reputation both in and outside China. For example, during 1992-1994, BGRIMM transferred the emulsion explosives technology to Mongolian-Russian "Erdenet" Joint Mining Corporation and built a multi-type BGRIMM emulsion explosives plant with annual capacity of 10000 ton. The comprehensive cost for manufacturing emulsion explosives in this plant is 700 USD/T less than the previous cost for importing explosives and the operation is going on well with excellent economic benefits.

BGRIMM emulsion explosives plants can produce not only commercial explosives, but also explosives at mines for self-consuming. Commercial BGRIMM emulsion explosives plants now operating in China include:

- Zhejiang Limin Chemical Engineering Plant;
- Sichuan Ya'an Chemical Engineering Plant;
- Shaanxi Hongqi Chemical Engineering Plant;
- Jiangsu Liyang Mine Chemical Engineering Materials Plant, etc.

BGRIMM emulsion explosives plants for self-consuming at mines include:

- Fankou Lead & Zinc Mine;
- Tongling Shizishan Copper Mine;
- Xinqiao Pyrite Mine;
- Panshi Nickel Mine;
- Jinchangyu Gold Mine;
- Miyun Iron Mine, etc.

4. Technological and Economical Analysis of BGRIMM Emulsion Explosives

In many developing countries, with the continuous development of raw materials industry and national economy, the demand for industrial explosives is growing bigger and bigger. But at present, the industrial explosives needed by most of the developing countries rely on importation due to the lack of industrial explosives technology and production plants of their own. Chinese experience in development, production and sales of industrial explosives indicates that it is essential to establish production bases and sales networks of explosives at home which are consistent with the development of the national economy. It can gain at least the following benefits:

1) Saving large amounts of foreign currencies;

2) Convenient production, transportation and application of industrial explosives, not being affected by the changes in the world political and economical environment;

3) Possible producing different types of explosives according to particular requirement and prompt supply;

4) Better blasting effects.

There is wide availability of raw materials for BGRIMM emulsion explosives production, main items being NH_4NO_3, $NaNO_3$, W/O emulsifier, composite wax and mineral oil, etc. And they are available all over the world.

Construction of BGRIMM emulsion explosives plant will not be affected by the regional & climatic limits. The plant scale can range from large to small ones, with less investment, higher benefits and shorter recovery of investment.

BGRIMM emulsion explosives technology features simple production technology, easily mastered techniques, safe and reliable operation, and free of environment pollution.

The production cost of small diameter (ϕ32-40 mm) cap-sensitive product of BGRIMM emulsion explosives is about 300-400 USD/T, that for large diameter or bulk non-cap-sensitive product is about 200-300 USD/T.

Provided the cost of imported or purchased commercial explosives is 800 USD/T, BGRIMM emulsion explosives production plant can save 400-600 USD/T (small and large diameter each accounting for 50%), a BGRIMM emulsion explosives plant with annual output of 5000 ton can make a profit of 2-3 million USD per year, showing economic benefits.

Table: Explosion & Storing Properties of BGRIMM Emulsion Explosives

Series name	Density (g/cm^3)	Detonation velocity (m/s)	Sympathetic detonation (cm)	Brisance (cm)	Critical diameter (mm)	Length of propagation (m)	Water resistance	Weight strength (%)	Volume strength (%)	Storing period (month)
EL	1.05-1.20	4000-5000	8-12	16-19	12-16	>3	good	88-108	105-143	≥6
CHL	1.35-1.55	4500-5500	/	/	40-60	>4	good	177-257	153-243	≥6
SB	1.05-1.10	4000-5000	8-10	16-19	14-40	>3.5	good	85-105	115-130	≥6
BME	0.95-1.40	3000-3800	/	/	50	>3	from weak to strong	98.4	175.6	>1.5
BMH	0.90-1.05	2800-3300	/	/	60	>2.5	weak	/	/	>1.0
BY	1.10-1.25	3000-3800	4-7	9-14	18-20	≥4	good	86	109	≥6
BSE	1.15-1.20	4500-5500	8-10	16-20	30	>3	good	150-180	250-290	≥6
BJ-1	1.10-1.40	3500-4500	8-10	16-18 (steel pipe)	15	>3.5	good	75	106	≥6

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R & D AND APPLICATION OF BGRIMM FLOTATION MACHINE

Shen Zhengchang, Liu Guizhi
Beijing General Research Institute of Mining & Metallurgy

1. Preface

Beijing General Research Institute of Mining & Metallurgy, BGRIMM has been striving for improving flotation technology since 1960s. Especially in the past 2 decades, BGRIMM has done a great number of projects on developing new type impeller-stator machanism, streamline of the cell design, establishing a reasonable path for pulp circulation, promoting the cell's adaptability to minerals of various sizes and scaling-up. In recent years, a lot of work has been made in diversifying and specializing flotation machines and utilizing composite force field. All of R&D efforts have achieved great success, resulting in unique BGRIMM flotation machines.

The flotation machine spectrum developed by BGRIMM mainly consists of 10 series, i.e. CHF-X, LCH-X, XCF, KYF, CLF, YX, SF, BF, JJF, and XJZ, with nearly 100 size specifications, which are extensively used in hundreds of concentrators to treat nonferrous and ferrous metals, precious and rare metals and non metallics. In the past 15 years, 9,600 sets of BGRIMM flotation machine have been sold in China, occupying 85% of the total number of machines applied in the newly built and renovated concentrators. Almost in China's concentrators built or up-graded during the Seventh Five Year and Eighth Five Year Plan Periods are used the flotation machines developed by BGRIMM.

Owing to their superior technological performances, lower price, and higher-quality service, BGRIMM flotation machines have also drawn attention the worldwide and entered the world market. They have not only been exported to such nations as Mongolia and Nigeria but also won several bids in both domestic and international projects.

BGRIMM flotation machines can fully meet the requirement for treating various kinds of minerals.

2. Features of BGRIMM Flotation Machines

BGRIMM flotation machines are divided into two major categories: pneumo-mechanical and mechanical cells; the former category includes CHF-X, LCH-X, XCF, KYF and CLF series while the latter one includes SF,BF,JJF,XJZ series. The detailed classification is shown in Table 1. In addition, there are XY series skim flotation machines for preconcentration in grinding circuit..

Table 1 Classification of BGRIMM flotation machine

Series	KYF	XCF	CLF	CHF-X	LCH-X	SF	BF	JJF	XJZ
Pneumatic	√	√	√	√	√				
Self suction						√	√	√	√
Self suction of feed and middlings		√	√			√	√		
No self suction of ore feed and middlings	√			√	√			√	√
Deep cell	√	√	√	√	√	√	√	√	
Shallow cell						√		√	√
Single side froth paddle	√	√	√	√	√	√	√	√	√
Double side froth paddle	√	√	√	√		√	√	√	

Generally, BGRIMM flotation machines have the following major characteristic features.

2.1 Higher adaptability to various minerals and operations

BGRIMM flotation machines are widely applied in the operations of roughing, scavenging and cleaning for treating copper, lead, zinc, tin, gold, silver, iron, molybdenum, nickel, coal, phosphate, sylvine and other minerals.

The concentrators' throughput ranges from 10 ton to 100,000 ton ore per day and all have gained better economic benefits.

2.2 Higher metal recovery

BGRIMM flotation machines, even the larger size one under the same flotation time, usually provide higher metal recovery. Compared to A type flotation machine at various mills, BGRIMM flotaton cells can improve metal recovery generally by 1%-3%, even by 5%-6% in individual cases.

2.3 Lower energy consumption

China is now short of energy supply. Therefore, BGRIMM pays particular attention to the reduction of energy consumption in flotation, with pulp flow path designed to enable all the energy to maintain pulp in suspension and air in dispersion. It is proved by practice that BGRIMM flotation machines usually can reduce the energy consumption by 15%-40% at the same throughput and by 50% and more for large scale mills.

2.4 Reagent saving

Reagent is one of the major consumables in flotation. BGRIMM flotation machine is designed with reasonable fluid dynamics inside cells and higher capacity of air suction. Owing to this reagent consumption can be cut down by 10% -20% on an average.

2.5 Longer life of wearing parts

BGRIMM flotation machine is designed with advanced impeller-stator mechanism, providing lower peripheral velocity and rotation speed of the impeller and reasonable pulp path. Thus, impeller-stator mechanism can work longer. When treating sulfide ores, its service life is averaged 1.5-3 years.

2.6 Even air dispersion and easy aeration adjustment

Flotation machine's efficiency increases with better air dispersion inside the cell. On the other hand, it can be applied more extensively with higher adaptability if the aeration rate can be easier adjusted in wider range. BGRIMM machine's air dispersion rate ranges from 3.5 to 5.5. Maximun aeration rate in clean water for pneumo-mechanical cell is up to 1.8-2.0 m^3/m^2-min, whereas that for mechanical one is up to 1-1.2m^3/m^2-min. All these performances are far superior to conventional flotation machines.

2.7 Satisfactory solids suspension

Good solids suspension is an important factor to acquire better flotation results. Only in suspension can the mineral particles effectively collide with bubbles, thus creating mineralized bubbles. Pulp flow and circulation patterns initiated by BGRIMM's impeller-stator mechanism can not only strengthen the collision between air bubbles and mineral particles but also prevent the solid particles from settling at the bottom of cells owing to good suspension. Up to now, no settling accidents with BGRIMM flotation machines have been reported in China and abroad.

2.8 Easy and convenient installation and maintenance

Owing to the reasonable design, BGRIMM machines are convenient for installation and maintenance. When installed, there is no necessity to have any fundament. Tanks, drive mechanism and other parts can be simply jointed by bolts without any welding work on the spot. Main shaft bearings can be lubricated by adding grease once a year. Wearing parts, such as impellers and stators are replaced once per 1-2 years or even longer.

2.9 Possible start and stop under full loading

Flotation machines in concentrators, especially large ones are required to start and stop under full loading conditions. For BGRIMM flotation machines when they stop whether necessary or due to power failure, the impeller will not be caught by mineral sand but can freely rotate, and it is therefore unnecessary to empty the cells when restarting under full load.

2.10 Availability for automatic control

In design of BGRIMM flotation machines, thorough considerations are made in terms of various requirements for manual, electric or automatic control of the pulp level. Manual control devices are designed and space is envisaged for auto-control signal and actuating mechanisms, which can satisfy various needs of concentrators for process control.

2.11 Creative flotation bank layout

Among BGRIMM flotation machines CHF-X, LCH-X, KYF air-blowing or pneumatic mechanical cells require stepped layout and froth pumps for recircling middlings, whereas XCF flotation cell has the capability of self sucking middlings and feed pulp, which can be arranged at the same level without resorting to pump for pulp circulation. Among mechanical flotation machines, JJF and XJZ cells do not have the ability to suck pulp and need stepped layout with pumps for recycling middlings wheras SF, BF machines have the capability to suck air and pulp, which is feasible for plane arrangement and need no any auxiliary equipment.

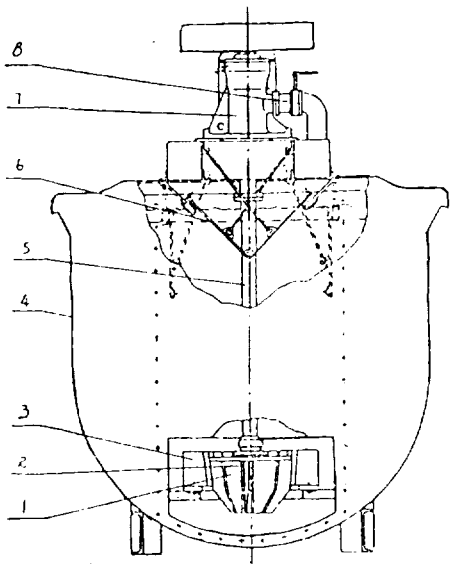
In general, with flotation cells unable to suck pulp the flotation bank arrangement is more complex, but they are of simple construction, and consume less power. In converse are the flotation machines able to suck pulp. Thus BGRIMM has developed a combined flotation unit for plane layout, that is, for self-aeration mechanical flotation machines, XCF cell acts as self-suction one, while KYF or other cells function as direct flow ones. For mechanical flotation machines, SF or BF acts as self-suction cell while JJF as direct flow one. Such a combined arrangement makes it possible to take the advantage of the merits of individual cells and to facilitate the daily operation and management and further improve the flotation performances.

3. Introduction to Major Flotation Machines

Among BGRIMM flotation machines XCF, KYF, CLF, YX and SF series have recorded the widest application and are most distinguished. Their characteristics and applications are described in the following passages.

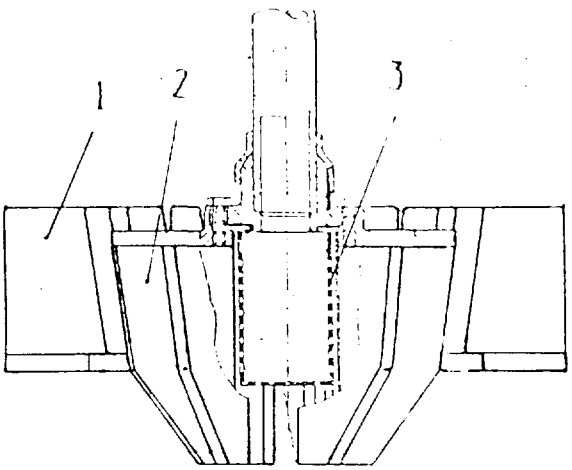
3.1 KYF flotation machine

KYF flotation machine is a new type of pneumo-mechanical cell developed successfully in 1980s. Its construction sketch is shown in Fig.1 and the impeller-stator mechanism in Fig. 2.



1. Rotor; 2. Air distributor; 3. Stator;
4. Cell; 5. Hollow main shaft; 6. Froth paddle;
7. Bearing body; 8. Air adjusting valve

Fig. 1 Construction of KYF Flotation Machine



1. Stator; 2. Rotor;
3. Air distributor.

Fig. 2 KYF Impeller Mechanism

3.1.1 Mechanical construction

The impeller is made of single wall retroversion blades in the form of inverted cone with high rpm. It is centrifugal and features smaller diametre, lower peripheral velocity, larger volume of pulp circulation, lower dynamic head, stronger ability to disperse air, and lower power consumption. Therefore, it can assure solids suspension and be beneficial to stabilizing the upper zone.

Air-disperser is designed as cylinder with holes opened on its wall, which evenly disperses air between the blades of impeller, providing a large pulp - air interface, thus improving the air-dispersion function.

The stator is suspended and made of radial short blades, which are installed inclined around on the impeller. A great gap exists between the stator and impeller. Such kind of stator is beneficial to elimination of unnecessary disturbance of pulp caused by the lower

parts, resulting in reduction of power consumption and promotion of the pulp circulation in lower circulation zone and the suspension of solid particles.

The tank is made as U shape deep cell, which is good for coarse particles to move towards the centre of cells and recirculate into the impeller zone, thus alliviating the phenomena of short circuit, promoting the utilization of bubbles and improving metal recovery and concentrate quality.

3.1.2 Characteristics of KYF flotation machine

Table 2

Model	Cell volume (m^3)	Inner dimensions L×W×H (m)	Rotor Dia (m)	Rotor Lin. vel. (m/s)	Installed power (kw)	Air pressure of blower (kpa)	Air consumption per cell (m^3/min)	Capacity (m^3/min)	Weight of one cell (kg)
KYF-1	1	1.0×1.0 ×1.1	0.34	5.00	3/4	>14	0-2	0.2-1	750
KYF-2	2	1.3×1.3 ×1.25	0.41	5.30	4/5.5	>16	0-3	0.5-2	990
KYF-3	3	1.6×1.6 ×1.4	0.48	5.50	5.5/7.5	≥18	0-5	0.7-3	1885
KYF-4	4	1.8×1.8 ×1.5	0.55	5.76	7.5/11	≥19.8	0-6	1-4	2084
KYF-8	8	2.2×2.2 ×1.95	0.63	6.00	11/15	≥21.5	0-10	2-8	3478
KYF-16	16	2.8×2.8 ×2.4	0.74	6.20	22/30	≥25.5	0-15	4-16	5423
KYF-24	24	3.1×3.1 ×2.9	0.80	6.84	37/45	≥30	0-17	6-24	8840
KYF-38	38	3.6×3.6 ×3.4	0.90	6.90	55/75	≥34.3	0-25	8-38	10136

3.1.3 Applications

Since 12 sets of KYF flotation machines applied in 1984 in indusrial production, additional 400 sets of such machines with single cell volume between 1-38 m^3 have been adopted in copper, lead, zinc, phosphorus, sulphur and other concentrators, obtaining satisfactory results in all cases.

A few cases are cited below.

At Mudin Copper Mine, Yunan Province, the 1500t/d mill has been renovated with KYF-16 flotation machines installed for roughing and scavenging instead of the ex-flotation

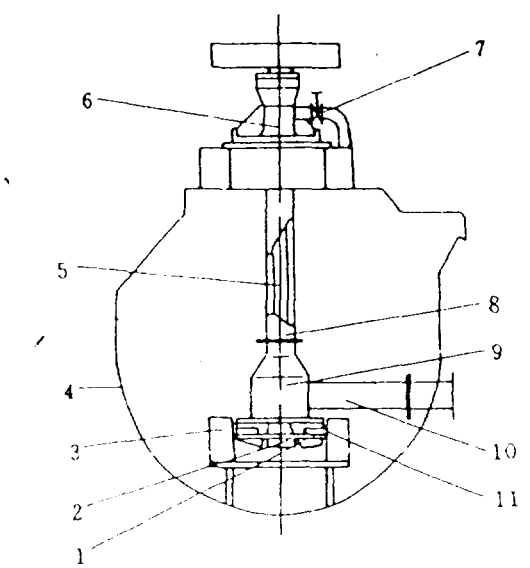
machines. After this, the copper recovery has been raised by 0.97%Cu, concentrate grade by 0.26%Cu, power consumption cut down by 42.97%, and sodium sulphide consumption reduced by 5.7%, that of xanthate and frother by 4% and 12.7% respectively. Service life of wearing parts has prolonged twice and floor space reduced by 45%.

At some large copper mine, KYF-38 flotation machines have recorded a reduction in power consumption by 51.40% under the same performances.

Phosphorus Mine of Wangji, Hubei Province has applied KYF-8 and KYF-4 flotation machines to renovate its concentrator and made distinguished benefits. On the basis of the concentrate quality guaranteed, phosphorus recovery has been raised by 1.91%P, water consumption cut down from 2.64 m^3/t to 1.44 m^3/t, power consumption cut from 10.03 kwh/t down to 7.66 kwh/t, and consumption of sodium carbonate, S711, S608, sodium silicate and sulfo-soap cut down by 12%, 28.94%, 44.39%, 4.37% and 38.38% respectively.

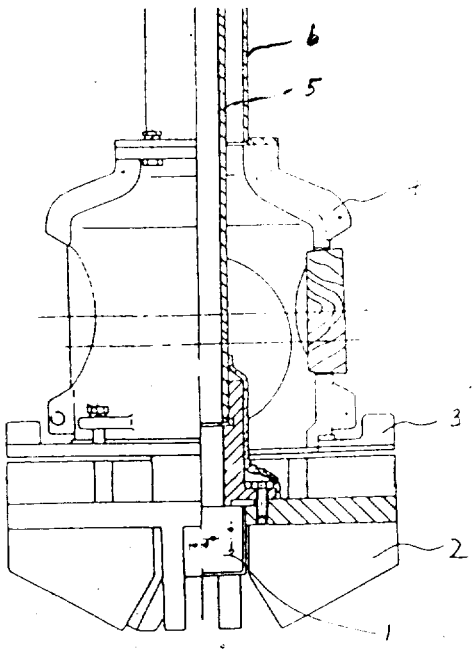
3.2 XCF flotation machine

XCF pulp-suction pneumo-mechanical flotation machine has not only the advantages of conventional pneumo-mechanical machines but also the capability of self suction of feed and middlings. Its construction is shown in Fig. 3 and the impeller - stator mechanism shown in Fig. 4.



1.Rotor
2. Air distributor
3. Stator
4. Cell
5. Main shaft
6. Bearing body
7. Air adjusting valve
8. Adapter
9. Central cyclinder
10. Middling pipe
11. Cover

Fig. 3 Construction of XCF Flotation Machine



1. Air distributor
2. Rotor
3. Cover
4. Central cylinder
5. Hollow main shaft
6. Adapting pipe

Fig. 4 XCF Rotor-stator Mechanism

3.2.1 Mechanical construction

The impeller is composed of upper and lower vanes and a big isolation disc. The upper vanes are radial and straight while lower ones are polygonal and retroverted. The diameter of isolation disc reaches or surpasses that of external vane diametre. The upper vanes mainly suck pulp from outside the cell, and together with the cover create the pulp suction zone while the lower ones are in charge of pulp circulation and air dispersion, creating a so called aeration zone. The isolation disc is designed to isolate the aeration zone from the suction one, which directly affects the capability of pulp suction. The air distributor is installed in the impeller's aeration zone.

The cover is a crucial part of unique structural parameters, creating a suction zone together with the upper vanes. It confines the upper vanes in order to create depression in the central zone. Meanwhile, it has isolation function to keep aeration air from entering into the suction zone, making pulp suction possible.

The linking or adapting pipe's function is to fix the central cylinder and cover, and is equipped with exhaust device to get rid of gases occurring during the rotation of flotation machines, preventing the air and pressure inside the linking pipe from increasing; otherwise the depression in the vanes' central zone would gradually diminish, which is harmful to pulp suction.

3.2.2 Technical characteristics

Table 3

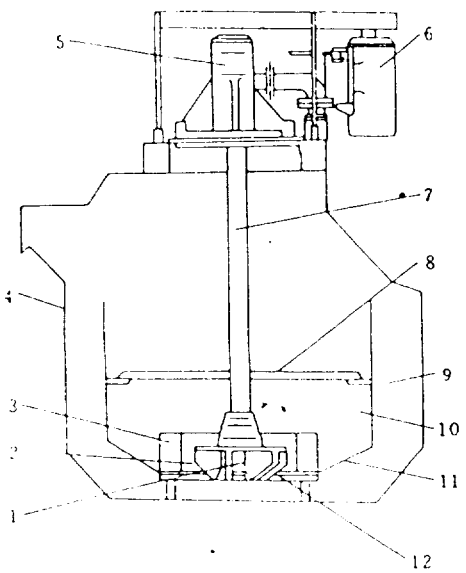
Model	Cell volume (m^3)	Inner dimensions LxWxH (m)	Rotor		Installed power (kw)	Air pressure of blower (kpa)	Air consumption per cell (m^3/min)	Capacity (m^3/min)	Weight of one cell (kg)
			Dia (m)	Lin. vel. (m/s)					
XCF-1	1	1.0×1.0 ×1.1	0.40	6.60	4/5.5	>14	0-2	0.2-0.5	837
XCF-2	2	1.3×1.3 ×1.25	0.47	6.80	5.5/7.5	>16	0-3	0.5-1	1150
XCF-3	3	1.6×1.6 ×1.4	0.54	7.00	7.5/11	≥18	0-5	0.7-1.5	1974
XCF-4	4	1.8×1.8 ×1.5	0.62	7.20	11/15	≥19.8	0-6	1-2	2305
XCF-8	8	2.2×2.2 ×1.95	0.72	7.35	18.5/22	≥21.5	0-10	2-4	3745
XCF-16	16	2.8×2.8 ×2.4	0.86	7.20	37/45	≥25.35	0-15	4-8	6299
XCF-24	24	3.1×3.1 ×2.9	0.95	7.80	45/55	≥30	0-17	8-12	9800
XCF-38	38	3.6×3.6 ×3.4	1.05	8.15	75/90	≥34.3	0-25	8-19	11600

3.2.3 Applications

XCF flotation machines are applied in more than 10 concentrators in the fields of nonferrous and chemical industries, all recording distinguished economic and social benefits. It is proved in production at Yinshan Lead and Zinc Mine, compared with the original 6A flotation machines, XCF-8 flotation machines have increased recovery by 0.67%Pb, and 1.94%Zn respectively. Its power consumption has cut down by 23.1%, No.2 oil consumption saved by 22%, floor space reduced by 40% and the life of wearing parts prolonged twice. At Jinduicheng Molybdenum Company, compared with the previous 7A flotation machines, XCF-24 flotation machines have increased molybdenum recovery by 1%Mo, reduced power consumption by 39.89%, consumption of No.2 oil, kerosene, xanthate cut down by 46.27%, 36.86% and 28.22% respectively, and expenses on wearing parts by 30%. At Huangmanling Phosphorus Mine, compared with A flotation machines, XCF-16 and XCF-8 flotation machines have cut down reagent consumption by 20%, power consumption by 21%. Besides the improvement of concentrate grade, the recovery rate has increased by 1.17%P, and the service life of wearing parts prolongs dramatically.

3.3 CLF coarse flotation machine

For sulfide ores, the best flotation size ranges from 10 to 100 μ , and beyond this range, the recovery will be low. In order to resolve this problem, CLF coarse flotation machine is developed recently which has broadened the scope of flotation size and sulfide ores can be flotated at size up to 0.5mm. On the basis of not lowering recovery from medium and fine size fractions, it dramatically increases the recovery rate from +0.15mm and +0.45mm fractions. Its construction is shown in Fig. 5 and the impeller mechanism shown in Fig. 6.



1. Air distributor 2. Rotor 3. Stator
4. Cell 5. Bearing body 6. Motor
7. Hollow main shaft 8. Grate
9. Circulating path 10. Division plate
11. False bottom 12 Holes

Fig. 5 Construction of CLF Flotation Machine

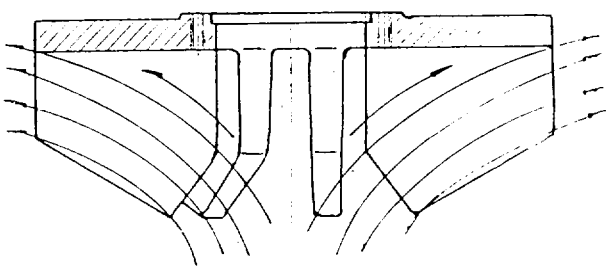


Fig. 6 Construction of CLF Rotor Mechanism

3.3.1 Mechanical characteristics

The impeller is made of high specific rpm, retroverted vanes. The lower vanes are designed to match the flow through the vanes. It has such characteristic features as of weaker agitation, larger pulp circulation and lower power consumption. And it can ensure the suspension of coarse particles and air dispersion with the help of a grate.

Grate: The grate is movable with openings 33-35mm. It is installed at 1/3 distance from the cell bottom. The grate enables the mineralized bubbles of coarse particles to flow up at shorter distance and keeps them under shallow-cell situation while reducing the pulp turbulence in the upper zone of the cells and maintaining a steady isolation and froth layer.

Circulating passage: The circulating passage spurs the larger area circulation of pulp in the cell, which maintains the solid particles in a good suspension condition. It also makes the pulp pass through the rotor agitation area for times, which increases the contact possibility of flotable minerals with fresh air. At the same time, it keeps the significant decreasing of solid content and size of the pulp in rotor area, which is advantageous to the fine particles flotaiton.

3.3.2 Technical Specifications

Table 4

Model		CLF-2		CLF-4		CLF-8	
		pulp suction cell	straight-flow cell	pulp suction cell	straight-flow cell	pulp suction cell	straight-flow cell
Cell volume (m^3)		2		4		8	
Inner dimensions LxWxH (m)		1.2x1.6x1.25		1.6x2.1x1.5		1.9x2.5x1.95	
Rotor	Dia(mm)	480	460	620	580	700	660
	Lin vel. (m/s)	6.71	5.3	7.0	5.62	7.33	5.91
Installed power (kW)		7.5	5.5	15	11	22	15
Capacity (m^3/min)		0.5~2		1~4		2~8	
Air pressure of blower (kpa)		≥ 14.7		≥ 19.6		≥ 23.5	
Air consumption of a cell (m^3/min)		0~3	0~5	0~5	0~7	0~8	0~10
Feed size (mm)		<1.0		<1.0		<1.0	
Weight of main parts (kg)	Single cell	1591	1418	3002	2702	4482	3912
	Main shaft	409	292	624	379	1007	773
	Feed box	140.0		281.5		499.6	

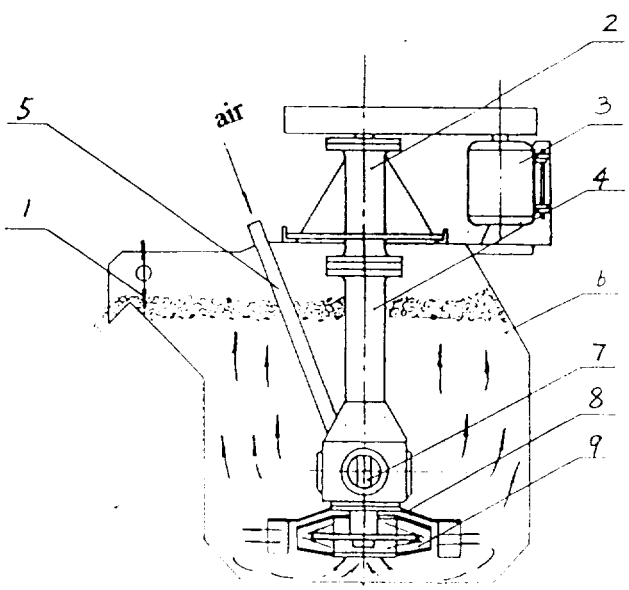
3.3.3 Applications

The commercial test of CLF coarse flotation machine at Changpo Tin Mine of Dachang Mining Bureau has shown that in the case of feed size 0.7mm, compared to 6A flotation machine, the recovery of minerals above 0.15mm is 5%~16% higher, that of minerals below 0.15mm is a little higher, and the power consumption is 12.4% lower. The service life of rotor and stator is more than tripled. The application research on increasing recovery of scheelite has shown that by changing the grinding process from coarse to fine for decreasing the over-grinding of valuable minerals, and applying CLF Flotation

Machine, in addition to increasing copper recovery by 1.67%Cu and that of sulphide by 0.571%S, the recovery of scheelite has been increased to 27.7% from 5%, the consumption of pine camphor oil and xanthate decreased by 42.11% and 7.14% respectively, and the power consumption cut down by 1 kwh/t.

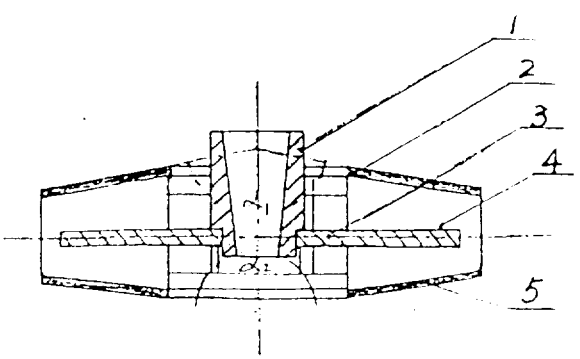
3.4 SF Flotation machine

SF mechanical agitation flotation machine developed by BGRIMM in the 80's has the features of self air and pulp suction. It is used to treat non-ferrous & ferrous metals, non-metallics, noble metals and polluted water. The SF series has 13 specifications. Until recently, more than 6000 pieces of SF flotation machine with different sizes have been adopted by more than 200 domestic and overseas mines. In 1992, it was exported to Nigeria for the first time. The commercial production has obtained significant economic benefits. The construction of SF machine is shown in Fig. 7, and that of impeller mechanism in Fig. 8.



1. Froth paddle; 2. Bearing body; 3. Motor;
4. Central cylinder; 5. Suction pipe; 6. Cell;
7. Main shaft; 8. Cover; 9. Rotor.

Fig. 7 Construction of SF Self-suction Flotation Machine



1. Wheel hub; 2. Upper cone;
3. Division disc;
4. Blade; 5. Lower cone.

Fig. 8 Construction of SF Rotor

3.4.1. Mechanical properties

The SF impeller mechanism is made of double cone with closed retroverted vanes. The stator is made of forward-inclined vanes of cone type. The two parts match each other and compose the special rotor-stator mechanism of SF flotation machine, which has more advantages to the flotation machines of similar kind. With the increasing of cell volume, a honeycomb duct and a false bottom are designed. The maximum volume of a single cell can reach 20 m^3. Main characteristic features of this machine are significant energy conservation, large air suction, high beneficiation efficiency, low peripheral speed of the rotor and long usage period of wearing parts.

3.4.2 Technical Specifications

Table 5

Type	Cell volume (m^3)	Internal dimensions (LxWxH) (m)	Impeller		Air section (m^3/m^2. min)	Installed power (kW)	Capacity (m^3/min)	Weight of a cell (kg)
			Dia. (mm)	Lin. vol. (m/s)				
SF-0.15	0.15	0.5x0.5x0.6	200	5.6	0.9-1.0	(Two shafts) 2.2	0.06-0.18	270
SF-0.25	0.25	0.6x0.6x0.7						370
SF-0.37	0.37	0.7x0.7x0.75	286	6.0 (7.2)	0.9-1.0	1.5	0.2-0.4	470
SF-0.65	0.65	0.9x0.9x0.9	300	7.35	0.9-1.0	3.0	0.3-0.7	932
SF-1.2	1.2	1.1x1.1x1.1	450	7.35	1.0-1.0	5.5	0.6-1.2	1370
SF-2.0	2.0	1.45x1.38x1.12	500					1750
SF-2.8	2.8	1.7x1.6x1.5	550	7.70	0.9-1.0	11	1.5-3.5	2130
SF-4.0	4.0	1.85x2.05x1.2	650	8.00	0.9-1.0	15	2-4	2585
SF-6.0	6.0	2.15x2.4x1.3	700	7.50	0.9-1.0	18.5	3-6	3300
SF-8.0	8.0	2.2x2.9x1.4	760	7.50	0.9-1.0	30	4-8	4130
SF-10	10	2.2x2.9x1.7	760	7.52	0.9-1.0	30	5-10	4500
SF-16	16	2.85x3.8x1.7	850	7.57	0.9-1.0	45	8-16	9400
SF-20	20	2.85x3.8x2.0	850	7.57	0.9-1.0	45	10-20	9800

3.4.3 Applications

The SF flotation machine has three functions of self air suction, self pulp suction, and flotation. The flotation cells can be horizontally arranged, without need for auxiliary equipment. The flowsheet is therefore simple and flexible, which is welcomed by operators.

The SF-4 flotation machine has been applied in Cu-Pb bulk flotation at Hengren Mine. Compared to 6A flotation machine in parallel, under the circumstance of concentrate grade being a little higher with the introduction of SF-4 machine, the recovery of copper, lead and gold increased by 1.25%, 1.38% and 22% respectively. Additional recovery of gold

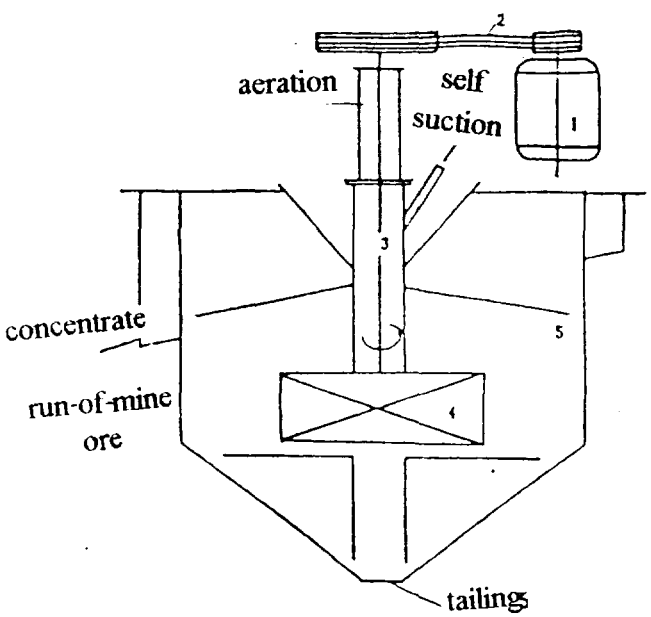
reaches 1.21kg per year. The silver recovery is increased by 9.6%, resulting in additional 1.5 ton silver per year. Moreover, the power consumption is decreased by 11.60% and the peripheral velocity of rotor decreased by 9.1%, providing significant economic benefits.

After the introduction of SF-1.2 flotation machine to copper roughing and scavenging operations at Naimiao Copper Mine, Inner Mongolia, the power consumption is decreased by 21.55%. Under the circumstance of concentrate grade being decreased by 0.44%, the recovery of copper increased by 2.50% and that of gold increased by 3.6%, showing sound technical and economical performances.

SF-20 and SF-10 flotation machines have been applied in a rare-earth concentrator of Baotou Iron & Steel Corp. The production picture shows that this model of machine has the features of reliable operation, stable pulp level and easy operation and maintainance. Compared with 7A flotation machine, the grade of iron concentrate is increased by 2.46%Fe, that of rare-earth concentrate increased by 1.0%, and the power consumption decreased by 319kw/h.

3.5 YX Skim flotation machine

YX skim flotation machine is specially designed as single flotation cell for grinding & classification to recover in advance part of free coarse valuable minerals or middlings. In this way the final concentrate or rough concentrate can be obtained directly. The construction of this machine is shown in Fig.9.



1. Motor; 2. V-belt 3. Main shaft
4. Rotor 5. Cell

Fig. 9 YX Skim Flotation Machine

3.5.1 Mechanical specifications

(a) The impeller mechanism: a pulp circulator is installed under the impeller and stator, its main function is to promote the circulation of pulp under the impeller, which is advantageous to the suspending of mineral particles and ensures the flotable minerals for entering the impeller area repeatedly, where minerals are mixed with fresh air and reagents, thus increasing the recovery possibility. There is also an upper circulating path above the impeller. The upper circulating path is firstly to increase the agitation intensity and homogeneity, and secondly to ensure the adequate contact of reagents with mineral particles during agitation.

(b) The cell: the bottom of the cell is of cone shape, which is designed to eliminate the dead spots to avoid sand settling and blockage and has the thickening function. The tailings are disposed homogeneously after thickening and accumulating in the lower part of the cone cell or return to regrinding.

3.5.2 Technical specifications:

Table 6 Basic parameters of YX skim flotation cell

Type	Volume (m^3)	Weight (t)	Installation Power (kw)	Capacity (t/h)
Laboratory Model	7.5 (L)	-	0.25	-
YX-2	2	2.4	15	40 ~ 60
YX-4	4	3.6	18.5	80 ~ 100
YX-6	6	4.8	22	120 ~ 140
YX-8	8	5.2	22	160 ~ 180

3.5.3 Applications

The application of YX-2 flotation machine in Sizhou Concentrator of Dexing Copper Mine shows that the machine can realize the flotation under high concentration and coarse particles conditions. The solid content of underflow can reach 70%-75%. The screening results show that the +74 μ m fraction in concentrate accounts for 68.89% while that for conventional flotation is 27.79%. The gold content in the flotation concentrate from YX-2 machine is 8.348g/t while that in final concentrate from previous process was only 7.0g/t. The operation recovery reaches 14.096%.

The application of YX-8 flotation machine at Shizishan Copper Mine, Anhui Province has shown that with introduction of this machine the concentrate grade of gold and silver is increased by 5.96g/t and 14.25g/t and the recovery is increased by 13.22% and 6.26% respectively. The section capacity is increased by 3.84%, and it is also advantageous to the following operations such as dewatering.

4. Conclusion

BGRIMM Flotation Machine has been developed to a complete system of flotation. It can meet all demands for flotation. Regarding the minerals treated, it can meet the needs for mines varying from non-ferrous, rare, noble, ferrous metals and non-metallics as well as for treating polluted water. Regarding the scale of concentrator, it can be used in concentrators of 10 ton~100,000 t/d ore capacity. Regarding the feed size, it can treat ores of both normal and coarse sizes. There are BGRIMM flotation machines used for roughing, scavenging, and cleaning operations, as well as for skimming in grinding & classification circle. As for the arrangement of the flotation cells, they can be either stepped or horizontally arranged. Especially, the unique conbined unit which can be horizontally installed without froth pump for middlings recirculation is most suitable to the renovation of old plants.

It has been proved by many years' commercial production practice that BGRIMM Flotation Machine has the merits of energy and reagent saving, higher metal recovery, lower management and equipment cost, etc. Applying BGRIMM Flotation Machine can enable a concentrator to obtain higher economic benefits with lower cost, making the concentrator's products more competitive in the domestic and world market.

Paper to
UNIDO & BGRIMM Co-organized
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25-29 June 1996, Beijing

ABATEMENT AND MANAGEMENT OF MINE WASTE

Dai Hongwen
Beijing General Research Institute of Mining & Metallurgy

Beijing General Research Institute of Mining & Metallurgy, BGRIMM has successfully developed proper techniques in the field of mine waste abatement and management of waste dumps, especially the rehabilitation of the dumps and the disposal of waste water, which are briefly described in this paper.

Environmental protection has become a worldwide topic of common concern.

In the long-term world industrialization process, the unreasonable exploitation and use of natural resources has caused a worldwide environmental pollution and ecological disturbance, soil erosion, deserification, decreasing of vegetation, frequent flood and drought, and even sudden secondary calamities.

It is the responsibility and mission for environment scientists to rationally exploit and use the natural resources, control and avoid pollution in the course of industrial development, striving for a cleaner environment.

1. The Impact of Mine Wastes on Environment

With the development of mining industry, huge amounts of mine wastes are accumulated which affect the environment. For example, in China, the total industrial waste water totalled 21.5 billion ton in 1994, which was treated at 75%, with 55.5% reaching the emission norm. 6.2 hundred million ton industrial solid wastes were discarded, with nearly 30 million ton harmful wastes. At present, the disposal rate is low, and the comprehensive utilization rate is only 40%.

The industrial solid wastes take up huge area, especially the arable land. According to the statistics in 1994, the waste occupied land has reached over 556,970 thousand m^2.

Dust is another severe pollution source from mine waste dumps and tailing ponds .It is more severe in dry season.

Soil erosion caused by the waste water pollution and destruction of plants and the management of mine waste are the common problems in mine areas.

In extreme environmental conditions like flood and earthquake, the stability of mine waste dumps is a very crucial environmental problem.

Since 70's, the disposal and reutilization of mine wastes, and the rehabilitation of mine waste dumps have seen improvements. Some developed countries have simultaneously carried out mining and rehabilitation work. Since the implementation of "Land Rehabilitation Rules", rapid improvements have been made in this area in China. BGRIMM has carried out a lot of research work in this area and recorded fruitful results.

2. Abatement and Management of Mine Waste

2.1 Research projects

Since 1980's, BGRIMM has completed and carried out a series of large projects regarding mine waste rehabilitation and mined-out land reutilization. The projects completed are:

- Comprehensive research on rehabilitation techniques for Mojiawa, and Hanjiagou tailings ponds of Zhongtiaoshan Non-ferrous Metals Corporation;
- Research on rehabilitation techniques for waste dump of Xiaoyi Aluminum Mine;
- Eighth Five Year Plan project: "the Environmental and Rehabilitation Investigation for China Nonferrous Metal Mines"; which is subordinate to the research project of "The Comprehensive Harnessing techniques on Ecological Environment in later stage of Mining and Advanced Research on Demonstration techniques;
- Research and formulation of Eighth Five Year Plan project "The National Land Rehabilitation technical standards";
- Eighth Five Year Plan project titled "The Evaluation Method of and Standards for Industrial Solid Waste";

The projects being carried out now are:

- Sino-Australia Mine Waste Research & Management Project;
- The Research on Exploitation and Rehabilitation techniques for Pingguo Aluminum Mine.

Some of the above mentioned projects have recorded positive outcomes, which have been applied by mines, promoting the rehabilitation work. Some have resulted in documents published nationwide, and others provide scientific basis for decision-making in this area. There are also projects on international co-operation, combining imported advanced techniques with China's experience for improving work in this field. At present, international co-operation research is still in progress. Based on such co-operation, we have set up "China-Australia Research Institute for Mine Waste Management" (CARIM). CARIM is equipped with national standard laboratories, which involves environmental chemistry, physical experiment, geotechnical engineering, sample preparation, etc. (shown in Fig. 1, China Australia Research Institute for Mine Waste Management (CARIM) and Fig. 2, Environmental science laboratory in CARIM)

2.2 Main techniques applied in the field of mine rehabilitation

The techniques applied in the field of mine rehabilitation include geotechnics, hydrotechnics, reclamation, dust control, re-planting and soil curing, as well as community development and public health. In the following we will introduce them with site examples.

1) Hydrotechnics

Following is an example of our research work done at Wugongli tailings dam:

The project is aimed at finding the environment impact of the tailings dam on the local water system and provide appropriate options to tackle this problem.

After initial investigation and test done on the site, we have identified the hydro-geological characteristics of this area; through about 3 years' trace observation of the changes in the pond water level, we have found the hydrological relations of the tailings pond with Yangtse river (shown in Figure 3, Hydraulic relations between water level of a tailings pond and Yangzi river); after long-term monitoring of the surface and underground water, we have found the existent and potential pollutants. Afterwards, by using computer models for conducting stable and instantaneous state simulation, the analysis of pollution potential is made, i.e. the prediction of potential changes of pollutants and the analysis of the impact of pollutant emission on the environment (shown in Figure 4, Potential analysis of distribution of contaimination in drainage system).

2) Geotechnics

This research mainly aims at evaluating the stability of the foundation and embankment of tailings dam, finding its possible environment impact and giving the remedial options when necessary.

Take Zhongtiaoshan tailings dam for example. According to the initial investigation on the field and borehole distribution in the tailings pond area, we have preliminarily known the geological and hydrogeological characteristics. Through over 2 years' tracing of the changes of water level in the tailings pond, and based on large amounts of observation data, laboratory test on soil mechanics and physical properties, and prediction data on current status and changes in water level from the hydrogeological work, we established computer models for simulating the embankment stability on site, and provided stability analysis of embankment wall under ordinary and extreme conditions (such as earthquake, flood, etc.), safety parameters under various conditions, and corresponding parameters of shallow and deep sliding surfaces and their equivalent figures (shown in Figure 5, Slope stability analysis for tailings dam). When there would occur instability of the embankment, we can simulate changes in the stability of embankment under various strengthening methods, and select an optimum option. The comprehensive evaluation of the stability of embankment wall can be conducted by using this method.

3) Reclamation

The following example is about reclamation research in Zhongtiaoshan Mine. Based on comprehensive investigation of the physical and chemical properties and the rehabilitation environment, planning design (include final scenery design) of the rehabilitation area for different application orientations has been done. Soil cross section structural design and selection have been made for area that would be used for agriculture or ordinary vegetation; and individual macro design completed for area that would be used for construction or waste dumping. We can also make general plan for the future. All of the above is completed by computer simulation. Site construction is carried out on the basis of this design (See Fig. 6, Rehabilitation design of abandoned tailings dam, and Fig. 7, Implementation of rehabilitation program in minesite).

4) Revegetation and soil curing

We have done research on revegetation and soil curing in Zhongtiaoshan tailings pond area. Selection test has been conducted on seven types of agricultural plants including maize, peanut, soybean, sorghum, wheat, cotton and legumes, and higher output per unit area of peanut and sorghum than the local level has been recorded. In the rehabilitated tailings pond area, comparison tests on soil curing by many green fertilizers such as Sudan grass and manual fertilize have been conducted, after 5 planting seasons' tests we have established the best planting and soil curing conditions. Now over 30,000 m^2 test area is totally greened by plants, bringing livelihood to the dry waste tailings pond (shown in Fig 8, Established system of revegetation on abandoned tailings dam).

This research also includes trace monitoring of food chains to avoid pollution of the replanting system by mine waste.

In order to select suitable plants, we have done over 3 years' observation on such factors as climate, soil humidity and water content in plant leaves, and provided scientific criteria for selecting growable plants.

5) Research on dust control

In dry winter time, dust pollution is very serious around the tailings pond area, especially for fine tailings which sometimes can move with wind several kilometers away. In order to identify the dust impact around Zhongtiaoshan tailings pond area, after investigating flowing patterns of tailings sand in different seasons and climate factors, we designed monitoring spots, types and plan, and conducted over 2 years' monitoring. Results from different monitoring projects are used for computer simulation to do analysis of dust distribution and its impact. According to these results, we designed a dust control test, including selection of 6 different types of control equipment and control effect observation. The total area is 20,000 m^2. This project is still underway (see Fig. 9 Necessity of dust pollution control in tailings damp dry beach).

6) Research on community development and public health

During the research on mine waste management, in order to improve the environment effect caused by mine wastes dumpimg upon the surrounding community and public health,

we have conducted researches on these items, which are important to the environment work. We have yielded obvious progress in these areas by introducing the purpose of our project to the relevant community, and improving and strengthening our relationship with the local people (Shown in Fig 10, Community development in the rehabilitation program).

2.3 Research on water treatment and purification equipment

To solve the problems like water purification, waste water treatment, fine particle filtration and comprehensive utilization of water for household, food & drinking, medicine, textile, printing and dyeing, chemistry, machine building, mining, metallurgy, thermal power generation and other industries, BGRIMM has set a team to do R&D work on water treatment, its materials & equipment, and gained results. A series of new space spheroidal structure polymer materials and complete sets of equipment for water purification have been developed. This technique has been patented overseas, and widely applied in many areas as mentioned above. In this area, BGRIMM and Kazakhstan National Industry Ecology Science and Production Corporation have jointly set up high-tech enterprise - Meisheng Industrial Ecology Engineering Corporation Ltd., which has been operating formally in China. At present, this corporation has developed series of water purification parts, multifuntional water purifiers and a series of filtering equipment, which have received favorable response from customers.

3. Working Areas and Advantages

3.1 Working areas

The following covers our working areas of R&D, design and technical service.

1) Investigation, research and evaluation of mine waste properties

This includes the investigation, research and evaluation of the physical, chemical, geotechnical, engineering and leaching properties of tailings, waste slag, mud, rock, waste water and gas, etc.

2) Investigation, restoration and rehabilitation of mine waste areas

- Investigation and evaluation of mine waste areas;
- Selection and design of rehabilitation program;
- Design of rehabilitation area (including the selection and design of the optimum constitution of topsoil for agriculture and forestry);
- Revegetation, selection of varieties, and research and design of soil curing;
- Development and application of mycorhiza techniques;
- Investigation, research, and evaluation of the stability of infrastructure (dam) and the improvement strategy;
- Investigation, impact evaluation, forecast of trend of surface and underground water pollution and the abatement strategy;

- Establishment of monitoring system for dust control in mine areas, and design of the control system with the technical service ;
- Regional planning and design of mine area and its nearby territory;
- Engineering measurement of the area and geotechnical test.

Besides, we can provide services in environment related chemical, geotechnical and other experiments and the design and construction of the laboratories.

3) Water treatment and purification:

We can develop the water treatment and purification equipment according to the requirements.

3.2 Advantages

BGRIMM's advantages and strong points for mine waste management and rehabilitation can be summarized as follows:

- Comprehensive spectrum of specialties and professions, including hydrotechnics, geotechnics, agriculture, forestry, rehabilitation, dust control, environmental engineering, community development, public health and etc., which is proved as the basis for sustainable development.
- Rich in experience in research, test, evaluation and disposal of iron, copper, zinc, lead, cobalt, nickel, chromium and cadmium slags, red, dust , electro-plating, and mercury muds, pulverized coal dust, acidic mud, various kinds of tailings, waste rock, etc.
- Experience in research on solid waste management and rehabilitation at various mines.
- Good technical skills and qualification of the staff with communication ability in foreign language and experience in co-operation with foreign partners, all advantageous to internatiol co-operation projects.
- BGRIMM is equipped with advanced test equipment, facilities and site devices to meet the needs for research and site investigation. It is also equipped with advanced multi-scientific computer software .
- BGRIMM is equipped with efficient communication facilities, such as Internet, Fax, IDD, etc.

4. Conclusion:

Environmental protection is the common problem for mankind, which needs the co-operation at the world level. We are willing to co-operate and communicate with environmental industries all over the world to solve the environmental problems, improve the living environment for mankind, and strive for sustainable development.

FIGURE 1 China Australia Research Institute For Mine Waste Management (CARIM)

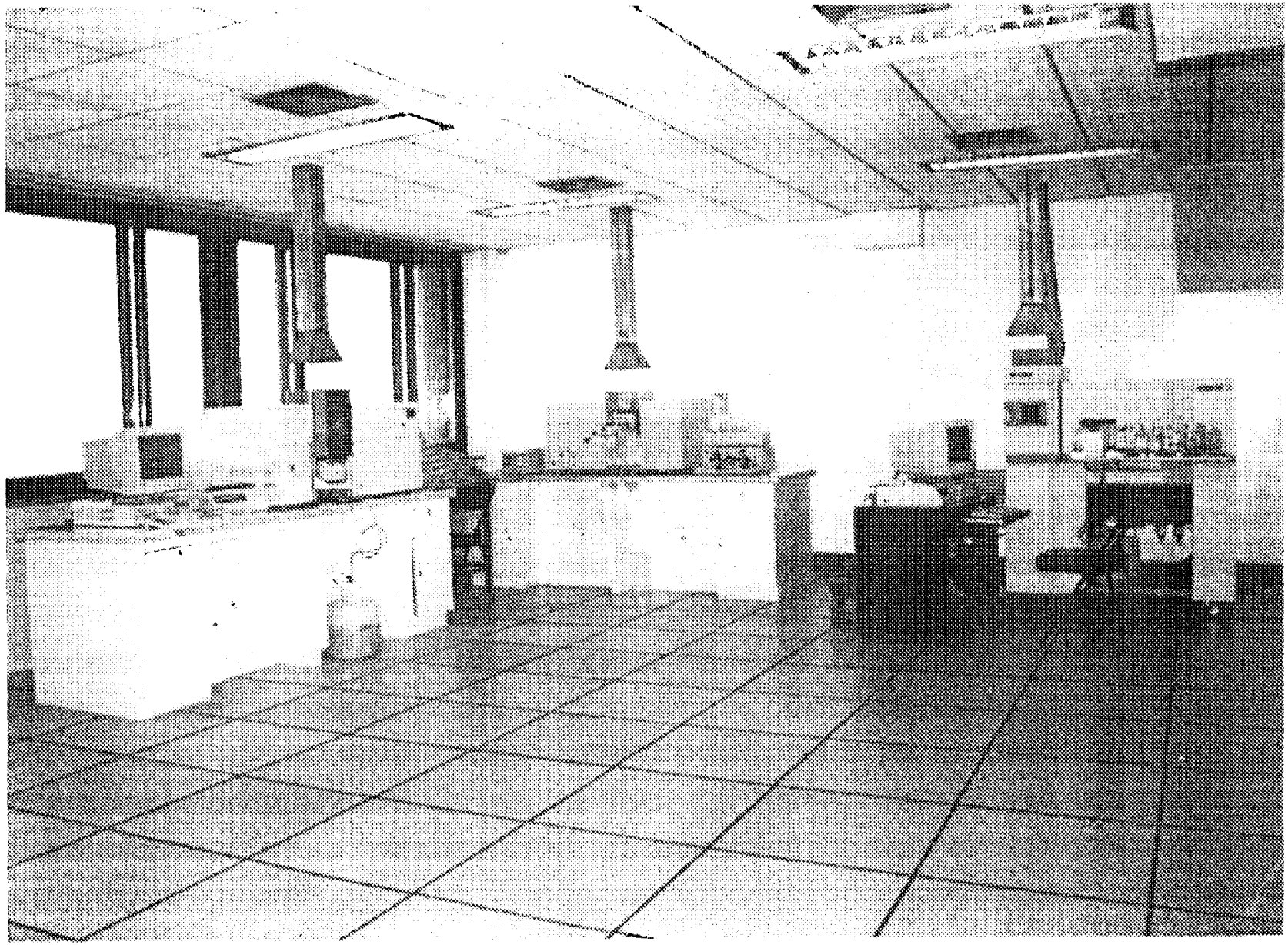

FIGURE 2 Environmental science laboratory in CARIM

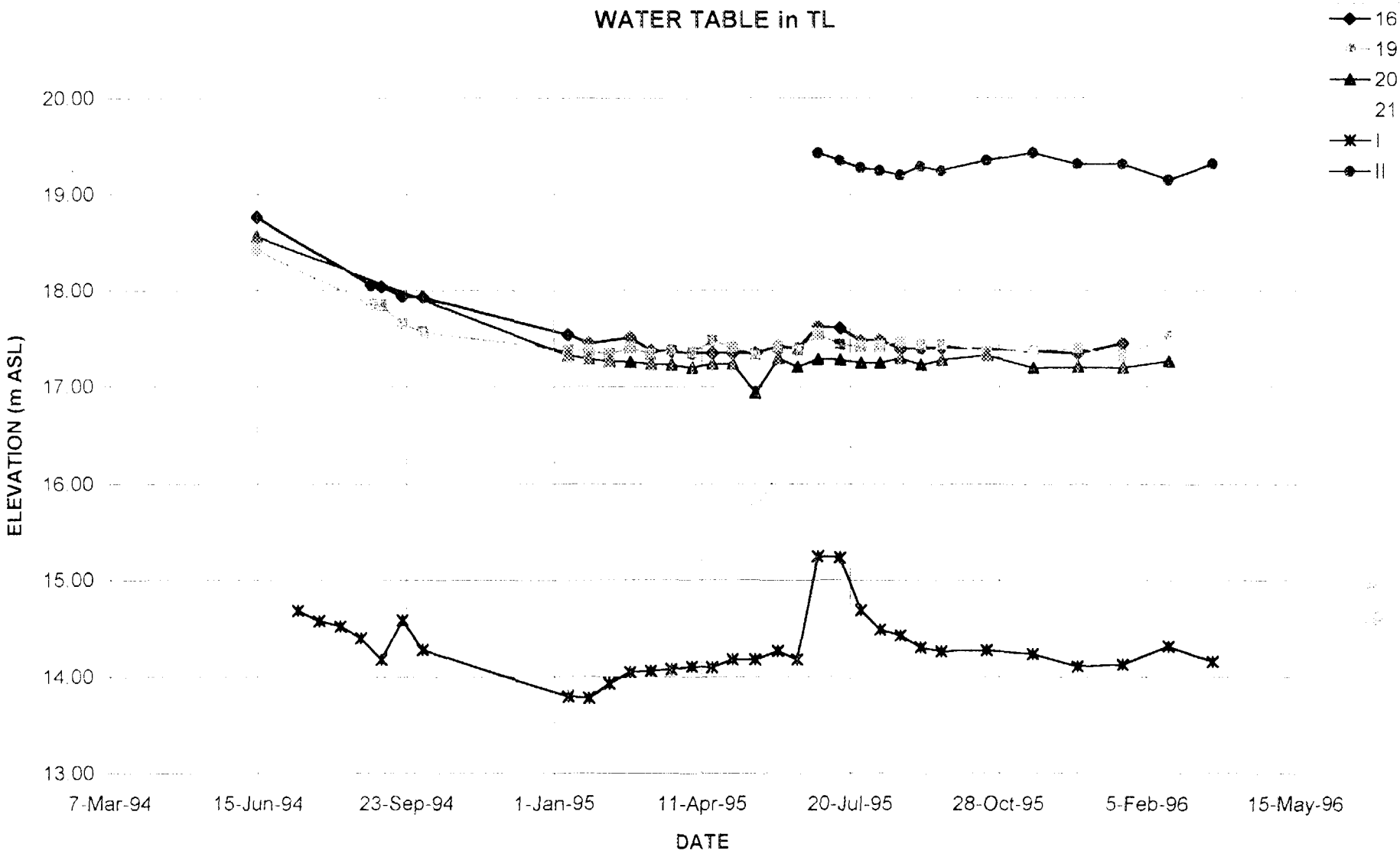

FIGURE 3 Hydraulic relations between water level of a tailings pond and Yangzi river

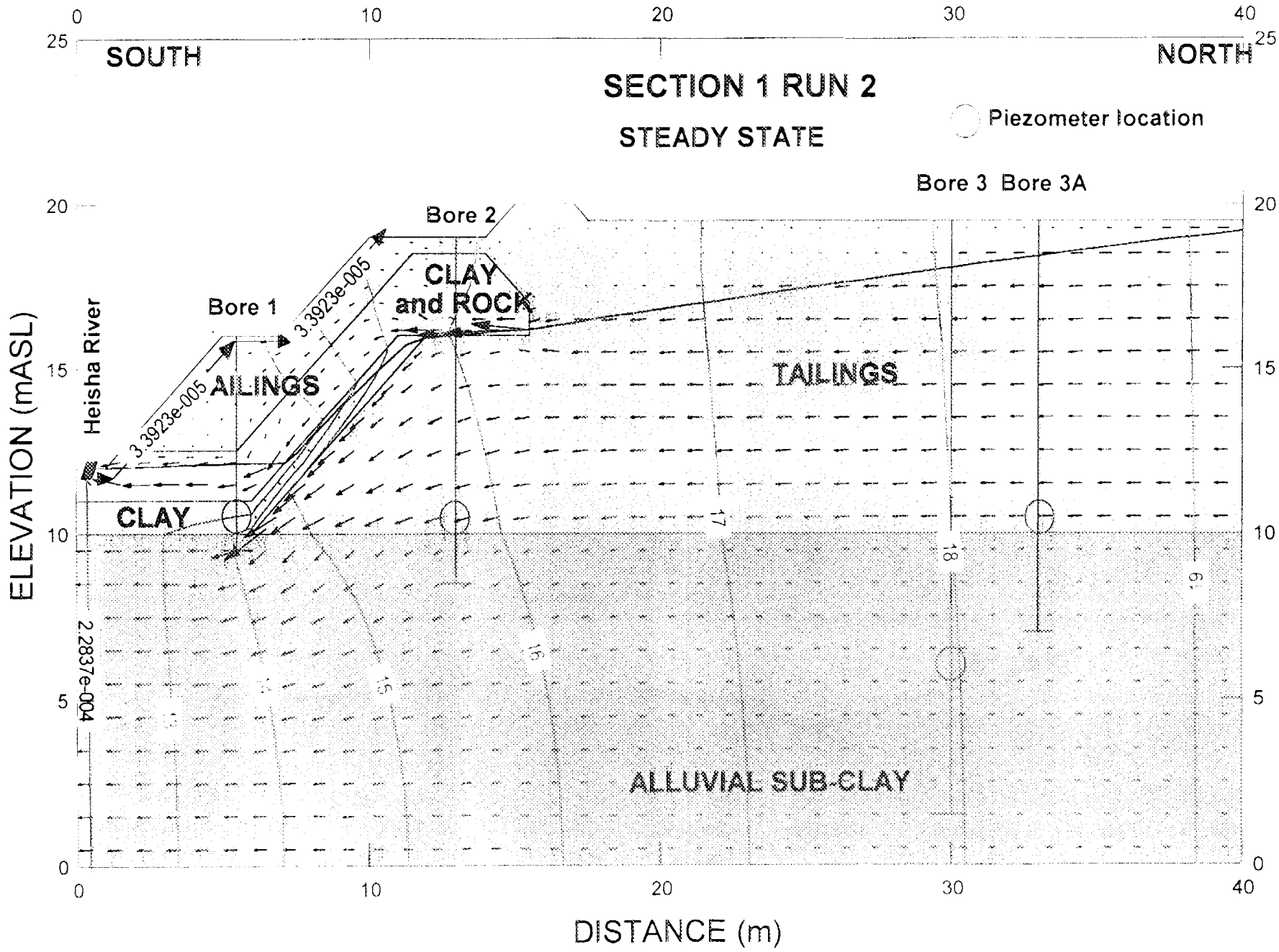

FIGURE 4 Potential analysis of distribution of contamination in drainage system

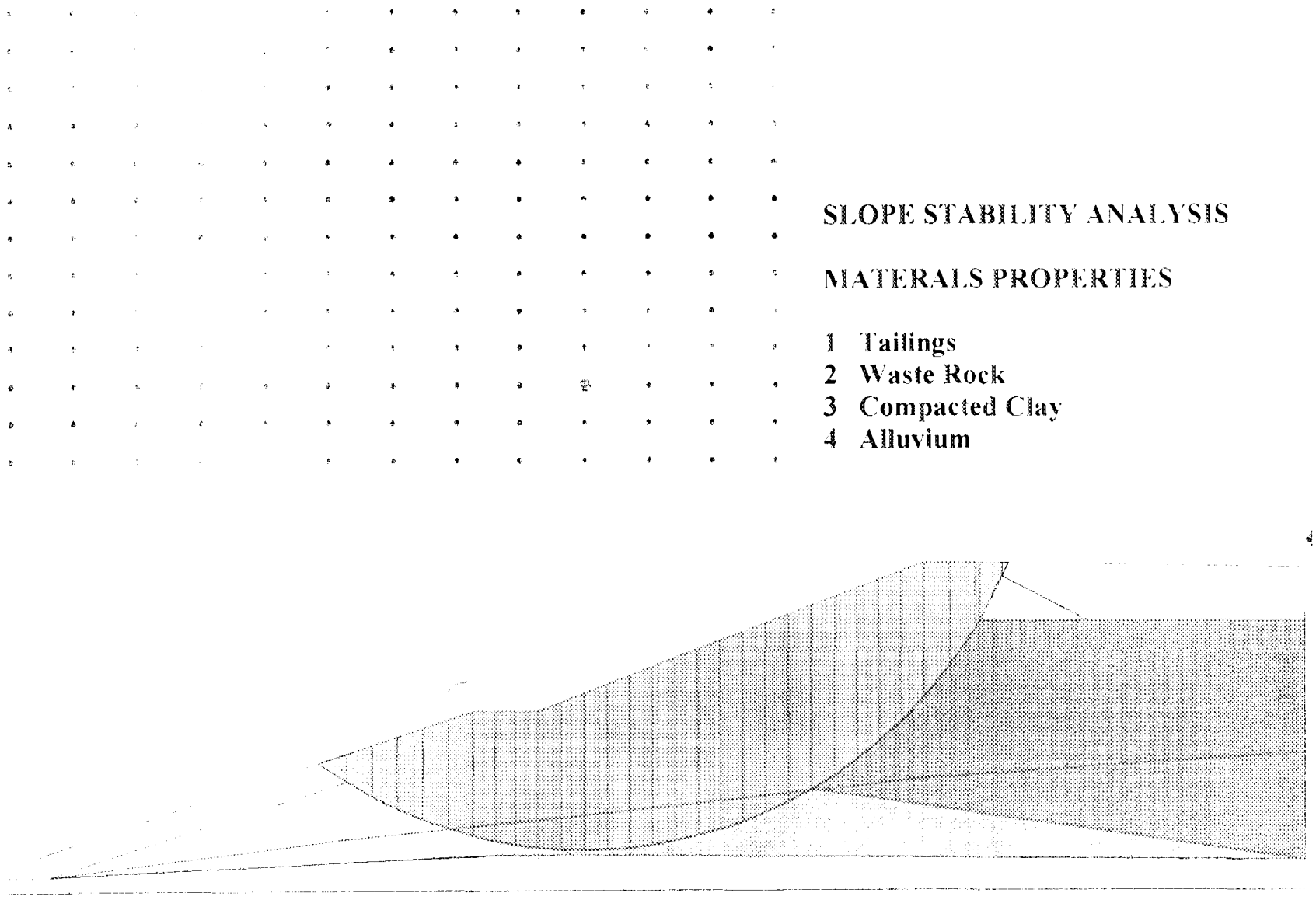

FIGURE 5 Slope stability analysis for tailings dam

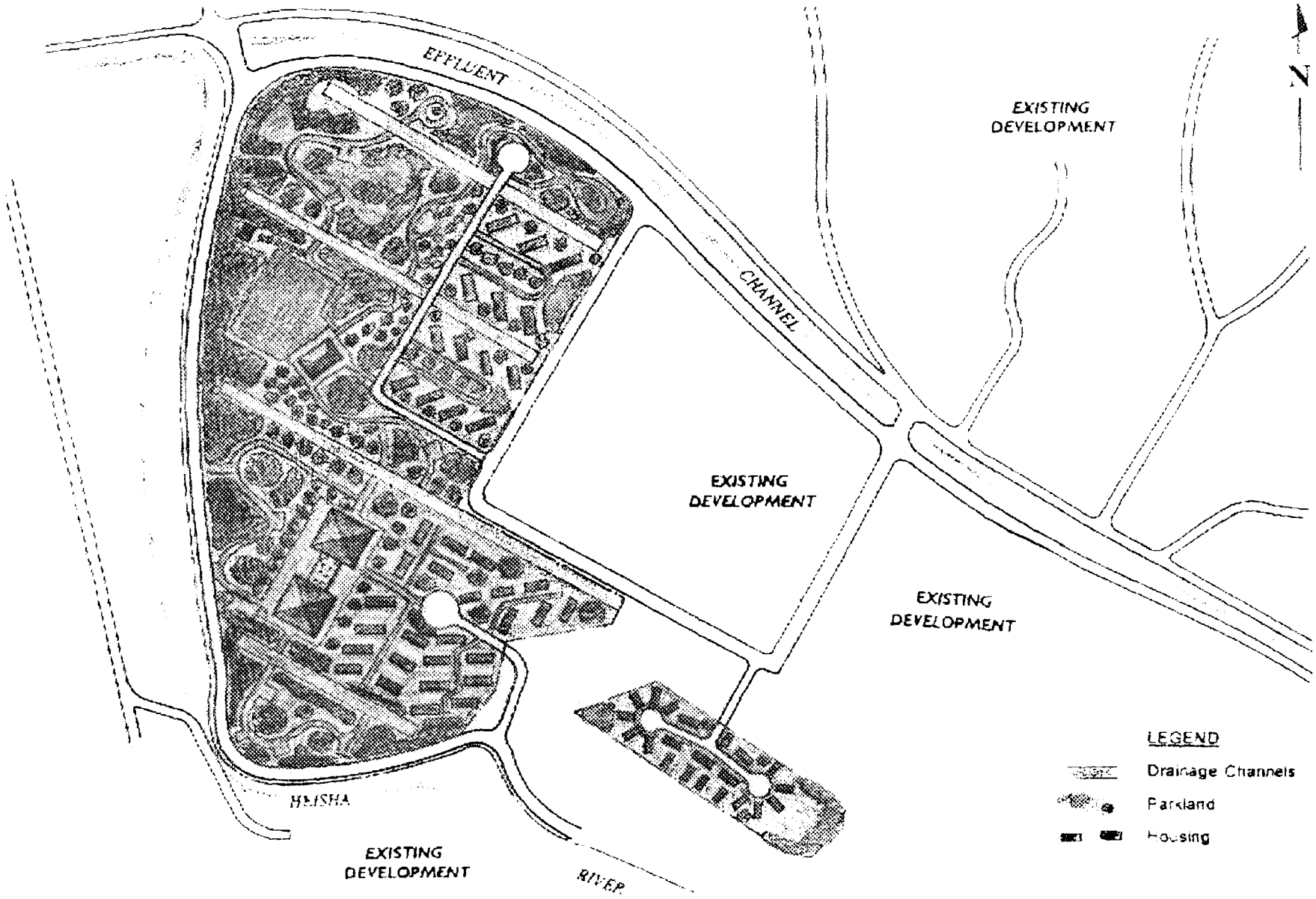

FIGURE 6 Rehabilitation design of abandoned tailings dam

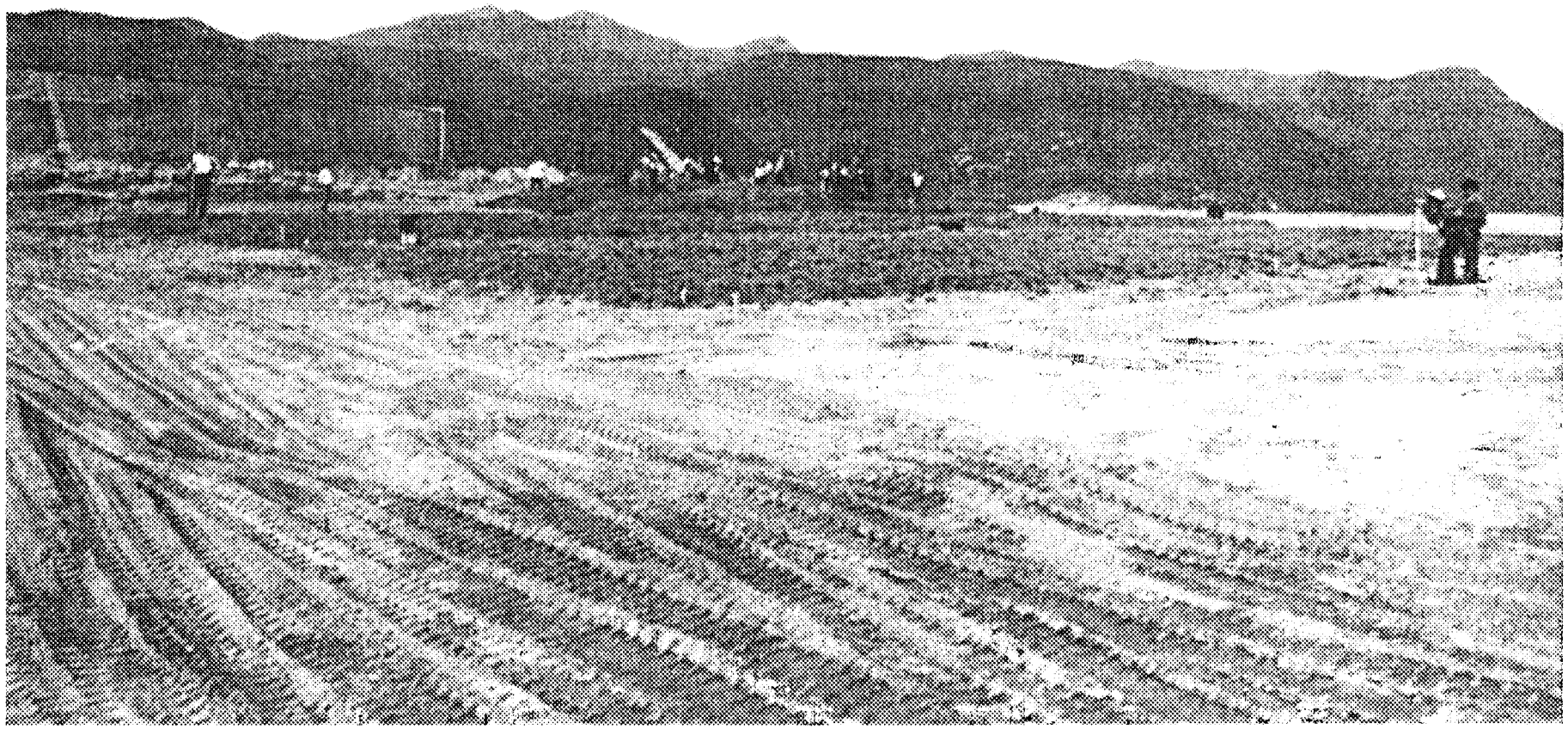

FIGURE 7 Implementation of rehabilitation program in minesite

FIGURE 8 Established system of revegetation on abandoned tailings dam

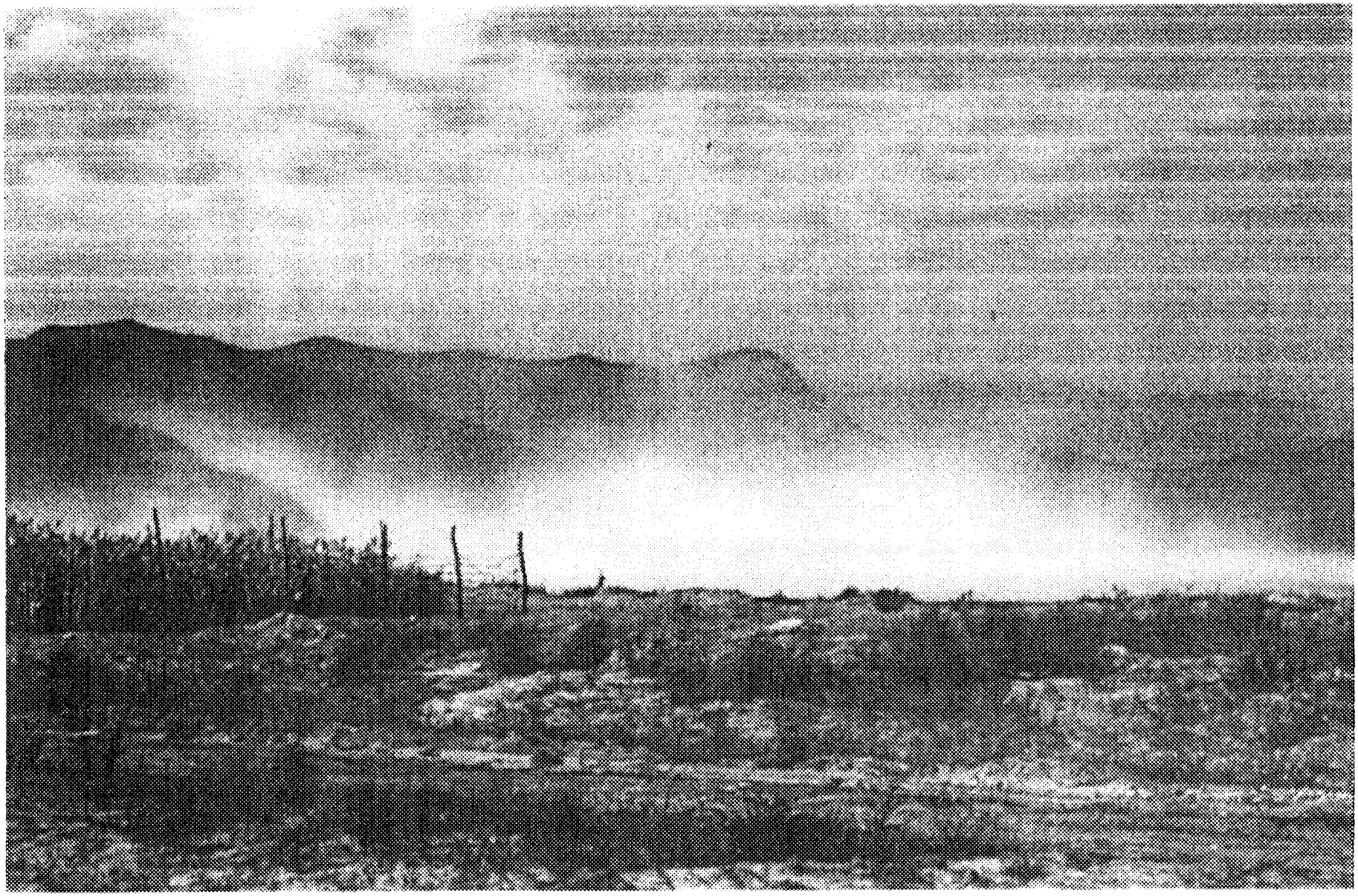

FIGURE 9 Necessity of dust pollution control in tainings dam dry beach

FIGUTE 10　Community deveopment in the rehabilitation program

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BGRIMM MOBILE CONCENTRATOR AND ITS PRODUCTION PRACTICE

Qu Li
Beijing General Research Institute of Mining and Metallurgy

Abstract:

The design principle, assembly mode, equipment arrangement and production practice of a mobile concentrator are briefed in this paper. It is proved by production practice that both trailer and frame type mills are fully equipped with good movability, short construction period, normal operation and smooth process. All the technological performances meet the production requirement. In general, it can be constructed, put to production and made profitable within one year.

Key Words: Mobile concentrator, Trailer-type, Frame-type

Mobile concentrators were developed in early 1960's, mainly due to human's increasing demand for raw materials, decreasing rich and big mineral resources and the acute competition in mineral market. Therefore, the development and utilization of those small but rich ore deposits ignored in the past are attracting significant attention. As a result, mobile concentrators used for this purpose came into being. The mobile concentrator is suited to exploit small but rich ore deposits, and treat by product ores left by exploratory and preparatory work and old tailings. It can also be used as a pilot plant to provide design criteria for the construction of large mines. A mobile concentrator can be installed on frame or trailer, including such units as crushing, screening, grinding, classification and beneficiation (flotation, gravity concentration, magnetic separation, cyanidation and dewatering). And it is also equipped with power&water supply systems, laboratory instruments, lifting facility and so on, all this forms a complete mineral processing plant.

Compared with a stationary ore concentrator, the mobile one has the advantages of less investment, shorter erection period, higher adaptability and the ability to reset the equipment or fast move the whole installation when and where necessary in accordance with the changing situation of mineral resources. Since the mineral processing equipment is assembled in advance, it is especially suited for severe climate or remote areas.

The mobile concentrator is capable of treating precious metals, non-ferrous and ferrous metals, non metallics, coal and other minerals. So far, it is extensively and satisfactorily

applied in China with the throughput ranging from 15 to 100t/d. The payback period of its investment is averaged 1-2.5 years.

1. Design Principles of Mobile Concentrators

The basic design principle of the plant lies in good movability, convenient transportation, reasonable construction, compact installation and readiness for operation and maintenance. In addition, it should be able to rearrange equipment for various operations in accordance with flowsheet changes.

According to the equipment characteristics, working conditions and driving requirement, the plant is designed as trailer or frame type. In the case of trailer type concentrator, all processing units are installed on a wheel trailer, which can meet both the requirement for operation and transportation. It can be driven by powerful truck or tractor. For frame type concentrator, major units are installed on specially designed steel platforms respectively. Each platform is of smaller volume and less weight. All platforms can be individually put on and transported by a truck. All processing units are connected by belt conveyor, pump and pipeline in line with the technological process.

The trailer and frame of a concentrator should have both movability and stability. Especially for crushing, screening, grinding, and tri-deck shaking tables which give strong impact, the stability becomes more important. For this purpose, measures such as combination of adjustable legs with detachable fixed supporters, and installation of anti-vibration pads are adopted, assuring the stability in operation.

Trailers are driven at speed 3 km/h with maximum climbing grade 15% and minimum turning radius 10 m. Trailers with reliable and sensitive brake system are able to be driven on roads in mountainous areas.

2. Equipment Arrangement

The complete equipment set of a mobile concentrator is made up of 5 major parts: crushing & screening, grinding & classification, beneficiation, dewatering, and auxiliary facilities. Each part consists of several individual machines to form a unit. All units are installed on trailer or frame of steel construction, forming a complete mineral processing plant of a few modules.

Crushing operation generally consists of newly designed cavity jaw crushers in two-stage open-circuit or in closed-circuit with screens. Because the grooved plate shape of the crusher cavity has been improved with smaller dynamic nip angle, and shortened longtitudinal zone, the particle size of product discharged is cut down and crushing efficiency is promoted, thus realizing the principle of more crushing and less grinding. (The two-stage open-circuit crushing unit is shown in Fig. 1)

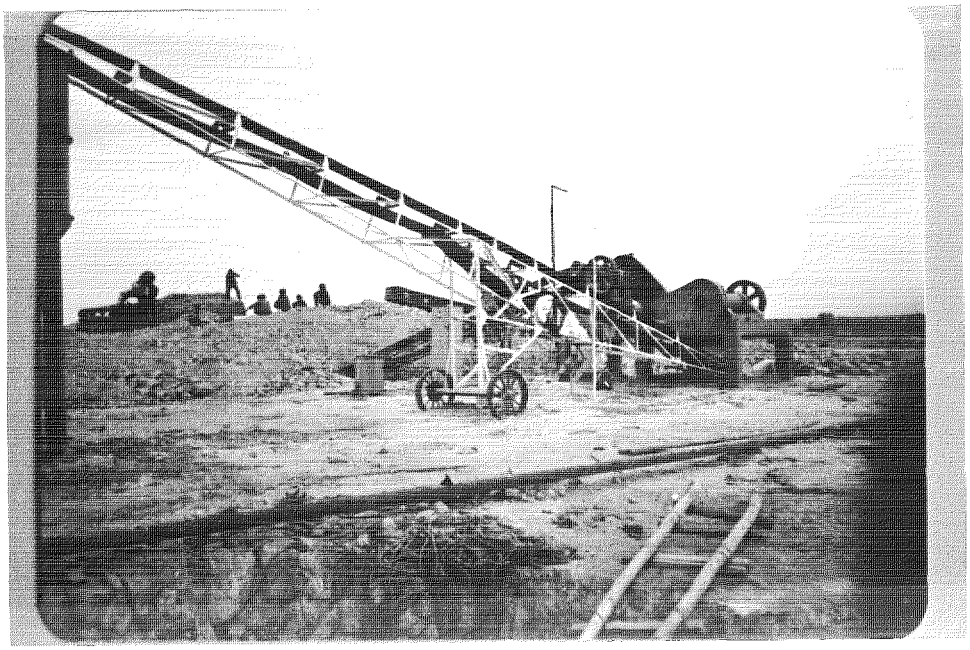


Fig. 1 Two-stage open-circuit crushing unit

Grinding operation generally applies ball mills in closed circuit with spiral classifiers or hydrocyclones. Improved ball mills can be installed in closed circuit with spiral classifiers and hydrocyclones to create one-stage grinding followed by two stage classification process when finer grinding is necessary for gold cyanide leaching. The improved ball mills adopt longer drum with angular spiral liner for classification, which enables the balls to be arranged according to size, thus promoting grinding efficiency. Spiral classifiers are used for first-stage classification and hydrocyclones for second one as control classification. Such an arrangement can reach the grinding fineness which can only be obtained by two-stage ball grinding. The close-stage grinding set composed by ball mills and spiral classifiers is shown in Fig. 2.

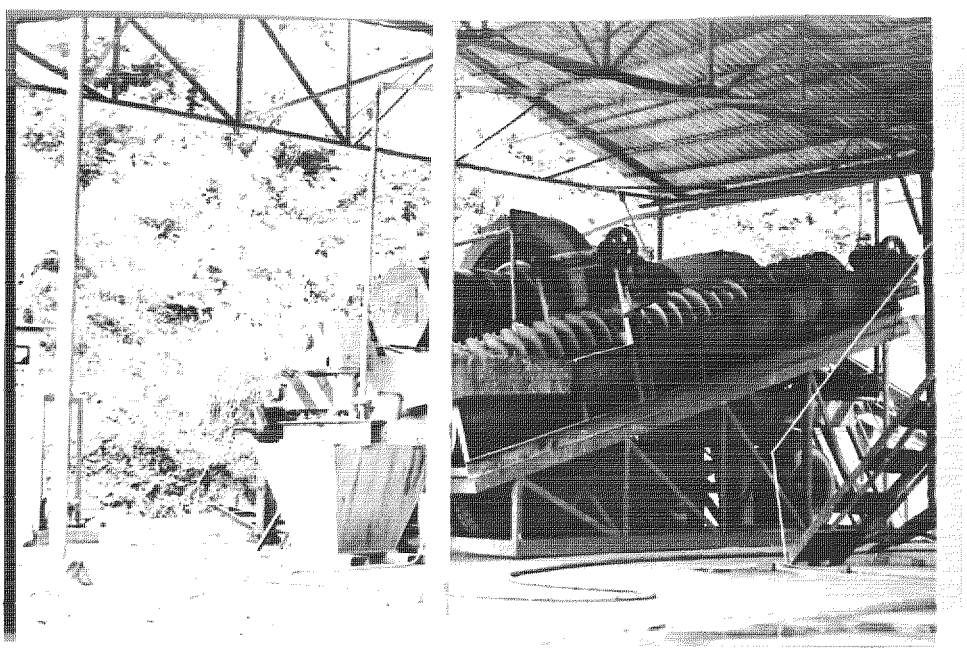


Fig. 2 Grinding & classification unit

Beneficiation process employs highly efficient flotation machines, magnetic separators and gravity concentration equipment to form the required process. Gold cyanide leaching operation consists of highly efficient thickener, two impeller aerated high efficiency and energy saving agitator, light and movable carbon drum screening, carbon air lift, leaching and absorption tank, etc. The flotation bank, tri-decked shaking table unit and cyanide leaching unit are shown in Fig. 3, Fig. 4 and Fig. 5 respectively.

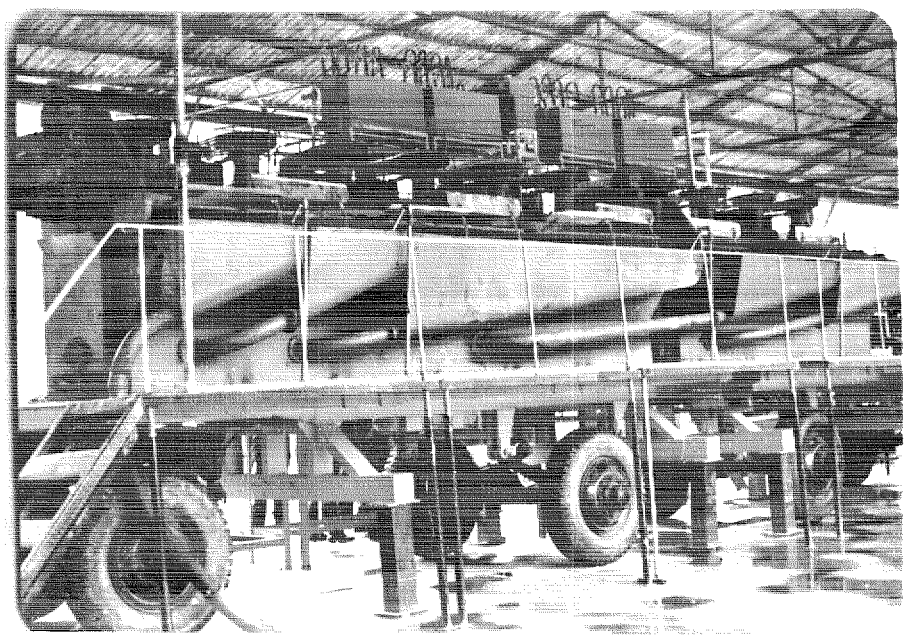


Fig. 3 **Bank of flotation cells**

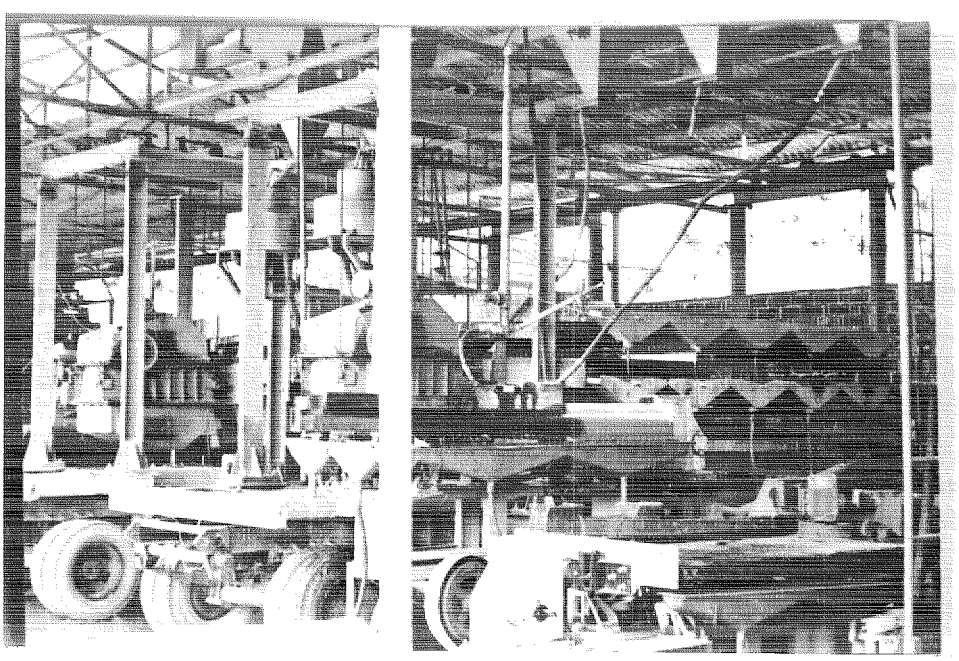


Fig. 4 **Tri-decked shaking table unit**

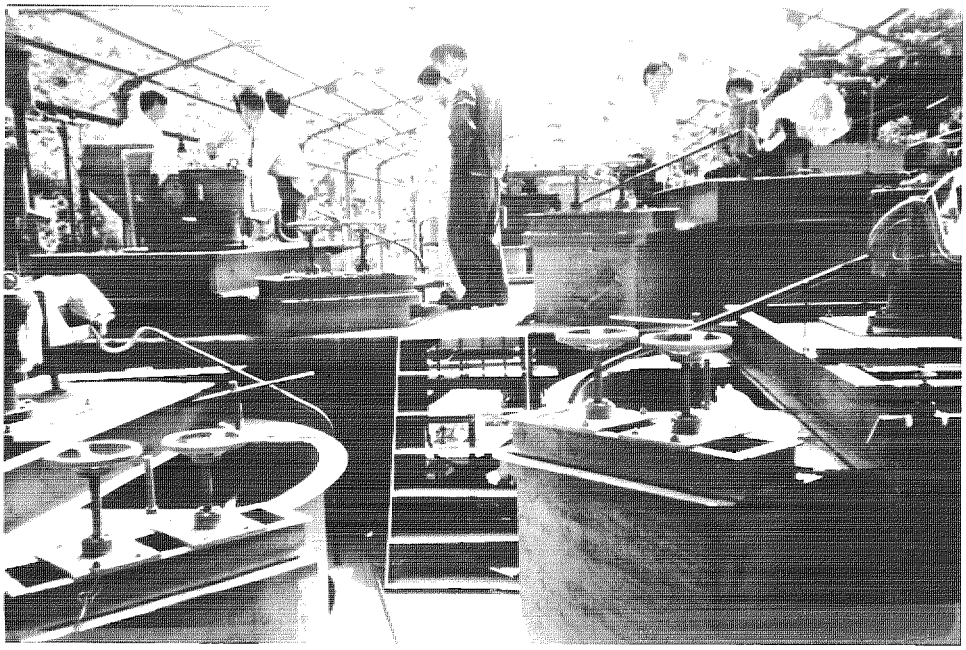


Fig. 5 Cyanide leaching unit

For dewatering purpose, highly efficient thickeners are used in combination with drum or disc filters. The dewatering unit composed of thickeners and disc filters is shown in Fig. 6.

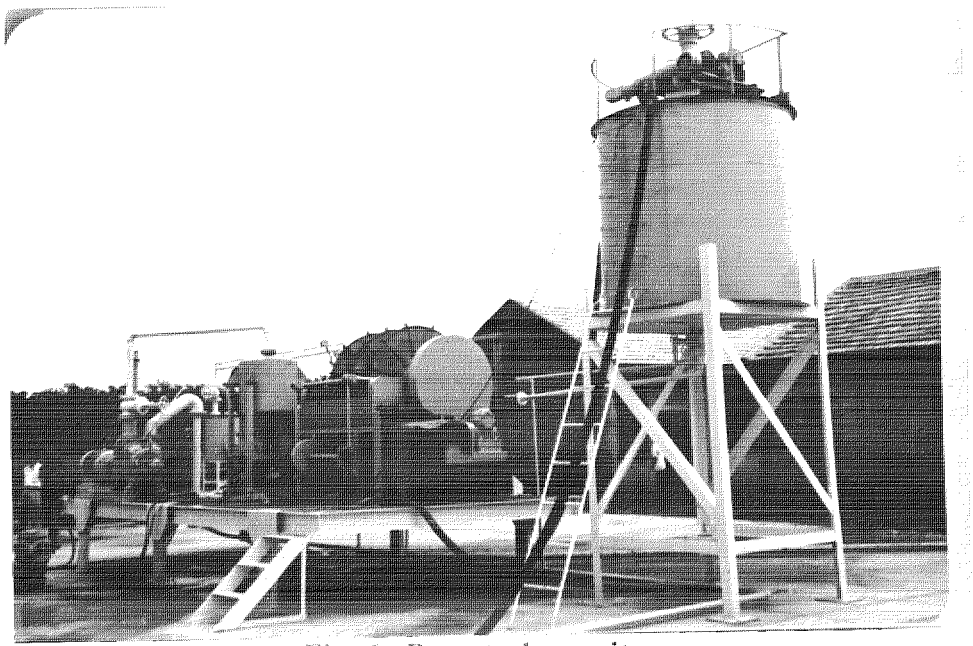


Fig. 6 Dewatering unit

Auxiliary facilities mainly are ore bin, ore feeder, agitator, reagent feeder, pump, laboratory instrumentation, belt conveyor, lifting facility, gold loaded carbon desorption column, electrowinning cell, gold smelter, power and water supply installations.

Generally the crude ore bin is not envisaged, but instead a leveled ore yard is designed with corresponding area. A fine ore bin made of steel plates can be detached and assembled when necessary.

Lifting facilities are employed to maintain equipment and handle heavy objects. Besides a hoisting jack and a manual hoist, there is 5 ton electric bridge crane with 5m lifting height and 7m span. (See Fig. 7.)

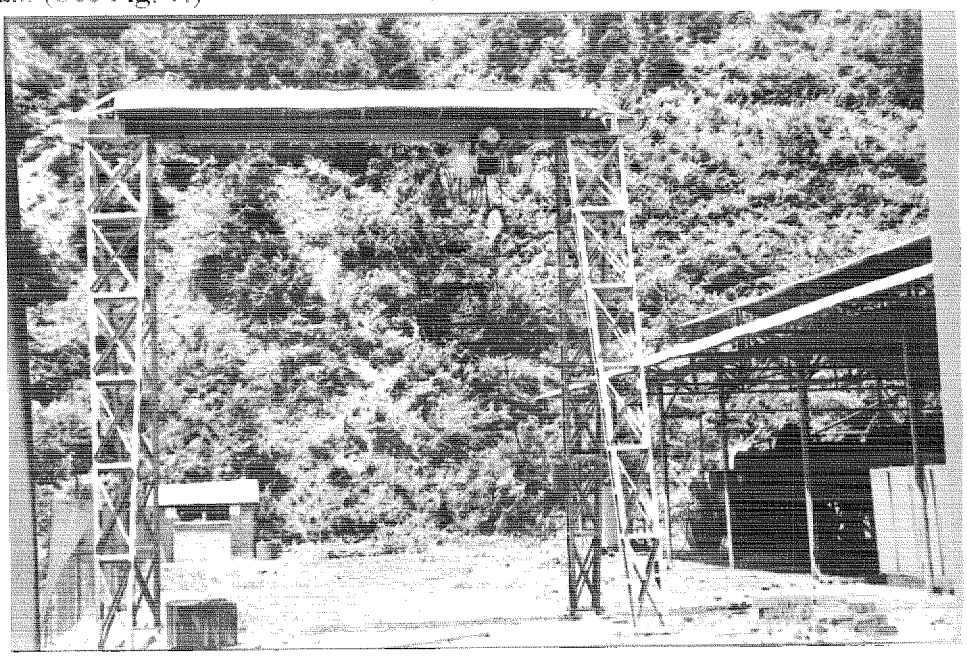


Fig. 7 Electric bridge crane

Power supply system: Each trailer or frame is equipped with electric control panel, and the concentrator has a central electric control panel. Diesel generators are installed where power supply is not available.

Water supply system: All operations inside the concentrators are equipped with pipelines. When a plant is built on a plain ground or there is no appropriate relief to set up high head reservoir, pressure water tanks are installed for water supply. (See Fig. 8)

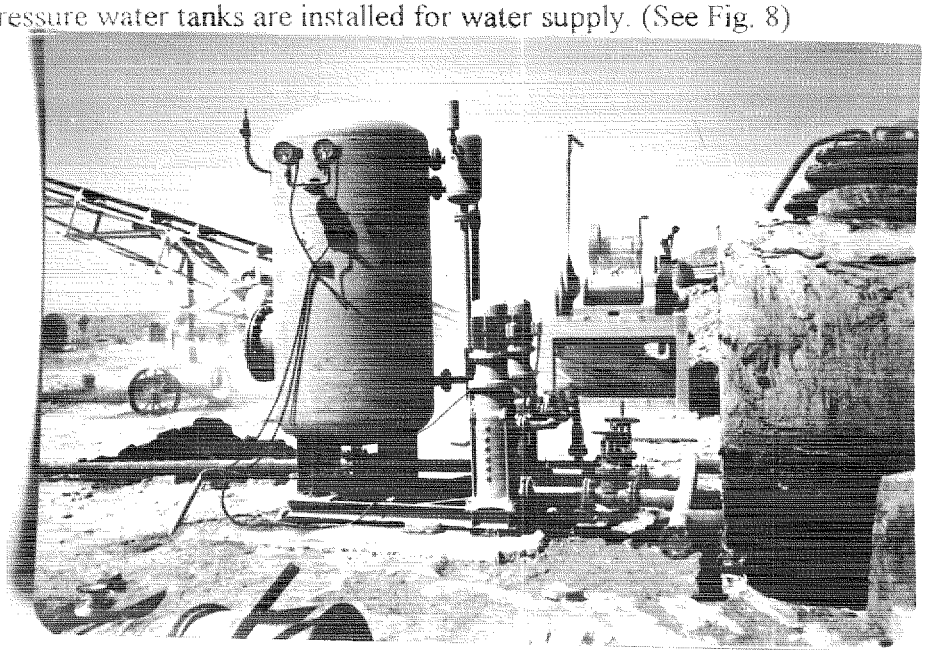


Fig. 8 Pressure water tank

The equipment layout of trailer and frame mobile concentrator is shown in Fig. 9 and Fig. 10 respectively.

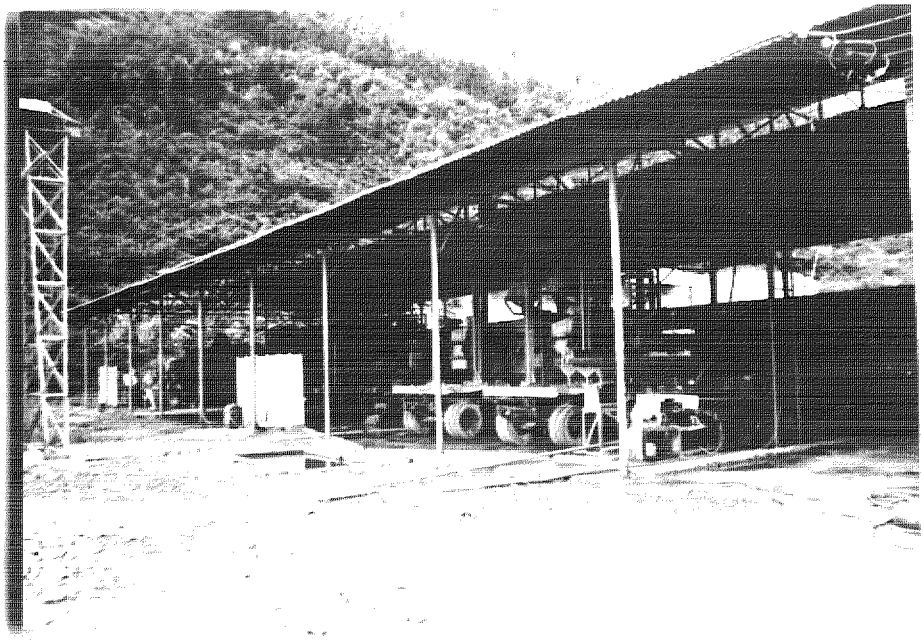


Fig. 9 Trailer mobile concentrator

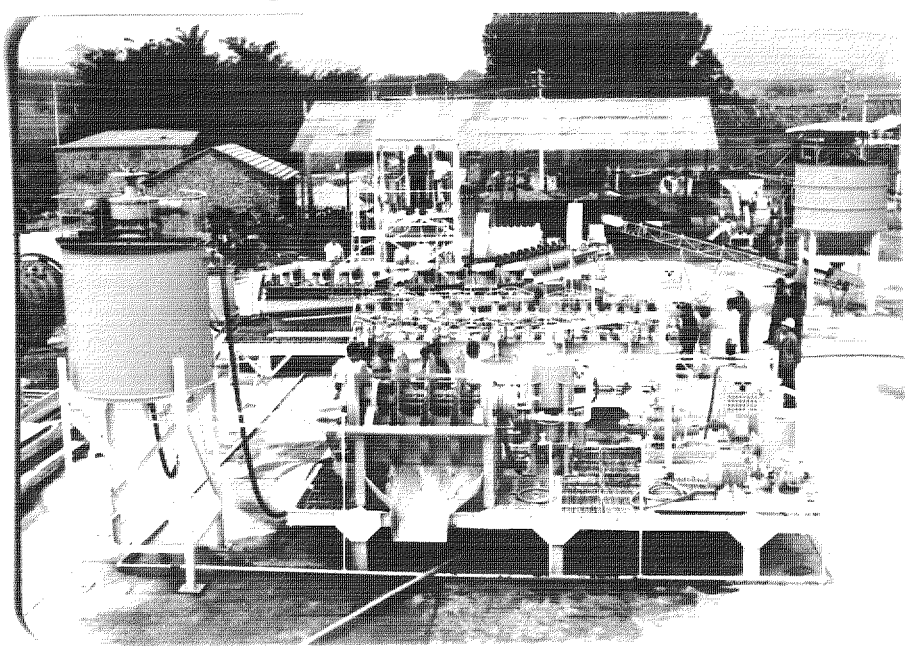


Fig. 10 Frame mobile concentrator

3. Production Practice

So far mobile concentrators of this kind have extensively been applied in China and exported to foreign countries. In this paper is briefed only their application in China. The technological process involves flotation, magnetic separation, gravity concentration and cyanide leaching.

Main technological and economic performances:

- All technological performances meet the design requirement
- Equipment availability factor >90%
- Construction period is 50% as long as for stationary mills
- Capital construction expense can be cut down by 20%
- Payback period of equipment investment is within 1-3 years.

3.1 Trailer-type mobile tin concentrator

The concentrator is located in a remote mountainous area of Hunan Province. Among various kinds of minerals cassiterite and sulphides are dominant. Major metallic minerals are cassiterite, pyrrhotite, pyrite, magnetite . Key gangue minerals include dolomite, calcite, quartz. Run of mine ore multi-element analysis is shown in Table.1.

Table 1 Multi-element analysis (%)

Element	Sn	Zn	Pb	As	S	Fe	Cu	Sb
Content	1.45	0.25	0.32	3.28	16.22	22.14	0.074	0.11
Element	WO_3	Bi	CaO	MgO	SiO_2	Al_2O_3	Au	Ag
Content	0.0188	0.055	13.49	8.78	11.96	3.95	21.00	37.80

* Gold and Silver grade -- g/t,the same in the following tables.

Cassiterite is the major target mineral for recovery. Csssiterite disseminates unevenly in the ore as medium and fine size particles and in a close intergrowth with gangue minerals. Meanwhile, part of cassiterite is closely associated with pyrrhotite. The ore belongs to the category of refractory cassiterie sulfides.

Small scale tests have demonstrated that due to cassiterite being closely connected with gangue minerals, preliminary discarding of gangue is difficult but owing to simpler relation between cassiterite and sulphides, and coarser particle size of sulfides, the latter can be removed by flotation after coarser grinding. Subsequently, the desulphurized tailing is subjected to magnetic separation to further remove sulfides and iron. Tailings from magnetic separation reports to shaking tables to recover cassiterite. Thus, the ore dressing flowsheet is made up of flotation, magnetic separation and gravity concentration. (Fig.11)

The flowsheet of this kind features multiple operations and equipment with complex arrangement. Its design throughput is 50 t/d. The concentrator consists of 6 carriages-platforms including one for crushing, one for grinding & classification, two for flotation and two for gravity separation. And it is also equipped with one 5-ton bridge crane, Model DS-electronic digital reagent feeder and a set of laboratory instruments to analyze tin, iron, sulfur, arsenic, antimony and other elements. Its principle equipment flowsheet is shown in Fig. 12.

Owing to the measures described above, the concentrator has been in satisfactory operation, although the ore grade is below design figure. Performance comparison

between the mobile concentrator and a nearby stationary plant which treats similar ore is shown in Table 2. Payback period of its equipment investment is 2.5 years.

Table 2 Comparison between mobile -type and stationary concentrator techological performances (%)

Item	Run-of-mine tin grade	Tin concentrate		Tin middling		Tin overall recovery
		grade	recovery	grade	recovery	
Designed performance	1.45	45	55			55
Trial production performance	0.705	61.34	57.02	29.29	5.58	62.60
Production performance of nearby concentrator	0.6-0.62	50-52	48-50	10-15	5-6	53-56

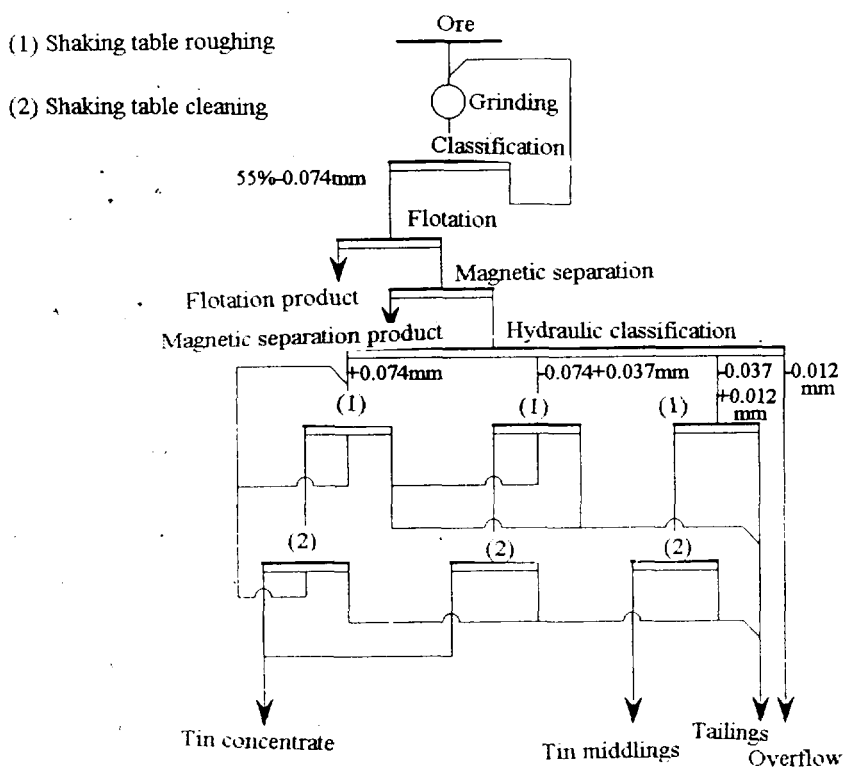
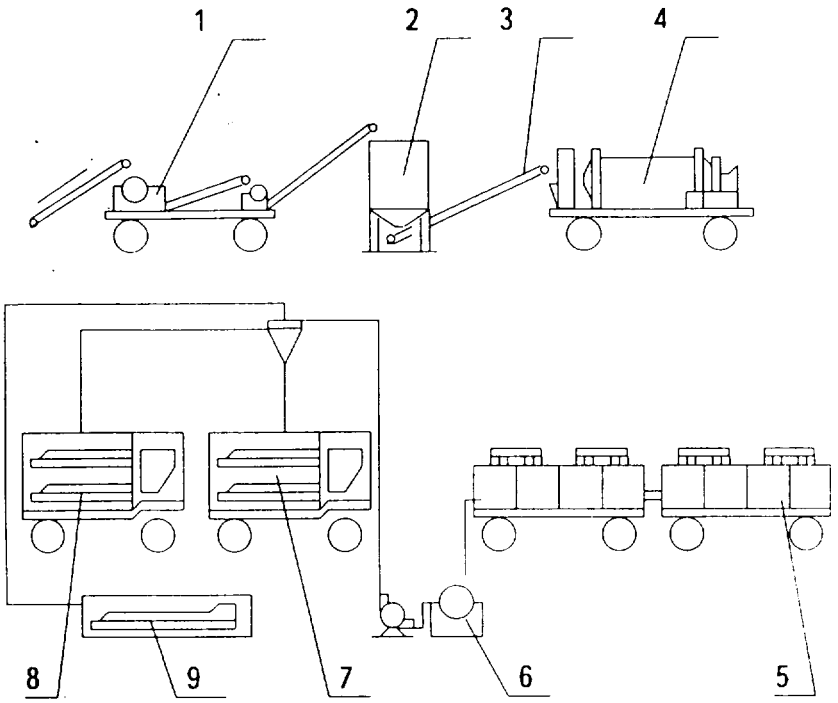


Fig. 11 The flowsheet of mobile concentrator for tin processing



1. Crushing unit (PE Jaw Crusher 250×400, PE Jaw Crusher 1250×750)
2. Fine-ore bin (capacity: 30t)
3. Belt conveyor
4. Ball mill unit (MQG 1200×1600 wet-grate ball mill, High Weir 750 Single-spiral Classifier)
5. Flotation unit (SF-0.32 flotation machine)
6. Magnetic separator (Φ600×600 permanent magnetic separator)
7. Coarse tri-decked suspended shaking table
8. Fine tri-decked suspended shaking table
9. Slime shaking table (XZ YN -100 ×1050 slime shaking table)

Fig. 12 Principle equipment flowsheet of tin mobile concentrator

3.2 Frame -type mobile copper flotation mill

The mill is located in Ganzi area, Sichuan Province. Because it is situated in a deep mountainous area with inconvenient transportation, large quantities of low grade copper ore are put away as waste,while rich ore was mined out. In order to promote its economic profits, a frame-type mobile copper mill has been established.

Major metallic minerals in the ore include pyrrhotite, chalcopyrite, marcasite, pyrite, sphalerite, galena, covellite. Gangue consists of quartz, feldspar, biotite, etc. Run of mine multi-element analysis is shown in Table3.

Table 3 Run of mine multi-element analysis (%)

Element	Cu	S	Fe	Pb	Zn	As
Content	3.61	14.26	23.80	0.042	0.034	<0.001
Element	SiO_2	CaO	MgO	Al_2O_3	Au	Ag
Content	40.85	1.36	1.00	7.35	0.18	19.5

Considering the difficulty in the local road transportation, combined frame and trailer constructions are applied, that is the heaviest grinding unit is installed on trailer while others are on single frame platforms with small volume, light weight, readiness in transportation. Its design capacity is 50t/d with technological flowsheet made up of two stage open circuit crushing, one stage of closed circuit grinding with classification, and single flotation process (Fig. 13). Its main equipment flowsheet is shown in Fig. 14.

Although the characteristics of ore treated during the commissioning period were dramatically different from those for laboratory test, i.e.poorer quality, higher oxidation radio and higher content of fines (sometimes up to 80%), the mill has reached the design criteria after trial production (Table 4).

Table 4. Design and trial production performance(%)

Item	Treatment capacity(t/d)	Run-of mine Cu grade	Concentrate Cu grade	Concentrate Cu recovery
Design performance	50	3.59	20	90.00
Trial production	52.76	3.23	21.43	90.80

It is proved by long-term production that the mill is running smoothly with satisfactory performances. Payback period of equipment investment is expected within 1 year.

3.3 Frame-type mobile gold flotation mill

The mill is located in the Gobi area, Xingjiang Autonomous Region, where the gold bearing quartz vein ore is dominant among other types of ore. The main metallic minerals include sphalerite, galena, pyrite, chalcopyrite, covellite, and free gold. Quartz is the dominant gangue mineral. Gold occurs mainly in free form , accounting for 2/3 of the total. The rest occurs in pyrite, sphalerite, and other minerals. Run-of-mine ore multi-element analysis is shown in Table5.

Table 5. Run of mine multi-element analysis (%)

Element	Pb	Zn	Cu	Fe_2O_3	S
Content	0.031	0.256	0.014	4.28	0.88
Element	TiO_2	MnO	SiO_2	Au	Ag
Content	0.31	0.48	86.45	8.82	7.2

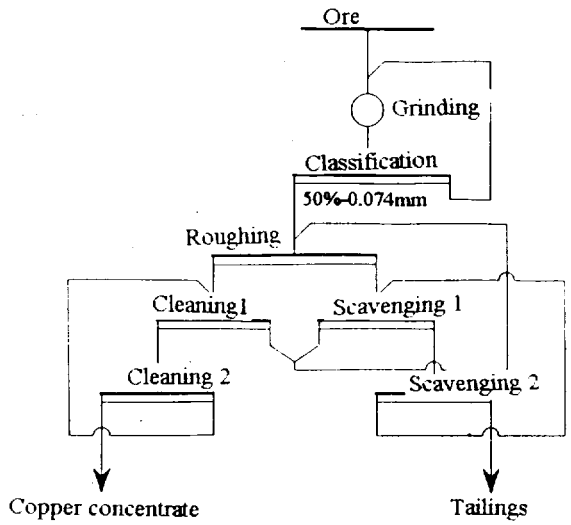
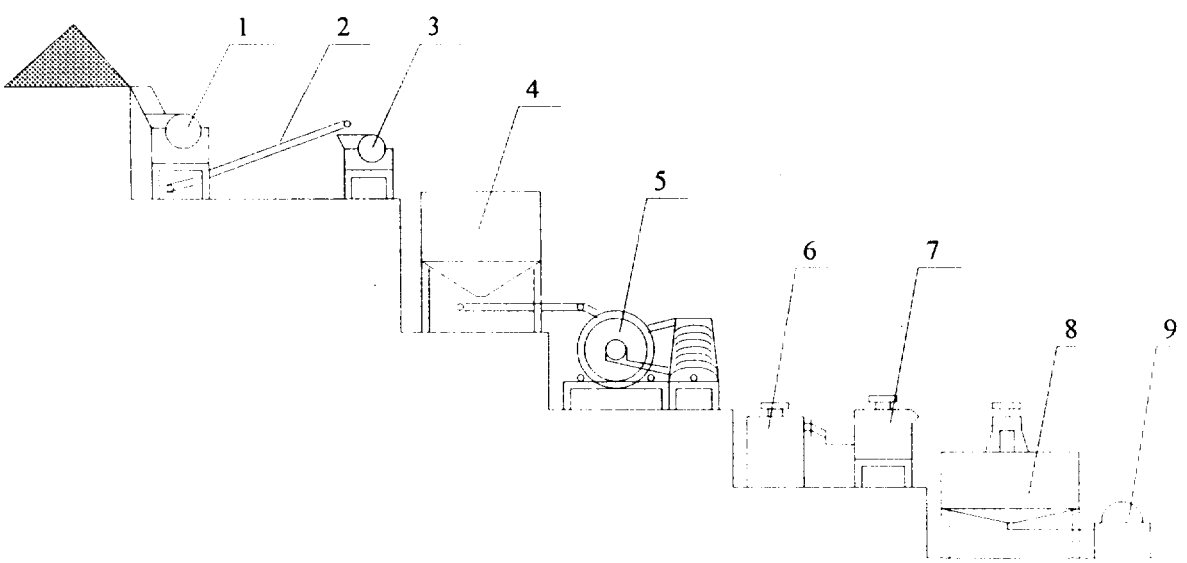


Fig. 13 Technological flowsheet of a mobile copper concentrator



1. Coarse crushing unit
2. Belt conveyor
3. Fine crushing unit
4. Fine ore bin
5. Grinding & claasification unit
6. Agitation unit
7. Flotation unit
8. Concentrate thickening unit
9. Concentrate filtering unit

Fig. 14 Principle equipment flowsheet of copper mobile concentrator

The mill is designed on flotation technology with 50t/d capacity (shown in Fig. 15). Equipment and facilities are mounted on platforms, including those for crushing, grinding & classification, flotation, dewatering and water supply respectively.

Its principle equipment flowsheet is shown in Fig 16. Due to the plain relief of the Gobi area, big investment is required for building a head reservoir, so a 1200mm water tank supply system with two pumps is designed which has been proved satisfactory in water supply.

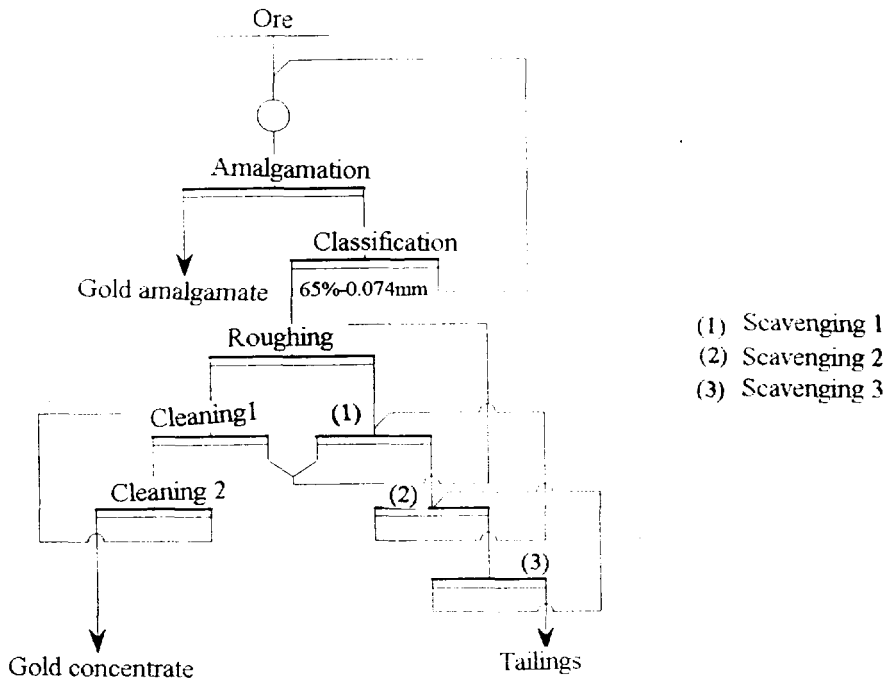
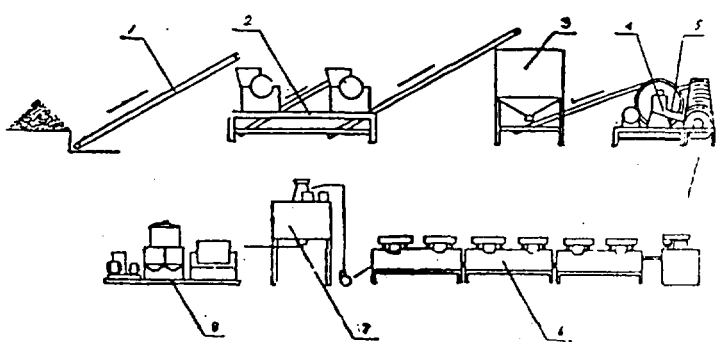


Fig. 15 Technological flowsheet of a mobile gold concentrator



1. Belt conveyor
2. Crushing unit
3. Fine ore bin
4. Grinding & classification unit
5. Amalgamation
6. Flotation unit
7. Concentrate thickening unit
8. Concentrate filtering unit

Fig. 16 Mobile gold concentrator - main equipment flowsheet

During the period of trial production, daily throughput was averaged at 54 ton ore. Although run of mine gold grade was 5.24 g/t, below the design figure (8.82g/t), the designed technological performances have been reached or surpassed (Table 6). Its payback period of equipment investment is less than one year.

Table 6 Design and trial production

Item	Treatment capacity (t/d)	Grinding fineness - 0.074mm (%)	Run of mine gold grade (g/t)	Concentrate gold grade (g/t)	Concentrate gold recovery (%)
Design performance	50	62	8.82	100.00	89.00
Trial production	54	65-67	5.24	166.80	88.60

3.4 Frame-type mobile gold cyanidation plant

The plant is built up in Luoning Hugou Gold Mine, Henan Province. The ore belongs to oxide one containing less arsenic and fewer non-ferrous metals. Its main metallic minerals include limonite, nasledovite, pyrite, galena and chalcopyrite. Gangue minerals are quartz, sericite and chlorite. Gold and silver minerals include electrum, native gold, argentite, cuproplurribite, etc. Gold minerals occur in fine particle size with 0.043mm fraction accounting for 86.18% of the total. The major gold carrier is martite formed by pyrite oxidation. The ore treated is mainly from Qingniushi and Caogou mine sites. Run of mine ore analysis is shown in Table 7.

Table 7 Run of mine multi-element analysis (%)

Content	Cu	Fe	As	S	C	Pb	Zn	Au	Ag
Qing-niushi	0.02	6-7	0.005-0.16	0.027-0.1	0.2-0.8	0.06-0.33	0.15	5-9	17-37
Caogou	0.01 - 0.05	5-7	0.004	0.08-0.12	1.7-2.2	0.06	0.07	15-19	15-19

Because the ore belongs to gold -bearing oxide, direct run -of mine ore cyanidation technology is applied. Cyanidation process involves carbon in leach (CIL) method, and the technological flowsheet is made up of grinding down to 90%-0.074mm, thickening, leaching & carbon absorption, desorption, electrowinning, smelting and purification of cyanide -containing tailings. (Fig. 17)

The plant is designed at 30t/d. In order to facilitate removal and cut down construction expenses, all the facilities are mounted on frames except the grinding unit installed on trailer. Its main equipment flowsheet is shown in Fig. 18.

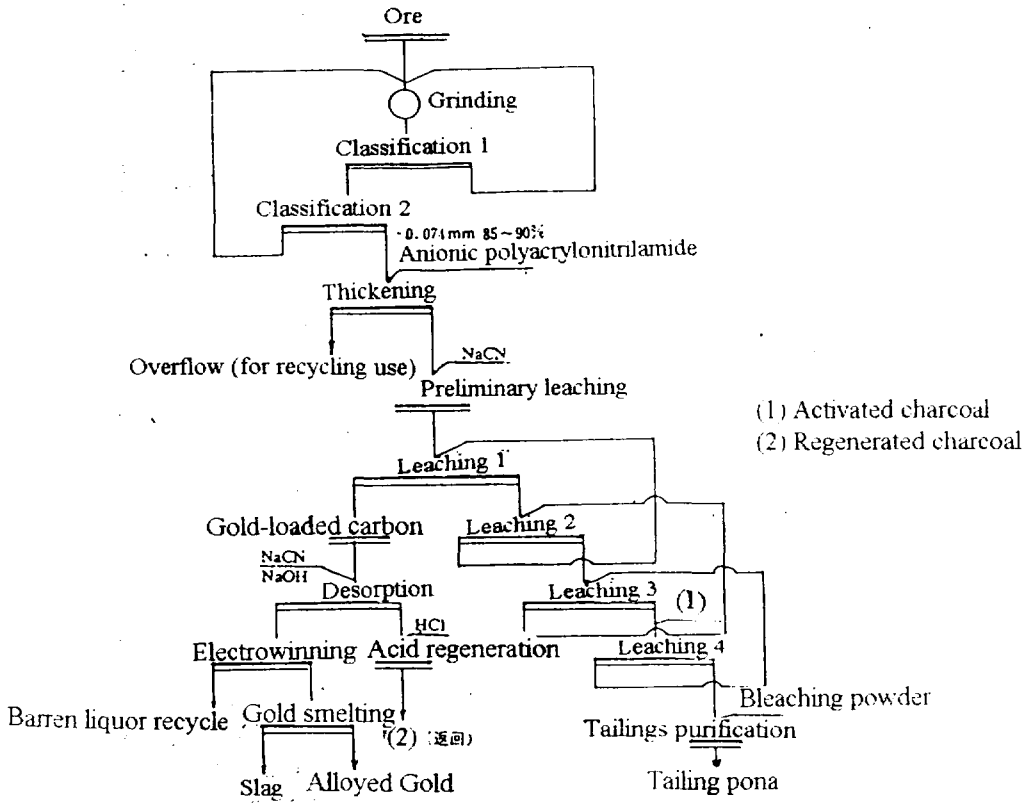
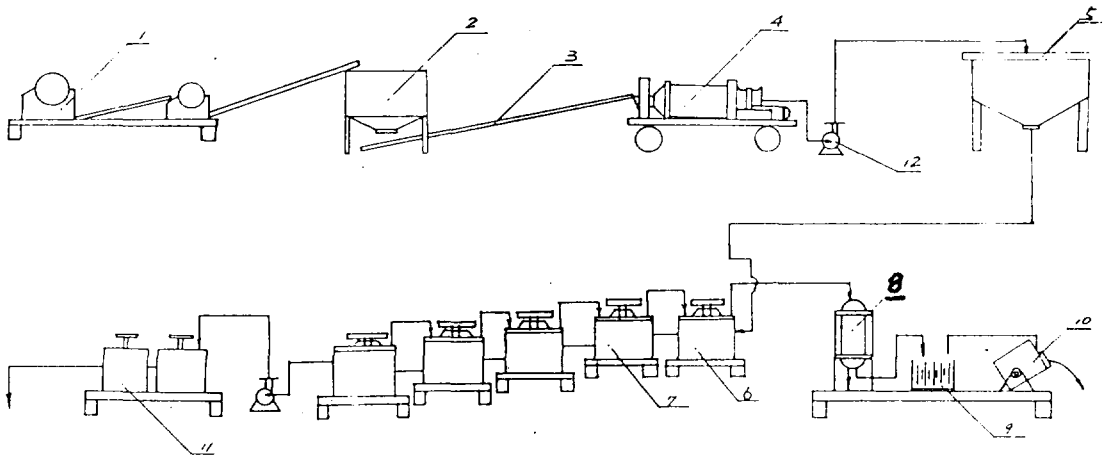


Fig. 17 Technological flowsheet of a mobile gold cyanidation plant



1. Crushing unit (250×400 mm deep cavity jaw crusher)
2. Fine-ore-bin
3. Belt conveyor
4. Ball mill platform (Φ1200×3000 mm ball mills; Φ750 mm spiral classifier; Φ 75mm hydrocyclone)
5. Φ 2.5 m simple highly effient thickener
6. Double-impeller aeration Φ 2.5×3.15 m leaching cell
7. 4 sets of double-impeller aeration Φ 2.5×3.15 m leaching tank
8. JC-B model Φ 400× 1200 mm desorption column
9. Electrowinning cell
10. RJX-8-13 model electric resistance furnace
11. Φ 2m agitation cell for purification of tailings

Fig. 18 Mobile Gold Cynaidation mill - main equipment flowsheet

Industrial tests showed when treating 31.2 t/d ore grading 7.36 g/t Au at pulp concentration 37.72% by preliminary cyanidation and leaching for 24.7 hours ,the recovery in leaching reached 93.07% Au and that for absorption 98.78% Au.

On the basis of industrial tests,production performance check was carried out, with the flowsheet and the ore treated basically similar to those for industrial tests. The gold grade in the ore was 3.5-12 g/t. The reagent regime is shown in Table 8. Comparison of industrial test, production and designed performances is given in Table 9. It has been proved by industrial test and production that all equipment and facilities work well and the performances have reached design criteria. When crude ore contains 5-7.5g/t Au, it is able to produce alloyed gold containing 84-95% Au with overall recovery up to 88% Au. All consumptions were verified and counted during the industrial tests and production check. When crude ore grade is 5-7.5g/t Au, its payback of equipment investment is calculated at one year and two months. It shows remarkable economic profits and the final gold product can be produced directly.

Table 8 Reagent usage in production check

Item	Lime (kg/t ore)	NaCN for leaching (kg/t ore)	Flocculant (g/t ore)	Bleaching powder (kg/t ore)	NaCN for desorption (kg/kg charcoal)	NaOH for desorption (kg/kg charcoal)
Control amount	6	1.2	45	8	0.1	0.05
Actual usage	5.5-6.5	1-1.5	40-50	8-9	0.09-0.12	0.05-0.057

Table 9 Comparison of design, industrial test and production performances

Item	Design	Industry test	Production check
Run of mine treatment capacity, t/d	30	30.77	33.77
Particle size of crushing product, mm	-10	-10	-10
Grinding fineness -0.074, %	85-90	92.31	91.6
Ore feeding grade, g/t	5-7	5.82	7.53
Tailing grade, g/t	--	0.45	0.645
Barren liquor grade, g/m^3		0.069	
Tailings concentration, %		33.4	
Leaching rate, %		92.27	91.34
Absorption rate, %		97.44	96.39
Gold smelting recovery, %		99.90	99.95
Au overall recovery, %	85-90	89.82	88.0
Tailings after purification CN^-, mg/L	<0.5	<0.5	0.05-0.48

4. Conclusions:

1. A mobile concentrator is not only suited to treat precious metals, non-ferrous &ferrous metals, non-metallics and other rich but small mineral resources,but also to reuse old tailings and used as pilot plant at earlier stage of big mine construction.

2. The equipment and facilities of the concentrator can be installed on frame or trailer. Mobile concentrators are equipped with crushing & screening, grinding & classification, beneficiation,dewatering and other machines, as well as water and power supply systems, laboratory instruments and lifting facility.

3. The concentrator is well equipped. Crushing process applies newly designed cavity jaw crusher with smaller particle size of product, thus realizing the principle of "more crushing and less grinding". Cyanide plant applies improved longer drum ball mills with argular spiral liners. One stage closed circuit grinding can reach the fineness down to 90% -0.074 mm.

4. It is proved by production practice that the mobile tin, copper and gold concentrators all run with satisfactory technological and economic performances.

Paper to
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BGRIMM, AN ACTIVE CONTRIBUTOR OF TECHNOLOGIES, SERVICES AND PRODUCTS FOR MINING INDUSTRY

Zhang Licheng
Director of Dept. of International Business and Cooperation
BGRIMM

INTRODUCTION

BGRIMM is the acronym of Beijing General Research Institute of Mining & Metallurgy. Founded in 1956 and affiliated directly to the Ministry of Metallurgical Industry (MMI) until 1983, the institute was then and is ongoing under the authority of China National Non-ferrous Metals Industry Corporation (CNNC). During the past decade, along with Chinese economic reform, BGRIMM has been shifted from the previous pure research institution to the present technological complex. Now, BGRIMM's activities are placed solidly on three strong pillars. The first, R&D and technical consultation; the second, engineering service, and the third, direct product manufacturing. BGRIMM integrates more than one hundred expertise, covering such aspects as mining, mineral processing, extractive metallurgy, advanced metallic and magnetic materials, fine chemicals, mineralogy, analytic chemistry, environment protection, land reclamation and the like.

Geographically, BGRIMM owns three sites in Beijing. One is in the downtown area of the city. There set are the headquarters and main laboratories, occupying nearly 2 hectare area. The second part is called the Branch 1 of BGRIMM, 6 hectare, located in the outskirts of the city, 20 minutes driving from the headquarters. The third part, 6.7 hectare, the Branch 2, is in the suburb of Beijing, another 20 minutes driving from the Branch 1. The functions of the two branches are mainly pilot and commercial production, plus some pilot scale trials.

On the aforementioned basis, BGRIMM provides not only technologies but also services and products through the efforts of her over 1,400 staff.

TECHNOLOGIES AND SERVICES

BGRIMM has been engaged in R&D of new technologies since her very beginning. When she celebrates her 40 years old birthday late this year people will see a remarkable list of her technological achievements. To quote the whole list here in this paper is impossible. It is, however, proper to say here that BGRIMM is one of the best in China to offer solutions, either theoretical or practical, to various difficulties in mining, mineral processing and extractive metallurgy.

Mining is a kind of complicated industry, requiring multi-disciplinary services. BGRIMM's organizational configuration fits this requirement. Her more than 100 expertises are distributed in three sub-institutes, 15 departments and over dozen companies. When being required, those expertises can be re-organized into various teams working for various projects and clients. Through providing customized services, BGRIMM can help clients to solve technical problems ranging from open-pit and underground mining, rock stability, underground machinery and service vehicles, blasting engineering, explosive selection and preparation, ore-dressing flowsheet development, tailoring and specific developing flotation reagent, processing equipment and automation, hydro- and pyro-metallurgical processes, energy saving facilities and skills, metallic powders and their applications including thermal spraying and other surface modifying techniques, environmental monitoring, auditing and remediation, and so on.

All those services are supported not only by various laboratory R&D works, but also by additional assistance, including on-the-spot consultation, engineering service and so on. For both greenfield and brownfield projects, either to develop mines, erect metallurgical plants, or build civil constructions, BGRIMM can first offer feasibility study, then offer package services including detail design and contract construction when requested. Her teams are quite experienced in providing *turn-key* plant to clients. For existing plant modification, BGRIMM's consultants can solve problems in daily operation, in updating process, and in contract administration to run the plant for reaching certain targets in the way either more technically or more economically.

BGRIMM's laboratories are well equipped with plenty conventional devices and necessary sophisticated instruments. It would be a very long list to mention all facilities. In mining aspect, facilities for rock mechanics study and tests are there besides the others for mining method tests. In mineral processing section, small and medium scale machines are running for sample preparation, magnetic, gravity, flotation, or electrostatic separation tests. In addition there is a mini-pilot system with the capacity of 1 t/h of crushing-screening and 1 t/d of milling and separation. With this flexible system BGRIMM can run tests continuously on various flowsheets combining different physical separation techniques. In the field of extractive metallurgy, besides a number of muffle furnaces and kilns, a complete pilot plant with comprehensive hydrometallurgical circuits offers possibilities for various trials. Two horizontal autoclaves, steam heated and 500 *l* each, can run continuous tests at escalated temperature and pressure. There are also 400 kg/h roasting facilities, a

vacuum induction furnace, a 100 kVA electric arc furnace, 400 kg heap leaching columns and L-SX-EW facilities.

To guarantee excellence in providing service, BGRIMM always recruits competent professionals. Currently, 11 doctors, 136 masters and hundreds bachelors have formed the back-bone of the institute. Among them more than 250 are senior professionals. Quite a few staff of the institute either got trained or worked overseas when being involved in international joint projects or personnel exchanging programs. BGRIMM is thus quite familiar with working together with foreign partners.

Reference of BGRIMM's services and achievements are widely seen all over China with several cases being abroad. BGRIMM is broadly involved in many state key projects. The flowsheets adopted by more than 60 percent of key mines, concentrators, smelters and refineries in China were initially developed by BGRIMM. Among them Baiyin, Jinchuan, Kalatongke, Fankou, Xilin, Xiaotieshan, Xitieshan, Dachang, Shizhuyuan, etc. are the most typical examples. One of the very successful abroad turn-key projects is the emulsion explosives plant in Erdenet, Mongolia. BGRIMM provided technology, engineering design, main equipment and construction materials, supervised the plant construction and commissioning. Now the plant is running smoothly, producing per annum over 10,000 t of emulsion explosives for the mine's open-pit operation. It ended a period in Mongolian history when the country needed to import all explosives from abroad.

PRODUCTION AND PRODUCTS

Is BGRIMM, a research institute, producing commodities and selling them to the endusers on market? Is BGRIMM's production in commercial scale instead of only at pilot scale? Really?

Yes. The answers to above questions are all absolute "**yes**". It is the economic reform in China that makes this great change possible.

BGRIMM's capacity of producing products for market has been dramatically growing in the recent years. It started along with the economic reform in China. Before the reform, BGRIMM, as a pure research organization, was entirely funded by the state government. The activities done by the institute were usually ended, at that time, by submitting test and/or research reports. Since the beginning of the reform, government's direct funding was considerably cut by steps and since 1991 the government's direct funding has been almost zero. Meanwhile BGRIMM was forced and also encouraged to re-organize her revenue through earning income from various sources. Marketing is since then contributing the dominant part of the cake. From experience BGRIMM learned that through only providing reports would not bring herself satisfactory income. She has to find a way to turn her research results into more beneficial products. Since middle '80s many new policies in China have created more possibilities. Licensing and even direct producing started to bring the institute more and more profits.

During the past decade, BGRIMM has turned out a variety of products, ranging from magnetic materials, mineral processing equipment, underground mining machinery, fine chemicals, through metallic composite powder materials, vegetable gum, to instruments for auto-control, and the like. Those products were all developed from BGRIMM's R&D achievements.

The scale and variety of BGRIMM's production is quite market oriented. For example, when market demand for magnetic materials had been estimated to grow, BGRIMM built up four new rotary kilns to dramatically expand her capacity of producing ferrite from 30,000 t/y to 60,000 t/y in two years. The newly increased capacity just filled the gap on market and of course is producing considerable profits. When the need for mobile mill arose from many miners working on scattered ore deposits in middle '80s, BGRIMM finalized the design of various mobile mills with capacity ranging from 30 t/d to 150 t/d. Very quickly, equipments were purchased and mills were assembled for clients in several provinces. Four mobile plants were provided in two years to Hunan, Fujian, Sichuan and Gansu. They are processing till now lead and zinc, copper and iron ores. After that, mobile CIP/CIL plant was also designed and provided, fully customized by client's requirement.

Quality is the life of the business. BGRIMM always attaches great importance to quality management. Necessary documentation, regular monitoring and auditing have become the organic part of her daily management. This year BGRIMM is applying ISO 9002 certification, started from her sub-institute of magnetic materials(MAGMET).

In order to provide more space for developing production, the land of the Branch 2 was specifically purchased two year ago. This expansion has provided BGRIMM 6.7 hectare of land and associated facilities, including all water supply and partial power supply. Infrastructure has been well constructed. Erection of three production lines totally to produce 24,000 t/y of presintered magnetic ferrite and one 2,000 t/y of sesbania gum plant has been completed and put into operation within the year of 1995. There are still 4 hectare land, not yet occupied, having been well prepared for any new projects, including various kinds of joint ventures.

With active development of production and marketing, this component of BGRIMM activity has been able to provide over two third of the institute's revenue.

THREE STATE ERCs

ERC is short for **E**ngineering **R**esearch **C**enter, which is regarded as the incubator of new technologies after being initially developed from laboratories. Since 1993 Chinese government has established nearly 50 ERCs with the sponsors being various key and prominent research institutes, universities and several huge industrial corporation groups. Among them, have only few institutions been chosen to sponsor three ERCs in one unit. Considering that there are over 300 independent key research institutes and hundreds key universities qualified to bid for the only fifty ERCs, the fact that BGRIMM is alone

sponsoring three ERCs can really show something. First, BGRIMM is a multi-disciplinary institution being able to exert comprehensive strength in solving problems when transferring lab achievements into commercial operations. Second, BGRIMM has accumulated rich experience in engineering incubation and technology transfer. BGRIMM itself is a good example in terms of engineering development. As having been described above, BGRIMM has successfully converted the lab tech of magnetic materials into commercial production with considerable capacity. Now BGRIMM is the largest supplier of Ba/Sr ferrite powders in China. The commercialization of vegetable gum production has also been successfully realized within the institute. Many other pilot production lines are all intermediate results, to various extent, of efforts in transferring lab achievements into industrial production. When government officers inspected BGRIMM before approving establishment of the ERCs, they were all deeply impressed by what they had seen. Because they did not expect to see such a technological complex with considerable commercial capacity, well managed and smoothly operated. Obviously, BGRIMM has been good at engineering development. In this way, one, two, three ERCs were approved to set up at BGRIMM. They are:

1. The State Engineering Research Center of Magnetic Materials (SERC-MAGMET);

2. The State Engineering Research Center of Comprehensive Utilization of Metallic Mineral Resources-Non-ferrous Metals (SERC-CUMMR[NM]);

3. The State Engineering Research Center of Clean Extraction and Energy Saving in Non-ferrous Metals Industry (SERC-CEES[NM]).

Now the MAGMET has been erected and passed the Government's acceptance examination. The CUMMR has been organized and waiting for authority's check and the CEES has fulfilled the feasibility study and is under detail designing. In addition to government input, CEES will be funded by a loan from the World Bank. Over 3.4 million US dollars have been allocated for procurement of necessary foreign instruments and devices, overseas training and compensation for foreign experts when they are needed for the activity of the Center.

The three ERCs won't only commercialize BGRIMM's achievements. They will pay even more attentions to absorb all promising results provided by Chinese and overseas institutes as well as universities. Copyright and intelligence right will be protected when ERCs acquire those results from outside researchers. Various partnerships will be formed to involve external experts in ERC's activities. The proprietary rights of the final commercialized achievements will be shared by all contributors. ERCs won't only apply those results in their own pilot plants but also license them to other users. Spin-off will also be considered whenever necessary. All ERCs will shift to independent limited corporations in five years.

INTERNATIONAL CO-OPERATION

BGRIMM is always active in international co-operation, especially after China started its opening-up policy. In the first wave of international co-operation, just after China opened the door to the world in late '70s, BGRIMM was deeply involved in dozens projects of raw materials exploitation. The foreign partners concerned include universities, research institutes, R&D divisions of mining and engineering companies from UK, Italy, Germany, Australia, Canada, the USA, Japan, and so on. Those projects were usually funded by EEC, UN, World Bank and the like. Since late '80s, intergovernmental funding has been mainly given to the projects of environment protection and new-material development. The typical joint projects in this period are *Mine Waste Management, Rare Earth Permanent Magnetic Materials Study* (China-Australia), *Waste Water Treatment in Wushan Copper Mine* (China-Japan), *New Technologies of Mineral Processing-Extractive Metallurgy-Materials Development* (China-USA), *Ocean Nodule Metallurgy* (China-Korea) and so on.

In addition to intergovernmental co-operation, BGRIMM also develops international inter-institutes co-operation. Information and personnel exchange is the normal way applied in this catalogue of co-operation. In recent years BGRIMM sent dozens of researchers and engineers to visit foreign institutes every year. Our senior and young staff worked in laboratories of several countries, such as Germany, England, Italy, Canada, Australia, Japan, USA, Russia, etc. Foreign experts also come and work in BGRIMM's laboratories. In Mine Waste Management Projects, two Australian long term experts lived in the institute for at least two years. Short termers came and will come working with their counterparts, BGRIMM's engineers, usually twice a year. Through exchanging and/or sharing experiences, many results and achievements are jointly obtained. Our young staff are trained meantime.

Besides cooperative R&D, BGRIMM is also active in cooperating with foreign companies in business. We have been agent for promoting some products of famous foreign companies, such as thermal-spraying devices and materials of Sulzer-Metco, Courier® On-line X-ray Analyzers and Ceramec® Filters of Outokumpu, Lix® copper extractants of Henkel, and the like. Since BGRIMM is not a pure trading company, its staff can not only conduct market survey and identify potential clients, but also provide technical service in decision making and post-sale period. BGRIMM is broadly involved in either strategic or practical stage of the projects when the judgment is required for procuring new equipment, instruments or reagents. BGRIMM is usually at the position to make recommendation. With her reputation BGRIMM's recommendations are widely accepted. In this way, BGRIMM keeps in introducing advanced technologies and/or devices which are not yet available in China. BGRIMM is good in protecting foreign partners' patent and proprietary rights. We have never released any business secret to any third parties without written permission from our cooperative counterparts. Many good equipment and devices are very attractive to potential clients. The main obstacle of buying them is always their high price. In order to cut the cost resulting from manufacturing overseas and long-distance shipping, BGRIMM often proposes joint manufacture in China. After signing further agreement on

keeping technical secrets, BGRIMM can arrange to manufacture such normal parts as shaped steel sections, general casting and normal machine-working parts. Key parts can be provided directly from overseas. Joint manufacture has proven a good strategy in China.

IMPORT AND EXPORT ACTIVITIES

BGRIMM started to exporting her products in 1980 when she participated the Guangzhou Fair[1] for her first time. In early '80s, the only product she could sell overseas was magnetic materials with limited variety. The buyers were mainly Hong Kong businessmen who were rarely endusers and would then shipped the goods to other countries or regions round the world. BGRIMM is one of the pioneers among Chinese research institutes who keep producing goods in commercial scale and selling them overseas. The scale of exportation keeps growing every year, as shown in Fig. 1, which made BGRIMM be granted a license by the government for direct import and export operation in 1993[2]. In the same year BGRIMM registered a corporation with the title of *Beijing General Mining & Metallurgical Corporation (GEMCO)*. In fact it is GEMCO that operates the I/E business on behalf of BGRIMM. Now BGRIMM is selling products to dozens countries and/or regions. Several appointed overseas agents are making contributions. Direct sale to foreign endusers have also become a normal operation.

The foreign currency income made by BGRIMM from 1981 to 1995 is summarized in Fig. 1. In the catalogue of "Products" given in Fig. 1, magnetic materials took the dominant share, followed by processing equipment. "Tech" means the USD income made from technology transfer and turn-key plant contract directly associated with the transferred technology, plus agent commission and technical service charge collected from foreign clients. No available data can be used to show the composition of income sources before 1984. Obviously, before 1987 the foreign income of BGRIMM mainly came from "soft" sources, while after 1990 "hard" sources became the master. 1993 and 1994 were the exception when the technical earnings were over the product earnings again due to a big contract of transferring technology and turn-key plant construction implemented in the period. Since 1991 BGRIMM has made over 1 million USD per annum from her foreign business. From 1994 to 1995, BGRIMM's foreign business made the fastest progress as Fig. 1 indicated. In 1994, over 2 million USD of foreign business income were over 13 % of the total annual revenue of the institute, and in 1995 about 4.4 million USD made from her foreign business represented more than 18 % of the institute's gross earning of the year.

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[1] The most famous fair for exporting China-made goods, with longest history of holding twice a year since late '50s. Before and even during the initial years of economic reform it was almost the only channel for Chinese I/E companies to directly contact foreign businessmen.

[2] 1993 was the first year when Chinese government started to issue I/E license to research institutes. Among 100 institutes granted license that year BGRIMM was ranked in the first ten. Before being granted the license BGRIMM exported her products through several trading companies holding I/E license, with them BGRIMM still keeps good co-operation in overseas marketing.

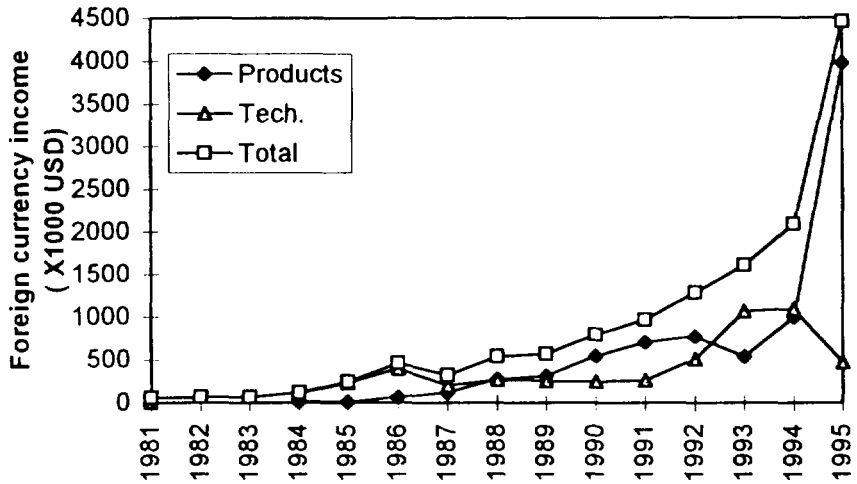

Fig. 1 USD made by BGRIMM in foreign business from 1981 to 1995

Those figures can show more than their values. On the way of reform and moving forward to the world market, BGRIMM has always been trying her best in making progress one after another. She is keen in providing technologies, services and products to mining industry not only in China but also abroad.

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Recovery of Copper, Nickel, Cobalt and Gold from Low Grade Ores and Other Materials with Hydrometallurgical Processes

Liu Daxing and Jiang Kaixi
Beijiang General Research Institute of Mining & Metallurgy

1. Recovery of Copper from Low Grade Ores with L-SX-EW process

The Leaching—Solvent eXtraction—ElectroWinning (L-SX-EW) technique for copper production from low grade ores has been developing rapidly all over the world. The annual copper production by this process is ca. 1.2 million tones.

As the national economy increases at a high speed in China, the copper consumption is also increasing very rapidly. Following USA, Russia, and Japan, China is now the fourth largest copper consumption nation. It is predicted that China needs one million tones copper in 1996, and in the year 2000 1.4 million tones. Unfortunately, China is short of copper deposits which are suitable to normal dressing-metallurgy processes. Therefore, China has been making great effort to develop the technology to recover copper from low grade ores.

In 1970's, Beijing General Research Institute of Mining and Metallurgy (BGRIMM) initiated to develop the technology of copper recovery from refractory copper oxide ores and low grade ores. The first copper plant, in which the L-SX-EW was employed, was established in 1983. Since then this technology has been spread widely. In 1992 this technology was classified by the State Science and Technology Commission (SSTC) into the major project list of the techniques to be promoted, and BGRIMM was selected as the technique key supporter of this project. Now there are several dozens of plants in China with a total copper production capacity of more than 10,000 t Cu/a.

The typical flow sheet is shown in Figure 1.
This technology includes the following unit operations:

1.1 Leaching of ores

Copper in ores is extracted with acid or ammoniac solution by leaching, which can classified as heap leaching, dump leaching, agitation leaching, vat leaching, in-situ/stope leaching with/without bacteria. Sulfuric acid may be the most suitable leaching lixiviant for ores with low alkaline gangues, while ammoniac solutions could be used for leaching ores containing high alkaline gangues.

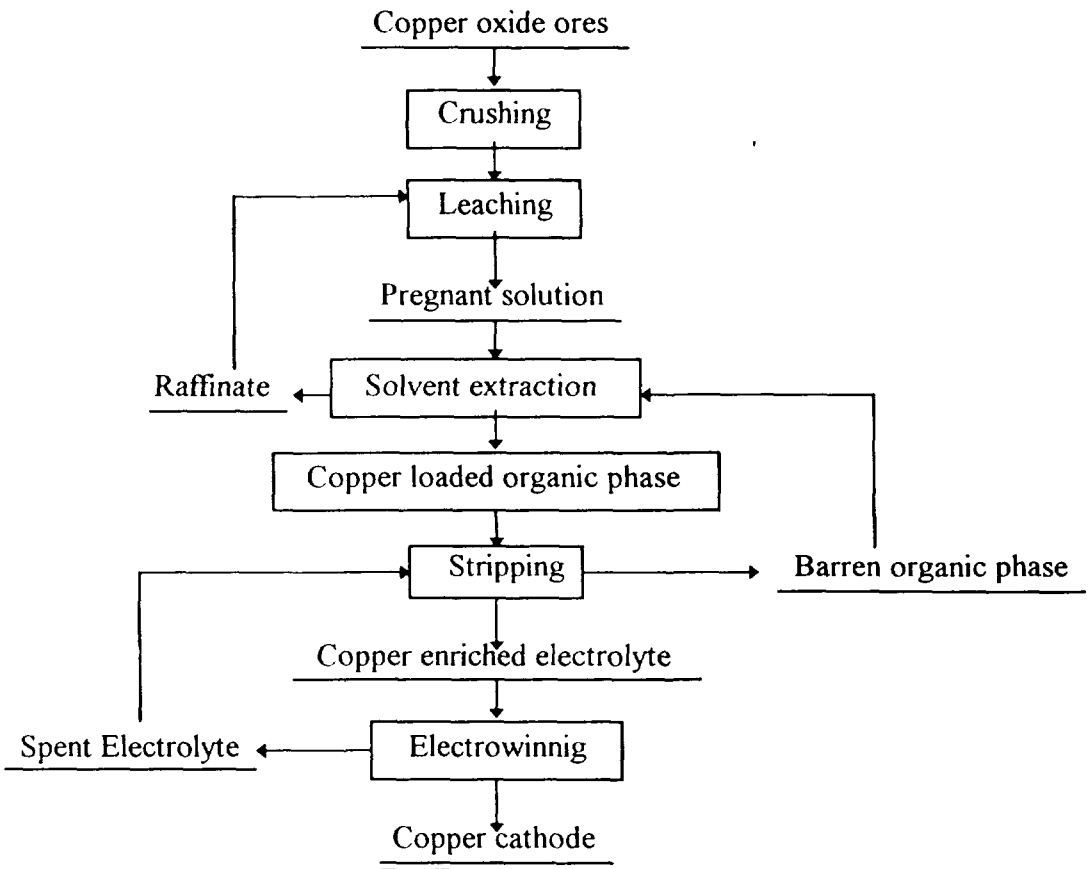

Figure 1: Principle flow sheet of L-SX-EW process for copper oxide ores

1.2 Solvent extraction and stripping

The different extractants can extract copper from different leaching liquors selectively, e.g. acidic liquor or ammoniac liquor. By stripping copper goes into electrolyte as concentrated copper sulfate in sulfuric acid solution . After solvent extraction and stripping, the purity and concentration of electrolyte is high enough to produce cathode copper of high quality. Solvent extraction raffinate is usually circulated to the leaching stage.

1.3 Electrowinning to produce cathode copper of high quality

Spent electrolyte is used to strip copper from the copper loaded organic. The copper enriched electrolyte is used to produce cathode copper of high quality. The electrolyte can

be circulated, until the impurity concentration reaches to a rather high level. And then part of the electrolyte is bled into the leaching stage.

This technology has been widely used in China and all over the world, because it has the following advantages:

(1) It expands the recoverable copper resources. Those which were classified as useless copper containing materials, for example, low grade copper oxide ores, tailings from dressing processes, waste rocks and surface rocks of copper mines, can be used to produce copper economically.
(2) It is quite simple and suitable for either large or small scales. The operation cost is very low, 700 ~ 800 USD/t of copper produced in China, while the actual copper price is ca. 3,000 USD per tone.
(3) Low capital invest and short construction time. The invest of this process is about 10,000 RMB (1,200 USD) per tone copper productivity. It will decrease as the scale increase. Because the process is uncomplicated, the construction time is about 8 months to one year for a 1,000 t Cu/a plant in China.
(4) No environment pollution. There is no sulfur dioxide emission and almost no waste water to drain from the process. All solutions can be circulated. The ores need not to be mined in the in-situ or stope leaching, so that the vegetation surface and ecosystem could not be demaged in mine areas.
(5) High quality Copper. The process can produce the cathode copper with very high purity (99.95 ~ 99.999 %).

During China's "Ninth Five Year Plan", BGRIMM will cooperate with mines and other research or engineering institutions to promote this technology. It is predicted that the annual copper production with L-SX-EW could reach 40~50 thousand tones in China at the century end. It is significant for Chinese copper industry to apply this technology in increasing copper production and in comprehensive utilization of various copper resources.

2. Extraction of nickel and cobalt from low grade ores

Both Nickel and cobalt are important non-ferrous metals. In 1960's BGRIMM began to develop the technology to recover nickel and cobalt from their low grade ores. Some processes have been successful in practice. The new techniques and industrial facilities, such as pressure leaching, solvent extraction, ion exchange, etc., have been used in the processes. The following are a brief introduction of typical processes.

2.1 Cobalt oxide powder with high purity from low cobalt containing pyrite

There is no good cobalt resource in China. About 60 ~ 70 % of cobalt is in cobalt containing pyrite. The pyrite is subjected to flotation to produce cobalt containing concentrates usually with cobalt content between 0.25 ~ 0.5 %. Figure 2 show a cobalt recovery process developed by BGRIMM.

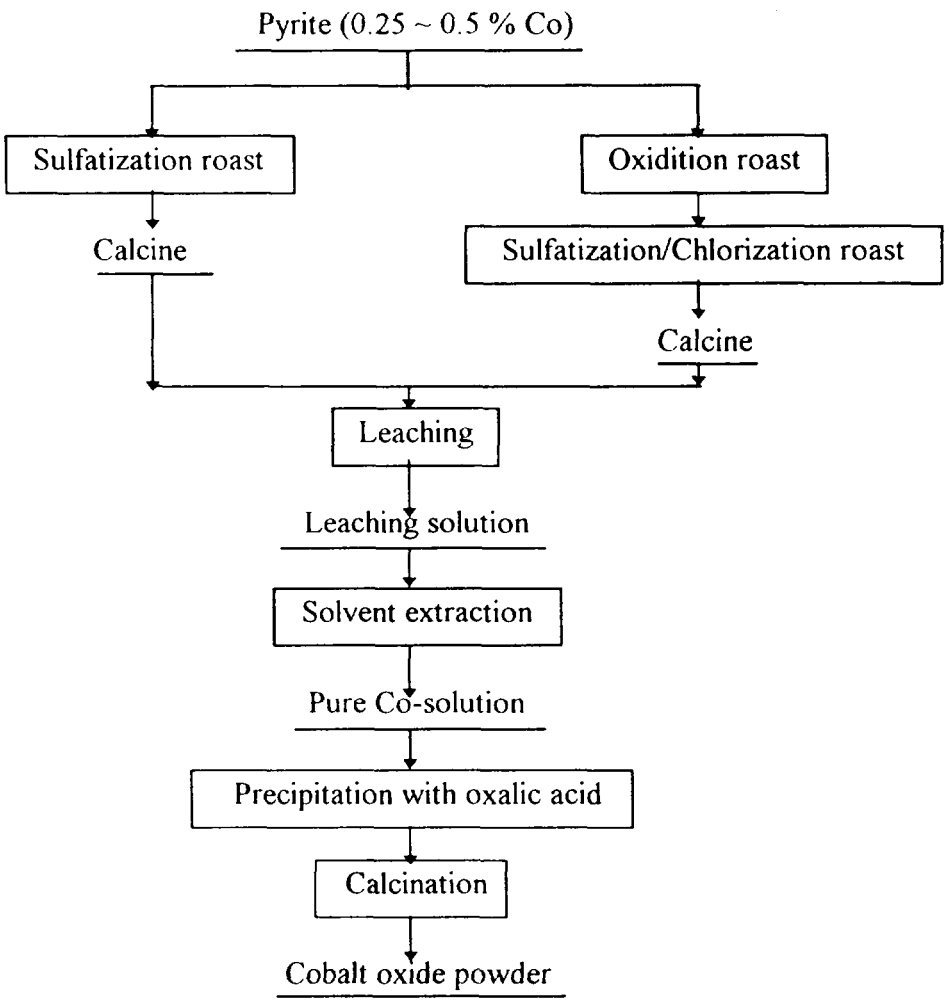

Figure 2: Principle flow sheet for the production of cobalt oxide from pyrite

The cobalt containing pyrite concentrate may be roasted either at the conditions of sulfatization, or firstly at the oxidizing atmosphere and then the calcine is roasted again at the condition of sulfatization. Of course the calcine may also be roasted for chlorization at moderate temperature. The calcines are leached by water or dilute sulfuric acid. Cobalt, nickel and copper desolve into the leaching liquor, whereas most of the iron remains in the residue.

The metal values, Co, Ni, Cu, Zn etc. in the leaching solutions can be concentrated or extracted by chemical precipitation or solvent extraction. By solvent extraction the Cu, Zn, Mn and Fe can be removed with a phosphoric acid P204, which is made in China and similar to D2EHPA. The further stage is to separate cobalt from nickel with the same reagent to

obtain pure cobalt chloride solution and nickel sulfate solution. Cobalt chloride reacts with oxalic acid to precipitate cobalt oxalicate, and cobalt oxide powder is the product of calcination, which can be used directly for manufacturing hard alloys. This process has been applied in practice since 1978.

2.2 Cobalt recovery from cobalt residue

Cobalt dissolves into electrolyte together with nickel in nickel electrolysis with sulfide anode, and then precipitates as cobalt hydroxide in purification of anode electrolyte. The so-called "cobalt residue" usually contains 6 ~ 7 % Co and 25 ~ 30 % Ni.

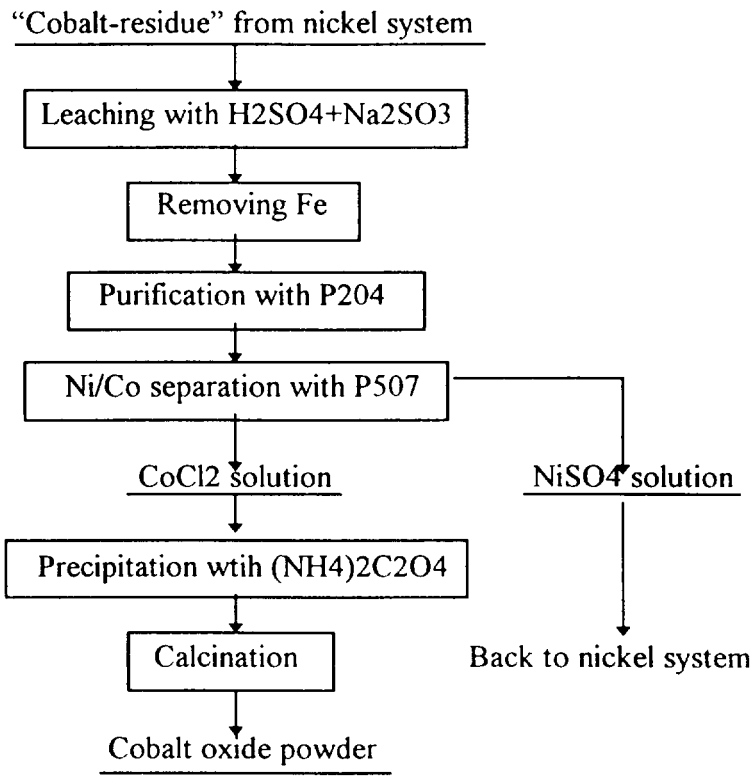

Figure 3: Principle flow sheet for cobalt oxide production

BGRIMM had developed a process to recover cobalt from cobalt residue, which was put into practical use in Jinchuan Non-Ferrous Metals Company in 1984. The capacity is 200 t cobalt oxide annually. Figure 3 is the follow sheet.

Firstly, the cobalt residue is leached with sulfuric acid at the reduction condition. Secondly, the solution is purified by solvent extraction with P204 to remove Mn, Zn, Cu, Ca etc. Thirdly, P507(PC-88A, SME-418) is used in solvent extraction for separating cobalt from nickel. The difficult task is to separate cobalt from nickel at the sulfate solution with low cobalt and high nickel concentrations. This problem is solved by two SX-systems, i.e. P204 for purification and P507 for separation. The investigation and practical results show that

P507 has much higher Co/Ni separation capacity than P204, about several dozen to more than one hundred times over the latter. Therefore, P507 is more efficient for the solution with wide Co/Ni range. Table 1 lists the typical chemical analyses of the solutions in P204-P507 process. After P507 SX process the Ni/Co ratio in raffinate is more than 7,000, and the Co/Ni ratio in the stripping liquor is more than 3,000. This satisfied separation guarantees the high purity and high quality of Ni and Co products. The purity and apparent density of cobalt oxide powder is given in Table 2.

Table 1 Typical chemical analyses of the solutions in P204-P507 process (gpl)

Element	Ni	Co	Cu	Fe	Zn	Mn	Ca	Mg
Leaching liquor of "Co-residue"	70 ~ 90	12 ~ 20	0.2 ~ 0.3	4 ~ 8	0.01 ~ 0.02	0.0 1 ~ 0.03	0.1 ~ 0.3	0.1 ~ 0.4
Solution after P204 purification	70 ~ 90	12 ~ 20	< 0.002	< 0.01	< 0.001	< 0.002	< 0.05	0.1 ~ 0.4
NiSO4 solution	70 ~ 90	0.002 ~ 0.01	0.0005 ~ 0.001	< 0.002	0.001 ~ 0.002	0.0005 ~ 0.002	0.005 ~ 0.02	0.1 ~ 0.4
CoCl2 solution	< 0.02	60 ~ 80	0.005 ~ 0.02	< 0.01	0.0005 ~ 0.005	0.001 ~ 0.003	0.02 ~ 0.05	0.005 ~ 0.01

Table 2 Purity (%) and fill density (g/cm^3) of cobalt oxide powder

Co	Ni	Mn	Ca	Na	Fe	As
≥ 70.0	≤ 0.3	≤ 0.05	≤ 0.008	≤ 0.005	≤ 0.006	≤ 0.005
Cu	Pb	Zn	Mg	S	Si	apparent density
≤ 0.05	≤ 0.005	≤ 0.006	≤ 0.01	≤ 0.065	≤ 0.005	0.4 ~ 0.6

The recovery of cobalt and nickel in this process is quite high, >92 % and >95 %, respectively. Moreover, the prices of reagents P204 and P507 are rather low, USD 4,000 ~ 5,000/t (USD1.82 ~ 2.27/lb.), USD7,000 ~ 8,000/t (USD3.18 ~ 3.63/lb.) respectively, and these can benefit most of Ni/Co plants in the developing countries.

2.3 Recovery of nickel and cobalt from the converter slag in nickel smelters

40 ~ 60 % of cobalt in matte goes into slag during converting. The key factor for raising cobalt recovery is the controll of converting and treatment of converter slag.

Since 1960's, amount of research work have been conducted in area of cobalt recovery in nickel smelters. In 1980's, a process was brought out which was comprised of cleaning of the converter slag converting of cobalt matte, pressure leaching, SX for Co/Ni separation. The pure cobalt solution is further treated as mentioned above to produce cobalt oxide powder, and nickel solution is used to produce nickel powder by means of hydrogen reduction at high pressure. The flow sheet is seen in Figure 4.

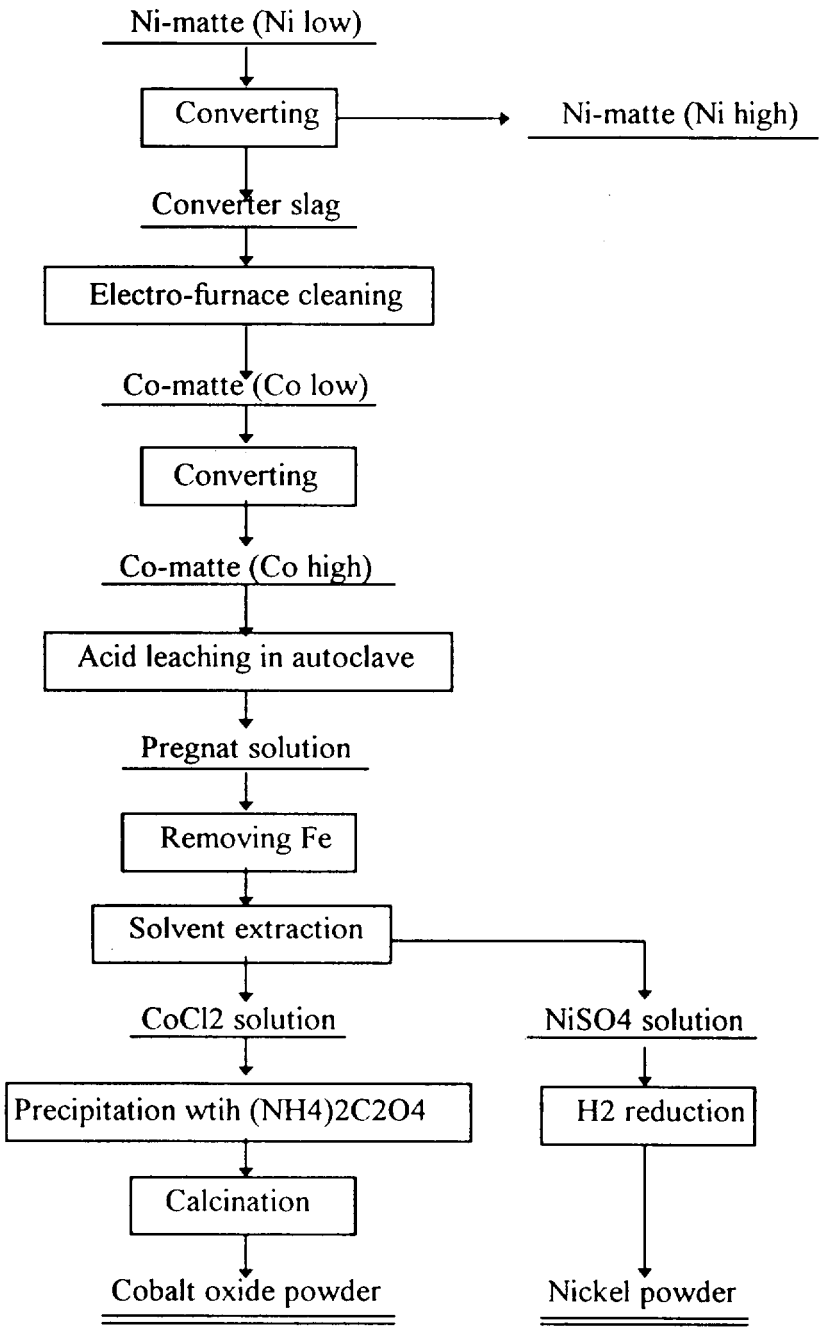

Figure 4 Flow sheet of the process for the cobalt extraction from converter slag

3. Recovery of gold from low grade gold ores

There are a lot of low grade gold deposits in China. The deposit types are quartz vein, porphyry, and iron oxide cap. The study on heap leaching for gold ores began in 1970's. In 1980's this technology was widely adopted. Now there are dozens of heap leaching operations in China, and the largest heap has piled up more than one million tones ore.

The heap leaching for low grade gold ores characterizes as following:
(1) There is no lower limit of gold grade for recoverable ores theoretically, most of ores contain less than 1 gpt of gold.
(2) It is quite simple in techniques, and is easy to put into operation on a large scale.
(3) The production cost is very low.

BGRIMM developed a heap leaching technique for the low grade ore with high clay content in Jiangxi Province. The host minerals are limonite and silicate clay (30 ~ 40 wt%). In order to improve the permeation rate of the heaped materials, ore is agglomerated before heap construction. The process flow sheet is shown in Figure 5.

Ore is crushed in two open circuits to minus 25 mm, and the crushed ore is mixed with cement, lime and water in a disc to form pellets. After the solidification the pellets are charged on the heap pad with about 2m height. The leaching period is 45 days. The pellet heap has permeation rate 20 times higher than normal heap. And the leaching recovery of gold is 10 % higher than that of normal heap leaching.

The pregnant solution is pumped to the active carbon absorption stage. Gold is recovered by electrowinning from the desorption solution and after smelting the crude gold is produced for sale.

In this process gold recovery is approximately 80 % for the ore with the average gold grade 1 ~ 3 gpt. This gold mine has gained a very good economic profit.

In recent years, Department of Gold & Silver Extraction of BGRIMM has been successful in developing the technology for recovery of gold and silver from complex ores. Many achievements and industrial applications in this area are reported. The following is a brief introduction.

(1) Gold and silver recovery from a silver concentrate containing high carbonIt is well known that the extraction of gold and silver from this kind of ores is very difficult, because the carbon containing in ores can absorb gold and silver leached by normal cyanide solutions. The department developed successfully a process with the gold recovery >90 % and silver recovery >95 %, in which chlorine water and thiosulfate are used as leaching lixiviant. The pilot plant tests accomplished very good results.
(2) Gold recovery from low grade ores and tailings with chlorine water

Pilot plant tests show that the gold recovery for the ores containing less than 5 gpt of gold can be more than 90 %.

(3) Technology of gold recovery from the ores with high arsenic content
Traditional cyanide leaching process can only get a 60 % extraction of gold, but in new process with chlorine water the gold recovery is higher than 95 %.

(4) Electrochemical technology for gold and silver recovery from the complex ores containing copper, lead, and zinc
This process can extract not only gold and silver with the recoveries of 99 % and 91 %, respectively, but also the co-existing copper, lead, and zinc.

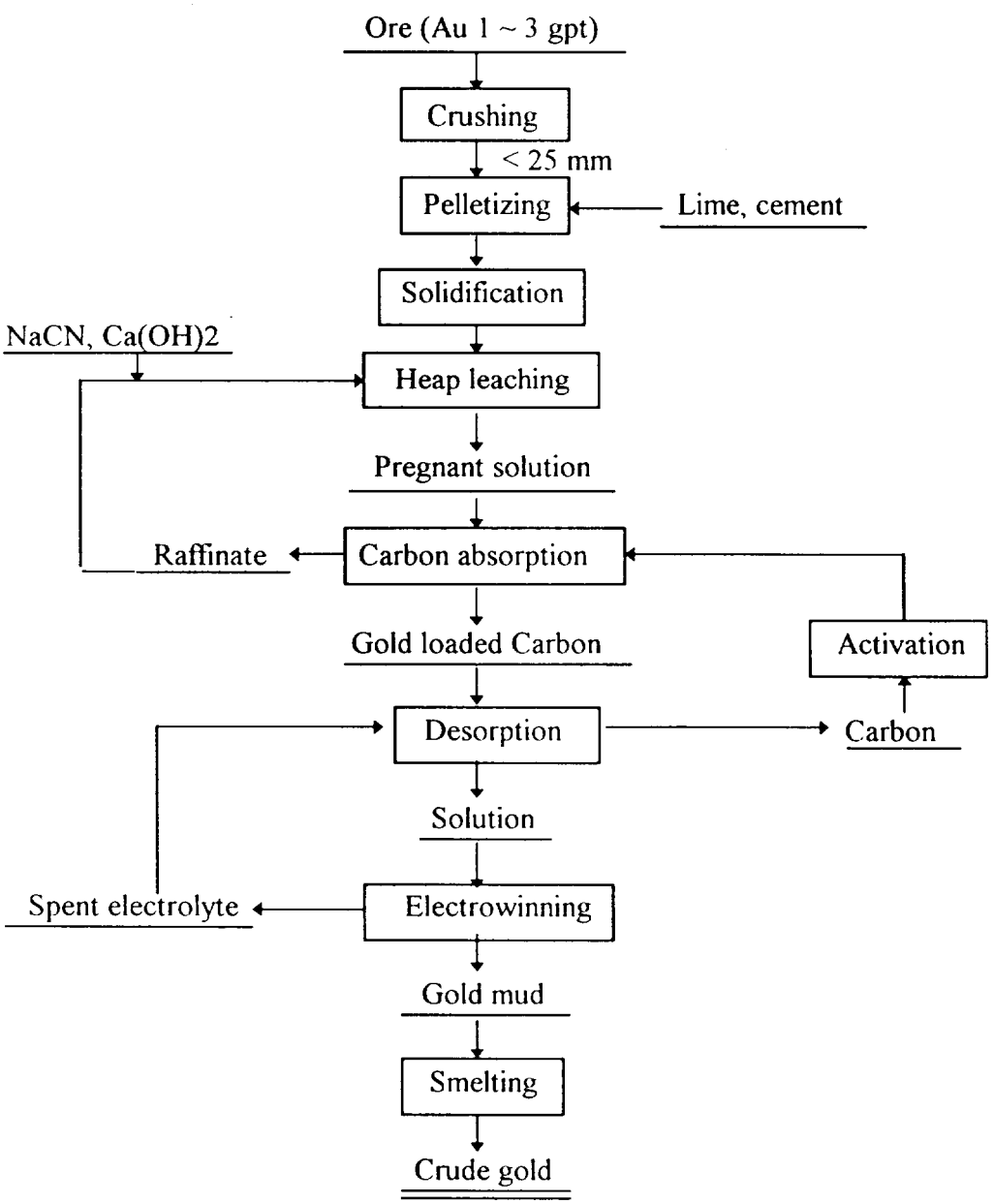

Figure 5 Pelletizing—heap leaching process for low grade gold ores

4. Conclusions

Hydrometallurgy has many advantages comparing with traditional pyrometallurgy. It could utilize most of mineral resources in the earth crust and bring much less environment pollution. It will play a more and more important role in today's society, which accompanies with the rapid increasing of economy.

Paper to
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RECOMMENDATIONS ON MINE WASTES TREATMENT AND RELEVANT ENVIRONMENT PROTECTION MATERIAL

Wu Yiqian, Chen Fangde, Wangjing

Beijing General Research Institute of Mining & Metallurgy

Mine wastes are featured by large variety, complexity, big volume and a lot of harmful elements, and they are among the main sources of environment pollution. At present, there are a lot of publications on technology in treating mine wastes and relevant environment protection materials. Here we would like to take this opportunity to recommend to you some practical technology in treating mine wastes at pyrite mines and an ideal material for environment protection.

1. Biological Treatment Technology for Mine Waste Water

1.1 Characteristic features of biological treatment technology

Here we will introduce a feasible technology in using thiobacillus ferrooxidans to oxidize and leach sulfides in treating mine waste water.

Thiobacillus ferrooxidans is a kind of chemically composted autotrophic bacteria. Within the range of PH 2.0-3.0, it can reproduce well and proliferate with energy produced when oxidizing inorganic substances (such as oxidizing Fe^{2+} to Fe^{3+}) and by fixing CO_2 in the air. These characteristics of thiobacillus ferrooxidans make it applicable for treating underground acid effluent from copper sulfide mines, waste water from hydrometallurgical process, pyrite containing coal mines and metal leaching, etc.

Compared to other methods for treating mine effluents, thiobacillus ferrooxidans has the following superior features:

1) Possibility to utilize natural reaction, with energy saved, lower consumption and cost, and without secondary pollution;
2) Compared to medium without bacteria, its oxidation rate is 500 thousand faster;
3) Since the oxidation taking place in the range of low PH, it is favorable for various metals to precipitate separately, and hence favorable for the separation and recovery of different metals.

4) The oxidation with thiobacillus ferrooxidans can change the precipitation behavior of the precipitates, and make dewatering easier, and the volume of precipitates smaller, thus greatly saving the storing volume for precipitates.

Because the bacteria oxidation has multiple advantages, its application is paid to more and more attentions.

1.2 Application case

The bacteria oxidation technology has been applied to treating waste water at Wushan Copper Mine, which is one of the biggest underground copper sulfide mines in China, with abundant high grade copper resources and over 100 years of service life. But the waste water produced during the mine operation causes serious problems to the surrounding environment, especially pollution to Chihu and Yangze river systems. It was previously designed to use lime to neutralize the acidic waste water from the mine, but because of such various reasons as high cost and big volume of precipitates, this option was difficult to implement. A new neutralization method - bacteria oxidation is finally introduced and its technological process is shown in Figure 1:

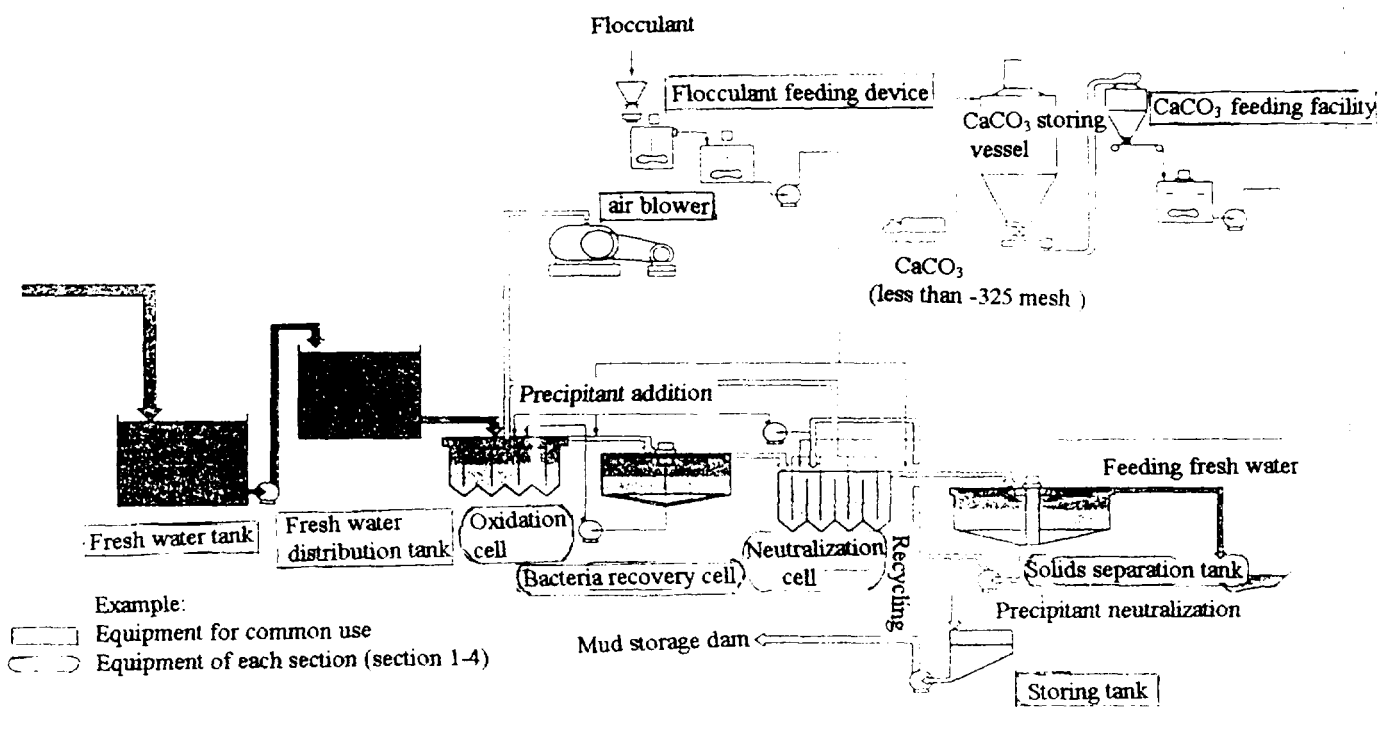

Fig. 1 Process of neutralization treatment of waste water using thiobacillus ferrooxidans

The treated water quality is as follows:

Table 1 The quality of treated water by the new neutralization method - bacteria oxidation

Unit: mg/l

Water sample	PH	Fe^{2+}	T-Fe	Cu	Zn	Pb	Cd	As	Al	SS
Original mine water	2.5	1680	1699	379	98	0.18	2.0	3.9	440	65
Water after treatment	7.9	ND	12	0.01	1.0	0.01	0.01	0.04	0.5	<10
Disposal standard	6-9	/	/	0.5	2.0	1.0	0.1	0.5	/	70

The precipitate produced by the new treatment method is only 1/2 ~ 1/3 of that from lime neutralization, significantly reducing the cost for their disposal.

In addition, it can recover such valuable metals as copper and iron from the waste water, with additional recovery of copper reaching over 200 tons per annum.

The fees for pollution disposal, compensation for pollution-related penalties, and fresh water usage, etc. are cut down by over 800 thousand USD per annum.

2. Production Technology for L Slag Silicate Cement and Concrete

2.1 Brief introduction

Abatement of pollution and most effective utilisation of wastes are the highest requirement and the radical way for resolving pollution problems engendered by industrial production. The core in clean technologies characterised by free-of or less wastes, being vigorously developed the world-wide nowadays, is to strengthen the comprehensive utilisation of industrial solid wastes.

Using industrial waste slags as raw material for cement production is one of the subjects which researchers in China and foreign countries have been engaged in for years. Adding a certain amount of such industrial slags as blast-furnace slag, phosphorus slag and steel slag into the Portland cement clinker can increase cement output, but at the expense of cement brand dropped down.

Beijing General Research Institute of Mining and Metallurgy has deeply researched L slag, including its chemical composition, physical properties, mineralogy, activity and its harmful element content, and for the first time drawn the conclusion that the addition of L slag can not only improve the output of cement, but also upgrade the brand of cement and concrete. Besides the environment pollution abated, it has opened a new resource of mixing materials for cement and concrete.

2.2 Characteristic features of the technology and product

Using BGRIMM technology to add 40% L slag into poorer quality clinkers of less than 425# and 425# can produce 425# and 525# L slag Portland cement. The technical parameters of the two products have all reached or exceeded the GB1344-92 cement standard. Using L slag as mixing material of concrete can not only replace 20-30% 525# or 425# cement, but also improve its strength at the 28th day, and eminently its later strength. Replacing equivalent amount of cement by L slag can not only prepare ordinary concrete, but also produce high strength concrete and even C_{80} super high strength concrete.

The similar properties of L slag to those of silicon powder provide favourable conditions for expanding application of high strength concrete to constructions.

As an industrial waste, L slag is of low price, greatly decreasing the cost of its cement and concrete. In manufacturing cement, 1 ton L slag is equivalent to 1 ton 425# clinker; while producing concrete, 1 ton L slag is equivalent to 1 ton 525# cement. The addition of L slag as mixing material of cement can reduce the cost of cement by 12 USD/t. For preparing C30 concrete, the addition of L slag can reduce the cost by 1.7-2 USD per cubic meter concrete; in manufacturing C80 high strength concrete, the price can be reduced by about 14 USD per cubic meter. Therefore it is concluded that using L slag in producing cement or preparing concrete has sound economic, environmental and social benefits.

Using L slag in the production of cement and concrete has the advantages of simple process, lower consumption of resources and energy, easily controlled technological conditions, absence of secondary pollution and suitability for large scale production, which is conducive to its diffusion and promotion.

2.3 Photos

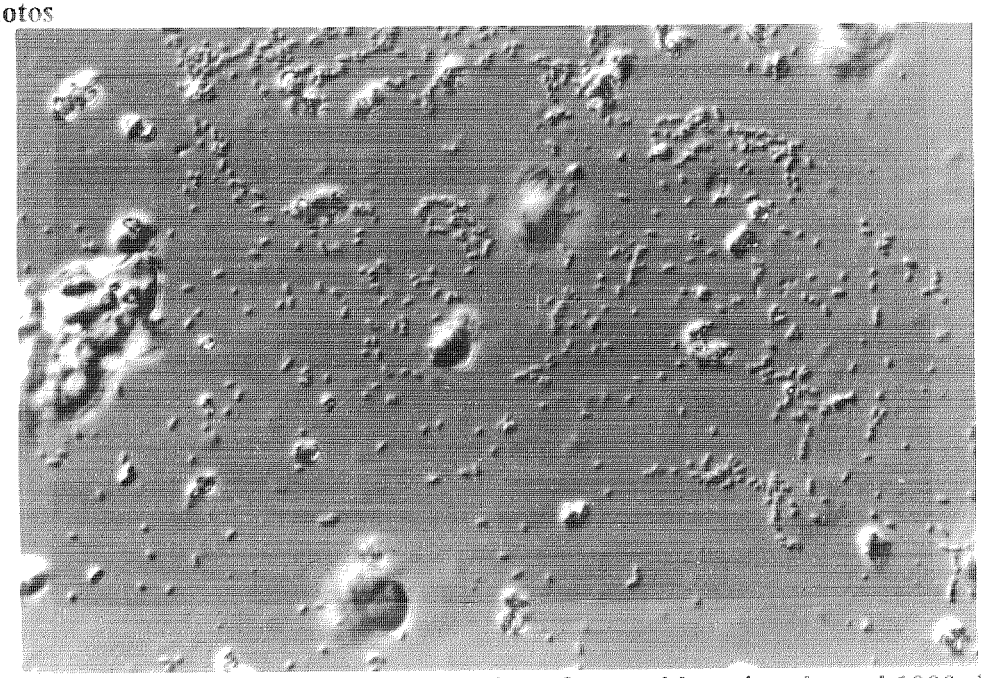

Figure 2: Photograph taken when thiobacillus ferrooxidans is enlarged 1000 times by microscope.

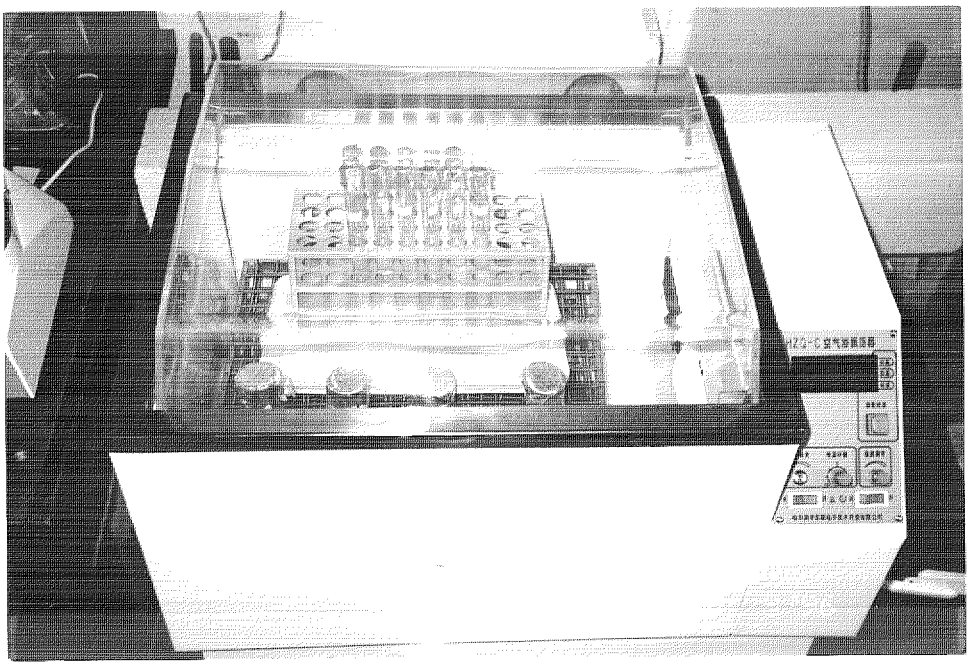

Figure 3: thiobacillus ferrooxidans cultivator: HRQ-C air pre-vibrator

Figure 4: Storage area of L slag raw material

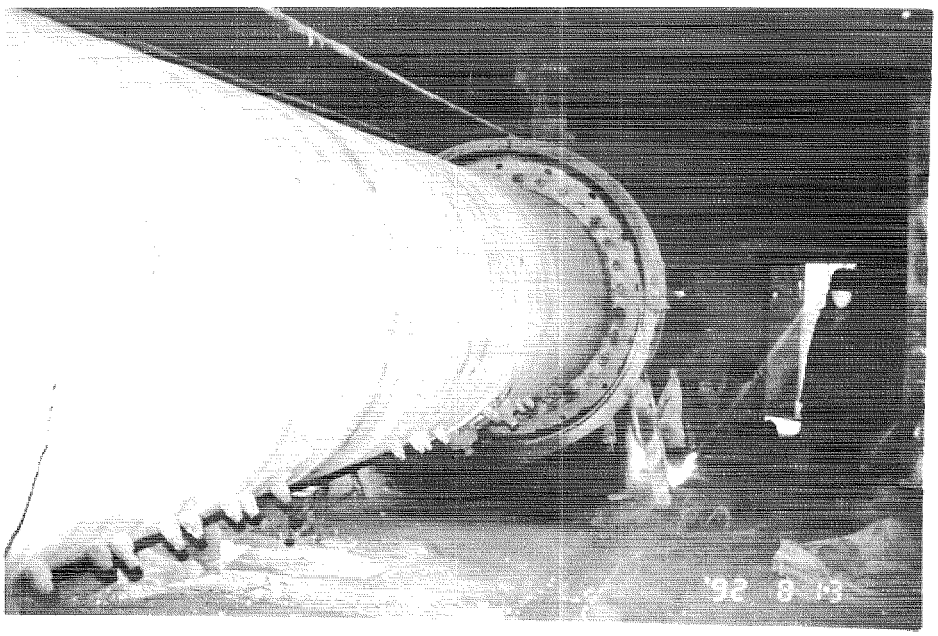

Figure 5: L slag cement production line

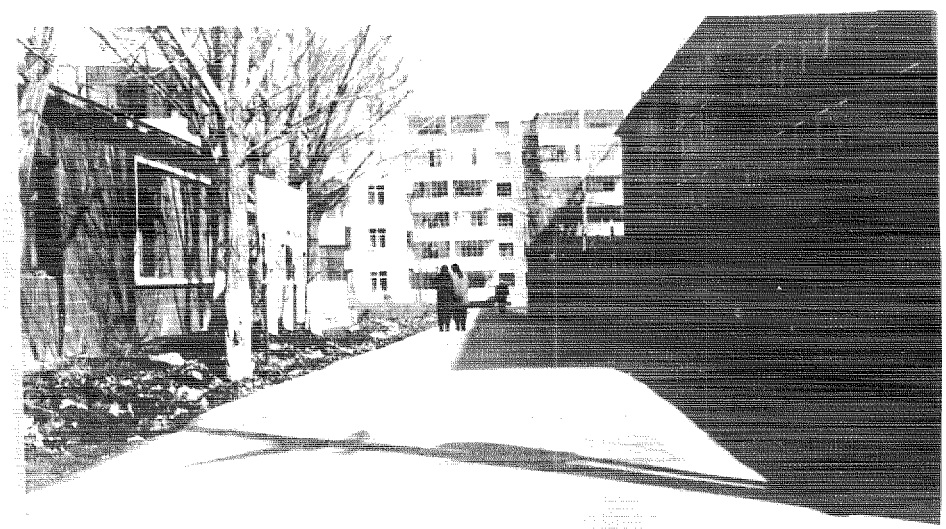

Figure 6: L slag concrete surface road

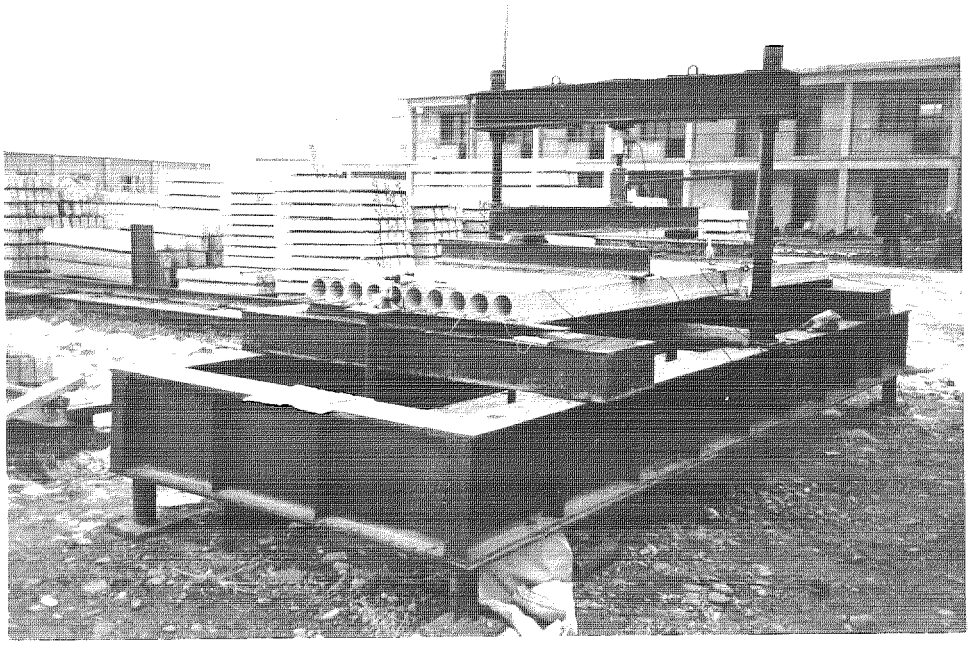

Figure 7: Structure check of perforated plates made of L slag concrete

3. DGB Type Decolourant for Environment Protection

With the rapid development of dye industry, the water system in China is under serious pollution. Each year about 160 million cubic meters of waste water composing dye materials are discarded into the water system. These dyed waste waters have complicated composition, high concentration, and colourity, large amounts of indegradable substances. It is difficult to treat this water with conventional methods mainly due to the high cost. BGRIMM has successfully developed DGB type decolourant, which uses inorganic minerals as raw material, and is manufactured by the technology combining physical and chemical methods. DGB can eliminate high density colours in the dye waste waters and reduce such pollutants as COD and BOD, etc. from such water, and make the quality of treated water up to the relevant discard standard.

3.1 Characteristics and properties

DGB decolourant is a kind of black powder, without toxicity or odour. Applying DGB type decolourant to treating high colourity waste water from dye chemical engineering industry is characterised by high speed and efficiency in decolouring with decolouring rate over 95%, simple treatment technology, low engineering investment and treatment cost; moreover, the new material itself is non-toxic. It can be reused after regeneration by appropriate method, and when being ineffective, it can be burnt without causing any pollution. It is a new type product for environment protection on the market nowadays, and welcomed by customers both at home and abroad.

3.2 Application cases

It is used in treating the waste water from Chemical Engineering Plant of Hangkun Enterprise, Zhejiang Province, China. This plant manufactures various kinds of dye, such as ZBLN and HGL etc., with annual production of 1000 t, and discards waste water amounting to 1500-2000t/d. The treatment result with DGB type decolourant is shown in the following table 2:

Table2 Result of waste water treatment at Hangkun Dye Plant

Waste water	PH	Colourity (dilution)	CoDcr* mg/L
Before treatment	2-3	1000 - 1500	1000
After treatment	8-9	<50	200-300

Note: CoDcr - Chemical oxygen consumption (Kcr_2o_7 method)

The treatment cost for DGB decolourant is 0.3-0.36 USD/M^3 waste water.

The adsorption spectrums of untreated and treated waste waters by DGB type decolourant are shown in the Figure 8 below:

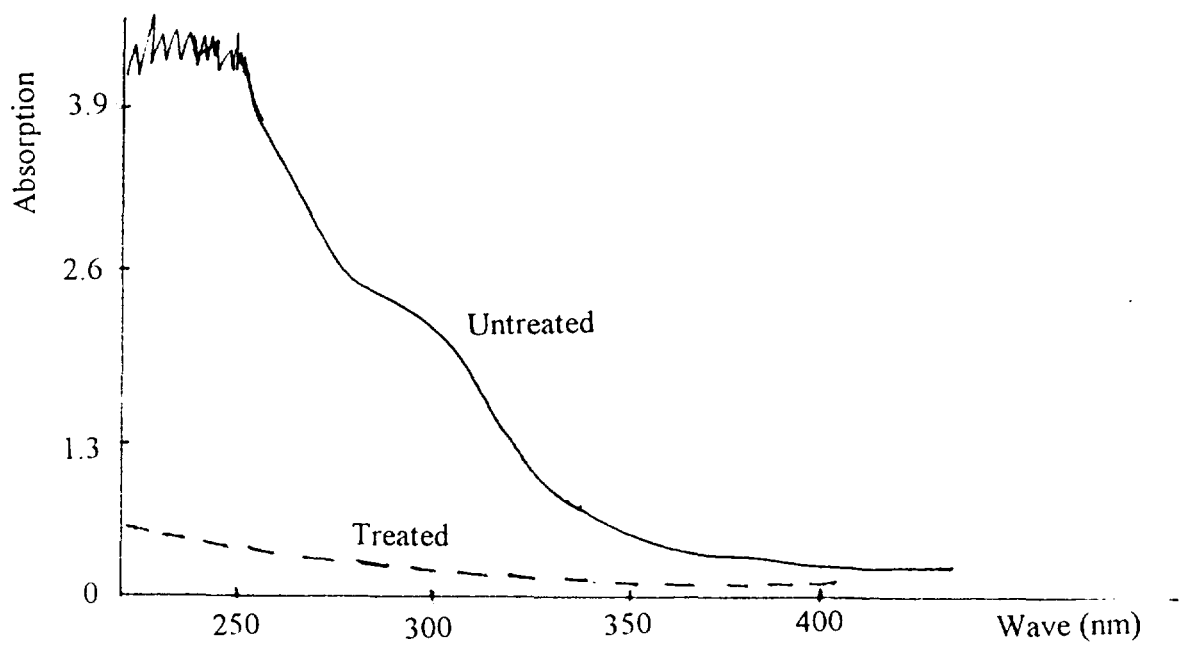

Figure 8: Comparison of adsorption spectrums of treated and untreated water

3.3 Photos

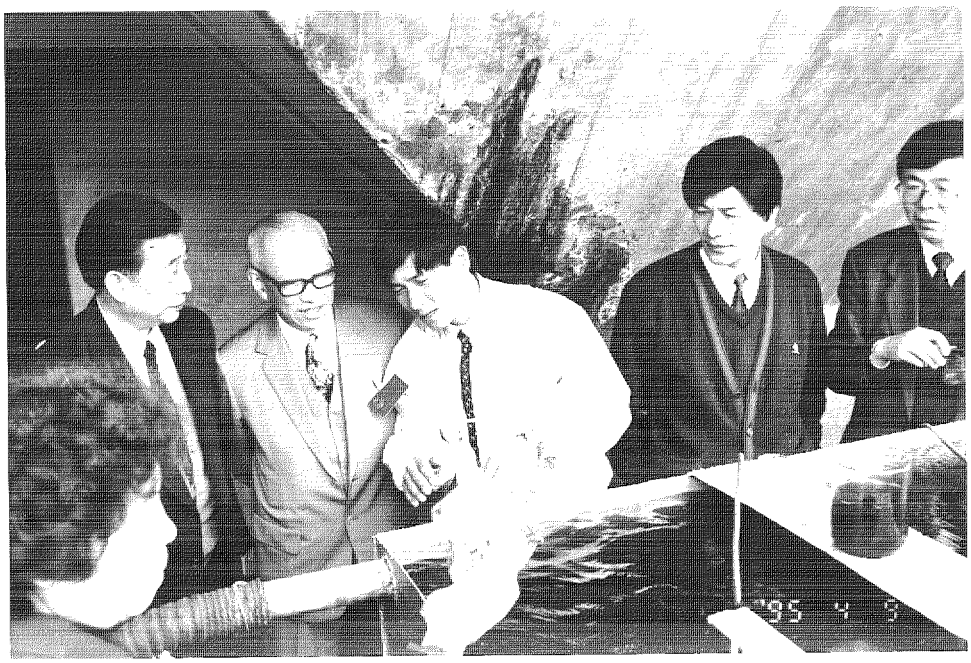

Figure 9: Specialists are watching the commercial test on treating dye waste water

Figure 10: The treatment of waste water from mine explosives with DGB type decolourant

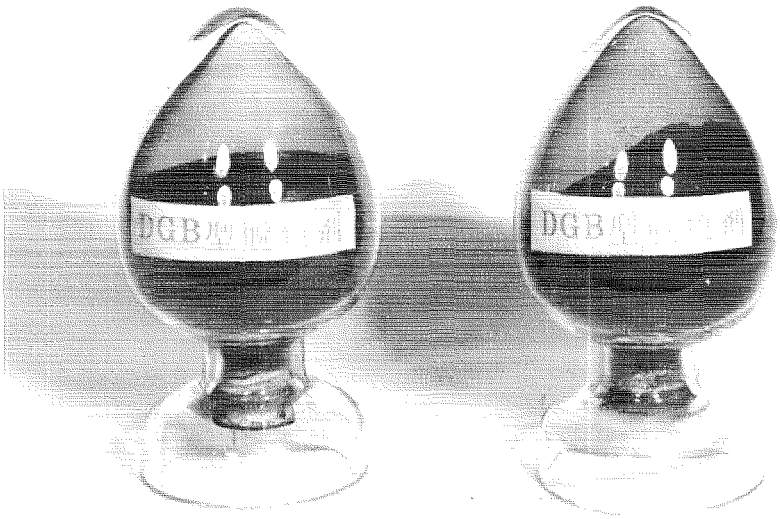

Figure 11: DGB decolourant