An Overview of Mineral Processing

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Following mining, preparation of ores for metal extraction in case of metallic ores, or production of end product in case of non-metallic ores and coal.

- Ore Dressing
- Mineral Dressing
- Concentration
- Milling
- Beneficiation
- Mineral Processing

Size Reduction
(Comminution)

To break apart and liberate valuable minerals from unwanted waste minerals by

- Crushing
- Grinding

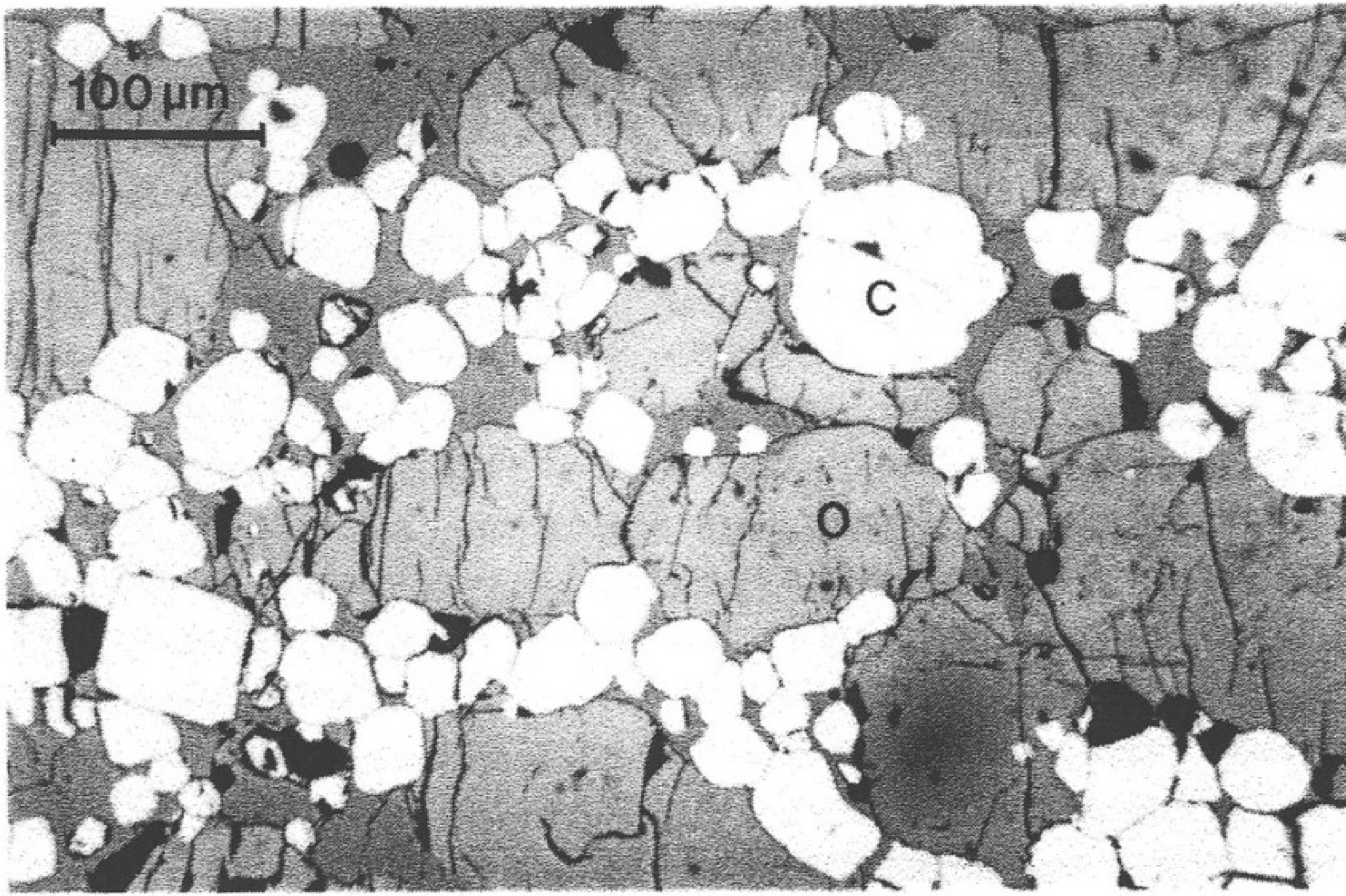
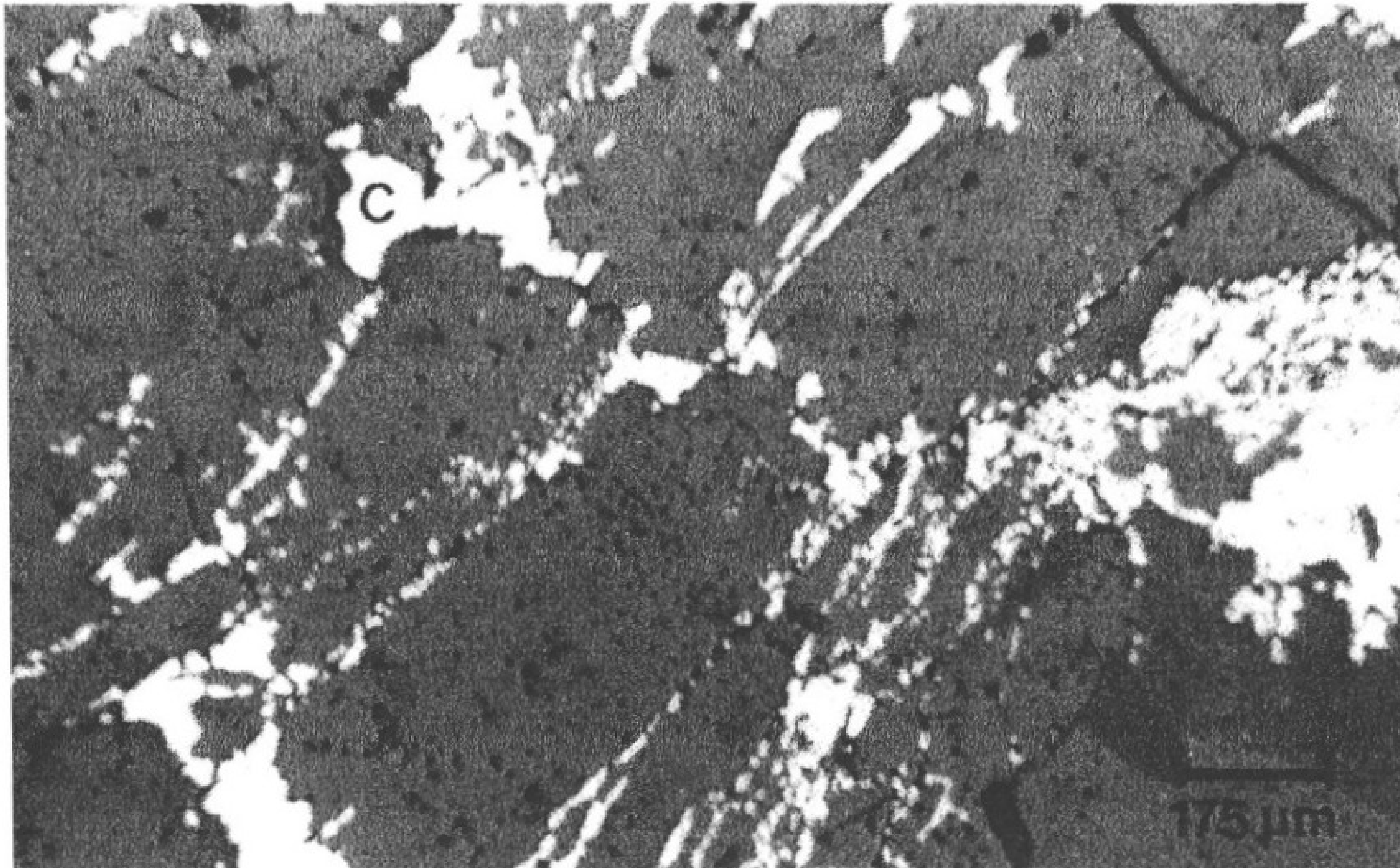


FIG. 1.2a. South African chromite ore. Relatively coarse grain size, and compact morphology of chromite (C) grains makes liberation from olivine (O) gangue fairly straightforward.



'. North American porphyry copper ore. Chalcopyrite (C) precipitated along in quartz. Liberation of chalcopyrite fairly difficult due to "chain-like" on. Fracture is, however, likely to occur preferentially along the sealed , producing particles with a surface coating of chalcopyrite, which can be

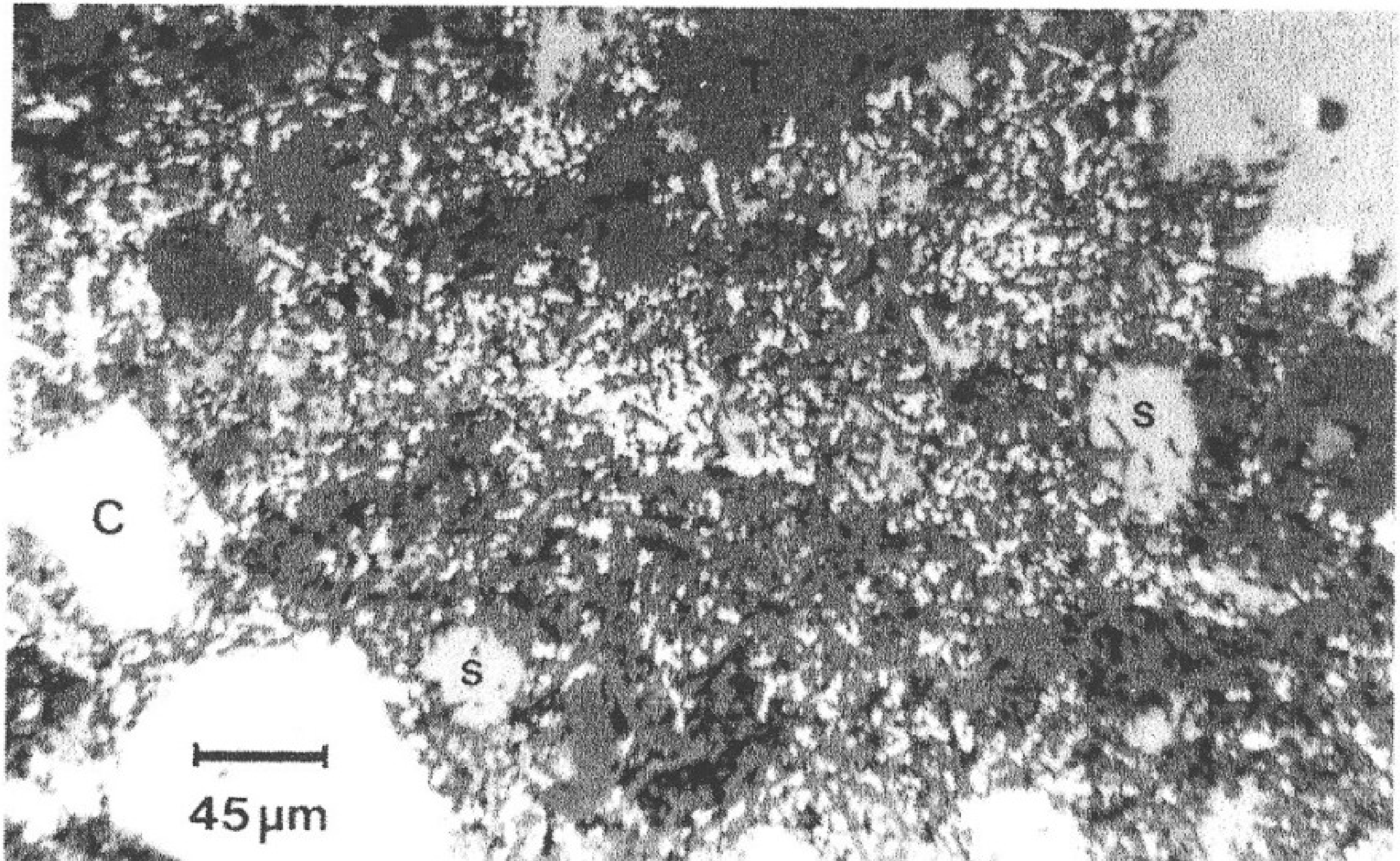
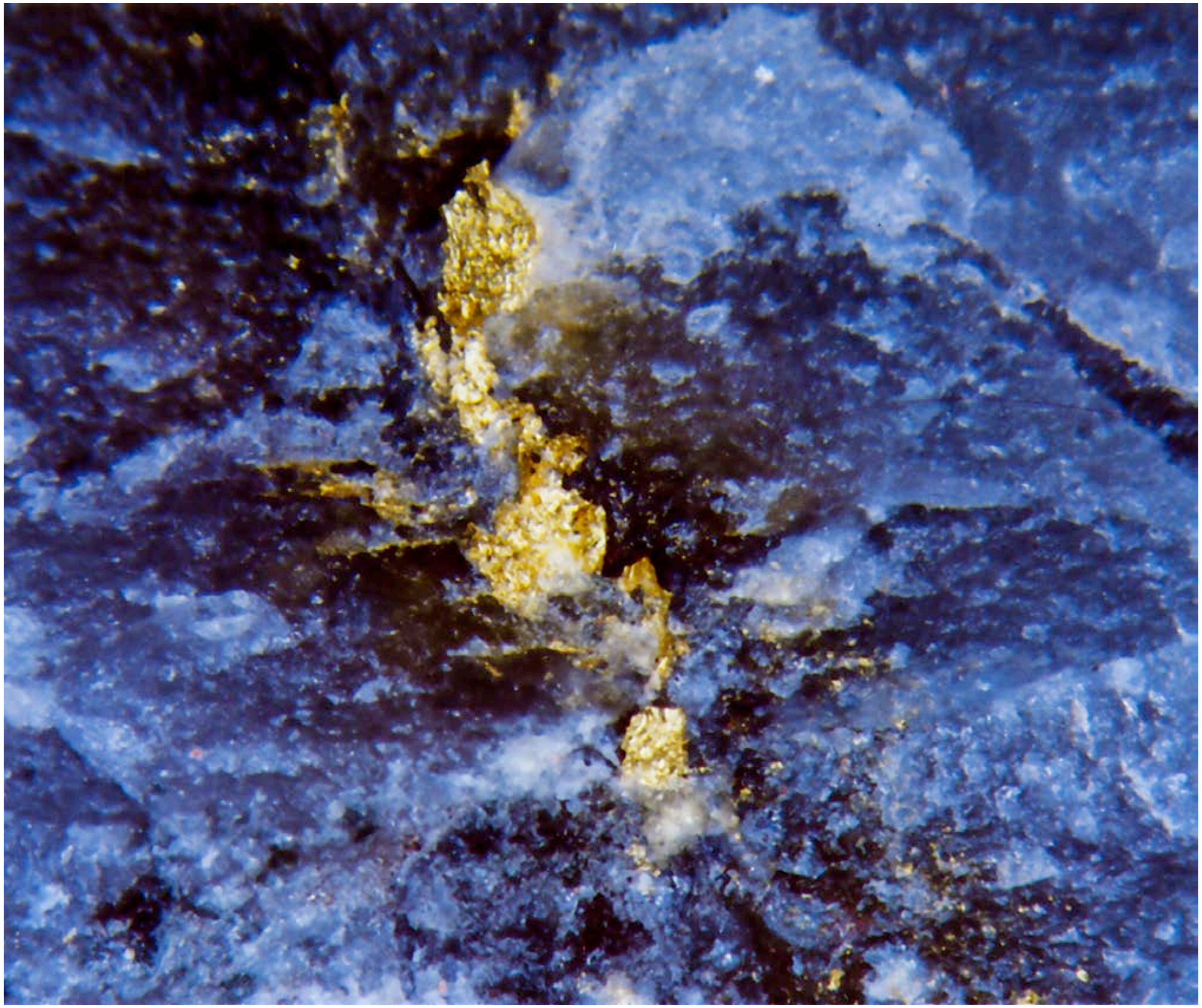
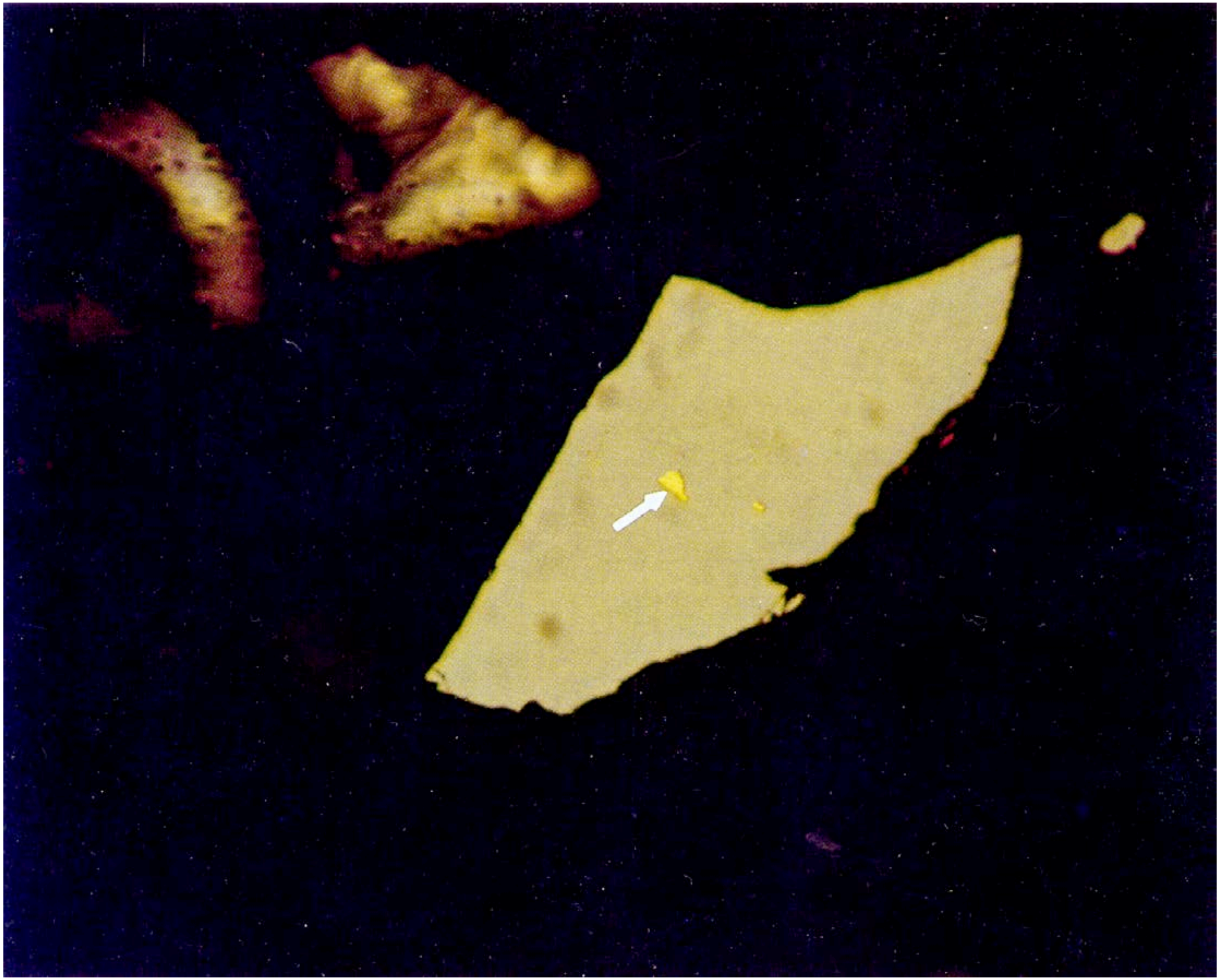


FIG. 1.2c. Mixed sulphide ore, Wheal Jane, Cornwall. Chalcopyrite (C) and sphalerite (S), much of which is extremely finely disseminated in tourmaline (T), making a high degree of liberation impracticable.

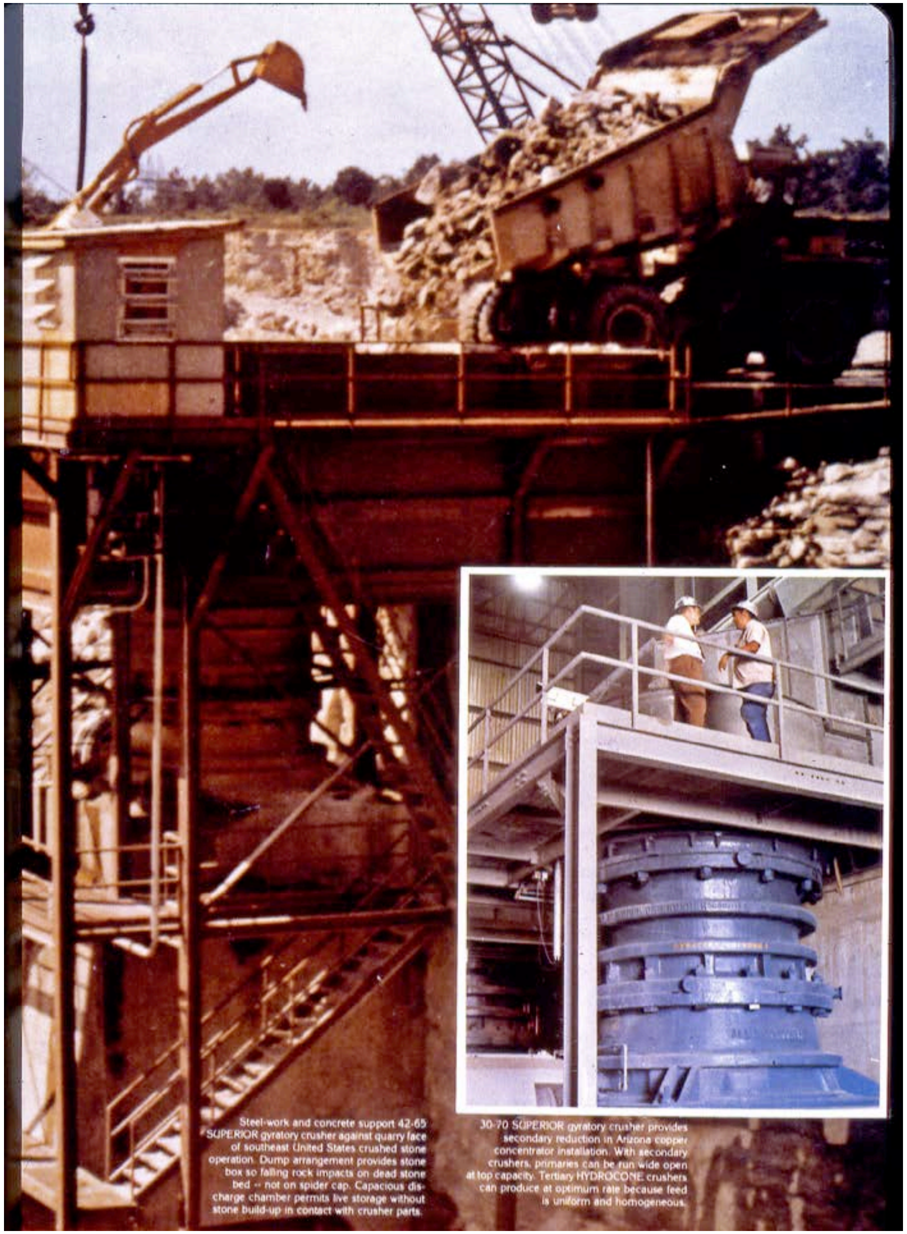
Free-Milling Gold



Refractory Gold in Pyrite

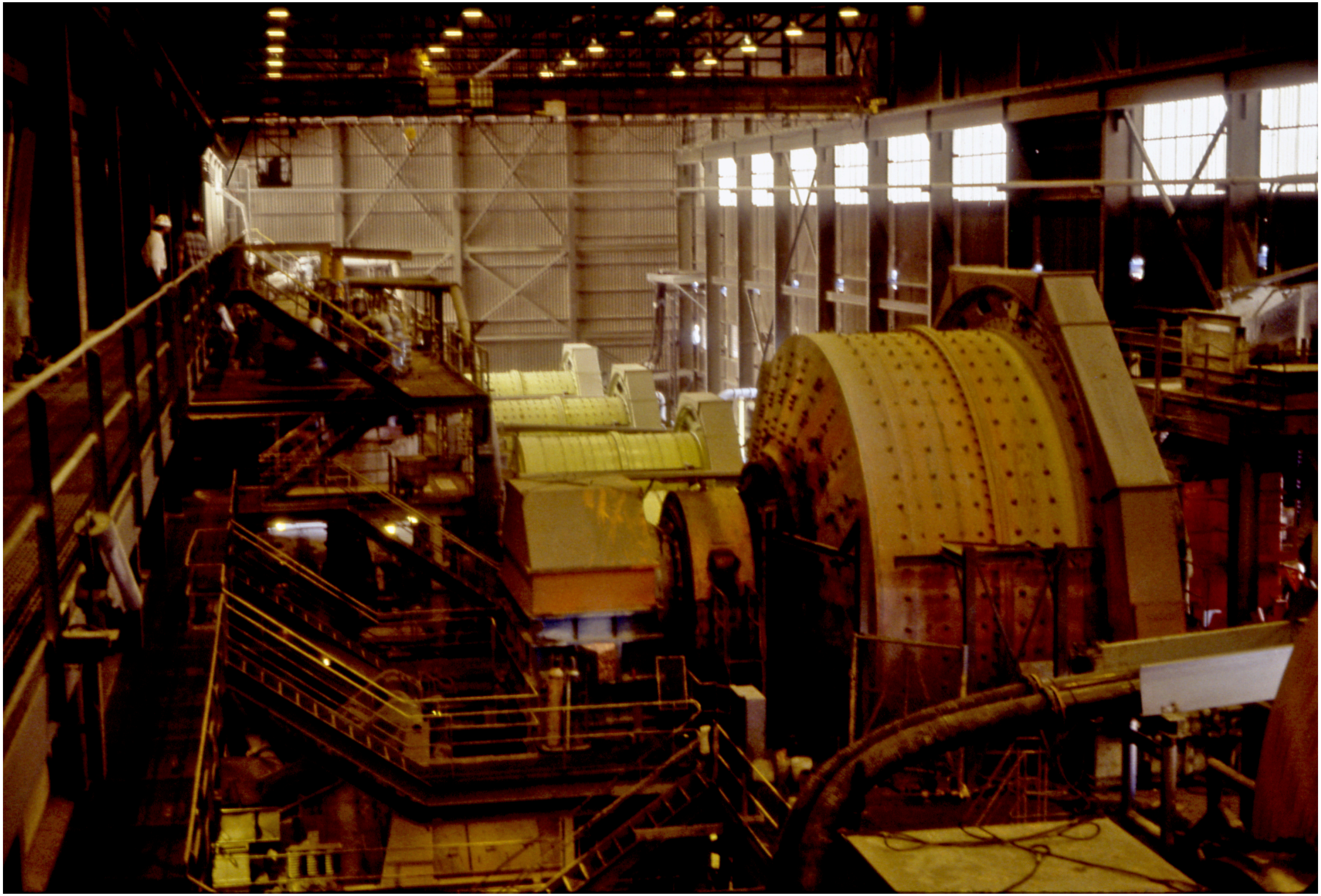


Gyratory Crusher



Coarse Ore Stockpile

SAG and Ball Mill Grinding



Ore Fragmentation after Grinding

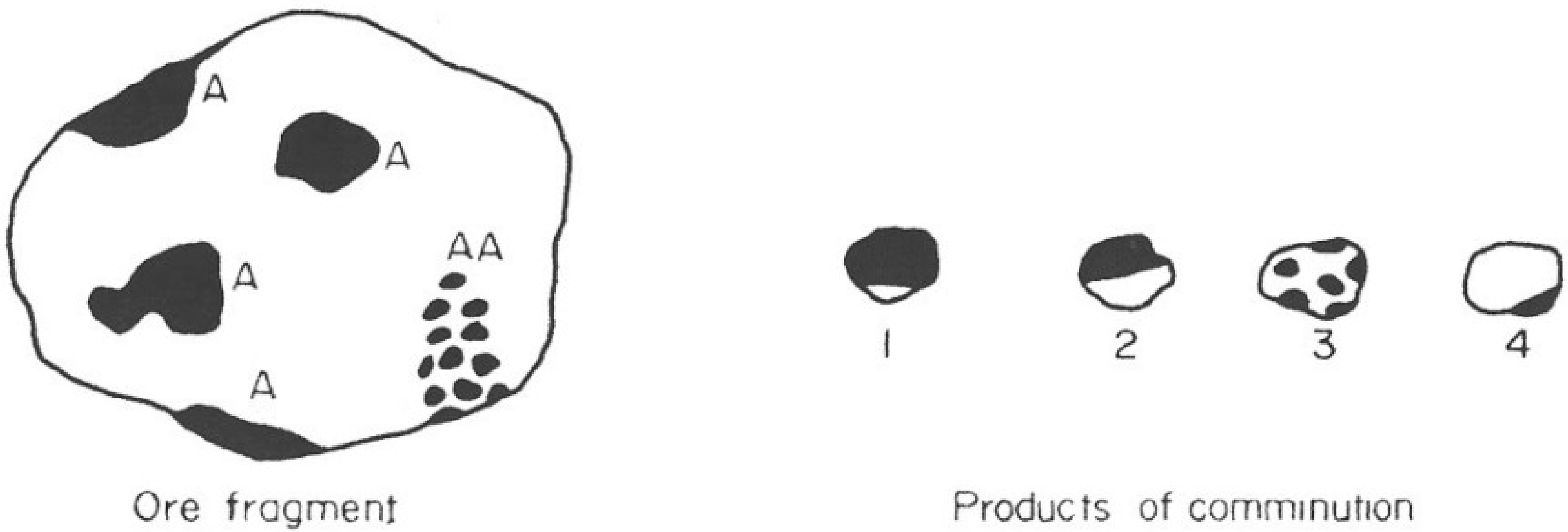


FIG. 1.6. Cross-sections of ore particles.

Minerals Separation

- Gravity Concentration
  - Spiral
  - Shaking Table
  - Jigging
  - Sluice
  - Heavy Media Separation

Gravity Concentration Principles

- Gravity concentration methods separate minerals of different specific gravity by their relative movement in a fluid medium, in response to gravity and other forces.
- For efficient separation heavy particles from the light particles the gravity separation feed must be closely sized.

Terminal Settling Velocity

- Stoke's Law: Free Settling $\quad d<50\ \mu m$

  $$v_t = gd^2 (D_s - D_f) / 18\eta$$

Newton's Law: Turbulent Settling $\quad d>500\ \mu m$

$$v_t = \{(3gd (Ds - Df)) / Df \}^{½}$$

V= Terminal velocity g= Gravitational Acceleration

d= Particle diameter η= Viscosity of Fluid Medium

Ds= Density of Solid Df= Density of Fluid

Settling velocity of particles depends on both particle size and specific gravity

Double-Start Spiral concentrators

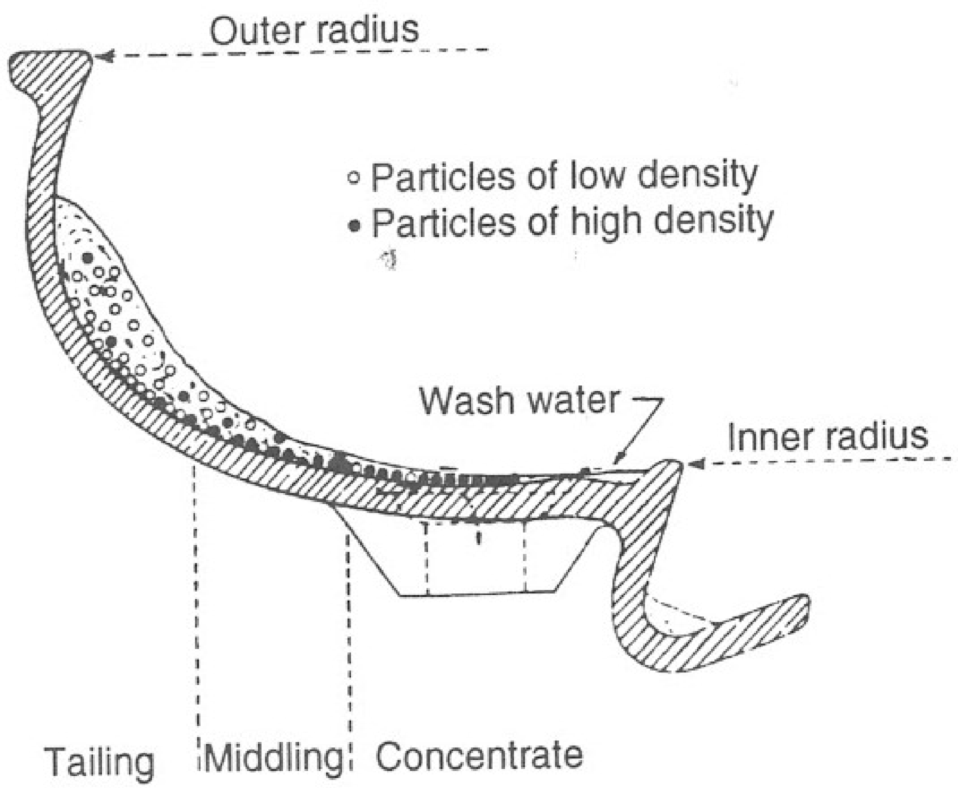


Figure 10.22 Cross-section of spiral stream

Spirals on Heavy Mineral Sands Dredges

Heavy Mineral Sands Mining Dredge

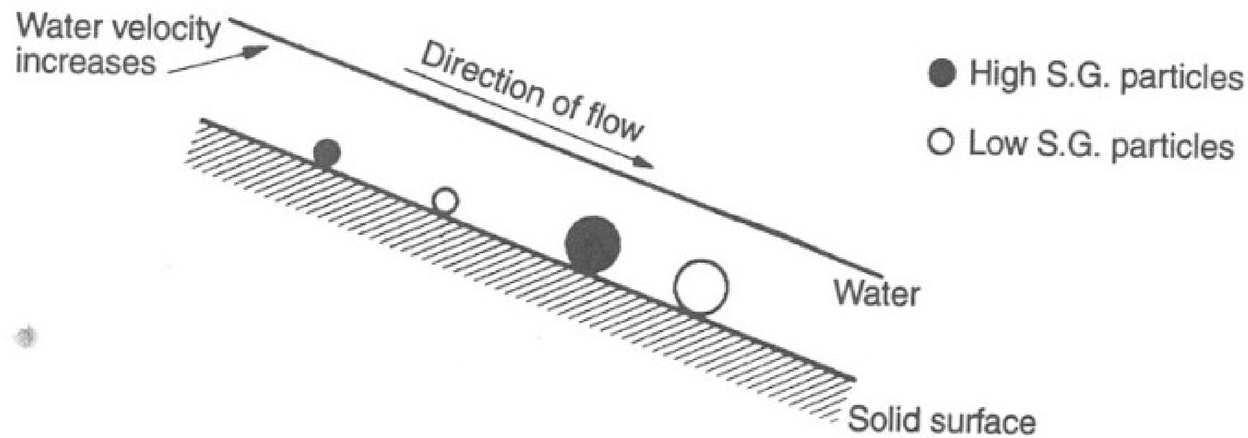


Figure 10.23 Action in a flowing film

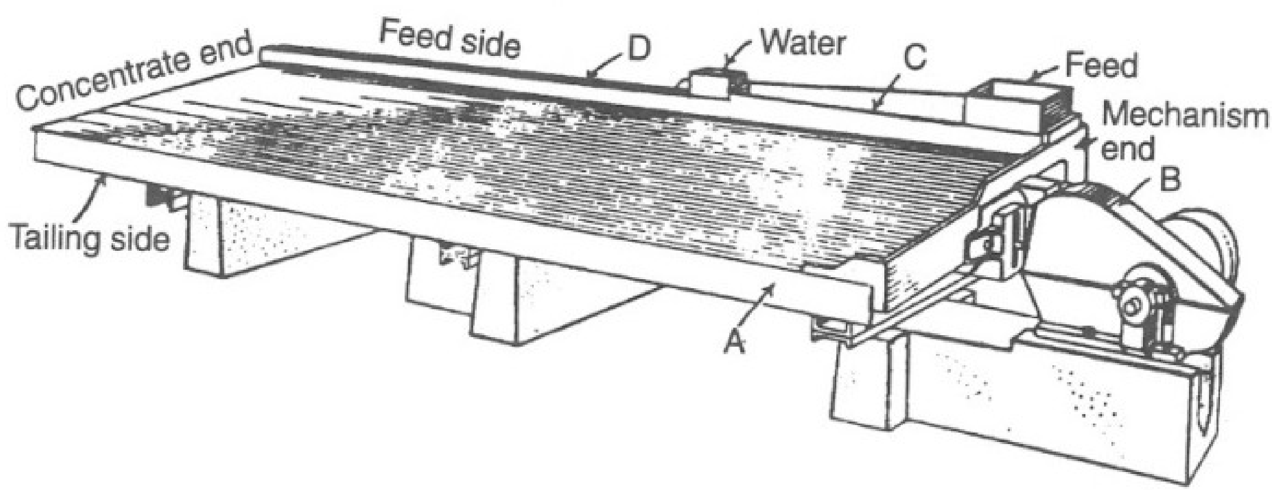
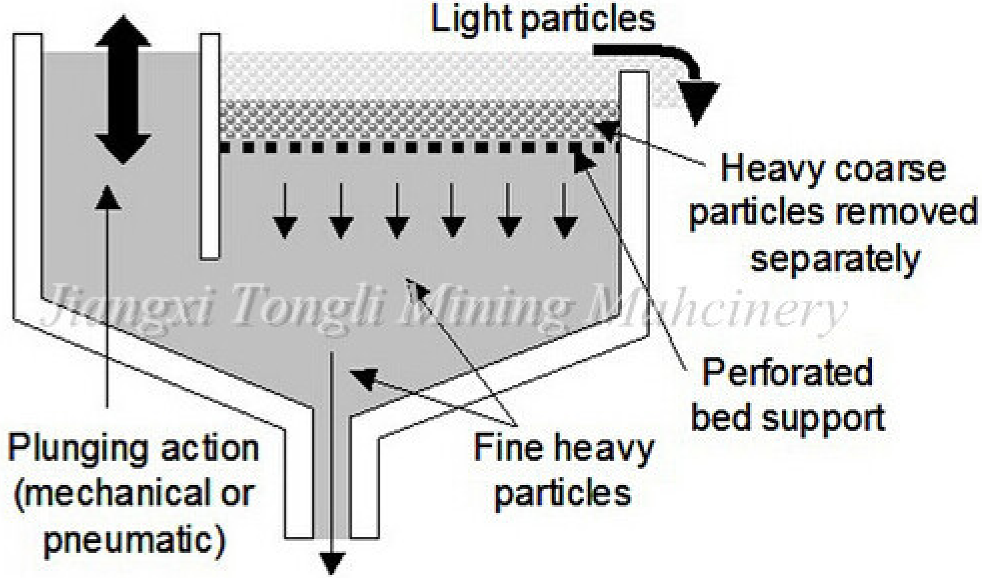


Figure 10.24 Shaking table

Heavy Minerals Separation on Shaking Table

Scrap Copper Processing with Shaking Table

Mineral Jig


Light particles
Heavy coarse particles removed separately
Perforated bed support
Fine heavy particles
Plunging action (mechanical or pneumatic)
Jiangxi Tongli Mining Mahcinery


JXSC Mine Machinery Factory

Magnetic Separation

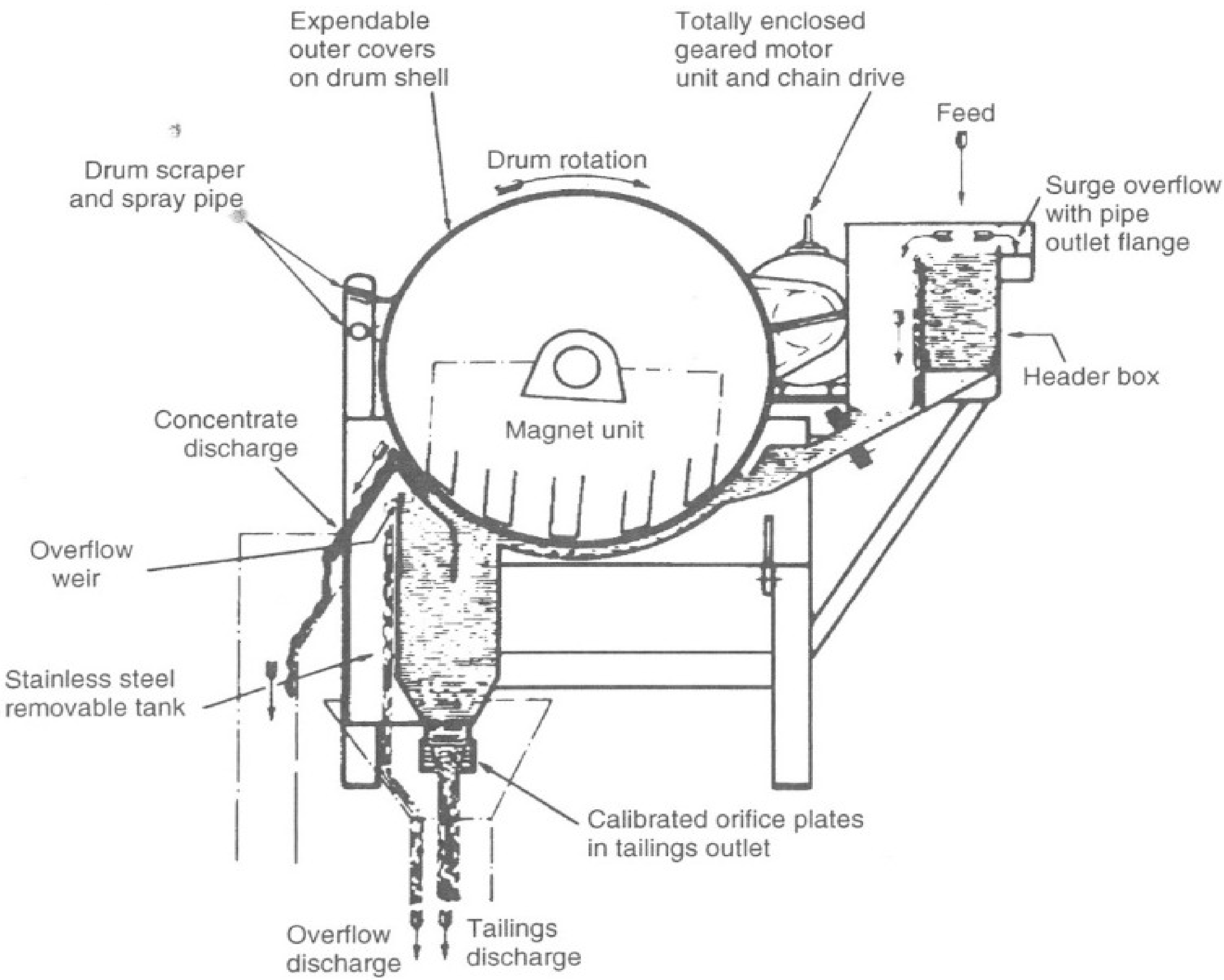
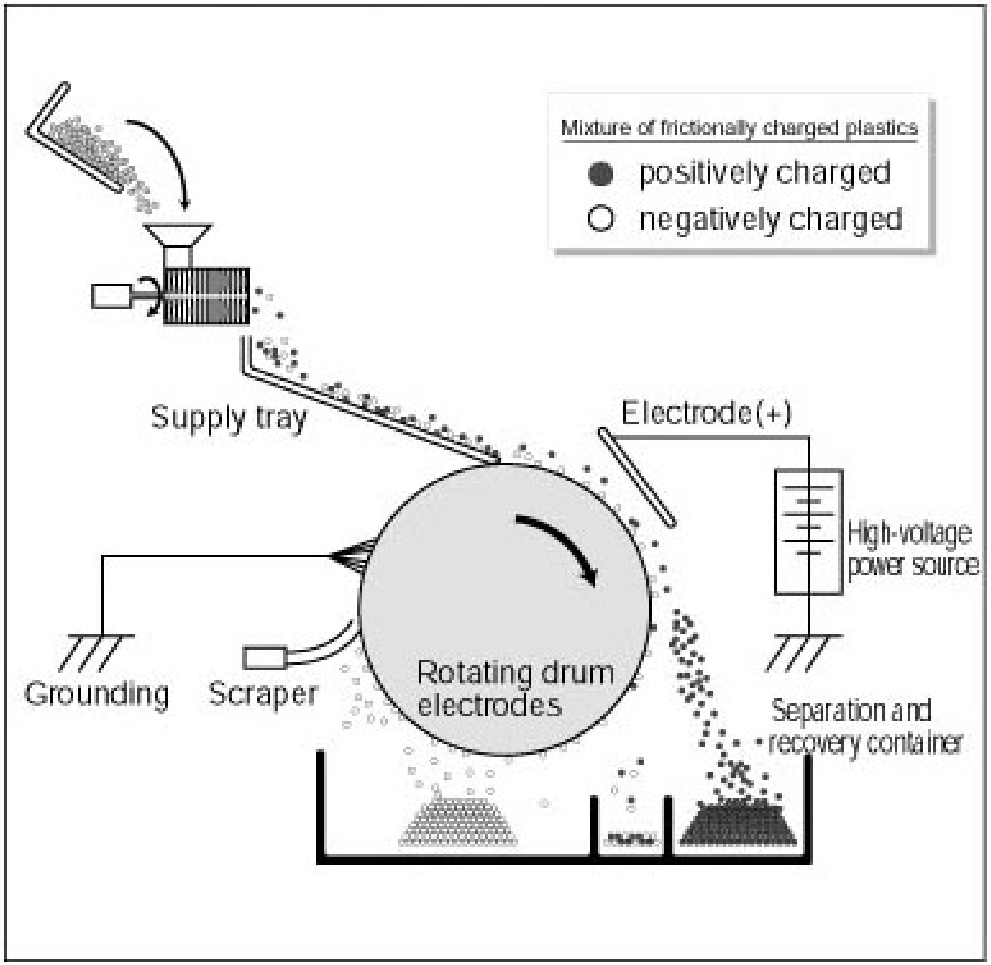


Figure 13.6 Drum separator

Magnetic Drum Separator

Electrostatic Separator



behaviour, as the surface charges on a coarse grain are lower in relation to its mass than on a fine grain. Thus a coarse grain is more readily thrown from the roll surface, and the conducting fraction often contains a small proportion of coarse non-conductors. Similarly, the finer particles are most influenced by the surface charge, and the non-conducting fraction often contains some fine conducting particles.

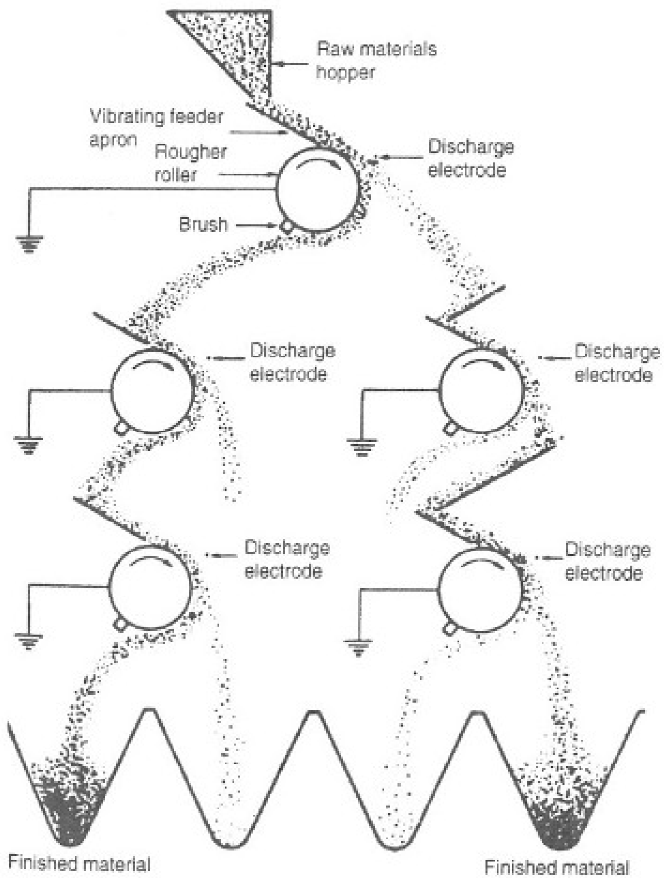


Figure 13.22 Arrangement of separators in practice

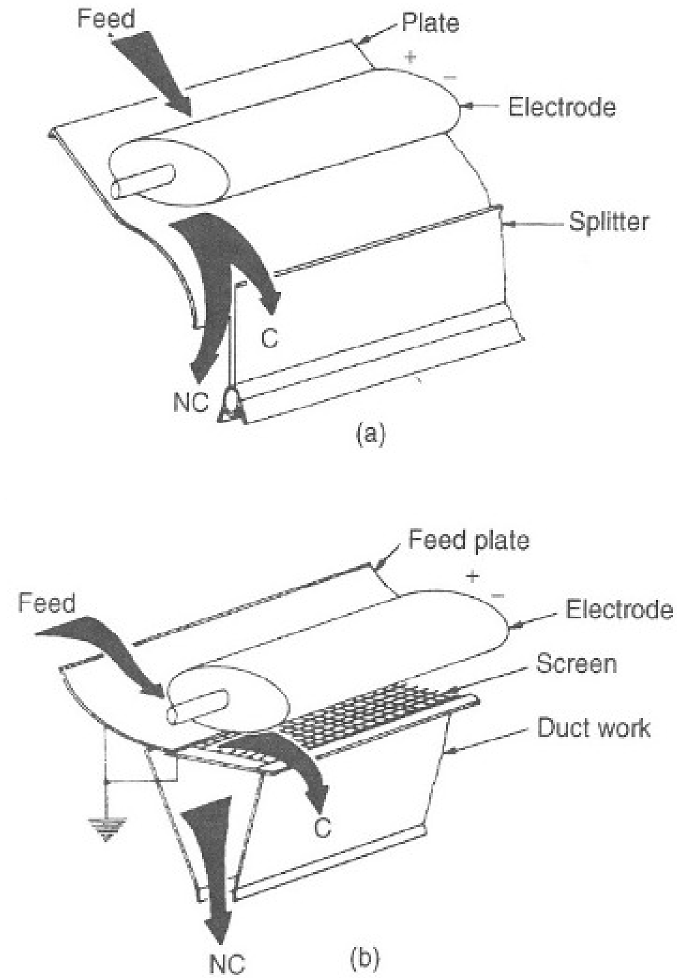


Figure 13.23 (a) Plate and (b) screen electrostatic separators

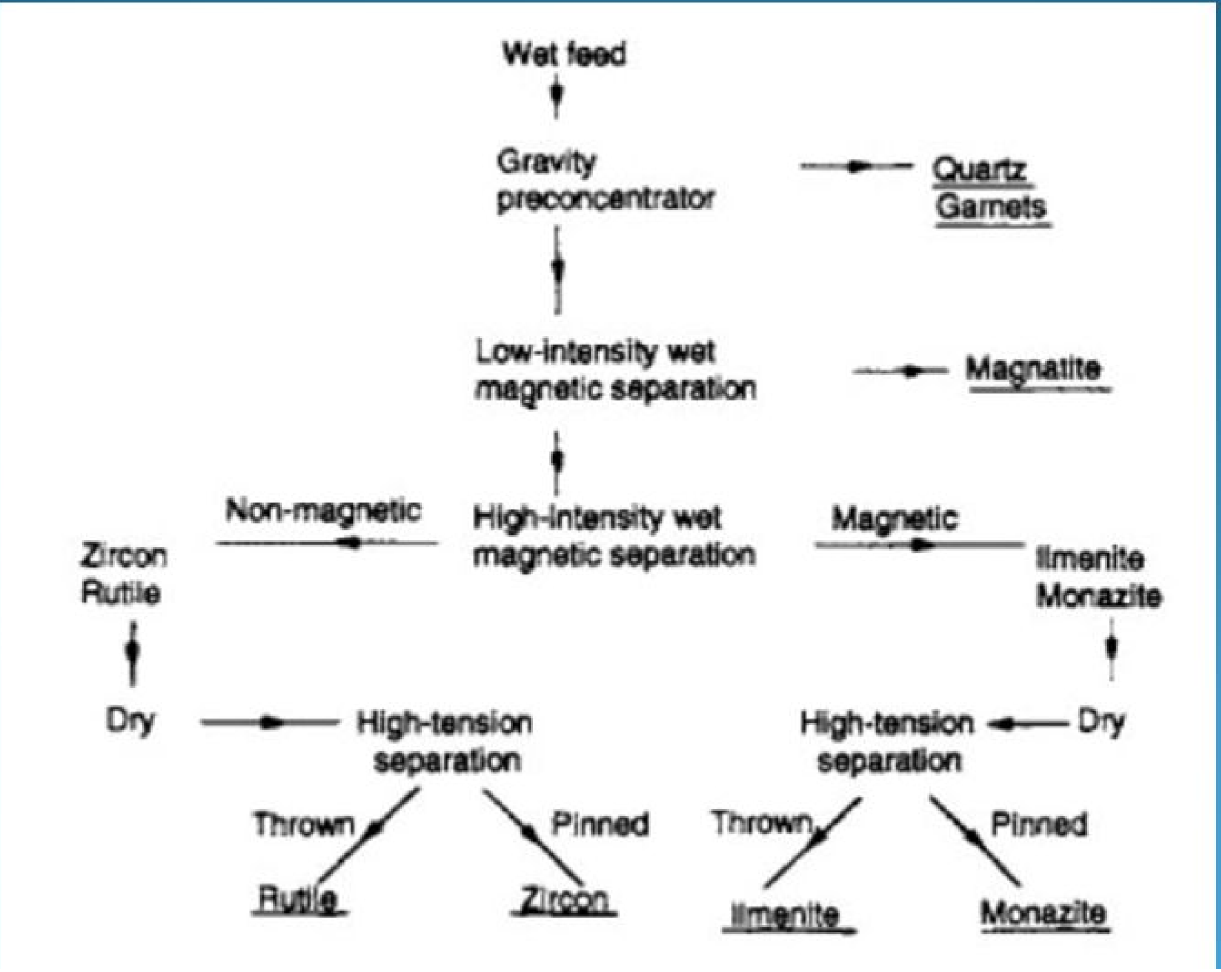
The electrostatic field is effectively shorted through the conducting particles, which are lifted towards the charged electrode in order to decrease the energy of the system. Non-conductor grains are poorly affected by the field. The fine grains are most affected by the lifting


READING
03-03-ER-034
Rutile RER 2

GINKGO MINE AND WET CONCENTRATION PLANT

CRISTAL

Beach Sand Processing for R-E and Zr



Froth Flotation

- Utilizes the differences in physico-chemical surface properties of mineral particles. Sought-after mineral treated with reagents to render its surface hydrophobic and attach itself to air bubble to rise to the surface.

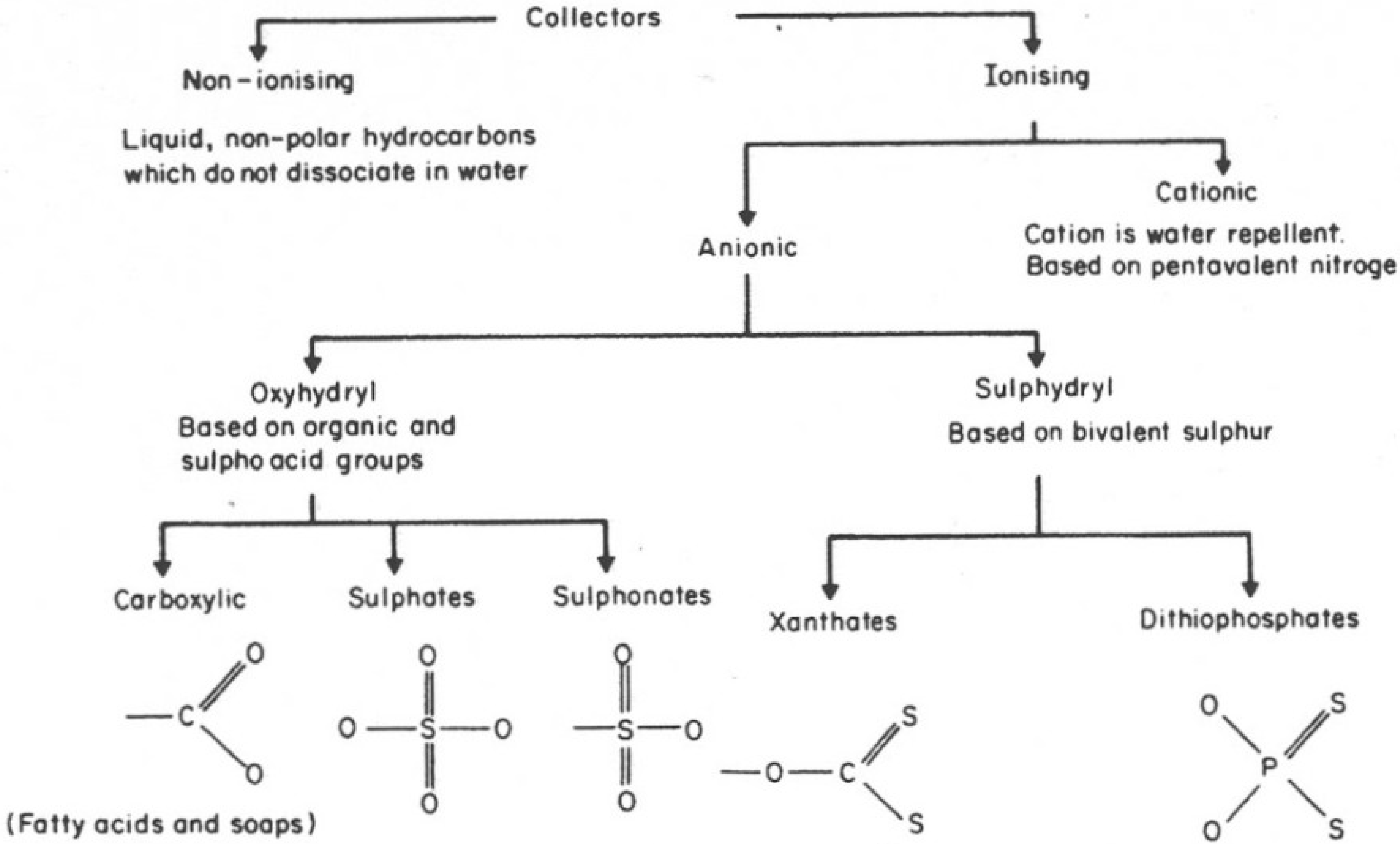


FIG. 12.4. Classification of collectors (after Glembotskii *et al.*[21]).

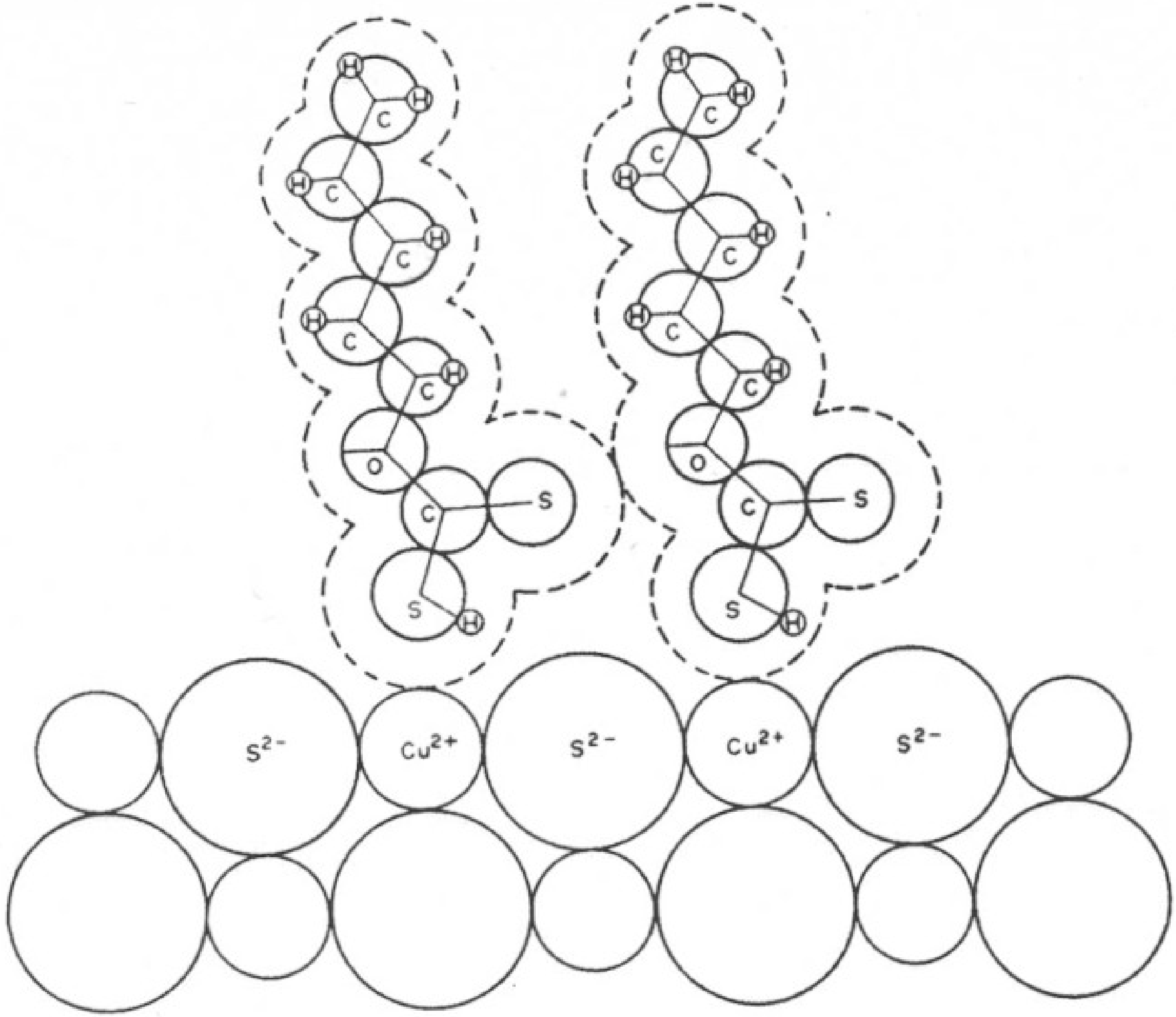
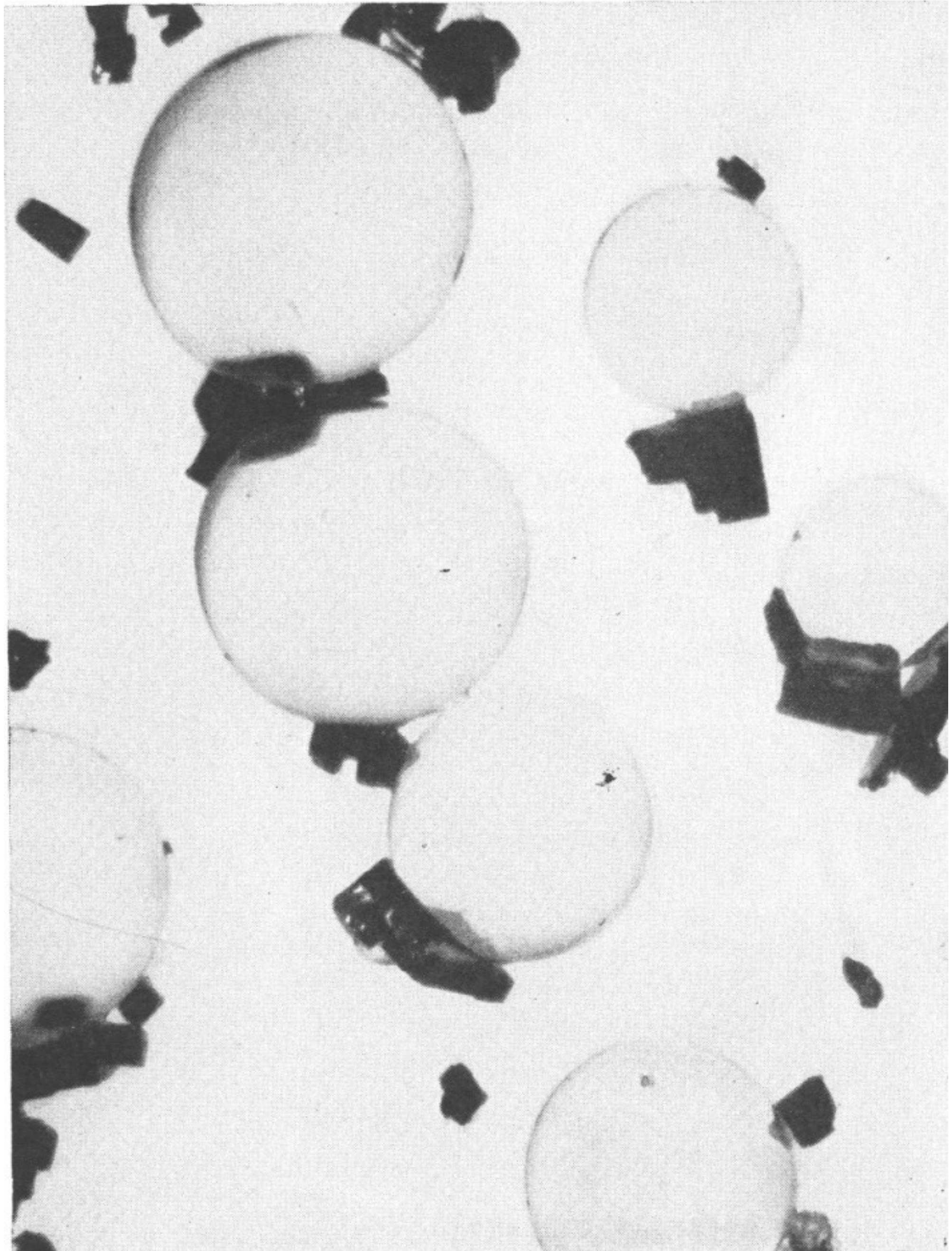


FIG. 3.8. Sketch Showing the Attachment of Amyl Xanthate Ions to Covellite. There is a hydrogen atom hidden behind each carbon of the hydrocarbon chain (after Hagihara, 1952).



Flotation in action. *(Courtesy of H. Rush Spedden.)*

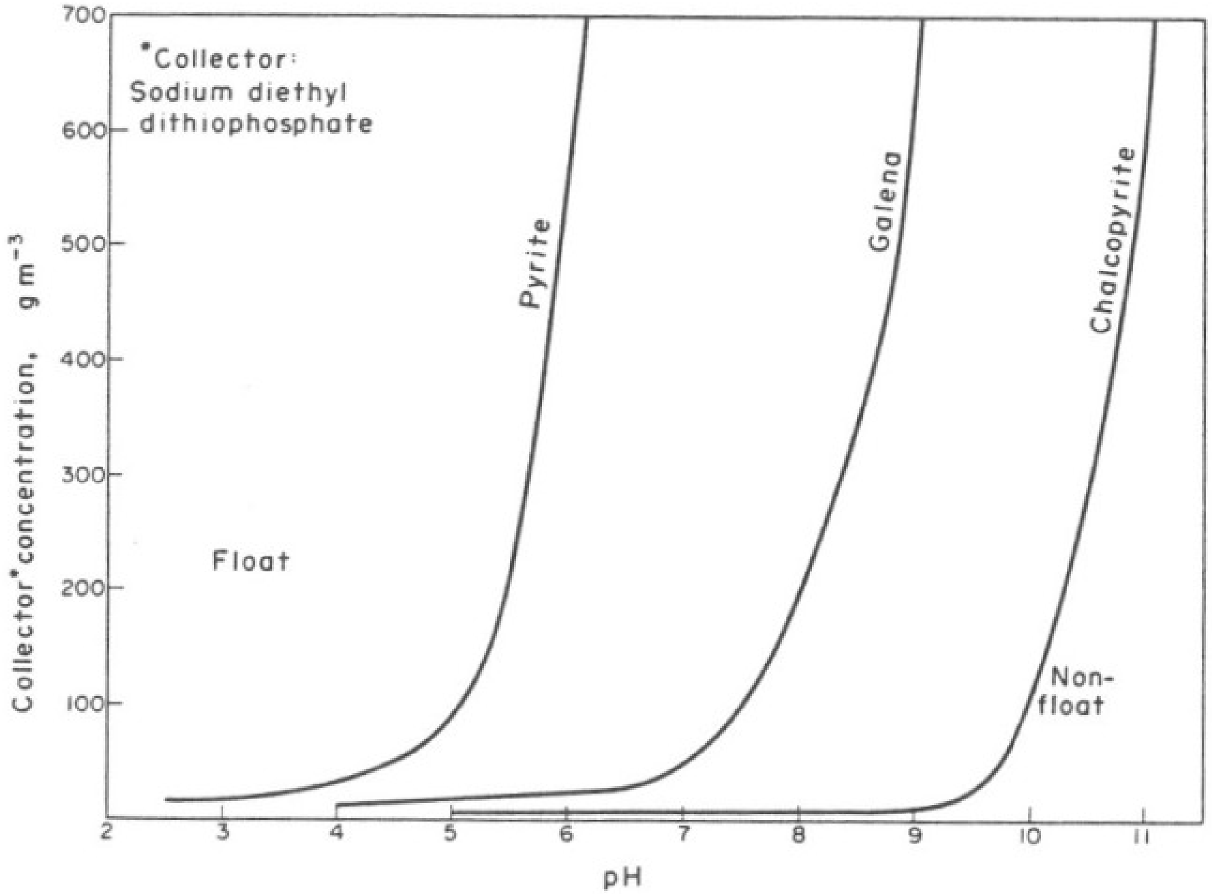


FIG. 3.9. Effects of Collector Concentration and pH on the Floatability of Pyrite, Galena and Chalcopyrite. Each line marks the boundary between 'float' and 'non-float' conditions for the specific mineral (Wark and Cox, 1934). Exact float/non-float boundary positions depend on the collector and on the water and mineral compositions.

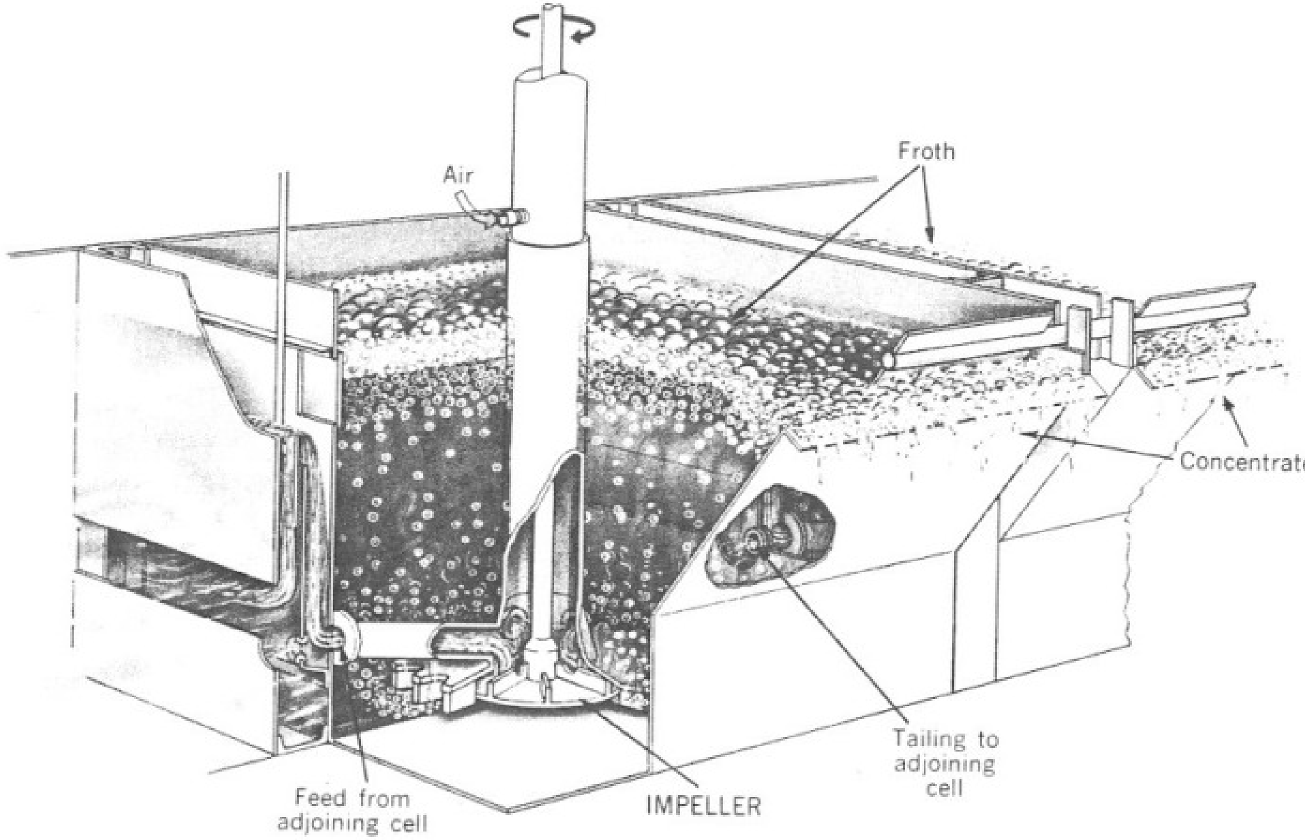


FIG. 3.7. Cutaway View of Subaeration (Mechanical) Flotation Cell. The method of producing bubbles and gathering froth are shown (Boldt and Queneau, 1967 courtesy Inco Limited). Modern cells are typically 15 to 100 m^3 in volume (Lawrence, 1993).

Copper Sulfide Flotation Concentrate

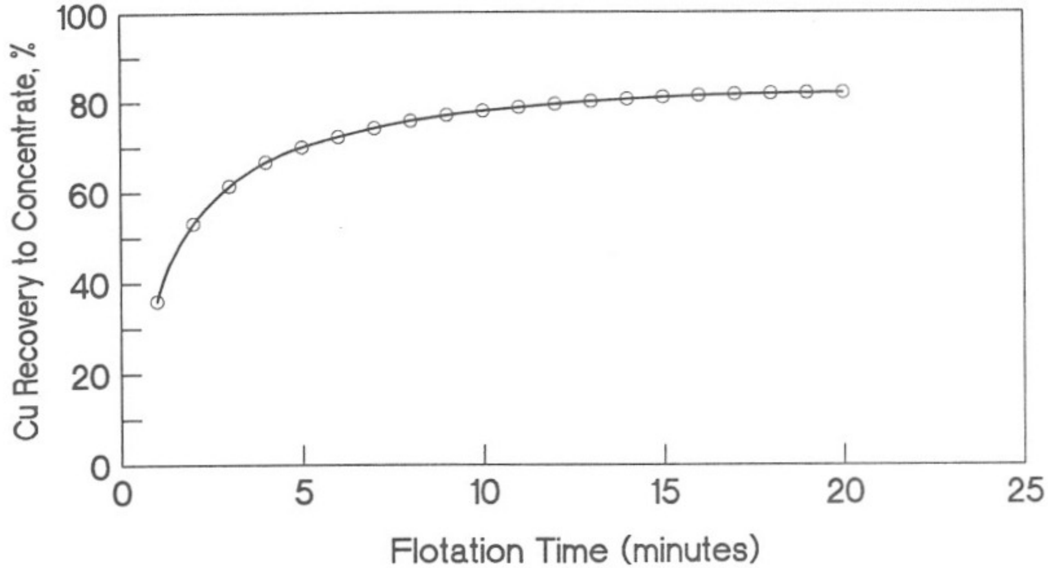


FIG. 3.12. Copper Recovery to Concentrate in Rougher-Scavenger Cells as a Function of Flotation Time in Rougher-Scavenger Cells (Metcalf, Arizona Concentrator, Dowling and Travis, 1993).

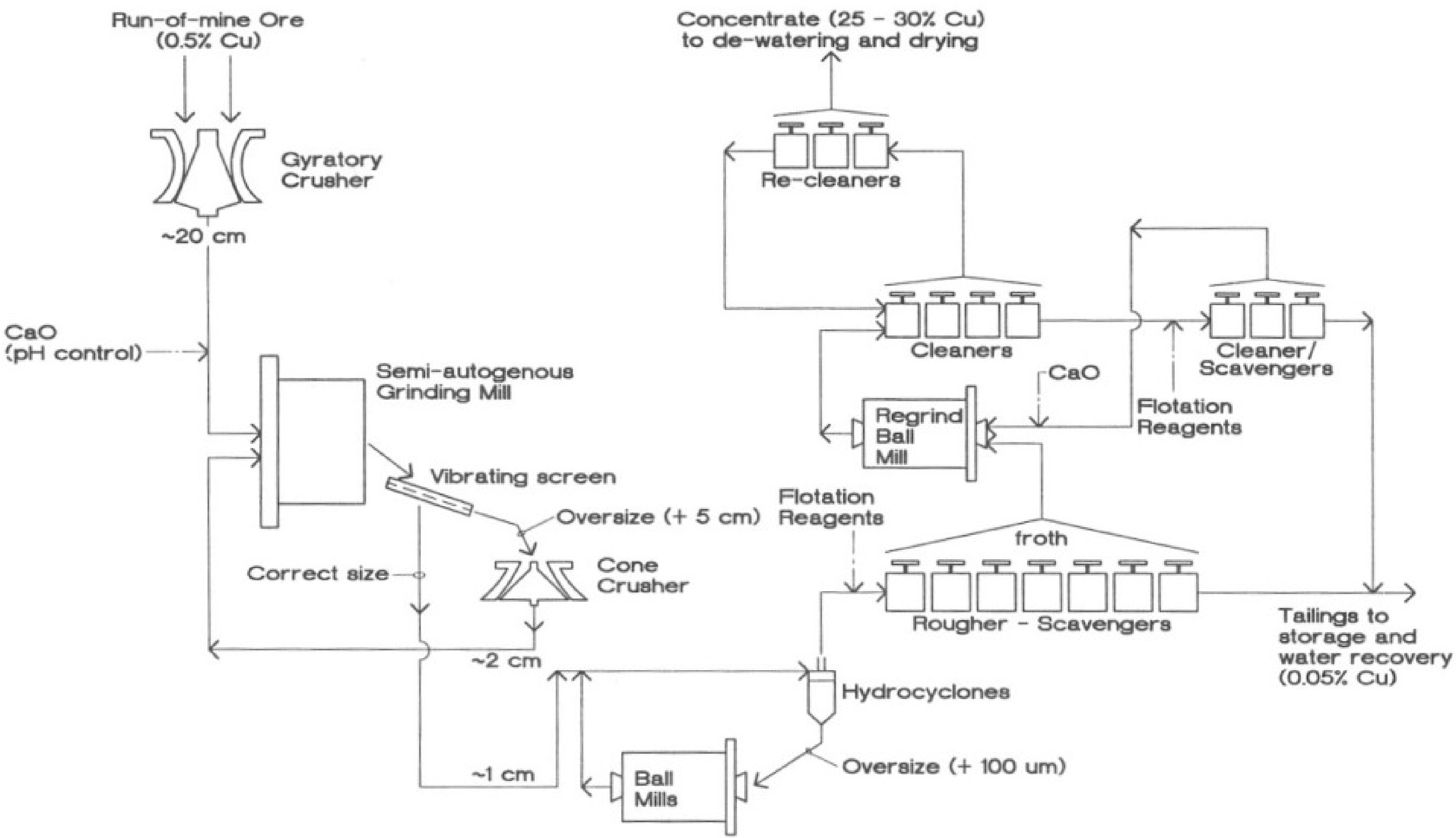


FIG. 3.1. Generalized Flowsheet for Production of Copper Concentrates from Copper Sulphide-Iron Sulphide Ores.

Tailings Thickeners

Miami (Arizona) Copper Smelter

Miami Copper Tailing Piles

Rehabilitation of Tailing Piles

Re-mining High Copper Oxide Tailings

Acid Leaching of Oxide Tailings

Solvent Extraction of Copper

Solvent Extraction of Copper

- Extraction Stage:

$$2RH\ (org) + Cu^{2+}\ (aq) \rightarrow R_2Cu\ (org) + 2H^+\ (aq)$$

Barren Organic PLS Loaded Organic Acid

- Stripping Stage:

$$R_2Cu\ (org) + 2H^+\ (aq) \rightarrow Cu^{2+}\ (aq) + 2RH\ (org)$$

Loaded Organic Spent Electrolyte Strong Electrolyte Stripped Organic

Electrowinning Tankhouse

Electrowinning of Copper

- Cathode:

$$Cu^{2+}\ (aq) + 2e \rightarrow Cu^{o}$$

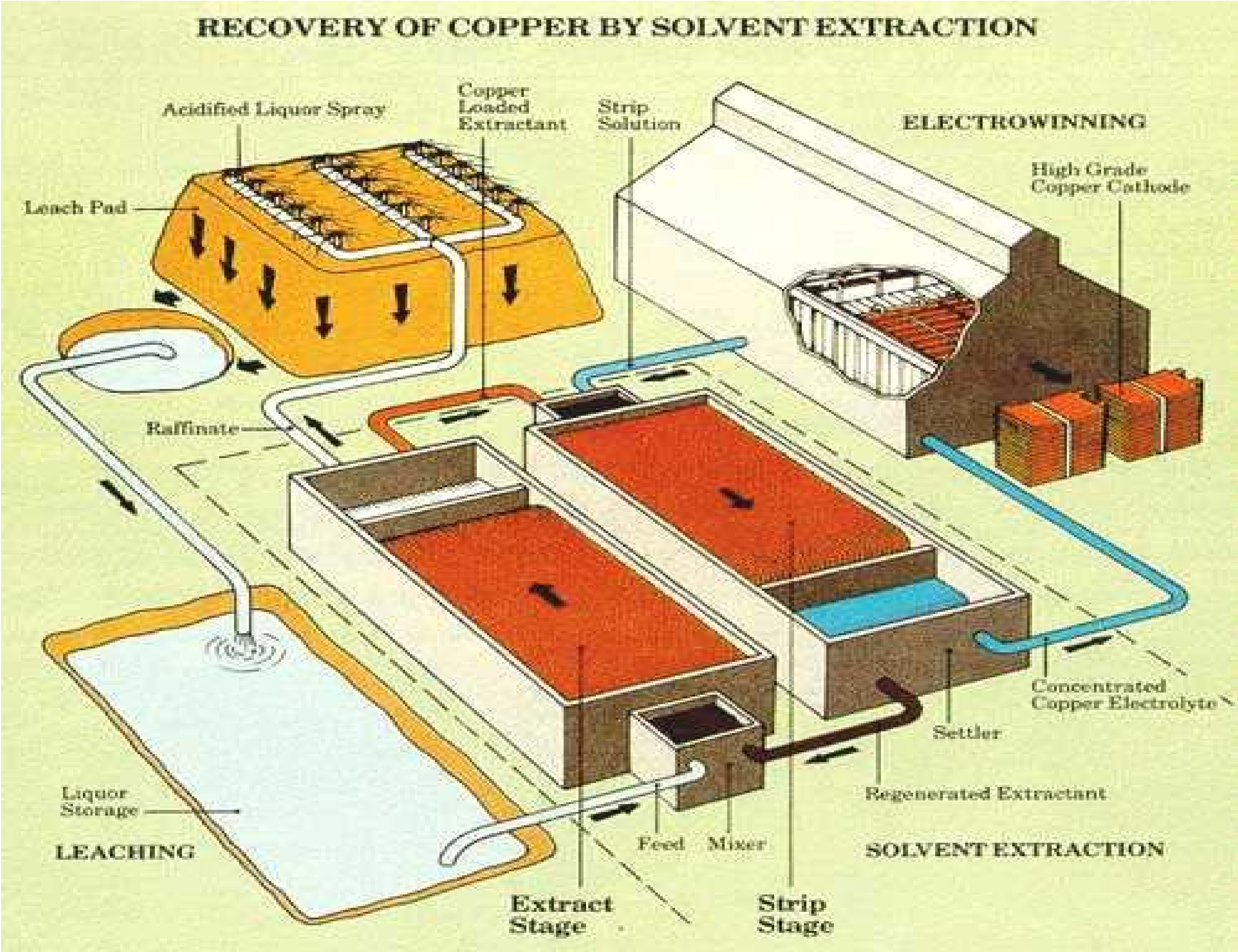
- Anode:

$$H_2O \rightarrow 1/2O_2\ (g) + 2H^{+}(aq) + 2e$$

- Overall Rx:

$$Cu^{2+}\ (aq) + H_2O \rightarrow Cu^{o} + 1/2O_2 + 2H^{+}$$

Heap Leaching Run-of-Mine Ore


RECOVERY OF COPPER BY SOLVENT EXTRACTION
Acidified Liquor Spray
Copper Loaded Extractant
Strip Solution
ELECTROWINNING
High Grade Copper Cathode
Leach Pad
Raffinate
Concentrated Copper Electrolyte
Settler
Regenerated Extractant
Liquor Storage
LEACHING
Feed
Mixer
SOLVENT EXTRACTION
Extract Stage
Strip Stage

Electrolytic Copper

Scrap Iron for Copper Cementation

Old Cementation Launders

Recovery of Sphalerite and Garnet from Hanover Empire Zinc Mine Tailings

- Recovery of zinc and garnet from four small tailing piles were studies before they were removed and placed on the large (#1) pile. After light grinding and desliming, zinc sulfide was floated, followed by sulfidization and zinc oxide flotation. Garnet was recovered from flotation tailings by gravity separation. Although smelter grade zinc concentrate was obtainable, the capital and operating costs of a new flotation plant were not justified. Garnet concentrate was mostly andredite and poor quality due to particle size and pyroxene contamination.

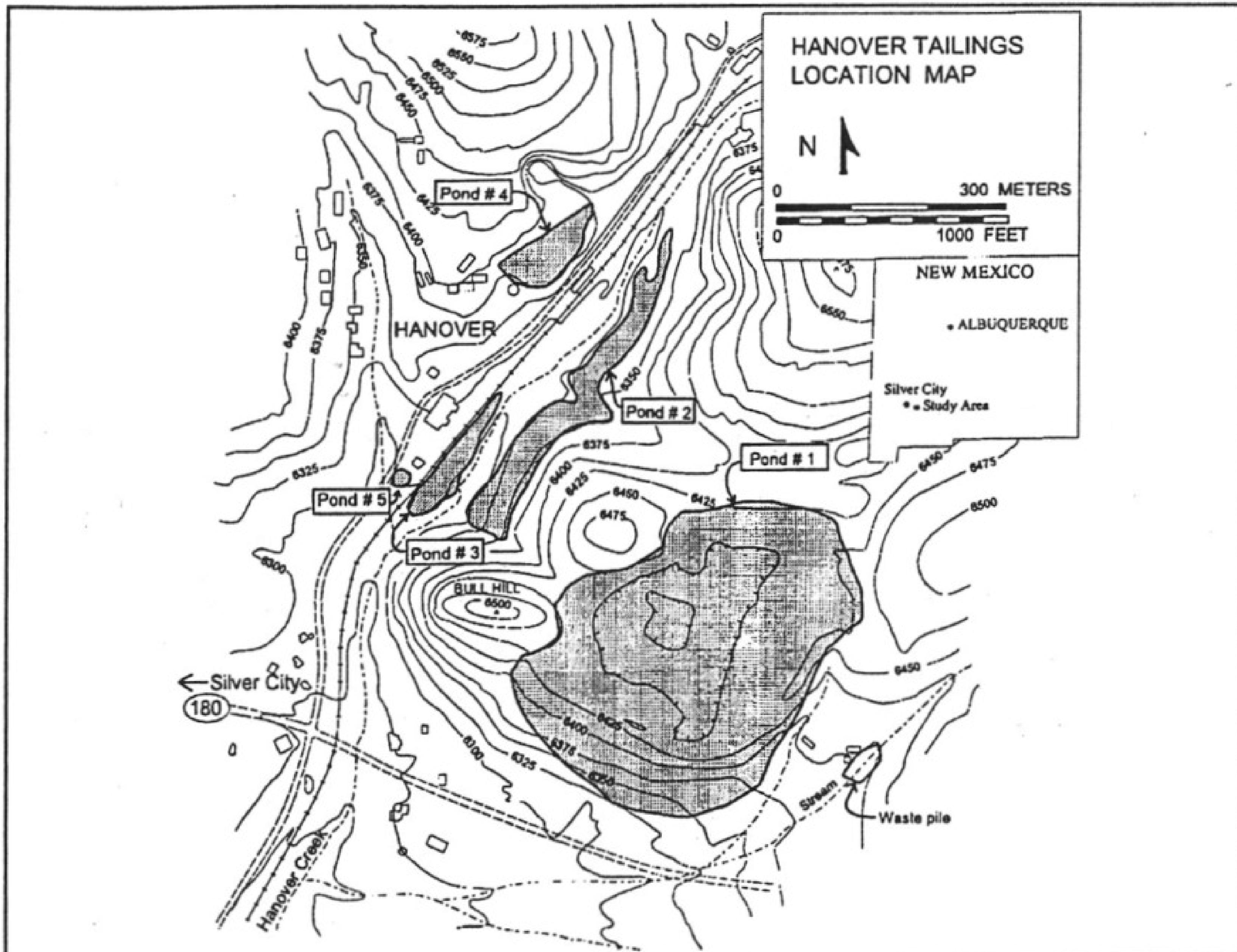


Figure 1.4: Location of Hanover Mill tailings (after Walder, 1993).

Hanover #1 Tailings Pond Rehabilitation

Tailings Pond #1 Topsoil Cap

Table 1.1: Estimated volumes and tonnages of Hanover Mill tailings (ACZ Inc., 1993).

	Volume (x 10^3 m^3)	Tonnage (x 10^3 mt)
Pond 1	2,021.1	3,638.0
Pond 2	22.9	41.2
Pond 3	21.3	38.2
Pond 4	22.6	42.5
Pond 5	6.9	12.4
Total	**2,094.8**	**3,772.4**

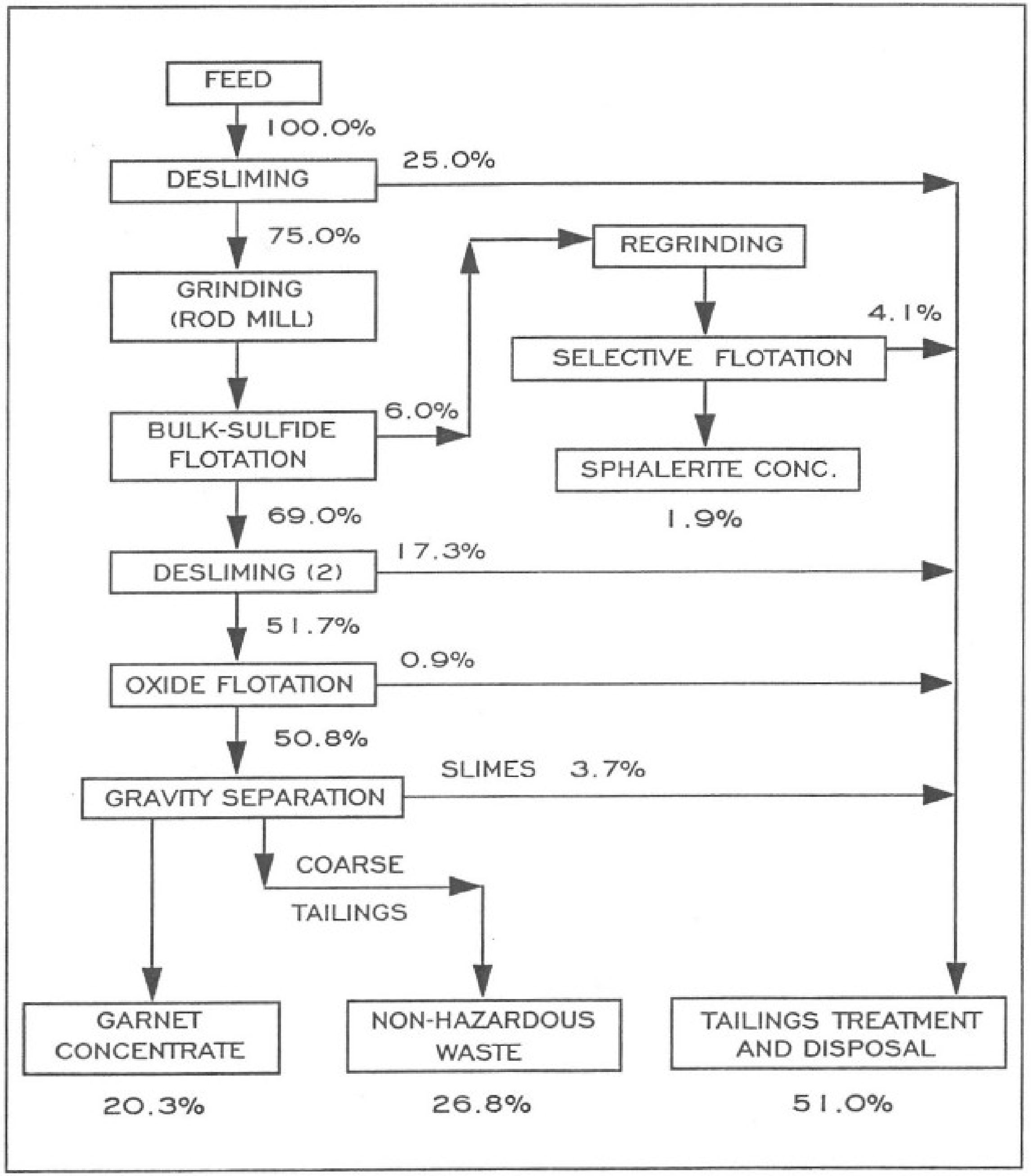


Figure 5.7: Flowsheet for recovery of garnet and sphalerite from Hanover Mill tailings.

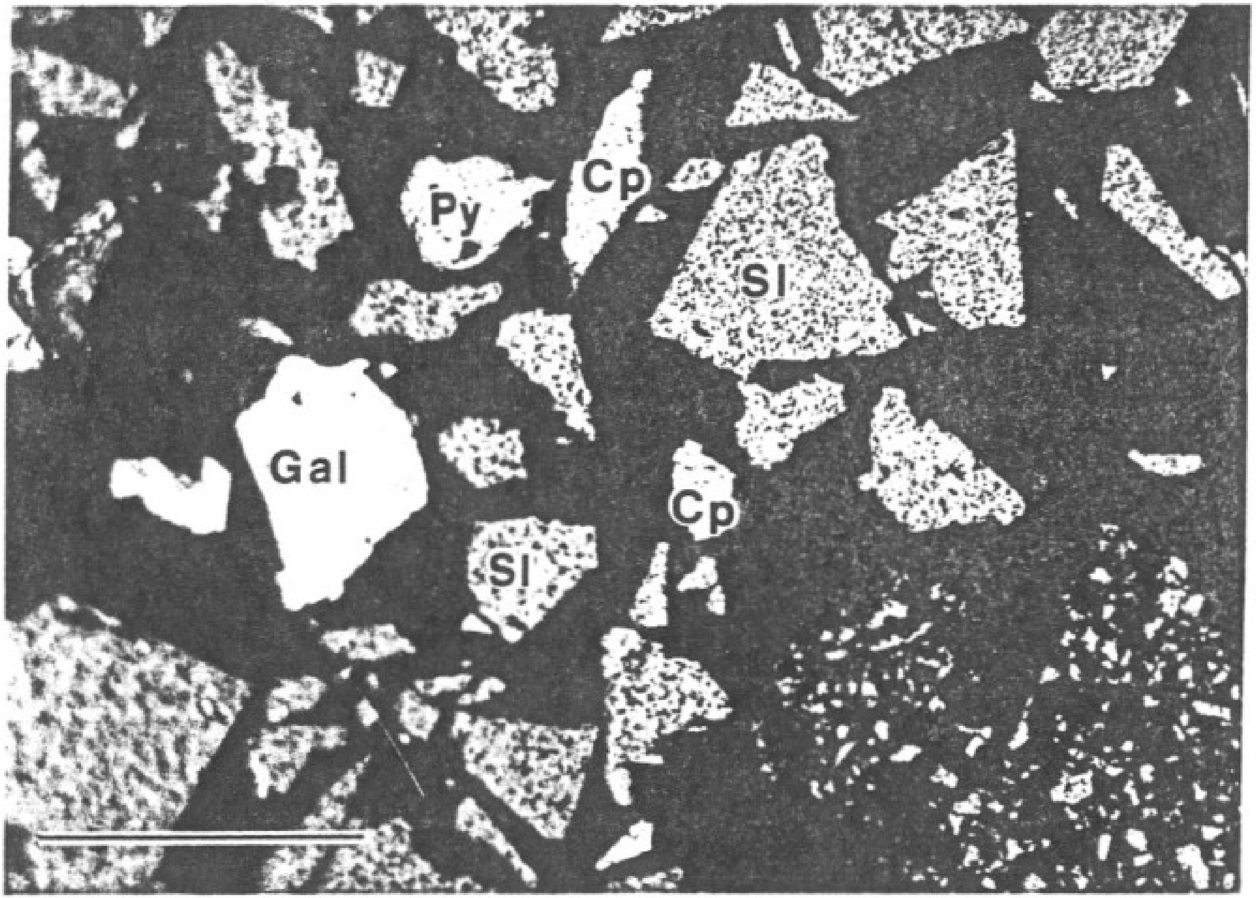


Figure 5.3: A polished section view from the sphalerite concentrate. Bar scale represents 0.1 mm. (Py=pyrite, Cp=chalcopyrite, Sl=sphalerite, Gal=galena).

Table 5.3: Acid-soluble metal content of the feed and products after reprocessing the tailings (Mass balance).

	% wt	Cd (ppm)	Cu (ppm)	Fe (%)	Pb (ppm)	Zn (%)
Feed	100.0	104	553	7.96	1,179	4.19
Sphalerite Concentrate	1.9	1,145	6,225	6.27	10,100	50.90
Garnet Concentrate	20.3	28	197	6.11	394	1.19
Coarse Tailings	26.8	33	225	8.12	445	1.31
Final Tailings†	51.0	133	656	8.68	1,544	5.16

† Calculated; (10,000 ppm = 1 %).

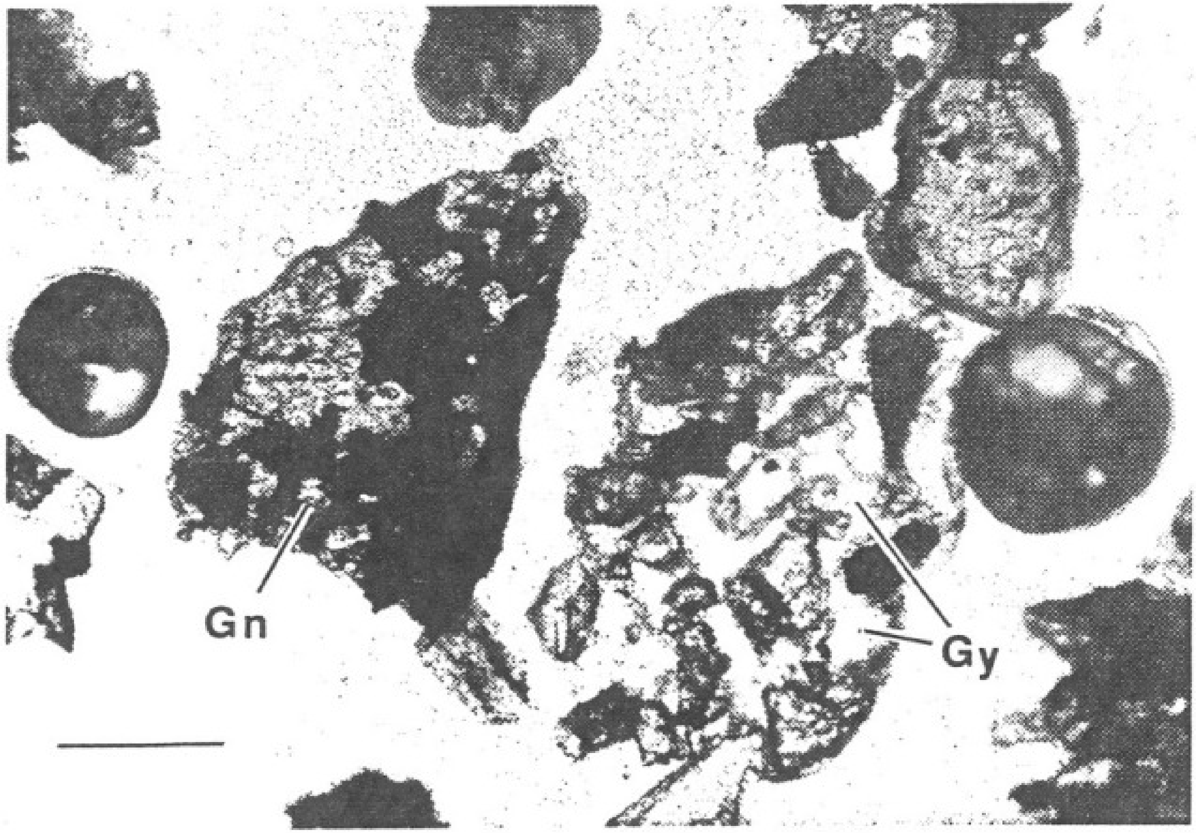


Figure 5.1: A photomicrograph of - 28 + 35 mesh (- 600 + 425 μm) composite sample shows garnet grains and gypsum cemented minerals lower right hand-side of the view. Bar scale represents 0.1 mm. (Gn=garnet, Gy=gypsum).

Summary

- Recovery of valuable minerals from ores is never complete due to incomplete liberation from the waste minerals and inefficiency of the separation processes.
- Recovery of valuable minerals from mill tailings will depend on the mineralogy, particle size, and economics.