

General Principles & Processes of Isolation of Metals:

Occurrence of Metals and Non-Metals

Native Metals

A metal that exists in metallic form, either as pure metal or as an alloy. **For Example:** Cadmium, Cobalt, Bismuth, Cobalt, Indium etc.

Aluminum is the most abundant element in nature. Iron is the second largest metal that exists in nature after aluminum. The process of extracting metals from ores is known as **Smelting**.

Alloys

It is a mixture of two or more elements in which the major component is metal. The basic idea to make alloy is to make metal less brittle, hard and more resistant to corrosion. For example, stainless steel, cast iron, alloy steel etc. Iron alloyed with carbon gives low, mid and high carbon steels.

The alloys of aluminum, titanium, and magnesium are valued for their high strength-to-weight ratios, and magnesium can also provide electromagnetic shielding. These alloys are used in jet engines.

Ores

Ore is a naturally occurring material from which a metal can be extracted. They are extracted from the earth by the process of mining.

The basic extraction of ore deposits follows these steps:

- Prospecting or exploration
- Conduct resource estimation
- Conduct a pre-feasibility
- Conduct a feasibility study
- Development
- The operation of the mine in an active sense
- Reclamation is the last step in which land is made suitable for future use.

Some Metals and their Corresponding Ores

Name of the Element	Ores
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Aluminum	Bauxite: $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ Corundum: Al_2O_3
Iron	Hematite: Fe_2O_3 Magnetite: Fe_3O_4
Copper	Copper Pyrite: CuFeS_2 Copper Glance: Cu_2S
Zinc	Zinc Blende: ZnS Calamine: ZnCO_3
Sodium	Rock Salt: NaCl Sodium Carbonate: Na_2CO_3
Potassium	Karnalite: $\text{KClMgCl} \cdot 6\text{H}_2\text{O}$ Salt Petre: KNO_3
Tin (Sn)	Tin Pyrites: $\text{Cu}_2\text{FeSnS}_4$ Classiterite: SnO_2

What is Concentration of Ore?

Ores are **solid material** from which a pure metal can be obtained. The process of removal of unwanted material from the ore is known as **Concentration or Dressing or Benefaction of ores**. It involves several steps.

Different Procedures for Concentration of Ores:

Hydraulic Washing

It is based on the difference in gravity of the particles of the gangue and the ore. So, it is considered as a type of gravity separation. During this process, an upward stream of running water is used to wash the powdered ore. The lighter gangue particles are washed leaving the heavier ore particles.

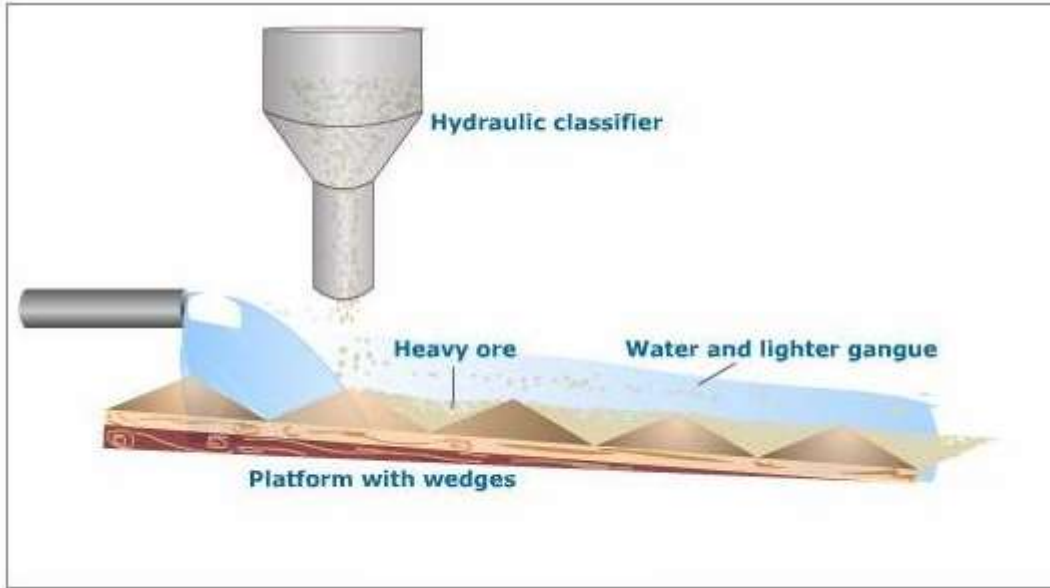


Fig. 1. Hydraulic Washing

Magnetic Separation

It is based on the principle of magnetic properties of the ore components. If either the ore particles or the gangue are capable of attracted in a magnetic field, magnetic separation can be used. Ore is kept in a conveyer which passes through the magnetic roller.

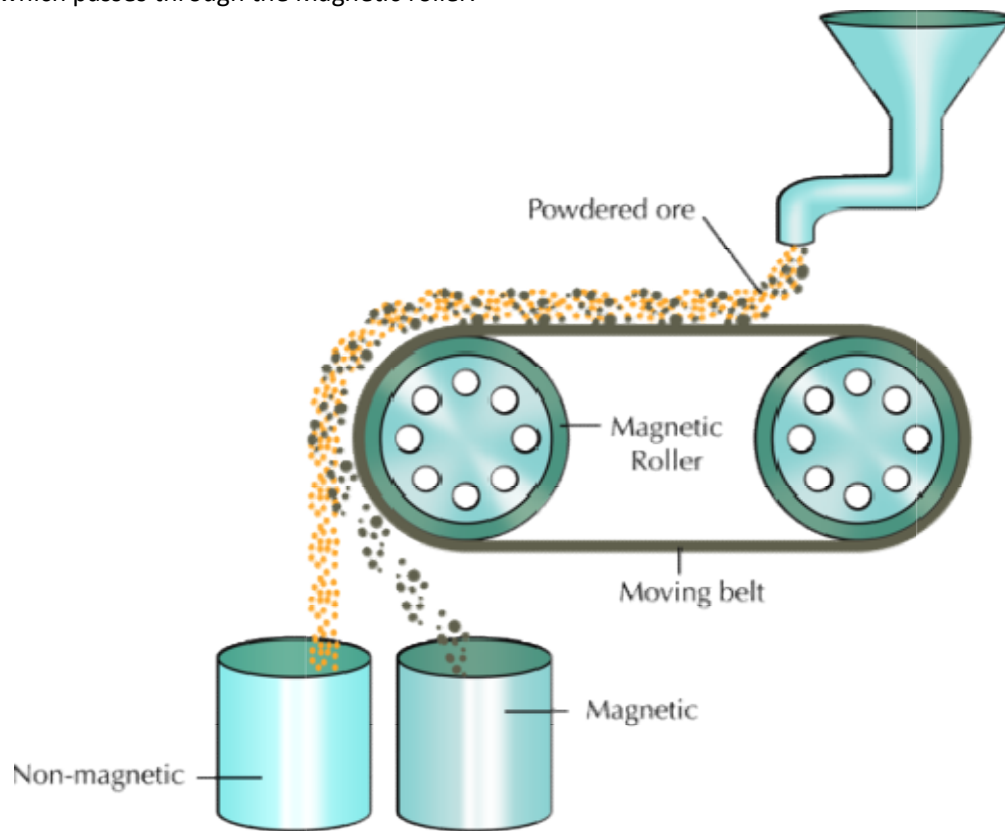


Fig. 2. Magnetic Separation

Froth Floatation Process

This method is used to separate gangue from the sulphide ores. Suspension of powdered ore is prepared using water. To this suspension, collectors and froth stabilizers are added. A rotating paddle agitates the mixture and draws air in it. This results in the formation of froth which carries the mineral particles. The froth is light and is scanned off. It is then dried for recovery of the ore particles. Sometimes depressants such as sodium cyanide are used to separate the sulphide ores by adjusting the proportion of oil to water.

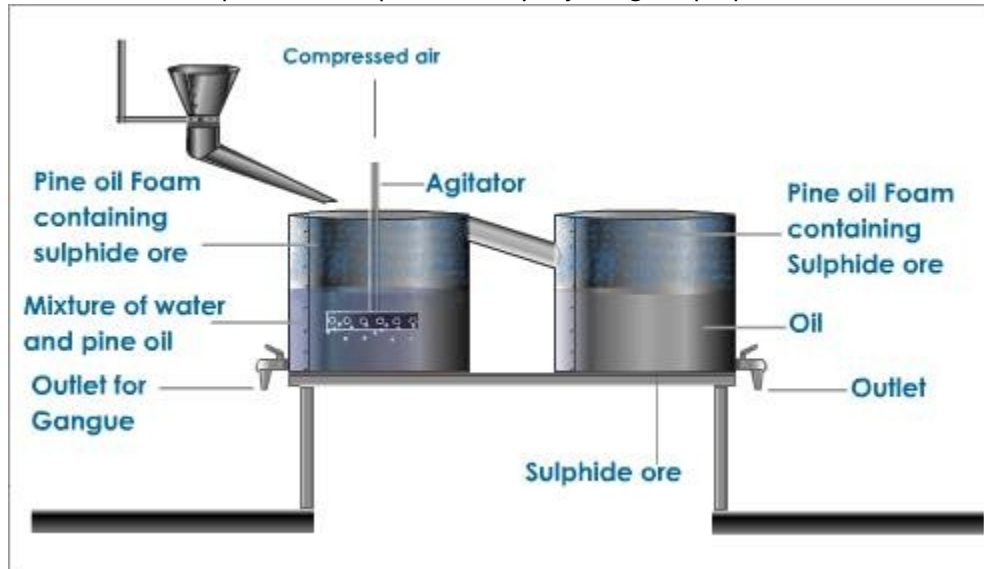


Fig. 3. Froth Floatation Process

Leaching / Extraction of Aluminum

It is used when ore is soluble in some solvent. It is explained based on following example:

- **Leaching of alumina from bauxite.** Bauxite is an ore of aluminum. It contains silicon dioxide, iron oxides and titanium oxide. Concentrated solution of sodium hydroxide at a pressure of 473–523 K and 35–36 bar is used for concentrating the ore. During this process, bauxite is leached out as sodium aluminate, leaving other impurities:

The carbon-dioxide is passed through and hydrated bauxite is obtained.

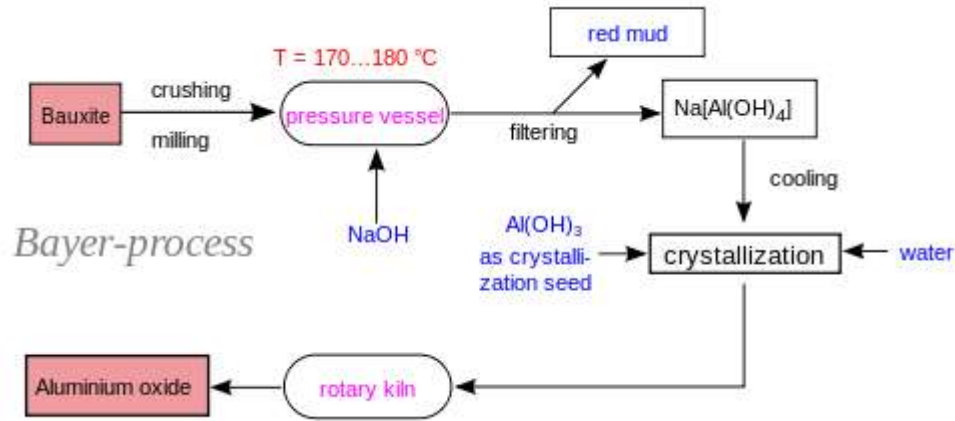


Fig. 4. Leaching of Alumina from Bauxite

Hydrated alumina is then heated and dried to obtain pure bauxite or Al_2O_3

What is Crude Metal?

The ore is considered as crude metal. It is a solid mass from which pure metal can be obtained.

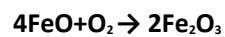
Steps for Extraction of Metal

Extraction of Metals Involves Three Major Steps:

- Concentration of Ore
- Isolation of metal from the concentrated Ore
- Purification of the metal

This is explained using an example of extraction of iron:

- The first step is the concentration of the ore. During this step, the ore is crushed in crushers, to broke down into small pieces. This is normally done using gravity separation as iron is magnetic.
- Step 2 is calcination. The ore is heated in absence of air. This results in decomposition of carbonates into oxides and then ferrous oxide is converted into ferric oxide.



- Step 3 is smelting. The concentrated ore is mixed with coke, limestone and then the mixture is kept in blast furnace.