Extraction of Gold
By Dr. Ahmed Ameed
Characteristics and uses of gold

- **Density**: $19.3 \text{ g/cm}^3$, $T_m:1064 \degree C$
- **Shinny**: for Jewelry
- **Durable**: does not tarnish or corrode easily, sometimes used in dentistry to make the crowns for teeth.
- **Malleable and ductile**: can be bent & flattened. For this reason it is used to make fine wires and thin, flat sheets
- **Good conductor for heat & electricity**: used in transistors, computer circuits & firefighting cloths.
Types of ores

- Gold occurs principally as a Native metal, usually alloyed with silver (as Electrum), or with mercury (as an Amalgam). Native gold can occur as sizeable nuggets, flakes, grains or microscopic particles embedded in other rocks.

- Ores in which gold occurs in chemical composition with other elements are comparatively rare. They include calaverite, sylvanite, nagyagite, petzite and krennerite.
Gold extraction

Gold mining

- Hard rock mining – used to extract gold encased in rock. Either open pit mining or underground mining.

- Panning (الفصل حصى) – sand and gravel containing gold is shaken around with water in a pan. Gold is much denser than rock, so quickly settles to the bottom of the pan.
Gold extraction

Gold mining

- Sluicing – water is channelled to flow through a sluice-box with riffles (تموجات) at the bottom which create dead-zones in the water current which allows gold to drop out of suspension.

- Sluicing and panning results in the direct recovery of small gold nuggets (خامات الذهب) and flakes.
Gold extraction

Gold ore processing

Gold cyanidation:

- The most commonly used process for gold extraction.

- Used to extract gold from low-grade ore.

- Gold is oxidised to a water-soluble aurocyanide metallic complex $\text{Au} (\text{CN})_2$.

- In this dissolution process, the milled ore is agitated with dilute alkaline cyanide solution, and air is introduced:

$$4\text{Au} + 8\text{NaCN} + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{NaAu(CN)}_2 + 4\text{NaOH}$$
Gold extraction

Gold ore processing

Gold cyanidation:

- At a slurry concentration of around 50% solids, the slurry passes through a series of agitated mixing tanks with a residence time of 24 hrs.

- The gold-bearing liquid is then separated from the leached solids in thickener tanks or vacuum filters & the tailings (مخلفات المعالجة) are washed to remove Au and CN⁻ prior to disposal.
Gold ore processing

Heap Leaching

• Is an alternative to the agitated leaching process.
• Drastically reduced gold recovery costs of low grade ore.
• Ore grades as low as 0.3 g per ton can be economically processed by heap leaching.
Gold extraction

Gold ore processing

• Generally requires 60 to 90 days for processing ore that could be leached in 24 hrs in a conventional agitated leach process.

• Au recovery is around 70% as compared with 90% in an agitated leach plant.

• BUT, has gained wide favour due to vastly reduced processing costs.

• Frequently, mines will use agitated leaching for high-grade ore & heap leaching for low grade ores that would otherwise be considered waste rock.
Gold extraction

Gold ore processing

Merrill-Crowe process

- Traditional method for Au recovery from pregnant cyanide solutions.
- Once dissolution of Au is complete, the remaining rock pulp is filtered off through various filters to produce a sparkling clear solution.
- $O_2$ is removed from the clarified solution by passing the solution through a vacuum deaeration column.

Gold cyanidation:
Gold extraction

Gold ore processing  Gold cyanidation:

Merrill-Crowe process

- Zinc dust is then added to the cyanide solution to chemically reduce the gold to the metal.

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2\text{Au(CN)}_2 + \text{Zn} \rightarrow 2\text{Au} + \text{Zn(CN)}_4
\]

- The metallic gold is then filtered out & refined.

Smelting of resultant powder (rich Au) into steel molds and the slug is remove from the top furnace.

Electrolysis is done to get high gold grade 99.999% purity.
Cyanide process of gold production