

**Gold extraction** or recovery from its **ores** may require a combination of **comminution**, **mineral processing**, **hydrometallurgical**, and **pyrometallurgical** processes to be performed on the ore.<sup>[1]</sup>

**Gold mining** from alluvium ores was once achieved by techniques associated with **placer mining** such as simple gold panning and sluicing, resulting in direct recovery of small gold nuggets and flakes. Placer mining techniques since the mid to late 20th century have generally only been the practice of artisan miners. **Hydraulic mining** was used widely in the **Californian gold rush**, and involved breaking down alluvial deposits with high-pressure jets of water. Hard rock ores have formed the basis of the majority of commercial gold recovery operations since the middle of the 20th century where **open pit** and or **sub-surface mining** techniques are used.

Once the ore is mined it can be treated as a whole ore using a **dump leaching** or **heap leaching** processes. This is typical of low-grade, oxide deposits. Normally, the ore is crushed and agglomerated prior to heap leaching. High grade ores and ores resistant to **cyanide** leaching at coarse particle sizes, require further processing in order to recover the gold values. The processing techniques can include grinding, concentration, roasting, and pressure oxidation prior to cyanidation.

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## Types of ore

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Gold occurs principally as a **native metal**, usually **alloyed** to a greater or lesser extent with **silver** (as **electrum**), or sometimes with **mercury** (as an **amalgam**). Native gold can occur as sizeable nuggets, as fine grains or flakes in **alluvial deposits**, or as grains or microscopic particles embedded in other rocks.

Ores in which gold occurs in chemical composition with



Gold miners excavate an eroded bluff with jets of water [edit] at a placer mine in **Dutch Flat, California** sometime between 1857 and 1870.



High-grade gold ore from a quartz vein [edit] near **Alma, Colorado**. The appearance is typical of very good gold-quartz ore.

other elements are comparatively rare. They include [calaverite](#), [sylvanite](#), [nagyagite](#), [petzite](#) and [krennerite](#).

## Concentration [[edit](#)]

Gravity concentration has been historically the most important way of extracting the native metal using pans or washing tables. Amalgamation with [mercury](#) was used to enhance recovery, often by adding it directly to the [riffle](#) tables, and mercury is still widely used in small diggings across the world. However, [froth flotation](#) processes may also be used to concentrate the gold. In some cases, particularly when the gold is present in the ore as discrete coarse particles, a gravity concentrate can be directly [smelted](#) to form gold bars. In other cases, particularly when the gold is present in the ore as fine particles or is not sufficiently liberated from the host rock, the concentrates are treated with [cyanide](#) salts, a process known as cyanidation [leaching](#), followed by recovery from the leach solution. Recovery from solution typically involves adsorption on activated carbon followed by solution concentration or stripping and or [electrowinning](#).

Froth flotation is usually applied when the gold present in an ore is closely associated with [sulfide minerals](#) such as [pyrite](#) or [arsenopyrite](#), and when such sulfides are present in large quantities in the ore. In this case, concentration of the sulfides results in concentration of gold values. Generally, recovery of the gold from the sulfide concentrates requires further processing, usually by [roasting](#) or wet pressure oxidation. These pyrometallurgical or hydrometallurgical treatments are themselves usually followed by cyanidation and carbon adsorption techniques for final recovery of the gold.

Sometimes gold is present as a minor constituent in a [base metal](#) (e.g. copper) concentrate, and is recovered as a by-product during production of the base metal. For example, it can be recovered in the [anode](#) slime during the electrorefining process.

## Leaching [[edit](#)]

If the gold can not be concentrated for smelting, then it is leached by an [aqueous](#) solution:

1. The [cyanide process](#) is the industry standard.
2. [Thiosulfate](#) leaching has been proven to be effective on ores with high soluble [copper](#) values or ores which experience pregrobbing by carbonaceous components.

## Refractory gold processes [[edit](#)]

A "refractory" gold ore is an ore that is naturally resistant to recovery by standard cyanidation and carbon adsorption processes. These refractory ores require pre-treatment in order for cyanidation to be effective in recovery of the gold. A refractory ore generally contains sulfide minerals, organic carbon, or both. Sulfide minerals often trap or occlude gold particles, making it difficult for the leach solution to complex with the gold. Organic carbon present in gold ore may adsorb dissolved gold-cyanide complexes in much the same way as activated carbon. This so-called "preg-robbing" carbon is washed away because it is significantly finer than the carbon recovery screens typically used to recover activated carbon.

Pre-treatment options for refractory ores include:



Gold Nuggets found in Arizona



1. [Roasting](#)
2. Bio-oxidation
3. Pressure oxidation
4. Ultrafine grinding

The refractory ore treatment processes may be preceded by concentration (usually sulfide flotation). Roasting is used to oxidize both the sulfur and organic carbon at high temperatures using air and/or oxygen. Bio-oxidation involves the use of bacteria that promote oxidation reactions in an aqueous environment. Pressure oxidation is an aqueous process for sulfur removal carried out in a continuous autoclave, operating at high pressures and somewhat elevated temperatures. Ultra fine grinding may be used when liberation of gold particles from the surrounding mineral matrix is the primary refractory characteristic of the ore.

## Gold smelting

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## Mercury removal

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**Mercury** is a health hazard, especially when in gas form. To remove this hazard, before smelting, gold precipitates from [electrowinning](#) or Merrill-Crowe processes are usually heated in a [retort](#) to recover any [mercury](#) present, that would otherwise cause health and environmental problems due to its release (volatilization) during smelting. The mercury present is not usually from the [mercury amalgamation](#) process that is no longer used by formal gold mining companies, but from mercury in the ore that has followed gold through the leaching and precipitation processes.

In the event that there are high levels of [copper](#) or [silver](#) present, leaching of the precipitate using [nitric](#) or [sulfuric acids](#) may be required.

## Iron removal

[[edit](#)]

Nitric acid or forced air oven oxidation can also be used to dissolve iron from the electrowinning cathodes before smelting. Gravity concentrates can often contain high grinding steel contents, and so their removal using shaking tables or magnets is used before smelting. During smelting iron can be oxidized using [nitre](#). Excessive use of nitre will corrode the smelting pot, increasing both maintenance costs and the risk of catastrophic leaks (known as *run-aways*, or holes in the pot through which the molten charge is lost).

## Gold Refining and Parting

[[edit](#)]

*Main article: [Gold parting](#)*

**Gold Parting** is primarily the removing of silver from gold and therefore increasing the purity of gold. The parting of gold from silver has been done since ancient times starting in [Lydia](#) in the 6th century BC. Various techniques have been practised; salt cementation from ancient times, parting using distilled mineral acids from medieval times, and in modern times using chlorination using the [Miller process](#) and [electrolysis](#) using the [Wohlwill process](#).

## See also

[[edit](#)]

- [Digger gold](#)
- [Gold mining](#)
- [Ore genesis](#)

## References

[[edit](#)]

1. ↑ "[Gold Extraction - Gold Mining - Washing, Amalgamation, Leaching, Smelting](#)" . geology.com. Retrieved 2008-03-20.

