

The Albion Process for Refractory Gold



The Albion Process technology was developed by MIM Holdings (now Xstrata Plc) to treat concentrates produced from refractory base and precious metals ores. The process was developed in 1993 and has been patented worldwide.

The Albion Process incorporates the IsaMill horizontally stirred bead mill to produce an activated, finely ground concentrate at relatively low specific energy inputs. This finely ground mineral is then leached at atmospheric pressure in conventional agitated tanks. The capital costs of an Albion Process plant can be substantially lower than a comparable pressure or bacterial leach, due to the simplicity of the process flowsheet.



Figure 1: The M3000 IsaMill Installed at Lonmin, South Africa

The key to the Albion Process is the ultrafine grinding stage. The process of ultrafine grinding results in a high degree of strain being introduced into the mineral lattice. As a result, the number of grain boundary fractures and lattice defects in the minerals increases by several orders of magnitude, relative to unground minerals. The increase in the number of defects within the mineral lattice 'activates' the mineral, facilitating leaching. The rate of leaching is also enhanced, due to the dramatic increase in the mineral surface area.

Passivation of the mineral surface by sulphur based leaching products is also minimised by ultrafine grinding. Typically, precipitates that form on the surface of a leaching mineral will slowly passivate the mineral, by preventing the access of chemicals to the mineral surface. Passivation is normally complete once this precipitated layer is 2 – 3 microns thick. Ultrafine grinding of a mineral to a particle size of 80% passing 8 – 12 microns will eliminate passivation, as the leaching mineral will disintegrate prior to the precipitate layer becoming thick enough to passivate the mineral.

The oxidative leaching stage is carried out in non-pressurised agitated tanks. Oxygen is introduced to the leach slurry to assist oxidation. Leaching is carried out autothermally, in that the temperature of the leach slurry is set by the amount of heat released in the leaching reaction. Heat is not added to the leaching vessel from external sources. Temperature is controlled by the rate of addition of oxygen, and by the leach slurry density.

When applied to the recovery of precious metals, the Albion Process can be operated across a broad range of pH conditions, depending on the feed mineralogy.

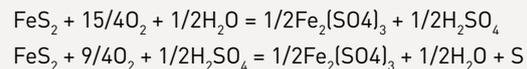
Where the main gold bearing refractory mineral in the concentrate is pyrite, the oxidative leach is typically carried out under alkaline conditions. The leach conditions are set to ensure the formation of goethite as the major iron reaction product. The alkaline leach conditions accelerate the rate of pyrite leaching, by continually neutralising acid formed in the oxidation of pyrite. Cheap alkalis such as limestone and lime are favoured for use in the oxidative leach.

Where the concentrate to be processed contains significant levels of arsenic, or recoverable base metals, the oxidative leach is carried out under acidic conditions, with the oxidised slurry then neutralised prior to cyanide leaching.

Process Chemistry

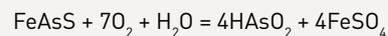
Some of the main oxidation reactions that occur in an Albion Process leach of a refractory gold concentrate are presented below. For simplicity, it has been assumed that the main carriers of the precious metals are pyrite, arsenopyrite and telluride species, however testwork has been carried out on concentrate samples containing a broad range of refractory sulphides.

Pyrite Leaching – Acidic Conditions



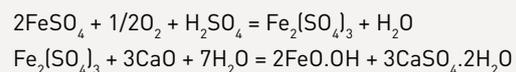
The first reaction is the main pyrite leach reaction, however the leach conditions can be adjusted to favour the second reaction and minimise oxygen consumption if required.

Arsenopyrite Leaching – Acidic Conditions

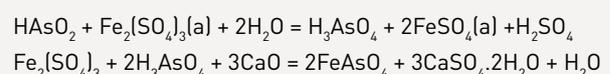


On completion of the leach stage, the iron and acid that are formed in the oxidative leach are neutralised with limestone and lime prior to cyanidation of the neutralised residue. The principle neutralisation reactions are:

Ferrous Oxidation and Precipitation as Goethite



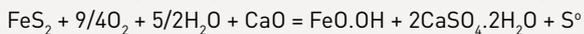
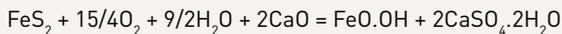
Arsenic Oxidation and Fixation as Ferric Arsenate



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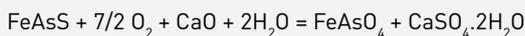
Where the concentrate to be processed does not contain significant levels of arsenic, or recoverable base metals, the oxidative leach is carried out under alkaline conditions, with the pH maintained above 4 throughout the leach train. The principle leach reactions are:

Pyrite Leaching - Alkaline Conditions

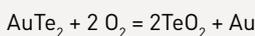


The first reaction is the predominant reaction under alkaline conditions.

Arsenopyrite Leaching - Alkaline Conditions



Telluride Leaching - Alkaline Conditions



Telluride and selenide phases are readily oxidised under the alkaline conditions present in the Albion Process leach.

Operation of the Alkaline Leach

The Albion leach is carried out at temperatures in excess of 70 degrees and at a pH above 4, and so goethite is the favoured iron precipitate. In the oxidation of pyrite ahead of cyanide leaching, goethite formation is desired above other forms of iron precipitate. Goethite will settle quickly, and tends to form crystal agglomerates, which can result in an 80% passing size for the leached residue that may be up to an order of magnitude higher than the finely ground feed.

In oxidative gold leaching circuits that are carried out at lower temperatures than the Albion leach, iron is precipitated in the form of residues containing significant quantities of sulphate (as jarosite or iron hydroxysulphates) and elemental sulphur. These sulphate bearing phases result in high cyanide consumption due to the instability of iron sulphate phases in alkaline cyanide solutions. Chemical occlusion of gold is also common, and these residues are typically difficult to settle. Goethite and ferrihydrite, however, are extremely stable in alkaline cyanide solutions, and will not leach to form iron cyanide complexes.

As the leach operates autothermally, there is sufficient heat released by the oxidation of sulphide minerals to maintain the leach temperature in a region where goethite is favoured.

The sulphate concentration in solution is maintained at less than 3,000ppm by the continuous addition of a calcium-based alkali (lime and limestone). The low concentrate of sulphate in solution ensures that the amount of iron sulphates present in the leach residue is less than 1% w/w. The leach pH is maintained above pH 4 at all times, maintaining ferric concentrations at less than 0.1g/l. This low iron background ensures that iron is precipitated as goethite. Goethite residues are suitable for direct addition to the cyanide leach stage.

Figures 2 and 3 show the preferred operating region for the Albion Process alkaline leach. The operating region for the alkaline leach is shown in green.

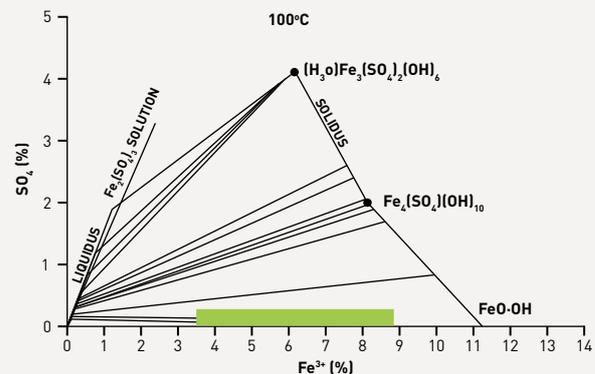


Figure 2: Operating pH and Soluble Iron Concentrations in the Albion Process Alkaline Leach to Favour Goethite Formation

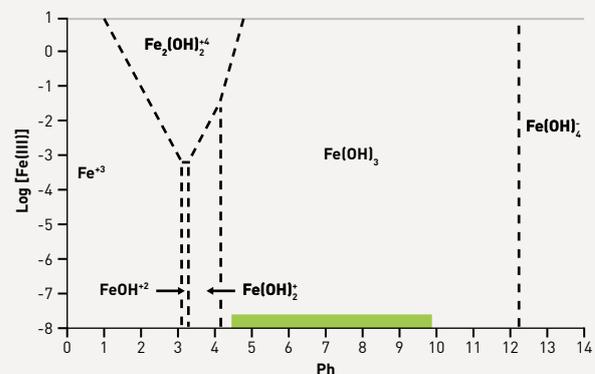


Figure 3: Phase Diagram Showing the Iron Precipitate Phase Formed in the Albion Process Alkaline Leach

Solid Liquid Separation and Leach Tailings Stability

The Albion leach is typically operated at a slurry density of 25 – 35% w/w, depending on sulphide levels in the concentrate. The discharge pH from the Albion leach is raised to 8 – 10 in the final Albion leach tank to further break down any sulphate phases prior to the cyanidation stage. The Albion discharge slurry is, therefore, suitable for direct transfer to the cyanidation stage, and solids/liquid separation is not required.

The final residue on completion of the oxidative leach contains predominantly goethite, and is environmentally stable, with any arsenic that might be liberated in the leach fixed in the solids phase as ferric arsenate.

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