Albion Process™ leaches the broadest feed variations, costs less and ramps-up faster

GLENCORE TECHNOLOGY

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> Albion Process™ exceeded expectations. Even with large swings in sulphur grade and feed rate, we maintain gold recovery in the cyanidation plant above design targets. Without Albion Process™ we would only achieve around 20% gold recovery and huge cyanide consumption, but with Albion Process™ we can achieve over 95% gold recovery and minimal cyanide consumption, giving the process plant outstanding return on investment."
>
> – GPM Gold

Albion Process™ at a Glance

- → Real-world success in delivering over 99% leach recovery
- → Replaces large complex high-cost capital assets with simple low-cost capital assets
- → Tolerates a broader low grade more variable content feed and works where others fail
- → Incredibly fast and simple to commission and operate
- → Modular so it can be implemented in stages but maintain economic performance
- → Strongest performance guarantee in the world

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Albion Process™ combines fine-grinding and oxidative leaching to create a hydrometallurgical asset that works where others fail

The Albion Process™ is a proven atmospheric oxidative leaching process for base and precious metals that is reliable, safe and highly favourable economically.

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Albion Process™ has real-world success in delivering over 99% leach recovery and creating significant downstream cost savings.

The process comprises two main steps for efficient recovery of valuable metals. The first step is mechanical liberation using an IsaMill™ to grind the Albion Process™ feed particles to a narrow size distribution. This prevents passivation of the mineral surfaces in the subsequent oxidative leaching step.

The second step is chemical liberation achieved by injecting supersonic oxygen into the base of a series of Albion Process™ Leach Reactors continuously fed with the ground concentrate. Oxygen is injected using the HyperSparge™ supersonic oxygen injection system to maximise oxygen mass transfer and drive the oxidative leaching reactions.

Albion Process™ has significant capital and operating cost advantages because the process oxidises as much of the sulphide as you need but as little as possible to achieve the target metal recovery in either acid or neutral systems. This means a small oxygen demand and a smaller leaching train.

The Albion Process™ operates under acid or neutral conditions.

Acid conditions are used for treating base metal concentrates. Metal species like copper are recovered by first dissolving them into solution.

Many metal compounds can be oxidised and leached into solution simultaneously making it suitable for polymetallic feeds of base and precious metals or complex feeds. This means a high grade concentrate is not required for feeding Albion Process™ and the upstream concentrator can operate in a simpler circuit configuration at a point on the grade-recovery curve that maximises global metals recovery.

Neutral conditions are used for treating iron sulphide concentrates where metal species are recovered by a downstream process after oxidation of the concentrate, such as gold in a cyanidation process.

By operating at near neutral conditions for iron sulphide oxidation, elemental sulphur is not generated. This adds more value to the downstream process as cyanide consumption is significantly lower compared to pressure oxidative leaching (POx) or bacterial leaching which operate under acidic conditions.

The Albion Process™ tolerates an incredibly broad feed variance. Throughput and sulphur content can vary significantly, as most real-world operations do, without causing a process interruption.

The result is the world's most proven and reliable leaching system delivered, operating in a simple, robust and easy to commission package.

The capital investment required for the Albion Process™ are roughly half the cost of traditional leaching processes.

Traditional and alternative leaching systems can be expensive or high-risk to operate and maintain. The Albion Process™ is simple and safe. It's also the fastest leaching process to install, and has taken as little as six weeks to commission and begin operating at design recovery and throughput rates.

The Albion Process™ is ideal for precious and base metal concentrates. It can boost recoveries for zinc, copper, molybdenum, cobalt, nickel, lead, platinum group metals (PGMs), and refractory silver and gold.

How Albion Process™ delivers better returns and reduces risk for your project

1. Accurate modelling means less risk

Your Albion Process™ plant is developed in three stages, from the laboratory to full-scale, to ensure it will deliver design throughput and plant recoveries.

- **Go/No-go:** A single batch test determines amenability of the process to your feed material and allows us to gather key design data.
- **Optimisation:** Optimisation of grind size, residence time and operating density to ensure the correct IsaMill™ size is selected.
- **Variability and parameterisation:** Batch testing of samples that represent the variability in the feed material conducted at optimised conditions to ensure that the selected flowsheet will treat the wide variety of feed qualities to be encountered in the real operation. Testwork on composite samples for rheology and solid/liquid separation performance for equipment sizing.

2. Significantly less expensive and easier to install

The capital equipment required in the Albion Process™ is considerably less than what's needed in alternative leaching processes.

It's about half the cost of a traditional POx or bacterial leaching system.

The Albion Process™ doesn't need pressure and so it doesn't represent a risk of catastrophic failure or require the consequential rigorous statutory checking. The ZipaTanks™ are modular and fast to erect.

In fact, the commissioning process is incredibly fast. The IsaMill™ is considerably easier to install than a large high intensity mill, taking as little as four weeks on site. At the same time, the Albion Process™ Leach Reactors can be commissioned. The result is that it's taken as little as one team member six weeks to commission Albion Process™ and get operating.

3. Easy to learn and on-board

As we install your Albion Process™ plant, we begin a thorough technology transfer with our technology experts, metallurgists and maintenance experts and we train your team at your site before, during and after commissioning.

- **First**, you'll have access to fully operational Albion Process™ sites during the construction process to help your operators be trained and prepared before your plant is commissioned.
- **Second**, we deliver classroom training at your site towards the end of the construction period so your team can retain and use what they've learned. During this stage, site-specific operating procedures are developed between GT experts and site personnel.
- **Third**, your team are familiarised with the plant and begin working under our guidance at site until they're comfortable, usually for one or two weeks. We also remain in regular communication. This means your plant is enabled to ramp up as fast as possible and maintain performance.

4. Tolerates a broader feed variation

Ordinarily, maintaining conditions in oxidative leaching processes that maximise kinetics and leaching extent can be challenging because the feed grade and feed rate varies. This is because the sulphide minerals are the fuel to the oxidative leaching process. Variability in the sulphide grade, feed rate, or fuel input of the feed causes process interruptions or loss of efficiency in pressure or bacterial leaching.

However, the Albion Process™ is not affected by variations in feed quality and quantity provided the oxidation demand is kept within the capacity of the oxygen plant which is not difficult.

GPM Gold in Armenia has increased recovery of gold from refractory ore from 20% to over 95%, outperforming the design of 92%.

Even with the feed rate varying from 25–70 tonnes per hour, and sulphur varying from 8–35% the recovery was maintained at or above design gold recovery levels from the residue.

5. Easier to operate and maintain

Pressure leach reactors are the opposite of Albion Process™. They're complicated and higher-risk in operation and maintenance. They require a high level of monitoring to ensure the process remains within defined parameters to prevent the risks of catastrophic failure. The procedures for isolating and maintaining are very rigorous and in most countries the pressure vessel requires statutory checks. These additional procedures impact on plant availability reducing throughput capability.

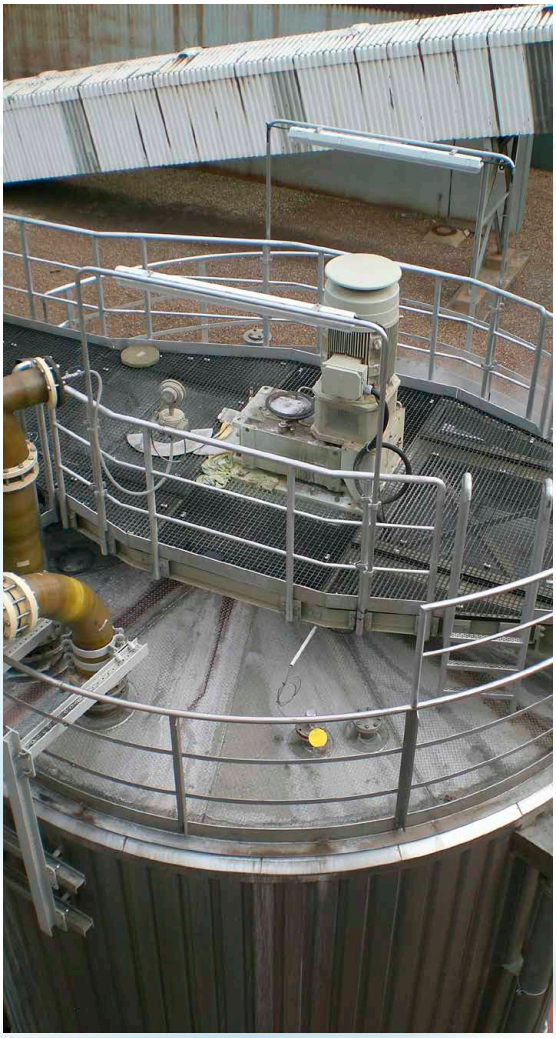
Installing more than one autoclave is common due to rebricking requiring another autoclave as a means of delivering continuity. So the capital costs are high compared to Albion Process™.

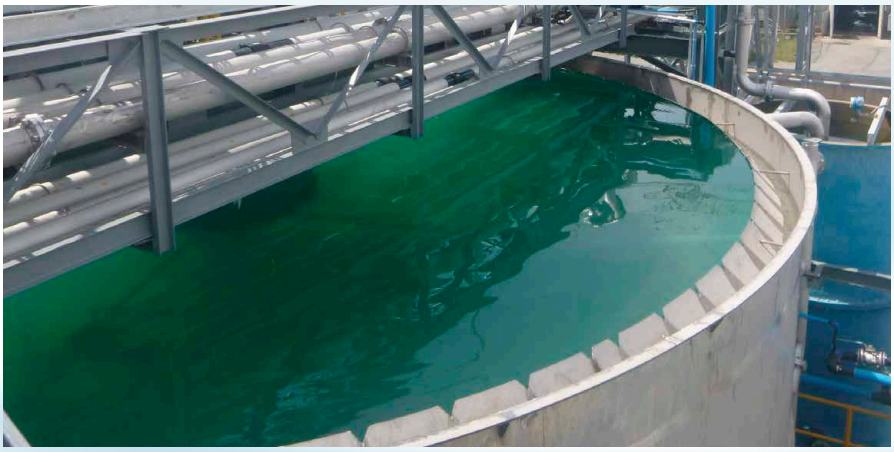
Bacterial leaching requires many more tanks, is less tolerant of feed variations and requires maintenance of a low-pressure air injection system which can become blocked. It also requires additional capital over time to manage water quality to continue operation.

Albion Process™ doesn't have complicated equipment operating at high pressures. The equipment consists of low maintenance slurry pumps, agitators, valves, HyperSparges, tanks and thickeners. These items are basic in design and require non-specialised skills and procedures to operate and maintain and are all well understood. Even if the instrumentation fails on an Albion plant, generally the plant can keep running.

Albion Process™ comprises established, reliable and proven unit operations such as the IsaMill™, Albion Process™ Leach Reactors, HyperSparge™, pumps and thickeners. This means the process is flexible, simple, robust and reliable.

The most critical part of the Albion Process™ is the delivery and transfer of oxygen to where it is needed to drive the oxidation reactions in the Albion Process™ Leach Reactors. This is achieved through the specially designed oxygen mass transfer system in the Albion Process™ Leach Reactors. Oxygen is injected at super-sonic velocities through a set of HyperSparge™ lances into the Albion Process™ Leach Reactors. Process interruption is minimised because the HyperSparge™ units can be removed from the Albion Process™ Leach Reactors and inspected while the other HyperSparge™ units are operating and without scuttling leach reactors.





How we help you get more from Albion Process™

Commitment in a partnership

Albion Process™ was developed and proven in real world mining applications, so we've built up a suite of services in a Technology Partnership concept.

As a Partner:

- You will have access to training and learning opportunities at real client sites.
- You will always have access to our most experienced technology experts around the world.
- Your team will have opportunities to learn from other users.
- You will have access to service and parts help.
- You will secure an ongoing technical relationship with us.

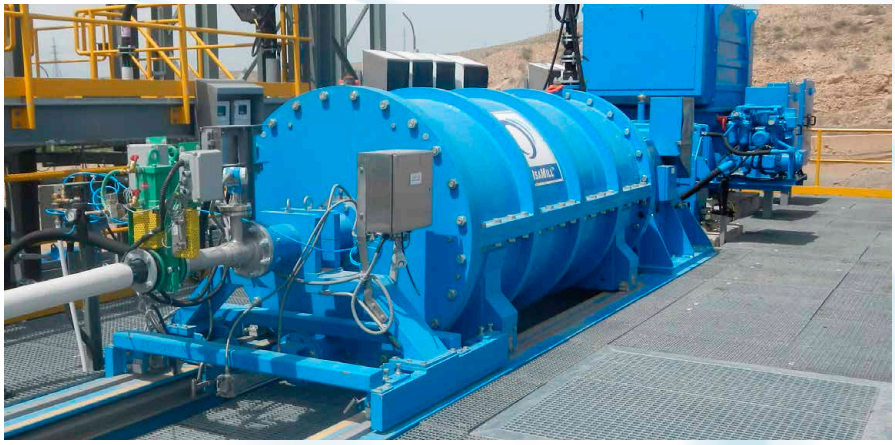
A strong performance guarantee

Albion Process™ leaches the broadest feed variations, costs less and ramps-up faster to deliver better returns.

The commitment and agreement is complete:

- The expectations we outline will transpose to your application and Albion Process™ will achieve minimums specified.
- The Albion Process™ plant will be commissioned completely, including testing, training and attainment of minimums.
- Our assumptions of feed variances, appropriate operation and maintenance schedules will be clearly identified.
- Glencore Technology will respond to any problems or faults.

How others have gained from Albion Process™



GeoProMining Gold quadruple plant recovery

GeoProMining (GPM) successfully increased recovery from sulphide concentrates in their Ararat plant from 20% to over 95%, defying expectations and targets. The plant was commissioned in June 2014 and achieved full capacity after three months.

GPM own and operate the Zod Gold Mine and Ararat Processing Plant in Armenia to produce gold and silver bullion. In order to expand, GPM needed to treat the underlying sulphide material at the Zod mine which achieved around 20–30% gold recovery through their existing conventional Carbon in Leach (CIL) flowsheet.

In 2010, GPM approved a refurbishment project at the Zod Mine and Ararat Processing Plant – in increased crushing capacity to deal with the harder ore and a refurbishment and re-commissioning of the existing flotation plant.

They added to this the installation of a new Albion Process™ plant for the oxidation of the sulphide concentrate prior to its treatment in the existing CIL plant. The new flowsheet would be configured such that the CIL would treat flotation tailings and oxidised residue from the Albion Process™.

The design basis for the Albion Process™ at GPM was oxidation of 100,000 tpa of concentrate to give an overall production of 100,000 ozpa of gold from concentrate and flotation tailings. The design recovery of gold from the Albion residue was 92% but the plant frequently achieves over 95% recovery with an overall plant-wide design recovery of 86% but commonly achieving 88%.

The refurbishment project was commissioned in June 2014, with ramp-up occurring for the remainder of 2014. The plant has achieved and exceeded nameplate production, treating in fact 120,000 tpa concentrate with an overall production of 129,000 ozpa.

Further, GPM successfully achieved an overall 88% plant-wide recovery exceeding the 86% design target due to better than design performance in the Albion Process™.

Despite wild fluctuations in grade and sulphur content, GPM has kept recoveries above design using the Albion Process™.

Nordenham hits 98.8% recovery

The Albion Process™ plant at Nordenham was commissioned in March 2011. The feed to the plant is also finely ground lead/zinc concentrate from the McArthur River mine.

Nordenham has a throughput of 36,000 tpa of concentrate, and the plant produces 16,000 tpa of cathode zinc from the concentrate, at a recovery of 98.8% w/w.

The Albion Leach Reactor consists of an 800 m^3 and a 280 m^3 reactor in series. The lead residue from the Nordenham Albion Process™ plant is also sold locally to secondary lead producers.

Other sites include San Juan de Neiva, Las Lagunas and Sable.

Case studies available on request.

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