Advanced Mineral Separations

IXOS® Technology
Pilot Plant Testing and Implications for Tanzanian Mining

July 17th – August 4th 2025

IXOS® Technology
Cleaner, More Profitable, Mercury-Free Gold Recovery

The IXOS® process, successfully piloted in Tanzania with GSB Mining (July–August 2025), offered a modern solution. It increased gold recovery by more than 2.5 times compared to traditional methods while eliminating mercury and reducing environmental impacts.

Why This Matters for Tanzania

Gold is one of Tanzania's largest sources of revenue. Yet much of the nation's gold is lost in inefficient processing and mercury-based methods—limiting national earnings and creating long-term health and environmental issues.

Key National Benefits

- Higher Government Revenue:
  - Increased gold recovery means higher royalties, taxes, and foreign exchange earnings.
  - Extends mine life, supporting long-term stability and growth in the sector.
- Cleaner, Safer Environment:
  - Mercury-free technology protects people, rivers, oceans, beaches, farmland, wildlife and communities.
  - Discharged water meets international safety standards (<50 ppb cyanide).
  - The IXOS® process can be used to remediate mercury poisoned tailings while successfully extracting gold that remains offering a profitable method of environmental cleanup

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Tourism Protection:

- Tanzania's economy thrives not only on gold but also on tourism—safaris, beaches in Zanzibar, and world-class natural parks.
- Cleaner mining practices: ensure rivers, landscapes, and coastlines remain healthy, supporting wildlife conservation and preserving the natural beauty that attracts millions of visitors each year.

Global Market Advantage:

- "Clean Tanzanian Gold" can be branded as sustainable and responsibly mined, attracting premium buyers worldwide.
- IXOS® technology is built on Molecularly Imprinted Polymers (MIPs), which can be adapted beyond gold to other strategic minerals
  - Including as silver, nickel, cobalt, lithium, and rare earth elements
  - Mercury and arsenic remediation
- Partnering with AMS positions Tanzania at the forefront of future clean mining technology and innovation.
  - AMS is made up of world-class innovators who have generated and continue to develop patented innovations in mining and other domains
    - These include biomedical innovations for the detection of viruses and bacteria

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Alignment with National Goals:

- Supports Tanzania’s commitments under the Minamata Convention to eliminate mercury.
- Advances industrialization policies by enabling more in-country processing and value addition.

The Path Forward:

Tanzania has the opportunity to become the first African nation to champion mercury-free gold recovery at scale.

The government can:

- Support and encourage adoption of IXOS® across small, medium, and large-scale mining.
- Position Tanzania globally as a leader in both sustainable gold production and environmental protection.

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Conclusion:

By supporting IXOS® as a preferred approach to gold recovery, Tanzania can secure:

- Greater revenue for the State.
- Healthier communities for its people.
- Cleaner environments for tourism and agriculture.
- Global recognition as a leader in sustainable mining.

This pilot also demonstrates the broader potential of IXOS® technology to expand into other strategic minerals and environmental applications, ensuring Tanzania remains at the cutting edge of resource development and sustainability.

Pilot Plant and Trip Overview

- Visited the Tanga region, partnered with GSB mining and setup a pilot plant with analytical laboratory for evaluating IXOS®.
- The new technology increases gold recovery efficiency and eliminates the need for mercury.
- On Site AMS demonstrated the effectiveness of IXOS® in Resin-in-Leach and Vat Leaching configurations.
- The full process was demonstrated on site including chemical leaching, adsorption, desorption, and recovery with electrowinning.
- Wastewater underwent cyanide destruct after use with measured values of released water being <50 ppb cyanide.
- Demonstrated gold recovery from a variety of tailings and virgin ore sources.
- Rapid elution shrinks the footprint needed and is operated at low temperature and ambient pressure.

Process Overview

Ore Preparation	• Grind size • Chemical Pretreatment
Chemical Leaching	• Basic cyanide leaching • Alternative leaching lixiviant as may be required
Adsorption	• IXOS® – AuC resin
Desorption	• IXOS® elution and conditioning in 4hrs, 60°C and ambient pressure.
Recovery	• Electrowinning • Smelting
Solid and Liquid Waste Management	• Cyanide destruct, sulfur/sulfide remediation, arsenic remediation, mercury retort

Experimental Setup

Container size: 50 L
Ore content: 10 – 40 Kg/container
Target ore grind size: 100 µm
Slurry percent: 30 – 40%
Ore inputs: Panning tailings, Virgin ore
Pretreatment: $PbNO_3$ and H_2O_2
Leaching times: 24 – 48 hrs.
Leaching pH: 11.5 - 12
Leaching free cyanide: 100 – 200 ppm
Resin loading: 140 - 280g
Pilot Simulation: Resin-in-Leach, Vat Leaching with fixed bed columns for adsorption

Lab Setup and Capabilities

- **Operations monitoring**
  - pH sensors
  - Dissolved Oxygen
  - Salinity
  - Cyanide ion selective electrode
  - IR thermometer
  - Scale
  - Laboratory glassware
  - Multimeter
- **Solid sample analysis**
  - Sample drying oven
  - XRF
  - Bottle Roll
- **Liquid sample analysis**
  - Portable PPB
  - UV/Vis photospectroscopy

Issues Experienced and Mitigation

- **Electrical** – Issues with blackouts and power surges negatively impacting equipment. Needed to install a UPS and power conditioner to compensate.
- **Charcoal** – drying ore with charcoal is a common practice, but when switching over to chemical leaching charcoal can be a source of organic carbon and impact gold recovery.
  - Reeducation to eliminate the drying step for chemical leaching.
- **Magnetic iron fillings** – metal fillings produced from the crushing process (likely from both the ore and the equipment) would interact with the magnet in the pump head and cause clogging.
  - New pumps to be sourced as needed.
- **Sourcing** – Finding and verifying appropriate suppliers for equipment takes longer than anticipated.
- **Heterogeneous ore** – inconsistent ore grades from bag-to-bag makes testing and analysis more difficult in determining mass balance.
  - Additional procedures for collecting and homogenizing samples can be implemented along with additional lab capability including fire assay and possibly Atomic Adsorption
- **Limited information** – ore characterization is limited and impacts the ability to appropriately develop process requirements and size potential operating facilities.
- **Inconsistent grind size** – the inclusion of larger particles made RIL impractical and was one of the reasons that led to the Vat leach setup recommendation.

Data and Results

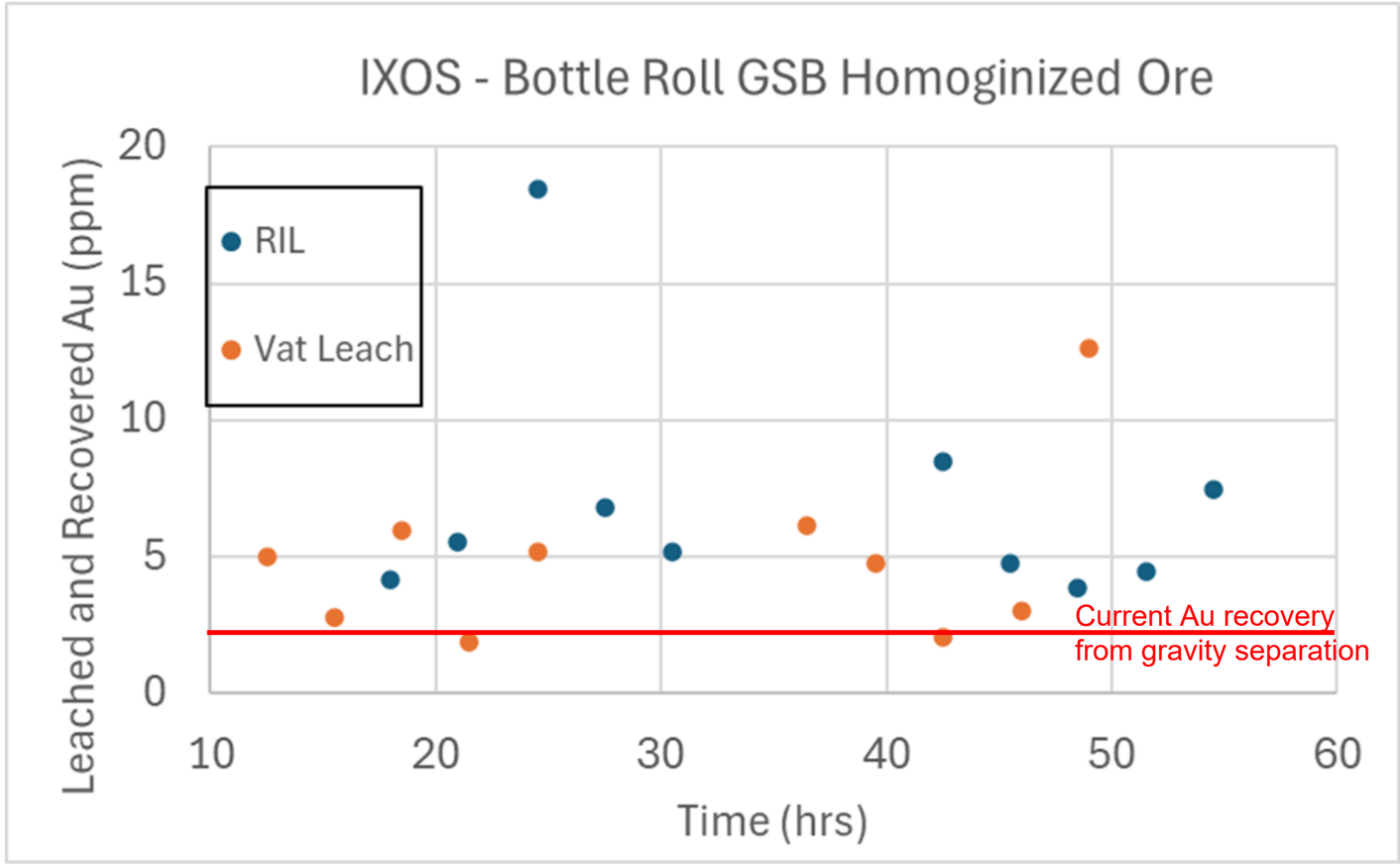
Experimental Setup

In a bottle roll 100g of virgin GSB homogenized ore was leached with 250 mL of cyanide solution for 48 hours. The solution was adsorbed by IXOS concurrent with leaching to simulate a RIL circuit, or in separate steps to simulate a Vat leaching process.

Average panning recovery for this ore is between 2-3 ppm.

Conclusions:

- Leaching yielded approximately 5.5ppm of gold or about 2.5 times more gold than gravity separation
- RIL and Vat leaching both showed improved recovery with RIL having slightly higher recovery in this testing.
  - Vat Leaching was not optimized.
- Majority of leaching appears to happen in the first 24hrs.
- Vat leaching showed very good performance compared to RIL with significantly lower cost and complexity.



Data and Results

Experimental Setup

In a 50L barrel an RIL process was simulated with ~40 Kg ore at 40% slurry and leached with cyanide and agitation for 28 hrs.

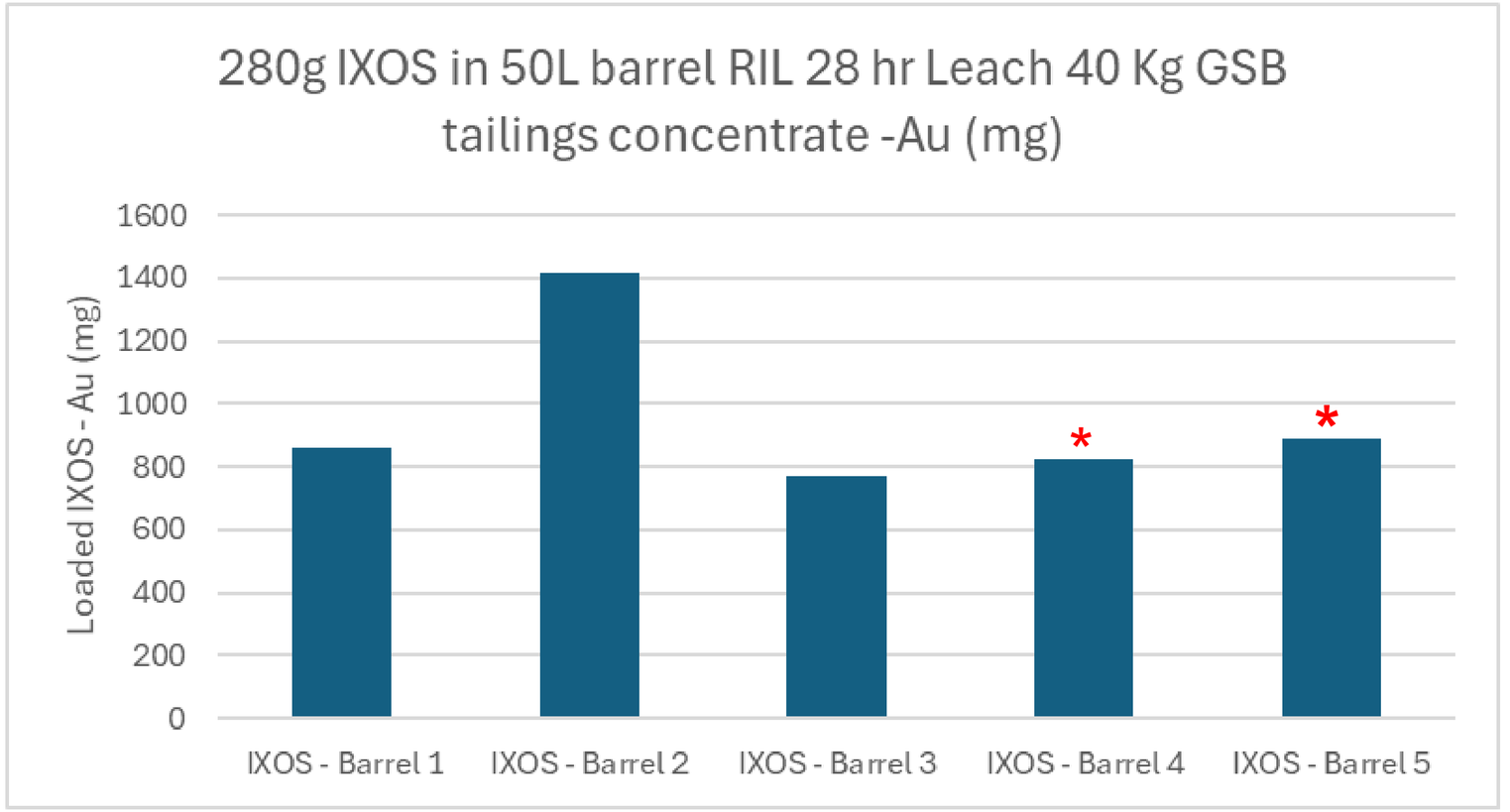
- 280g of the IXOS® resin was added to each barrel.

Ore description: Tailings concentrate Au values measured ranging from 10 - >100 ppm.

- Range of gold in each barrel estimated to be between 400mg and 4grams.

Notes: Power surges/outages and a resulting leak in one barrel resulted in loss of ore and the majority of the IXOS® resin in some barrels which contributed to incomplete leaching and recovery in some of the barrells.

This ore was highly variable in gold content and had to be sieved to remove large charcoal particles prior to leaching.



* = No Au detected in solid tailings after leaching

Data and Results

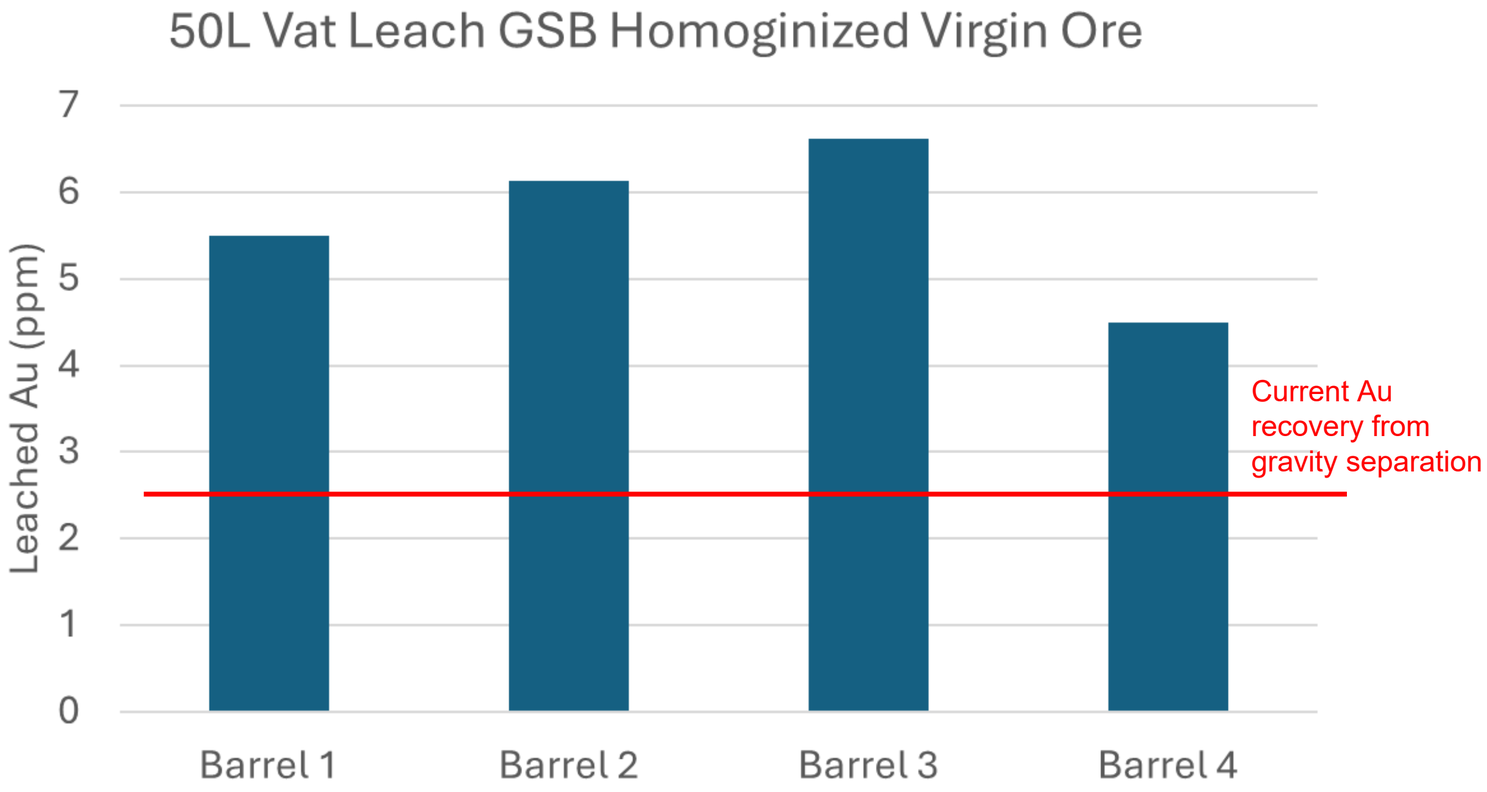
Experimental Setup

In a 50L barrel a Vat leach process was simulated with 40 Kg ore at 40% slurry and leached with cyanide and agitation for 36 hrs. The PLS was adsorbed with IXOS® in a fixed bed column.

Average panning recovery for this ore is between 2-3ppm.

Conclusions:

- Vat leach recovery was approximately 2.5 times more gold than gravity separation
- Better agitation during leaching improved oxygenation and leaching.
- Scale up from the bottle roll testing showed even better leach results.



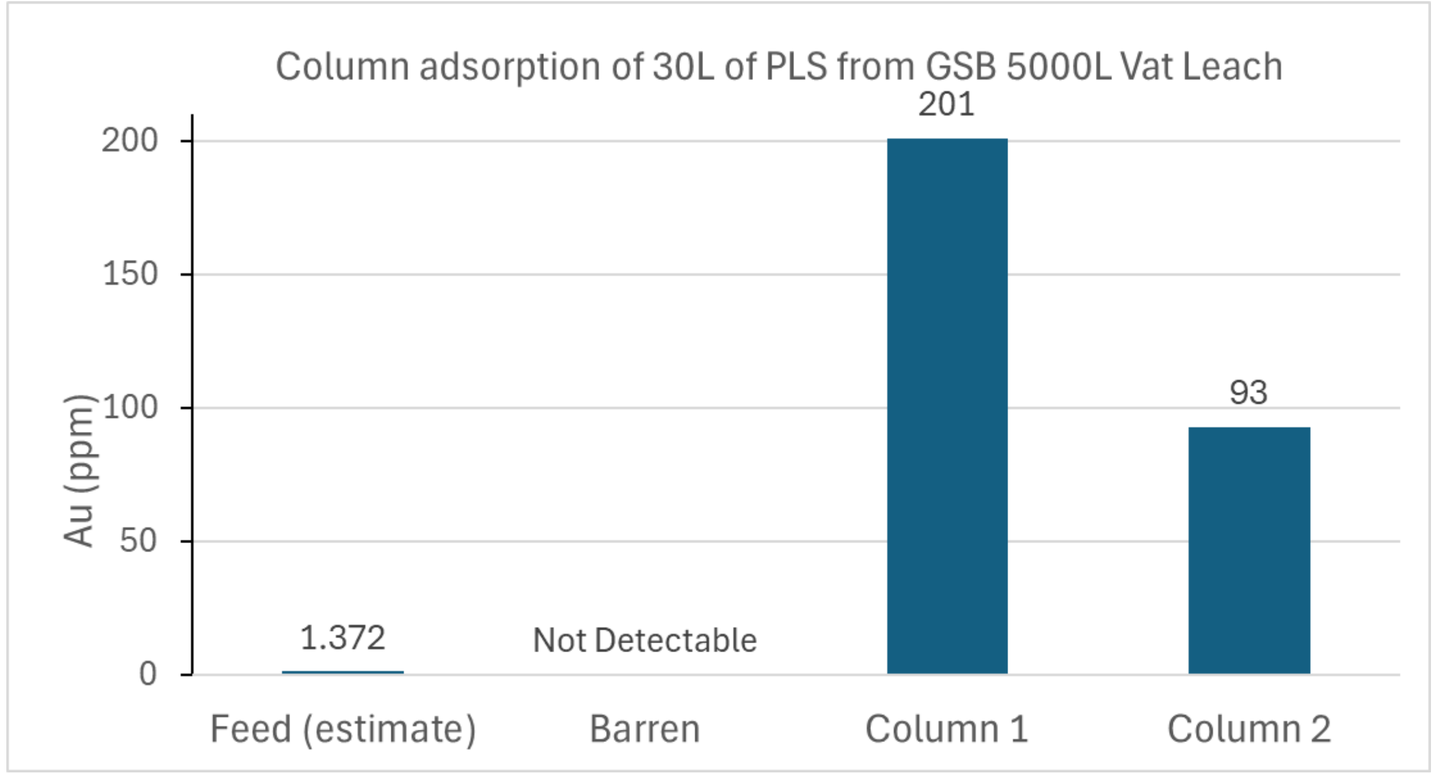
Data and Results

Experimental Setup

30L of PLS from GSB 5000L Vat Leaching trials was passed over a series of 2 columns of IXOS beads at a rate of 400 mL (1BV)/min.

Conclusions:

- Chemical leaching in a Vat leaching configuration was demonstrated and confirmed by AMS and GSB mining independently to successfully extract significant amounts of gold from tailings produced from gravity separation.
- Similarly, virgin ore was processed with a higher recovery rate using a chemical leaching process.
- **IXOS® was proven to have fast and efficient adsorption at both high (300 ppm) and low grade (1ppm) pregnant leach solutions.**



*Note: Solution samples are difficult to analyze in the field and can only be measured indirectly. Solution samples submitted for AAS analysis to confirm results.

Conclusion

- Gravity separation is inherently inefficient
  - It is especially ineffective with small particle and microscopic gold

- Leaching is the conventional method for recovery in such situations
  - The full process was demonstrated included leaching, adsorption, desorption and recovery.
  - Demonstrated recovery of the Au via electrowinning to produce "Gold Mud". This precipitate is filtered and smelted to produce a solid gold dore.

- Data from this testing is consistent with these principles showing increased gold recovery of approximately 2.5 times over gravity separation of the same ore. This was independently verified by AMS and GSB mining at the 50L and 5000L scale.

- Adsorption and elution of IXOS® was demonstrated to be fast, effective, and is operated at lower temperatures and ambient pressure, resulting in a smaller plant footprint and lower operating costs, compared to activated carbon.

- IXOS® was demonstrated to be effective in RIL or fixed bed columns, compatible with Vat leaching.

- **Based on current process and infrastructure a Vat leaching process is recommended to reduce operating complexity and cost.**

IXOS®: A Cleaner and Enhanced Gold Recovery Solution

- IXOS® specifically developed for gold extraction from cyanide leach solutions
  - Successful pilot testing at Agnico Eagle (Mexico), Kinross, Cortez (Barrick) and Fenix Gold (Rio2)
  - Selectivity of 97% versus 40% for existing alternatives
- May be used in both **heap leach, vat leach** process or mill circuits (RIP/RIL)
- Faster, cleaner, circular and more cost effective than Activated Carbon
  - Lower CO_2 emissions (1,165 t for 85,000 oz/year mine)
  - Circularity: Eluent is re-used continuously, meaning less reagents and chemicals
- Current use with **Activated Carbon** > 100 years old technology
  - Attracts other metals in leach solution, thus less efficient
  - By-product of coconut husks (puts high pressure on agricultural growth and harvest)

OVERVIEW OF RESULTS IN GOLD RECOVERY		
	IXOS	**Activated Carbon**
Capex	-30%	
Opex	-70%	
Recovery Rate (%)	±98% (Up to 99.4%)	±83%
Product Purity	Unchanged	
Environmental Footprint	Closed loop	
Process	Lower CO_2	
Duration (Hours)	3	18 - 24
Note: Actual results dependent on type of ores, conditions and operating environments		

Benefits: Superior Performance Based on All Metrics

Compelling Attributes of IXOS® in Gold Recovery

- Selectively adsorb **gold** and **silver** cyanide complexes from cyanide leach solution
- High metal recovery performance in **more complex solutions** where activated carbon, solvent extraction, and other purification technologies are lacking
- Non-reactive with kerosine when used in gold and silver recovery where carbon blinding is needed to enhance metal recovery
- Better alternative to Merrill-Crowe for Au-Ag mines, where Ag is in high concentration (up to about a 10:1 Ag:Au), then it is a perfect solution to scavenging Au/Ag post Merrill-Crow to reduce metals in the tailings
- Rapid stripping of the adsorbed precious metals (gold and silver) under ambient pressure and low temperatures of 60^{o}C (in comparison to Zadra and AARL circuits)
- Remediation applications where **Mercury** removal is of great concern

IXOS®: Summary and Conclusions

- An **environmentally friendlier** gold recovery solution that outperforms on **all** relevant metrics (opex, capex and recovery rate)
- Successfully tested and validated by several independent parties
- Works in more **complex solutions**, including mercury/arsenic remediation, preg-robbing environment and Au-Ag mines where Ag is high concentration
- This outcome arises due to its **high selectivity** from its **unique design** using nanotechnology called MIP (Molecular Imprinted Polymers)
- IXOS® has been tested in multiple pilot plants globally and has already reached **commerciality**

Until Next Time …