XPS
BULLETIN
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# Working Collaboratively to Solve Process Challenges

COLLABORATION... STRATEGIC ALLIANCES... PARTNERSHIPS... ALL WAYS TO DESCRIBE COOPERATION BETWEEN BUSINESSES, INDIVIDUALS AND ORGANIZATIONS TO ACHIEVE SYNERGIES AND DELIVER A MORE COMPREHENSIVE SERVICE TO THEIR VALUED CLIENTS.

Working collaboratively is always important and continues to be critical to success during this market downturn. Access to capital is tight and finding ways for our clients to maximize the use of their existing assets can be best accomplished by expanding on the skillsets of complementary businesses by making

**1 + 1 = 3!**

Often there is a natural extension in the services offered, a complementary or lower cost service, leveraging innovation or simply joint support of potential clients.

At XPS, we have acted on these opportunities for many years and have strategic relationships with companies such as Endress+Hauser, Bestech, J.L. Richards, Kingston Process Metallurgy (KPM) and Glencore Technology (GT). We also have working relationships with ABB, Hatch, the newly formed DRA/Metchem and Outotec to name a few, as we work together to cover a wider scope of services and deliver maximum value to our clients. On the innovation front, XPS is an active member of CIM, MetSoc, CMP, Canada Mining Innovation Council (CMIC) and CAMIRO and directs and funds research at McGill, U of A, UBC along with holding board positions at MIRARCO and the Laurentian Bharti School of Engineering.

The message is clear... XPS is more than the provider of quality metallurgical testing, process engineering, process control and materials technology expertise as it's connected to a vast network of technical and operational knowledge that is available to solve our clients problems.

## Organizational Changes

XPS is pleased to announce the addition of Dr. Graeme Goodall, P.Eng., Ph.D. as Superintendent of Extractive Metallurgy and Sergey Lazhnikov, M.Sc., MBA, an experienced mineral processing engineer from Kazzinc that is based here in Sudbury for 1 year. We welcome Graeme and Sergey to the team at XPS.

## XPS at IMPC

This September 11-15 in Quebec City, XPS will be active at the MetSoc COM 2016 hosted by the International Mineral Processing Congress (IMPC). We are coordinating the technical content in several streams, submitted short courses in Process Control and Materials Technology, presenting several papers including our experience in commissioning of Lundin's Eagle Operation and once again have sponsored the Airey Award for Excellence in Extractive Metallurgy. **We are participating in the trade show at Booth 307, so drop in to see us!** We have been active on the organizing committee in sponsorship. A personal thank you to all that have contributed to this worthwhile event!

As always, we appreciate your feedback and comments and hope you enjoy this edition of the XPS Bulletin!

Dominic Fragomeni, FCIM, P.Eng.
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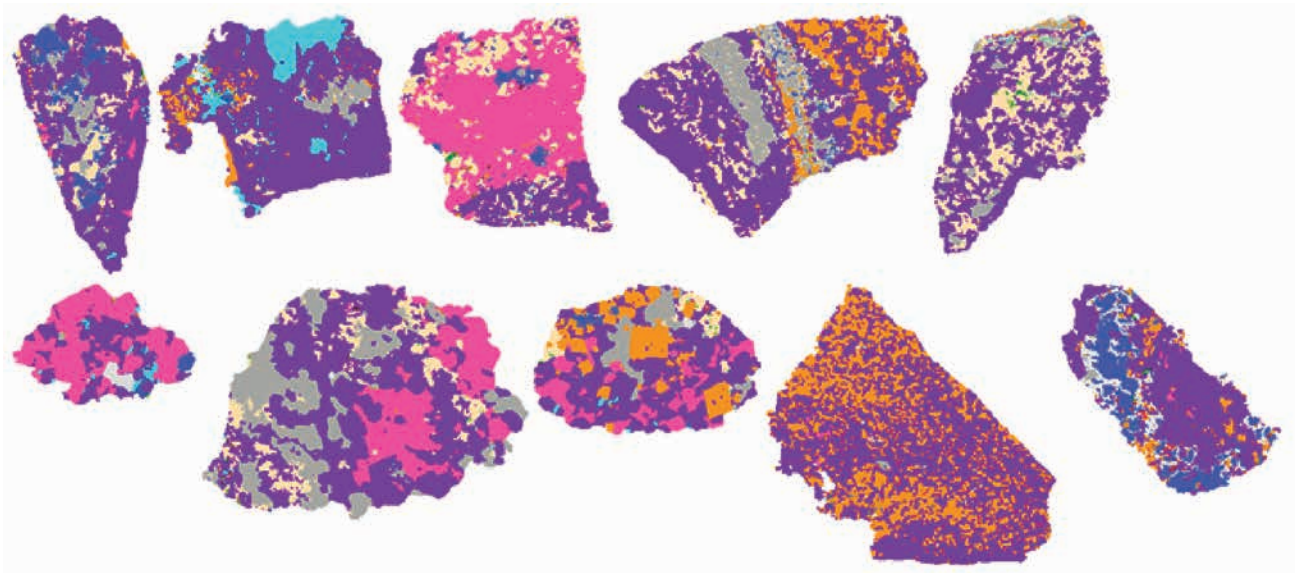
# Maximizing Concentrator Economic Performance

## SUCCESS IN A COMPETITIVE MINING ENVIRONMENT REQUIRES MAXIMIZING THE OPERATIONAL EFFICIENCY OF ALL ASSETS.



A zinc ore showing QEMSCAN images of sphalerite (purple) associated with galena (blue), pyrrhotite (pink), pyrite (orange), quartz (grey), carbonates (dark blue), orthoclase (cream).

Glencore Zinc asset managers are currently working with XPS to benchmark operational results for individual Zn concentrators, an initiative that will guide mining and processing decisions and capital investment.

Metals within ores can distribute themselves over a broad array of minerals even within a single deposit, and it is not uncommon to find that one or more such minerals represent a fraction of the metals content that cannot be economically exploited. This gives rise to the concept of "recovery entitlement", or the fraction of the head assay of a pay metal that occurs as recoverable minerals. This number is important to know, since the anticipated cash flow from a mass of ore and the metallurgical upside potential of the associated processing operation is no better than that which is dictated by the recovery entitlement. The entitlement calculation impacts mining cut-off grades, production planning and asset valuation.

The benchmarking exercise currently underway with XPS and Glencore Zinc involves fourteen separate operational assets spread across five continents, representing a truly global initiative that is being applied to a broad spectrum of zinc deposit types and sizes. A rigorous process of feed sampling and validation has been initiated which involves definition of short to medium term feed grade variability (from historical operating data) and collection of five random feed samples which are then individually validated as being "representative" feed (+/- 2$\sigma$ for all pay elements). It also involves the creation of a composite to represent the concentrator operation.

Feed composites are analyzed to determine the recovery entitlement of zinc, lead, copper (if appropriate), and precious metals (usually Ag, Au). XPS provides high-precision assessment of metals deportment and entitlement using advanced process mineralogical methodologies (QEMSCAN modal mineralogy, EPMA microanalysis of mineral species, LA-ICPMS laser ablation for trace analysis of solid solution). Comparison of metals entitlement versus actual operational results yields an indication of the success of the operation, and on a general level the magnitude of potential for improvement.

The benchmarking exercise beyond the Phase 1 comparative feed survey is preparatory for a deeper level of Phase 2 performance assessment based upon plant sampling. In a plant sampling exercise, XPS uses the

same mineralogical tools for analysis but includes size by size performance data and liberation data, in conjunction with performance data for individual minerals and metallurgical assay balancing across key nodes in the separation process. The data from the Phase 2 study defines not only the snapshot of performance during the time of sample collection but also the relationships between parameters of economic importance such as mineral liberation-based limits of grade versus recovery.

The detailed Phase 2 survey allows the assessment of opportunities for improvement, especially on an economic level. The net revenue is clearly improved by reaching toward the limits of entitlement, but revenue is also affected by smelter/upgrading terms, concentrate grade, transport costs, presence of penalty elements, and partitioning of precious metals into the various concentrates. The best operating point for the plant from an economic standpoint may vary according to changes in the market environment, including the relative values of the pay metals in a multi-element asset. Glencore Zinc will combine the technical results of the Phase 2 survey with proprietary economic modelling to set metallurgical targets which will dynamically maximize economic results. In addition, Phase 2 will potentially identify new technical opportunities that can either be explored in the plant, or tested in a laboratory setting as a Phase 3 optimization program.

It is recognized during this benchmarking initiative that ores are rarely homogenous. Nonetheless, variability is frequently measurable and mappable, allowing "geometallurgical units" to be defined within orebodies. It is not uncommon in general mining practice for orebodies to be defined in such a manner, for example as "sulphide zones" versus "oxide zones". The better an ore body can be defined by geometallurgy, the more useful production models become. Thus the benchmarking exercise also anticipates Phase 4, which is the geometallurgical characterization of future ores from Glencore Zinc assets.

The collaborative effort between XPS and Glencore Zinc illustrates the power of process mineralogy and geometallurgy for benchmarking and optimizing metallurgical operations. Mineralogically based process models allow objective assessment of asset performance, as well as yielding proactive tools for maximization of asset revenues and identification of process opportunities, allowing the most efficient realization of economic potential.

**For further information, contact Gregg Hill at gregg.hill@xps.ca or Jorge Oliveira at jorge.oliveira@xps.ca**

# ASSET PERFORMANCE MONITORING

## Process Controls

### MOST OF US ARE WELL AWARE OF OUR 'CHECK ENGINE' STATUS LIGHT IN OUR VEHICLES.

This is a constant monitoring device to alert us of failure/malfunction within our engine or the emission related systems. It helps to prevent expensive engine damage and provides key diagnostic information in where a sensor, valve etc. malfunction has occurred.

**Asset and performance monitoring** monitoring is crucial if we are going to fully realize the optimum returns from the large investments which are made in mining and mineral processing plants and operations. At the instrument level, this is far more possible now than it was three decades ago.

XPS Process Control has used the AMIRA P893 Concentrator Benchmarking Study to drive instrumentation and automation reviews using predictive maintenance and fault detection tools. The control system vendors (like ABB and Emerson for example) also offer ***diagnostic*** tools within the control system to do key monitoring and diagnostics continuously.

XPS Process Control has experience with asset monitoring and can perform a review of your plant or process. It starts with a Process Control questionnaire and includes a site visit and final report complete with recommendations. Recently, we have reviewed the mill controls at Chelopech and Antamina. Contact Phil Thwaites or processcontrol@xps.ca for further information on how to review your Mill's controls and benefit from improved asset monitoring and improved process control. We take it for granted in our private and company vehicles – as it helps us to keep our own vehicles running and safe!

Phil Thwaites
*phil.thwaites@xps.ca*

# Refractory Gold Treatment

WHILE THE RECOVERY OF FREE MILLING GOLD BY GRAVITY AND DIRECT CYANIDATION IS STRAIGHTFORWARD AND WELL-ESTABLISHED, REFRACTORY ORES POSE A VERY DIFFERENT CHALLENGE TO PRODUCERS.

The first challenge is determining the reason for the poor recovery by direct cyanidation, which can be caused by one or more contributors. The oldest and best understood reason is gold locked in sulphide, and most frequently pyrite. Another contributor to refractory behaviour is arsenic and antimony, which affects recoveries even at low concentrations. The presence of carbon in the ore is also a frequent cause of poor recovery, not because it makes the gold unresponsive to cyanidation but because it readily absorbs gold in solution and leads to "preg-robbing". When these refractory contributors present themselves in combination, obtaining satisfactory gold recoveries can prove a real headache. Fortunately there are solutions.

Once a cause has been identified, there are a number of alternatives for treating the ore. Firstly, the gold can be made more amenable to cyanidation by ultra-fine milling to improve the level of liberation. If fine grinding does not improve liberation, some form of sulphide oxidation to liberate the gold would be required. This can be accomplished by pressure oxidation (POX) in an autoclave or innovative solutions such as Albion Process™, a combination of ultrafine grinding and oxidative leaching at atmospheric pressure. Roasting – either the well-established simple dead roasting to convert pyrite to hematite while oxidizing any carbon present, or two-stage roasting to firstly remove arsenic by partial roasting followed by dead roasting can also be used in the treatment of refractory ores. Flotation can also be performed at XPS to concentrate the gold bearing minerals in advance of pre-treatment and cyanidation.

Since XPS has expertise in fine grinding, pressure hydrometallurgy and pyrometallurgy, all these skills have been bundled into a "one-stop-shop".

**Here a client can receive:**

- a diagnostic leach test to determine the cause of a particular ore's refractoriness;
- a comprehensive review of solutions;
- a recommendation as to which of the alternatives best suits the project needs;
- appropriate testing in XPS's well equipped laboratories.

With our combined experience in mineral processing, pyrometallurgy, and hydrometallurgy, XPS is well suited for the detailed metallurgical testwork required for successful refractory gold processing.

The key to curing the headache is proper diagnosis of the cause. XPS recommends QEMSCAN mineralogy, Electron Microprobe Analysis (EPMA), Laser Ablation (LA-ICP-MS) which will define the proportion of free vs refractive gold along with liberation and association data. The mineralogical data supports Diagnostic Leach results that clearly identify where the gold is in the ore by systematically destroying key minerals, followed by cyanide leaching of the residue until all of the gold has been recovered

## Fluid Bed Roasting

Comparative testing of all three options can be carried out at bench scale at XPS using the facilities and expertise on hand. Roasting can be completed in either 2", 4" or 12" diameter continuous fluid bed roasters, each equipped with a cyclone, afterburner for combustion of arsenic and/or sulphur vapour, condenser, and scrubber. Typically, 1-5 kg of feed is sufficient for preliminary comparative evaluation using the 2" roaster, while 20-50 kg can be sufficient for longer duration testing in the 4" roaster. The 12" roaster can run at 100-150 kg/hr for larger pilot tests! All roasters are fully instrumented with thermocouples, pressure measurements, and gas analyzers to ensure reliable data capture.

## The Albion Process™

The Albion setup at XPS consists of an M4 IsaMill to efficiently produce the ultrafine ground ore or concentrate, followed by leaching in an agitated tank at atmospheric pressure. Fifteen kilograms of feed is required for determining the signature plot in the IsaMill, but a single Albion leach test can be carried out on as little as 1 kg of ground material. Typically, more sample is required to do a full process design. XPS works closely with Glencore Technology (GT), the inventors of

Albion Process™ to ensure their experience in testing and scale up is included in the program.

## Pressure Oxidation

Pressure oxidation tests are carried out in a stirred 2L Parr bench-scale autoclave, which typically handles charges of approximately 1 kg. The autoclave is constructed of titanium and can be operated with an optional glass liner. It is fully automated to measure and control the temperature and pressure within the autoclave and the gas flow into the autoclave. The process measurements are captured continuously.

## Cyanidation

Having 'neutralized' the deleterious elements by roasting, pressure oxidation, or Albion leaching, the residue from the pre-treatment stage is leached in a cyanide solution and voila... the gold is recovered!

**Contact Gregg Hill at gregg.hill@xps.ca for discussion on treatment of your refractory gold for maximum recovery.**

# PROCESS GAS ANALYSIS

## One of the most revealing process streams in any smelting or processing plant is the off-gas.

GAS IS A DYNAMIC PHASE WITH VERY SHORT RESIDENCE TIMES WHEN COMPARED TO THE CONDENSED PHASES. A CHANGE IN A FEED OR CALCINE COMPOSITION MAY TAKE HOURS OR DAYS TO APPEAR IN THE ASSOCIATED SLAG AND METAL STREAMS, WHILE THE CHANGE IN THE GAS STREAM WILL OCCUR IN SECONDS OR MINUTES.


This advanced knowledge of process changes provides valuable time for corrective action. However, many smelters and process plants find that the benefits of gas analysis are outweighed by the burden of onerous maintenance and frequent calibration costs, and choose to let analytical equipment become defunct.

XPS has recently acquired experience with tunable diode lasers for gas analysis. The laser systems can be configured in either an extractive system, where sample is pulled out of the process, or as an in-situ installation, where the laser is mounted across the duct to measure the process stream itself. In-situ applications are very low maintenance with high sensitivities and zero lag.

Calibration of the analytical setup is maintained by splitting the laser and continuously passing a portion of the beam (normally 5-10%) through a sealed calibration cell of known concentration.

During plant trials and audits, measuring process gas at various locations can yield invaluable information. For these applications, a portable gas analysis rig suitable to the harsh environment of a smelter is preferable to in-situ analysis.

XPS is pleased to announce that custom analytical rigs can be tailored and built to meet any need. Units are industrial rack-mounts with IP68 dust and water ingress ratings and support simultaneous analysis of 3 to 5 gases. Provisions for crane lifting and integral fork-lift channels ensure they are plant friendly and robust.

**For more information on this technology or applications, contact Graeme Goodall at graeme.goodall@xps.ca**

# XPS provides hands-on practical training to its client base.

Our expert consultants have delivered several courses this year including Mineral Processing – a Primer Covering Flotation & Controls & Important Mill Measurements, and Introduction to Mineralogy Liberation & Mineralogical Interpretations. We are also currently developing and preparing other courses for clients on Flotation and Sampling.

**XPS also partners with other field experts to deliver focused and relevant training seminars.**

**This year two such courses have been completed with a third being planned for late 2016.**

In January, XPS and Ross Mackay of Ross Mackay Associates Ltd. provided a two-day Practical Pumping course to the Glencore Kidd Metallurgical Site in Timmins, ON. The course was attended by a cross-section of people from varied disciplines from millwrights, technicians, engineers and superintendents. The course covered the basics of pumping, including sizing, system design, pump types and troubleshooting typical problems with countless examples and anecdotes from Ross' decades of industry consulting experience.

In May, XPS and Jenike & Johanson Inc. (www.jenike.com) presented a two-day seminar on Bulk Solids Flow at the XPS Centre in Falconbridge, ON. The seminar presented the key principles in the design of solids material handling: establishing operating conditions and critical flow properties for each type of material, selecting appropriate flow pattern(s), and then designing hopper geometry, outlet size, feeder types and size to ensure reliable handling.

The seminar was led by Tracy Holmes, P.Eng., Vice-President of Jenike & Johanson Inc.

Both courses were enthusiastically received and attendee feedback was excellent!

### Pump School Feedback:

*'Very good training' ; 'Really good course, very knowledgeable on subject with good practical experiences.' ; 'Ross was very engaging'.*

### Bulk Solids Flow Feedback:

*'enjoyed the course' ; 'demonstrations were great' ; 'great course' ; 'applicable to many engineers'.*

**A second Ross Mackay Pump Course is planned for the fall of 2016. Please contact ron.bose@xps.ca for details.**

**If you or your organization has any specialist training needs please don't hesitate to contact us.**

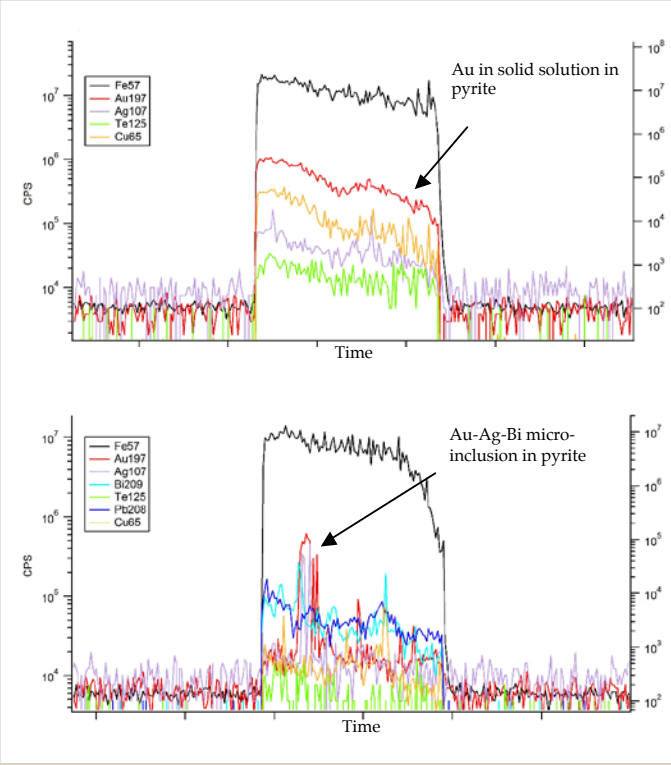
Ron Bose
*Chief Engineer, Process Control, ron.bose@xps.ca*

# Laser Ablation Services now offered by XPS

## XPS CONSULTING & TESTWORK SERVICES IS PLEASED TO ANNOUNCE WE NOW OFFER LA-ICP-MS (LASER ABLATION – INDUCTIVELY COUPLED PLASMA – MASS SPECTROMETRY) ANALYSIS, A KEY COMPONENT OF AU OR PGE MINERALOGICAL DEPORTMENT STUDIES.

LA-ICP-MS is an in-situ micro-sampling technique capable of performing highly sensitive element analysis while achieving detection limits at the ppb level. The technique quantifies ultra-low concentrations of precious metals (e.g. Au, Ag, Pt, Pd) that occur as solid solution within a variety of mineral phases (sulphides, arsenides and oxides). This form of precious metal often requires different processing techniques to those that occur as discrete grains. Metallurgists attempting to recover precious metals need to understand if a portion of them occur in a form that is not recoverable by the methods they use in their current flowsheet. The analysis can help diagnose reasons for lower than expected recoveries in a plant, or when included in a larger geometallurgical program, it can define areas of an orebody which may require different processing routes.

LA-ICP-MS is a cost-effective method compared to other techniques for determining contents of precious metals in solid solution because it offers quantitative multi-element analysis, which allows improved throughput. The depth profiles (or time resolved spectra) generated during each analysis can be inspected offline to scrutinize between precious metals that exist as discrete micro-inclusions and those that occur in solid solution. Examples of these types of profiles and how the LA-ICP-MS results have contributed to deportment studies are shown in the figure at right.




Laser Ablation Outputs and Diagnostics

**For more information on Laser Ablation at XPS, contact Michelle Kelvin at michelle.kelvin@xps.ca**

# XPS is very pleased to announce the addition of Graeme Goodall, P.Eng., Ph.D. to XPS as Superintendent, Extractive Metallurgy

## GRAEME WILL LEAD OUR TEAM OF PYROMETALLURGISTS AND HYDROMETALLURGISTS.

GRAEME GOODALL, P.Eng., Ph.D.

Graeme brings several years of experience in safe pilot plant startup and operation, design of bench and pilot scale experiments for process development and operations support, development of extractive pyrometallurgy laboratory testing procedures and best practices and client support to operations and production. He has filed several patents, supported business strategies and has performed fundamental studies in thermodynamics and process kinetics.

Prior to joining XPS, Graeme was a senior research engineer with Vale and metallurgist with NRCan. He also held several teaching and research positions with McGill University, Rio Tinto and Noranda. Graeme studied at McGill University where he earned his undergraduate degree along with a Masters and Ph.D. in both Metallurgical and Materials Engineering.

**Graeme extends an invitation to all his colleagues and friends to contact him to discuss technical challenges in your operations at graeme.goodall@xps.ca**

**Join me in welcoming Graeme, Stephanie and their family to Sudbury and XPS.**

# XPS HOSTS MEMBERS OF PARLIAMENT


THIS PAST JULY, XPS WAS PLEASED TO HOST CANADIAN FEDERAL MEMBERS OF PARLIAMENT FROM SUDBURY, MR. PAUL LEFEBVRE AND NICKEL BELT, MR. MARC SERRE TO DISCUSS OUR CAPABILITIES AND FURTHER UNDERSTAND OUR ROLE IN INNOVATION AND TECHNOLOGY DEVELOPMENT IN CANADA.

A tour of the XPS Centre and technology was included which the highlight of the visit. Following the visit, Mr. Serré shared: *"We were very impressed with the tour and presentation from XPS Consulting & Testwork Services yesterday... this Glencore company is truly composed of an impressive team of multi-disciplined engineering and technical professionals. We really do have world-class talent and services right here in Greater Sudbury and Nickel Belt!"*

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