XPS
BULLETIN

ISSUE 20: **SUMMER EDITION**

IN THIS ISSUE

XPS EXPERT PROCESS SOLUTIONS
A GLENCORE COMPANY
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Value Delivery from Our Talented Team

AS METAL PRICES RECOVER - AND WITH ASSOCIATED EXPLORATION AND PROJECT DEVELOPMENT ACTIVITY INCREASING - SO DOES THE NEED FOR TECHNICAL TALENT.

This technical talent frequently comes in two forms: younger engineers and technicians with the new skills to challenge the status quo; or from experienced project managers and technical experts who can lead and define even the most complex and multidisciplinary programs.

During the last 12-18 months, XPS has hired additional technical talent in all parts of our business. For example, we have retained extra experienced metallurgists and process engineers but complemented them with some young, fresh-thinking technical talent from our universities and local community college. We welcome all our new employees to the XPS team!

Some of our new hires have entered XPS through our EIT program, either at the XPS Centre or at the Glencore Cu Kidd Metallurgical Operations. Other new members of our team are well beyond EIT and have joined the ranks to organize and manage projects. *(See the articles in this bulletin on pages 4 and 11.)*

Our team and approach is critical to delivering value to our clients

One thing is clear, not all test programs, studies and operations support projects are created equal. The value delivered is most often based on the project team and its technical expertise; its care and diligence in organizing laboratory and pilot tests, plus its project management and a collaborative, open environment during project execution.

What is also critical to success is the team's ability to distinguish the value of a specific approach during scope definition using economic criteria, and then developing an execution plan to achieve the project objectives.

XPS prides itself on selecting the best candidates for our positions in order to ensure value delivery for our clients. Our approaches to flowsheet design and testing, automation, materials selection and optimization are unique; they add much more value than the conventional approach and are recognized by clients who have chosen us as their partner and technical resource.

Some of these examples are described in this Bulletin, such as remote monitoring of control system health, flotation flowsheet design, pyrometallurgical testing at a range of scales, modeling of flotation processes using qemscan data, and the maintenance and inspection of process equipment using Asset Integrity Management.

In closing, I am honored to have been selected as one of the 2018-19 CIM Distinguished Lecturers. I would like to thank Canadian Mineral Processors, CMP, for leading the nomination, the endorsers of the award, and all the kind words and well wishes I have received either personally or on-line.

Please see https://www.cim.org/en/Services/Distinguished-Lecturers to arrange for a presentation at your next CMP or CIM meeting.

XPS will be attending Extraction 2018 in Ottawa.

Please visit us at Booth 309 at the Trade Show.

- Graeme Goodall, XPS Superintendent Extractive Metallurgy, is front and centre in the Peter Hayes Pyrometallurgical symposium. Graeme is also co-authoring a paper on CFD modeling of reactors in chromite smelting on Wednesday Aug 29th at 5:00 pm.
- XPS is also included in the U of A poster session describing our work on monoclinic and hexagonal pyrrhotite depression at Strathcona Mill.
- Wilson Pascheto, Manager Materials Technology, is co-author of a paper on furnace refractory failure analysis to be presented on Monday Aug 27th at 5 pm.

Hope to see you at the conference.

As always, I hope you enjoy this 20th Edition of the XPS Bulletin!

Dominic Fragomeni, P.Eng., FCIM
Vice President, XPS | dominic.fragomeni@xps.ca

Remote Control Loop Performance Monitoring Service: An XPS First

WITH COMMUNICATION TECHNOLOGY BECOMING MORE AND MORE SEAMLESS - AND MINE/PLANT INSTRUMENTATION AND CONTROL SYSTEMS MORE COMMON - XPS HAS EMBARKED ON AN AGGRESSIVE CAMPAIGN TO FURTHER SUPPORT ON-SITE PROCESS ENGINEERS, OPERATIONS, AND MAINTENANCE TEAMS.

Early in 2018, XPS received a 'FULL GO' from five Glencore sites to set up and manage a centralized control loop performance monitoring (CLPM) system. The system was envisioned to remotely monitor (read only) the control performance of between 50-150 loops in various plants in Canada and the South Pacific, all from the XPS Centre in Sudbury, Ontario.

Understandably, there was some hesitation in having experienced control engineers remotely review and recommend changes to critical control loops from many thousands of kilometers away. This reluctance was easily overcome when the value of the process was demonstrated by a brief audit of control loop performance and the protocols established for communication back to the sites.

After benchmarking the most advanced software and hardware available on the market, XPS finally selected Control Station's PlantESP product to offer this service to our clients. Installation and configuration of the product was accomplished at the end of March with the support of local IT Departments. The first tests were done in April with a sample of loops from several divisions.

Since May 2018, XPS Process Control has been monitoring the key loops in these operations, and we combine our specific expertise with this powerful tool as a service to our clients. We have already identified performance issues that would otherwise be difficult to identify automatically without this centralized system.

These included poor performance (stiction) in some valves, under- and over-sized actuators, poor PID tuning, and the example below of an oscillation created by a loss of control in the previous stage of the plant as shown in Figure 1.

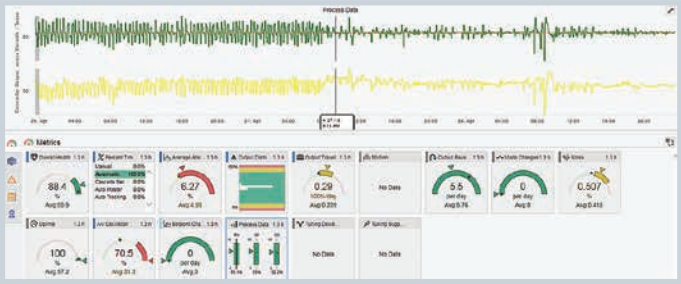


Figure 1: The oscillation on the left side of the marker - and operator work around on the right - had not been identified before CLPM was implemented.

Power Spectrum analysis is also used to fully define sources of oscillations and is used to further rectify the problem and return the plant to optimum performance.

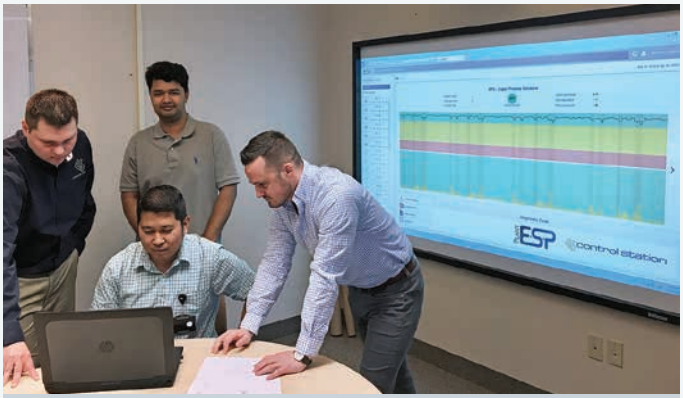


Figure 2: Configuration of the system (Control Station) at the XPS Technology Centre in Sudbury, Ontario.

Left to right: Robert Rice, Control Station Vice-President, Engineering; Napoleon Reata, XPS Process Control Engineer; Naseeb Adnan, XPS Process Control Engineer; Jon Stevens, Control Station Sales Manager, Eastern US/Canada.

Analysis of interactions between loops using a Power Spectrum Analysis is used to find common oscillation frequencies and determine which loop was leading the other(s) using a Correlation Analysis.

XPS is applying this tool to hundreds of loops in Mines, Mills, and Plants to focus attention on the under-performing loops. The software, combined with expert analysis, creates reports adapted to every role in these units (Management, Maintenance and Process Engineers). We will also identify poorly-tuned loops to allow our experts to prioritize analysis and to re-tune the loops using Control Loop Tuning *(See Control Loop Tuning: A Companion Service to Control Loop Monitoring Service on page 3 of this Bulletin!)*

We acknowledge and are very pleased with our relationships with our operating plants, site resources, and management. Our on-site champion is critical to success and we have great cooperation and support from our site champions right through to implementation. We are also pleased with our Control Station partnership. Some objectives of this partnership are:

- To promote the value of better process control in the mining and metal industry
- To add value to many more Glencore plants globally
- To work with Control Station to add new features that will address our more challenging client requests.

The system is used to capture and analyze process data generated at operating sites around the world.

For more information on Control Loop Performance Monitoring (CLPM), please contact Nicolas Lazare, Manager, XPS Process Control at nicolas.lazare@xps.ca

The Companion Service for Loop Monitoring

The XPS Process Control Group has championed the use of loop-tuning software for more than 20 years. This software shortens the time to achieve benefits through the efficient use of plant test data and the trial simulation of candidate tuning sets before they are used in the plant.

It also provides sophisticated analyses that the seasoned control professional can use to produce an optimized result. XPS has used and compared several different packages over the years to determine which has the best combination of technical features, usability, and repeated benchmarking. This has formed part of our recent survey of control-loop monitoring products.

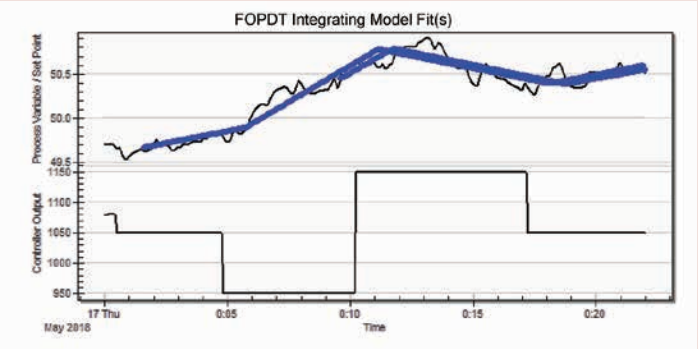


Figure 1: Fitting an integrating model over two time periods (second to fourth manual change, and third to fourth manual change). Loop-pro Tuner calculates quickly, and produced models where another package did not. The user interface allows the quality of the whole data set to be evaluated and for a visual comparison of the models.

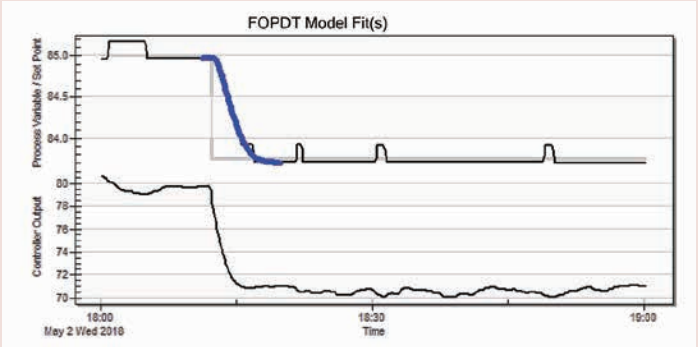


Figure 2: A process model is calculated from a setpoint change with the controller in automatic.

Recently, XPS selected Control Station's Loop-Pro Tuner to complement our Remote Loop Monitoring Service being rolled out at five different Glencore sites in 2018. (See Remote Control Loop Monitoring Service - CLPM service – An XPS First on page 2 of this bulletin). Process loop tuning has included blower power control, gas cooler temperature control, and pump tank level control.

The user interface makes it easy to quickly select different segments of data and compare models, as shown in Figure 1 below. The software quickly and robustly identifies models from manual output changes and automatic setpoint changes without the need for extensive data editing, as shown in Figure 2.

These control parameters can be tested and simulated to determine the best parameters for performance and robustness, as shown in Figure 3 with results tabulated in Table 4.

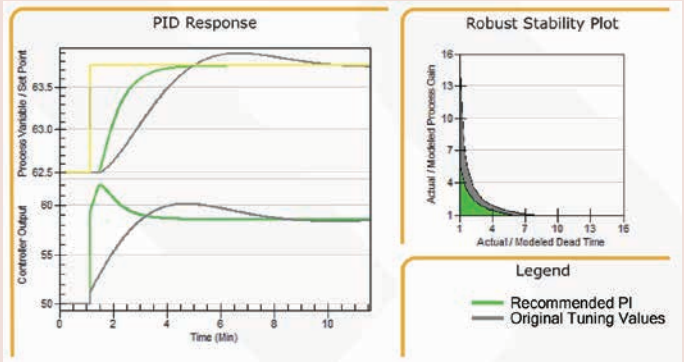


Figure 3: The simulated response of the process to proposed tuning is compared to the original tuning. The stability plot allows the trade-off of performance and reliability to be assessed.

PID Performance Statistics

	Stability Factor	Settling Time (Min)	Overshoot	Output Travel	IAE
Recommended	2.31	3.624	None	134.7	1.09
Existing	2.75	8.73	11.2	103.5	2.38

Figure 4: Statistics relevant to the expected performance change are calculated from the identified models and included in the tuning report. When the tuning is implemented, the achieved benefit in the plant calculated by PlantESP can be compared to the expected one.

XPS has partnered with Control Station to create new valuable features for mining and metal industries and will incorporate them in upcoming releases.

We anticipate identifying and improving many under-performing loops as we roll out our Remote Loop Monitoring Service to clients around the world. Having a good loop tuning package will allow us to achieve the desired benefits with low cost and ease of implementation as most of the work can be done remotely from the site

For more information on Control Loop Tuning and Remote Control Loop Performance Monitoring (CLPM), please contact Nicolas Lazare, Manager XPS Process Control at nicolas.lazare@xps.ca

Meet the XPS Engineers-in-Training

FOR THE LAST THREE YEARS, XPS HAS BEEN OFFERING AN ENGINEER IN TRAINING (EIT) PROGRAM, PROVIDING REAL LIFE, PLANT EXPERIENCE AND MENTORING TO RECENT GRADUATES FROM OUR CANADIAN UNIVERSITIES.

The existing EIT Program has roots in a similar program, run from 1996 to 2013, where Falconbridge and XPS sponsored, managed and trained more than 45 metallurgical engineers in a variety of operations and technology assignments.

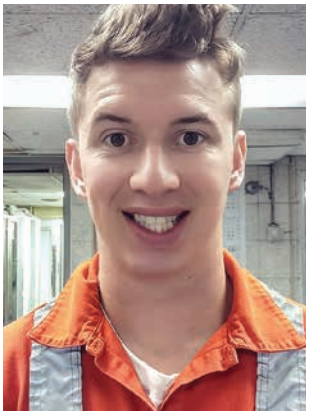
Since 2014, Glencore Zn Canada Kidd Operations have sponsored the XPS EIT program. At the Kidd Mill, three young metallurgists – Joey Fyfe, Ryan Ayerst and Mike Khouri – work on shift providing metallurgical surveillance to the operations and guidance to address some of the most challenging milling and flotation issues.

The benefit to the operation is significant and the learning curve is steep. Kidd Operations are commended for their vision in supporting this program, particularly through the latest metal price downturn. The first cohort of the XPS/Kidd EIT program Vince McIver, Jennifer Taylor and Lauren Woods are currently in full-time roles at the Glencore Sudbury Smelter and at Kidd.

At the XPS Centre, David Chern recently joined our Materials Technology Group and is both in the field and in the lab learning about inspections and troubleshooting equipment and material failures.

Ravi Multani joined XPS in 2017 as a contract lab technician while completing his Ph.D. in Mineral Processing at McGill University. Once Ravi defended his thesis and received his degree he joined XPS as a full time EIT in the XPS Process Mineralogy group.

PLEASE MEET OUR XPS EITs!

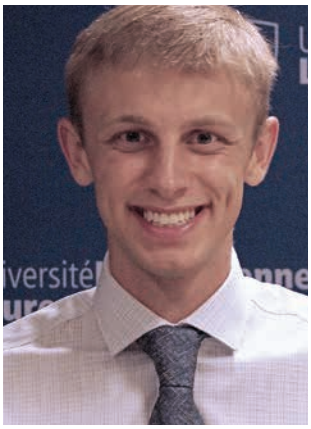


JOEY FYFE

As a member of the XPS process metallurgy team, Joey Fyfe works as an Associate Metallurgist on contract with Glencore's Kidd Operations at the Kidd Creek Metallurgical site.

Joey is currently an engineer-in-training working towards obtaining his P.Eng. He holds a Bachelor of Engineering degree in Chemical Engineering from Laurentian University and has a demonstrated knowledge of process metallurgy, having worked at two separate Glencore-operated mineral processing facilities. At the Kidd Creek Metallurgical site, Joey provides ongoing input on day-to-day grinding and flotation operations. He has also played a vital role in metallurgical projects, such as analyzing data from reagent trials and altered plant startup and shutdown procedures, as well as increasing the reliability of the Courier on-stream analyzer.

Please join us in welcoming Joey to XPS and Glencore.



RYAN AYERST

XPS is pleased to welcome Ryan Ayerst to the extractive metallurgy team as an engineer-in-training. Ryan graduated in 2018 from Laurentian University with a degree in Chemical Engineering, specializing in extractive metallurgy. Prior to graduating, Ryan completed a 16-month internship at Ontario Power Generation where he worked on decommissioning, and on long-term reliability of the instrument and service air systems at Pickering Nuclear Generating station. This allowed Ryan the opportunity to collaborate with many different groups within the organization, including operations, maintenance, health and safety, and plant design. These skills will play an essential part of his role as an OSA metallurgist at Kidd Operations.

Please join us in welcoming Ryan to XPS and our Glencore team.

MIKE KHOURI

Mike is a graduate from Laurentian University in Sudbury where he received his bachelor's degrees in Biochemistry in 2013 and Chemical Engineering in 2017.

Following graduation, Mike started his career at Northern Sun Mining Corp. as an engineer-in-training where he optimized particle sizing, flotation efficiencies and recoveries, tracked key production performance indicators and recommended improvements, and performed laboratory testing and experiments. His experience in the mineral processing industry will be valuable in his role at Kidd Operations.

Please join us in welcoming Mike to XPS and Glencore.

DAVID CHERN

David graduated with a B.Eng in Materials Engineering from McGill University in 2018. Through his CO-OP terms and part-time work contracts, he carried out research at McGill's Nanomechanics and Tribology Laboratory and at École des Mines de Saint-Étienne's Laboratoire George Friedel. During this time, he researched cold-sprayed metals, diamond-like carbon coatings, and self-lubricating polymer composites.

Joining XPS as an engineer-in-training in the Materials Technology Group, David brings a strong background in mechanical testing and materials characterization that will enable him to support and learn from his experienced colleagues. Welcome David to the XPS team.

RAVINDER MULTANI

Ravinder holds Ph.D. and M.Eng degrees in Materials Engineering from McGill University and a B.A.Sc. in Chemical Engineering from the University of Waterloo.

His primary specialty is in mineral processing and mineral surface chemistry (aqueous environments); essentially utilizing the mineral chemistry toolbox for the beneficiation of industrial minerals and for the stabilization of industrial tailings. Ravinder's Ph.D. study focused on the flotation behaviour and rejection of pyrrhotite polytypes (monoclinic and hexagonal) which is certainly an asset as it's a very common sulfide gangue in base metal deposits around the world and its rejection proves to be challenging.

Prior to his graduate studies at McGill, Ravinder worked for various companies, namely Umicore, Petro-Canada, and XPS and Vale. Highlighting his experience at Vale, he worked in their milling operations in Sudbury (Clarabelle Mill and Matte Processing) during which he gained valuable plant commissioning, project management, and lab-scale flotation testing experience. While at XPS, Ravi performed many of the lab test procedures he now manages.

Ravinder brings strong technical, interpersonal, and professional experience to the XPS team with a versatile background that will complement the XPS Process Mineralogy Group. His ability to apply his mineral processing knowledge to lab-scale testwork and working with operations and technologists personnel is one of his strengths and is part of the XPS value proposition to our clients.

Welcome back Ravi to the XPS and Glencore team.

For more information on our XPS EIT Program, contact Dominic Fragomeni at dominic.fragomeni@xps.ca or Mike Muinonen at mika.muinonen@xps.ca

XPS Flotation Mini Pilot Plant Successfully demonstrates Nickel Creek Shäw Project Flowsheet

THE XPS FLOTATION MINI-PILOT PLANT (MPP) IS A POWERFUL AND COST EFFECTIVE TOOL FOR PROCESS DEMONSTRATION AND PILOTING USING MODEST SAMPLE REQUIREMENTS.

FEATURES OF THE XPS MINI FLOTATION PILOT PLANT

- Flexible to allow testing for a wide array of flowsheets and ore types
- High confidence results due to sampling protocol, process stability and replicability from batch testing
- Scale up validated and tested by comparison to full scale plant performance
- High run time allowing for accumulation of concentrates and tailings for marketing and downstream testing
- Ability to test multiple operating conditions, ore types, geomet units and production period composites within a single 4 day run
- Recently featured in the Canadian Contributions to Mineral Processing Technology – CMP 2018

XPS Flotation Mini Pilot Plant

Most recently, process development was completed on the Nickel Creek Platinum Shäw Project with a mini pilot plant (MPP) demonstration of an XPS-developed process flowsheet. In batch testing, locked cycle testing of a feed with 0.33% Ni, 0.15% Cu, and 0.48 gpt PGM (Pt+Pd+Au) had resulted in the production of a 9.5% (Cu+Ni) concentrate containing recoveries of 54% for nickel, 57% for copper, and 42% for (Pt+Pd+Au). These results were consistent with the mineralogically measured metal entitlement (quantity of recoverable nickel) and the fine textures of the ore.

The flowsheet in Figure 1 was piloted in the XPS mini pilot plant (MPP) using primary grinding mills, small flotation cells, drum magnetic separation and two pin mill regrinds. The circuit stabilized within two to three hours, leading to an uninterrupted production run of four days duration at an average feed production rate of about 12 kg/hr. Over this time the final products of the circuit were sampled and assayed 25 times (3-4 hour resolution) and complete balances including internal streams were generated four times. The entire process run was completed with a requirement of only 1,100 kg of feed material, making the MPP an economically attractive option for this project where the metallurgical samples needed to be specifically drilled for the pilot run.

The stability of the circuit allowed the pilot operation to be tuned and optimised, finally producing a stable-state concentrate containing 9.1% (Cu+Ni) at recoveries of 53% for nickel, 60% for copper, and 52% for (Pt+Pd+Au). Thus, the pilot operation managed to replicate with precision and a high level of confidence the projections made from open circuit testing. The replacement of the original lengthy batch procedure with the continuous pilot procedure was particularly beneficial for the recovery of precious metals.

The MPP operation was stable with no significant process upsets for the entire duration of the campaign. This allowed the collection of usable final concentrate for the whole operating period, producing material for the testing of copper-nickel separation. Such testing had been impossible in batch development due to the low yield of concentrate from the ore. Approximately 30kg of bulk concentrate was produced in the MPP, which was homogenized then split into 500g batches and stored as frozen wet filter cake.

The bulk concentrate was subjected to locked cycle copper-nickel separation. Pentlandite was depressed using aerative conditioning in the presence of lime and sodium metabisulfite. A copper concentrate was produced containing 53% of the bulk concentrate copper at a grade of 13.8% Cu,

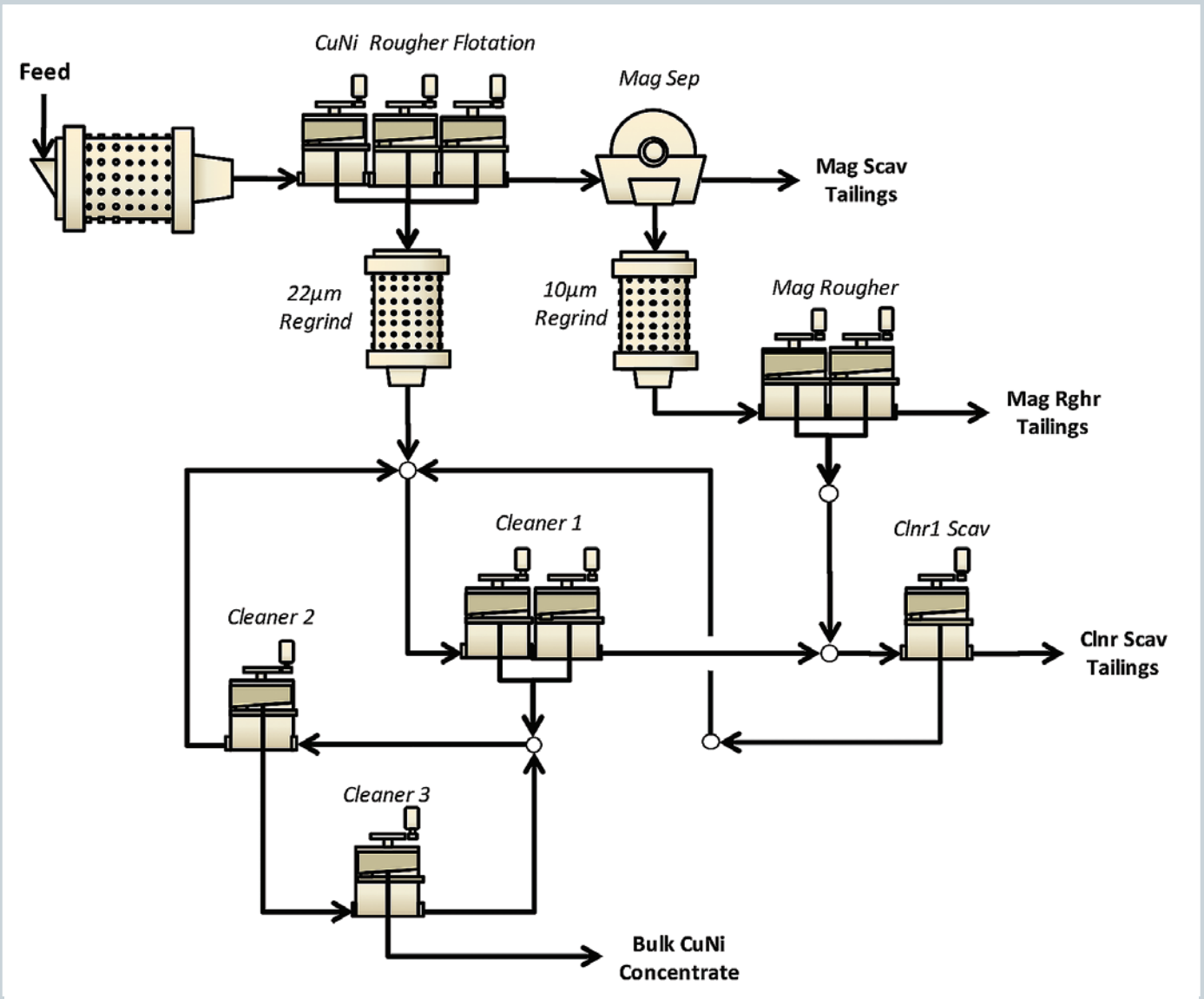


Figure 1: Nickel Creek Flowsheet

with relatively low nickel content. The nickel concentrate contained 98% of the nickel and 91% of the (Pt+Pd+Au). A mathematical simulation of process scale-up to commercial high efficiency cleaning based upon the split factors observed in the copper-nickel locked cycle test suggest the feasibility of a copper concentrate containing 18% Cu at a stage copper recovery of 62%. This projection is consistent with the actual observation of ~20% Cu open circuit concentrates observed in batch flotation of the bulk concentrate.

The successful completion of MPP piloting executed for the Nickel Creek Platinum Shäw Project provides an excellent demonstration of the power of the MPP for process development even for a low grade ore with low mass pull rates. The modest sample requirement versus conventional piloting, 1.1 tonnes versus 10-20 tonnes offers the advantage of significantly reducing costs both in sample acquisition and in project execution, improving sample representivity and at the same time accelerating the development time line.

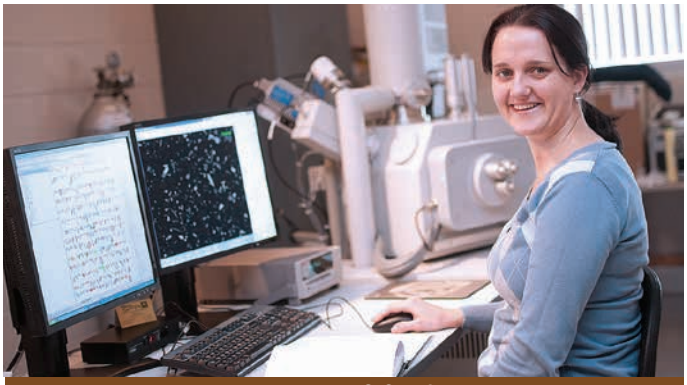
With experience from over 20 runs on over 35 different ore samples including Ni, Cu, Au bearing pyrite, arsenopyrite, Pb, Zn, rare earths and Cu-PGM the MPP has succeeded in generating stable and reliable data that is consistent with the results of prior laboratory development and suitable for design, scale-up and economic modelling.

For more information on the XPS Flotation Mini Pilot Plant, contact Gregg Hill at gregg.hill@xps.ca
See our MPP video at www.xps.ca/media.

Flotation Grade Recovery Modelling from Mineralogical Measurements

XPS IS CONSIDERED ONE OF EARLY ADOPTERS OF PROCESS MINERALOGY AND HAS BEEN PRACTICING THE HYBRID DISCIPLINE FOR OVER 20 YEARS.

The value of quantitative mineralogy, through QEMSCAN or other automated mineral measurement technologies, to inform process development and optimisation is no longer debated. The XPS Process Mineralogy team uses quantitative mineral measurement as an integral part of most programs and not an analytical measurement to be interpreted in isolation, this is where we distinguish ourselves.



Elizabeth Whiteman, XPS Chief Mineralogist

As part of the Onaping Depth project, a phase was developed to generate a mineralogical model that can predict the grade recovery curve of feed material and the expected bulk concentrate grade as the ore is processed through Strathcona Mill. Modelling of flotation response allows for significantly less empirical flotation testing and only testing and investigation for ores that are not predicted to provide acceptable responses.

The flotation model uses first order flotation kinetics to predict the floatability of each particle based on its mineral composition, liberation and texture. For Strathcona, a down the bank rougher kinetic survey allowed the calibration of mineral floatability factors for the mineralogical model.

The Strathcona model predicts flotation to a final bulk Cu+Ni concentrate and then simulates Cu/Ni separation. The bulk concentrate grade, recovery, mineralogy, Po/Pn selectivity and estimated mass pull can be predicted and compared for multiple ore sources. Characteristics impacting performance such as different Po/Pn ratios, Cu/Ni ratios and fringe zones with higher bornite or millerite can be compared. Zones higher in bornite and millerite provide indicators for millerite flotation to Cu concentrate.

The model also allows up to 4 separate feeds to be mathematically blended in a targeted ratio to predict flotation response. This is extremely valuable as the Strathcona Mill receives ores from multiple mines at varying ratios.

The model methodology can be prepared for many ores to predict rougher recovery and cleaner recovery depending on circuit configuration. It is more robust than typical theoretical grade recovery curves that are produced from mineralogy as these are idealised and based on perfect separation.

Since it is a liberation based model, there are some limitations for circuits incorporating regrinds however overall rougher recoveries can then be subjected to static models of subsequent regrind and cleaner circuits. This is a great tool for geometallurgical assessment without flotation testing and

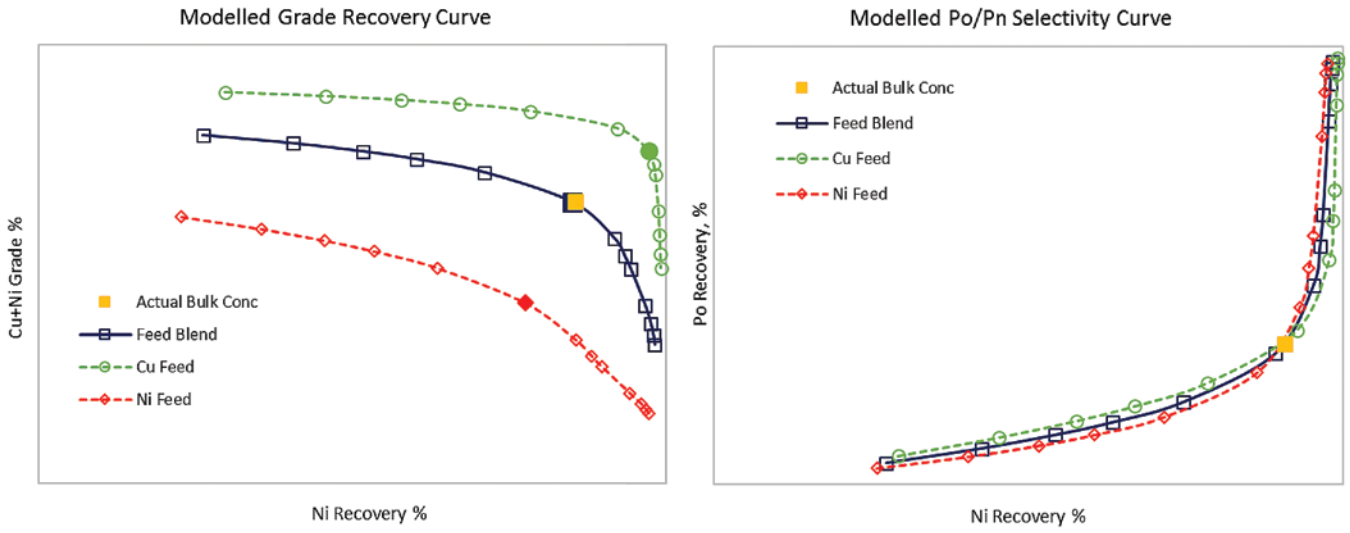


Figure 1. Modelled Grade recovery curves (left) and Po/Pn selectivity (right) for a Ni Feed, Cu feed and a feed blend of the 2 ores. Solid markers indicate predicted bulk concentrate performance point.

overcomes some of the laboratory limitations such as cell type or water quality.

The model results are shown in Figure 1.

In addition to model predictions of performance from mineralogy and plant data, XPS has used quantitative mineral measurement to define modal mineralogy with QEMSCAN combined with mineral chemistry from the Electron Microprobe. The combination of these equipment, under one roof at XPS, can lead to definition of ore entitlement based on metal deportment in a range of minerals and recovery to concentrate. This has been used extensively in recent projects including Ni Creek Shaw project described in the associated Bulletin article. *(XPS Flotation Mini Pilot Plant demonstrates Flowsheet at Nickel Creek Shaw Project Flowsheet, XPS Bulletin 20th Edition, pg 6)*

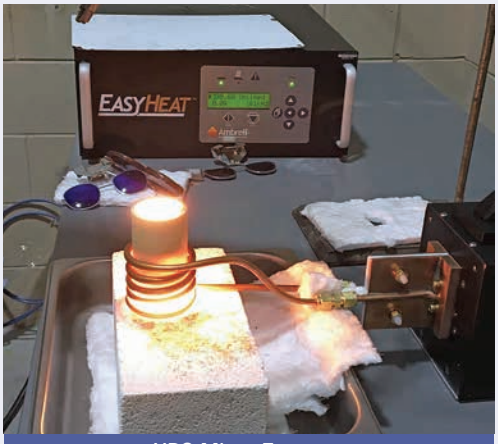
Another example of how XPS Process Mineralogy continues to demonstrate value to our clients. For more information, contact Elizabeth Whiteman, Chief Mineralogist, Process Mineralogy at elizabeth.whiteman@xps.ca)

RING OF FIRE

XPS Conducts Ring of Fire Chromite Smelting Tests

XPS HAS EXTENSIVE PYROMETALLURGICAL TESTING CAPABILITIES AVAILABLE AT ITS XPS CENTRE IN FALCONBRIDGE, ONTARIO.

XPS Induction Furnace



XPS Micro Furnace

XPS 350 KW DC Electric Arc Furnace

These include Vertical Tube Furnaces, Hazen Rotary Kilns, Induction Furnaces a new Bench Top Induction Furnace and the largest of them all, a 350 KW DC Electric Arc Pilot Furnace.

XPS commissioned the DC Arc Furnace in 2012 and ran several campaigns for Ring of Fire Chromite ore demonstrating its amenability to conventional DC electric arc smelting. Early in 2018, XPS ran another smelting campaign using this furnace as part of the NRCan Chromite Development initiative. Approximately 1 tonne of ore from Noront's Ring of Fire Black Thor deposits was prepared, fed into the furnace and smelted at 1600°C generating a ferrochrome alloy and slag which were tapped from the furnace into molds. Extensive workplace and process gas monitoring were also included in the program. A pilot water granulator was installed to generate slag granules to simulate industrial granulation.

The data collected and samples from the testing are currently being evaluated by NRCan at their laboratories in Ottawa, Ontario. The information will assist Noront in the permitting, design and construction of a conventional but modern, full scale, Chromite smelting facility.

In recent years, the steady, reliable, and secure supply of critical metals has become increasingly important to major industrialized economies. Canada, with its significant critical metal reserves, has an opportunity to supply some of the global demand for these critical metals.

Test programs with the equipment such as these carried out at XPS, will assist in developing these world class chromite deposits located in Ontario's Ring of Fire making Canada a significant global producer, processor and supplier of products that contain the critical metal chromium.

Contact Mika Muinonen at mika.muinonen@xps.ca for more information on XPS capabilities to test, pilot, design and engineer your metallurgical processes and concepts.

Physical Asset Integrity Management

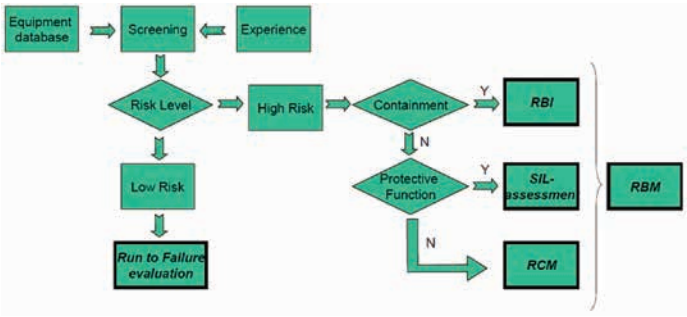
NEXT TO SAFETY OF OUR EMPLOYEES, THE CONDITION AND OPERABILITY OF FIXED ASSETS ARE CRITICAL TO OUR OPERATIONS.

Asset Integrity Management (AIM) is a defined process of inspection and coordinated maintenance to minimize risk of unplanned failure and the on-going costs of maintaining a physical asset.

The Publicly Available Specification 55 (PAS 55), published by the British Standards and the Institute of Asset Management, was the precursor to the ISO 55000 series. These standards are the core of asset management and defines the practice as coordinated activities of an organization to realize value from its assets. One important feature of an asset management system is the integrity of its physical assets. An asset's integrity is defined as its capacity to achieve the required functions efficiently, while ensuring people and process safety, and environmental protection and at the same time reducing operating costs.

The Materials Technology group, with its extensive plant experience and knowledge of failure mechanisms, is your ideal partner to maximize value from your assets, throughout their life. This partnership, stemming from an asset renewal to operation, maintenance, safety and reliability, will help you manage your risk at every stage of your asset life.

XPS customized methodology will consist of the following steps, as illustrated below:



1. Audit of the current asset integrity system: this can be done with the Self-Assessment Methodology tool developed by the Institute of Asset Management. The audit tool covers all aspects of asset management; however, XPS focus will be on the physical asset integrity aspect.
2. Risk definition, evaluation and ranking: physical assets will be screened by risk level, according to your corporation risk matrix, and in line with the plant operating and maintenance experience as well safety and environmental impact. The low risk assets will be monitored or could be run to failure, depending on your requirements. The identified high-risk assets will be contained and protected through a set of practices, components of the Risk Based Maintenance (RBM). XPS is currently collaborating with the Glencore Risk Management Team at the Strathcona Mill, to develop a risk registry for the mill's static equipment.
3. Risk Based Inspections (RBI): the methodology derives from API 580/581 Risk Based Inspection and the Materials Technology Institute Implementing RBI in Process Plants and will consist of:
   - Establishing risks based on Failure Mode Effect Analysis (FMEA)
   - Data gathering, re-assessing risk and refining inspection plans
   - Assessing equipment condition & selecting optimum inspection intervals
   - Performing inspections based on physical methods (Visual Inspection & Non-Destructive Testing (NDT)
   - Establishing mitigation options

   XPS has implemented a RBI program at the Horne Smelter sulfuric acid tank farm since 2009 and performs an update, annually.
4. Safety Integrity Level (SIL): when the risk is not easily contained, it can be reduced with appropriate selection of a safety function or target level where the risk is acceptable to the client. This can be done with the use of continuous asset monitoring tools that allow measurement of process and or physical parameters. The collaborative approach between the XPS Materials Technology and Process Control groups will ensure a customized solution is carried forward to your requirements and objectives.
5. Reliability Centered Maintenance (RCM): when the risk cannot be contained nor reduced, the maintenance strategy will adopt a reliability centered maintenance, with the goal of achieving the optimum maintenance required to maintain the function of the asset. XPS will provide you solutions, ensuring that
   - Emergency procedures and contingency plans are in place
   - Repair procedures are ready and spare parts inventory is aligned with the emergency and contingency plans
   - Perform root cause failure analysis and re-adjust the RCM program accordingly.

The RBM components described above will feed the asset whole life cycle evaluation, and will feed the capital expenditure program, through evaluation and determination of:

- Aging assessment & life cycle cost analysis
- Equipment degradation mechanisms and rate
- Time of equipment retirement

XPS has developed an aging assessment program for the Horne Smelter acid plant since 2013 and the program is continuously updated with inspections and monitoring, readjusting the assessment and realigning the aging with the capital expenditure program.

Whether you are deciding on expanding your operations, reducing maintenance costs, improving plant availability, replacing a critical equipment, XPS can be your partner in maximizing value from your assets, at every stage of their life.

Contact Umugaba Seminari, Senior Materials Engineer for more information at umugaba.seminari@xps.ca

Welcome to XPS

Scott Brindle MEarth.Sci – Program Mineralogist, Process Mineralogy

XPS is pleased to welcome Scott Brindle to XPS and a Project Mineralogist. Scott is a graduate of the University of Manchester (UK) where he received a master's degree in earth science with honors. Scott is an experienced geoscientist having worked seven years for CGG, a major oil and gas and mining service company specializing in automated mineralogical techniques including QEMSCAN. He has contributed to the development of new applications of the technology enabling better oil and gas reservoir characterization in a wide range of reservoir types and locations. He also brings valuable industrial experience having worked on well-site operations in the Middle East. His main professional interests are in the implementation of integrated mineralogical techniques to optimize the discovery and extraction of natural resources.

Please join us in welcoming Scott to the XPS team and contact Scott at scott.brindle@xps.ca for your automated mineralogy needs.

Felix Whitehead, XPS Technician 1

XPS is pleased to announce Felix Whitehead has joined XPS as a Technician 1 in the metallurgical lab.

Felix is a recent graduate of the 3 year Chemical Engineering Technology Lab and Process Control program at Cambrian College in Sudbury where he studied the science and practical aspects of chemical processes, including grinding and flotation, execution of lab tests and chemical plant automation systems. Felix is presently involved in execution of various mineral processing and pyrometallurgy projects such as lab batch flotation tests, locked cycle tests, mini pilot plants, furnace campaigns on a variety of ore, concentrates and intermediate products.

His previous experience includes student co-op opportunities at Strathcona Mill as well as in mineral processing research and development at COREM in Quebec City.

As a Technician 1, Felix is part of a experienced and knowledgeable group of technicians and technologists who are tasked with efficient execution of lab and pilot tests.

Please join us in welcoming Felix to XPS.

Rolando Huaraz, XPS Program Metallurgist – Process Mineralogy

XPS is pleased to announce the appointment of Rolando Huarez as a Program Metallurgist in Process Mineralogy. Rolando is a Metallurgical Engineer and graduated from San Marcos University, Peru in 1995. He has has over 22 years of experience in operations and testing and flowsheet development, 12 in gold processing plants and also in tin and polymetallic mineral processing.

Prior to joining XPS, Rolando worked as a Mill Superintendent at Kirkland Lake Gold Inc. (Holt Mill), Ontario as part of the management team. He also worked as a Senior Metallurgist at Barrick Gold (Pueblo Viejo) Dominican Republic as part of the commissioning, start-up and ramp up team. In addition, he was part of SGS Lakefield Canada Inc. Gold Metallurgical lab.

Rolando has experience on flowsheet development for metallurgical projects, operations management, plant optimization, sampling and metallurgical accounting.

Rolando is currently a candidate for a P.Eng. designation as a Professional Engineer in Ontario.

Please join us in welcoming Rolando to XPS.

Alex Lamarche, XPS Technician 1

XPS is pleased to welcome Alex Lamarche to the XPS lab team. Alex is a recent Cambrian College graduate from the Chemical Engineering Technology program. After completing both of his program's four month Co-op terms with XPS, Alex happily joined the XPS team permanently in May 2018. As a student, he worked on various Plant support projects including Nevsun Resources Ltd.'s Bisha (Cu/Zn) flotation flow sheet development, NRCan's DC Furnace Chromite Smelting Campaign, Nickel Creek's Pilot Campaign as well as many other sizing, flotation and rheology programs.

Alex has been working extensively on Nevsun's Timok (Cu) flotation flow sheet development and optimization.

Alex is looking forward to learning from (and working with) the team here at XPS.

Please join us in welcoming Alex to the team at XPS.

Congratulations!

Maxine Hoffman, PEO Limited Licensee

XPS is pleased to announce that Maxine Hoffman, XPS Metallurgical Technologist, has recently passed all qualifications for a Limited Engineering License (LEL) with the PEO (Professional Engineers, Ontario).

Through her experience and self-study, Maxine has received PEO certification to, "Develop, review and/or endorse flotation flow sheets and material balances for base metal ore processing."

Maxine has over 27 years of experience with Falconbridge FTC, Xstrata (Xstrata Process Support) and XPS (Expert Process Solutions), a Glencore Company. She has worked in all groups at XPS, including Mineral Processing, Mineral Science, Extractive Metallurgy, and Materials Technology and many of the operations in Sudbury.

Her expertise spans all facets, from flowsheet development and test execution from batch scale testing to all scales of pilot plant operation. Maxine plays a key role in leadership, training, planning, and coordination of activities at the XPS laboratories and is a key resource in flowsheet development activities in mineral processing.

We acknowledge Maxine, her dedication and hard work in serving our clients' needs and proudly representing XPS and our capabilities.

Congratulations Maxine!

Dominic Fragomeni, P.Eng., 2018 CIM Distinguished Lecturer

Dominic Fragomeni, VP – XPS CIM Distinguished Lecturer (left) being presented with the award by Ken Thomas, CIM President, May 2018

XPS and Glencore are pleased to announce Dominic Fragomeni, P.Eng., has been selected as a 2018 CIM Distinguished Lecturer 'in recognition of his contributions to the Canadian minerals industry and his vision for the future of mineral processing in Canada'.

CIM Distinguished Lecturers are chosen on the basis of their accomplishments in scientific, technical, management, or educational activities related to the minerals industry and speak at CIM Branch, CMP and Student Chapter meetings across the country.

Dominic's Distinguisher Lecturer presentations are entitled, "Innovation in Mineral Processing, Celebrate the Past…Look to the Future", and, "Where do I Start? – A Troubleshooting Guide for the Mill Engineer."

Dominic joins other CIM Distinguished Lecturers from XPS: Norman Lotter (2010), Phil Thwaites (2012), and Wilson Pascheto (2015).

Visit the link at CIM, https://www.cim.org/en/Services/Distinguished-Lecturer or contact Dominic Fragomeni at dominic.fragomeni@xps.ca to arrange for his presentation at your next CIM or CMP function.

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