XPS BULLETIN

ISSUE 17: SPECIAL 10 YEAR ANNIVERSARY EDITION

IN THIS ISSUE

XPS – Celebrating 10 years in Business

… THE OLD ADAGE, 'TIME FLIES WHEN YOU ARE HAVING FUN' CERTAINLY APPLIES TO XPS!

2017 marks 10 years since XPS was converted from a corporate research and development centre to an autonomous business working collaboratively to develop innovative solutions for our internal and external clients.

XPS has retained all the process expertise, relationships, plant and project experience from the previous organizations. We have evaluated and field tested some of our process concepts in our own Glencore plants and as a result, continue to implement practical solutions to complex technical problems.

We are extremely proud to have reached this significant milestone and thank all of our past clients for their confidence in using our services.

XPS – 10 years at a Glance
Approximately 2,500 projects have been executed and delivered value
QEMSCAN measurement of over 5,000 ore, plant and lab samples, totalling more than 40,000 polished sections and ½ billion particles measured
Over 100 physical separation tests including magnetic separation, gravity separation and cyclone separation evaluations
Over 40 Flotation Mini Pilot Plant runs on 20 different ore types
Over 4,000 Thermogravimetric Analyses (TGA Mass Spectrometer)
Approximately 50 roaster pilot runs using the XPS 50mm, 100mm, 150mm and 300mm diameter continuous pilot fluid bed roasters
Furnace campaigns of variety of sizes up to the 350KW DC Electric Arc capable of feeding 150kg/hr of feed
Well over 1,000 failure analysis and over 80 acid plant inspections
Over 1,000 control loops have been tuned and re-tuned and over 20 Process Control or Metal Accounting Audits

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

XPS at PDAC

XPS will be at PDAC in Toronto in March 2017 in its familiar Booth #615 on the trade show floor!

In addition to our booth presence, Liz Whiteman, Senior Engineer with XPS Process Mineralogy will be presenting the XPS's approach to GeoMetallurgy as part of the technical program on the Monday, March 6th.

We will also be raffling off a Michellutti original print at our booth, please ensure to drop off your business card in order to win! Look forward to seeing you all in Toronto in March to discuss your project or operational needs.

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

New XPS WebSite! www.xps.ca

XPS has launched a new website and we welcome you to have a look and review our message, new offerings and how we can add value to your project or operation.

Check out our News Section and also White Papers available on areas of technical interest available for download on our home page.

XPS EXPERT PROCESS SOLUTIONS
A GLENCORE COMPANY
10 years
xps.ca

Extractive Metallurgy Testing on a Micro Scale

ONE OF THE CHALLENGES WE FACE IN THE EXTRACTIVE METALLURGY TESTING BUSINESS IS LIMITED QUANTITY OF MATERIAL.

Often a sample reaching the extraction stage represents many thousands of dollars and hundreds of hours devoted to exploring, drilling core, and producing concentrate; yet the sample is frequently less than a kilogram in mass. Preserving every gram of this precious material is important to both XPS and our clients.

The XPS Extractive Metallurgy group has been working diligently to reduce the sample size needed for pyro-metallurgical work from hundreds of grams to tens and even single gram samples. The secret to our success is two-fold. First, we carefully screen the test conditions using advanced thermodynamic software to ensure we can accurately control the test conditions as needed. Secondly, we use the analytical capabilities of our world class Mineral Science group to analyze the results of our tests in situ. Most of the time, large samples are needed to generate clean fractions of slag and metal for analytical testing. For instance, a large melt of 500g is generated and the two or more resulting phases are physically separated, ground and sent for analysis. XPS approaches this problem from a different perspective. We test 5g under the same conditions, section the entire crucible [Figure 1] and map the composition of the contents with a scanning electron microscope. [Figure 2].

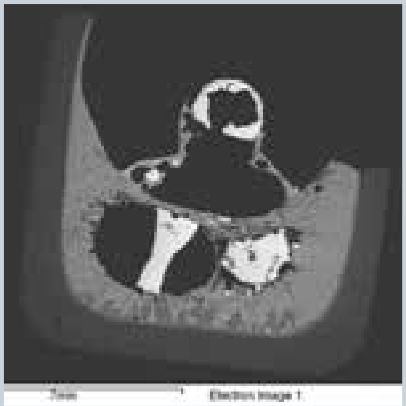


Figure 1 – Cross section of a 2g reduction melt producing metal and slag. Sample was drop-quenched from 1,550°C resulting in suspended metal phases.

From samples of 5g or less we can accurately measure the resulting compositions of the molten phases. Different stages of the process route can be tested by either quenching the sample to preserve the compositions present in the furnace at operating temperature, or slow cooling the samples to promote phase separation for further grinding and liberation. The QEMSCAN maps the resulting phase size fractions automatically.

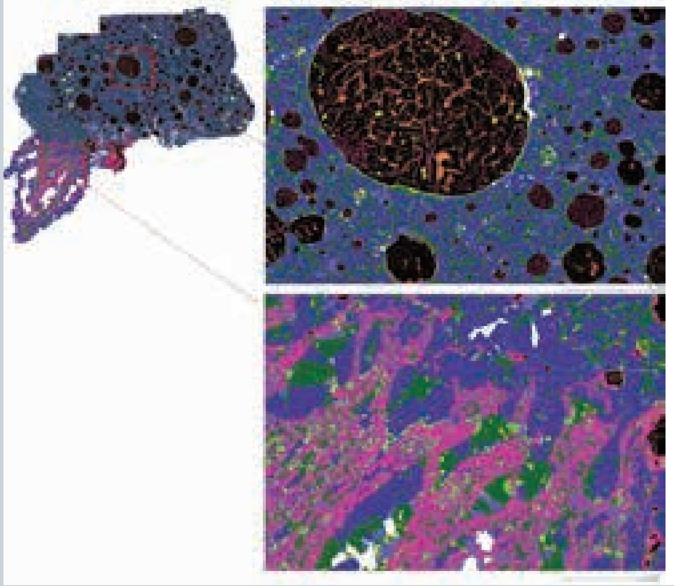


Figure 2- Quantitative Electron Microscopy (QEM) images of an alloy and slag phase produced at small scale. Microprobe analysis gives compositional data to combine with phase proportions for quantitative analysis.

We employ a number of different furnace apparatus to arrive at the precise control required for each individual test. Vertical tube furnaces can generate great quenched samples as crucibles are held at temperatures in excess of 1,600°C under precise atmospheres have less than 1 meter to fall before being quenched. While slower than water, liquid nitrogen can be used for the quench to ensure no reaction with oxygen occurs. Our small 15kW induction furnace is ideal for rapidly melting small samples and can be well blanketed with flowing gas.

Whatever your Extractive needs may be, the XPS team is here to help. We have innovative and proven techniques using cutting edge technology to generate maximum value from hard won samples.

Contact Graeme Goodall, P.Eng., Ph.D. at graeme.goodall@xps.ca for further details on micro testing in Extractive Metallurgy

Electrical Energy Use

ELECTRICAL ENERGY USE IS AN IMPORTANT PART OF AN INDUSTRIAL FACILITY'S COST OF PRODUCTION AND THE PRESSURES TO REDUCE COST IS EVER INCREASING.

A major factor in the cost of electrical energy is fuel pricing. bThe cost of fuels is being affected by global pressures, as well as carbon pricing, and in many cases geographic based delivery charges.

At an industrial site, the first step to reduce your energy costs is to appoint an energy manager who has the full support of the management team in developing and implementing an Energy Management Program (EMP).

The first step of an EMP is to conduct an energy audit. The audit will:

- Clearly identify the types and costs of the energy consumed
- Identify where energy is utilized
- Review alternatives such as modified operational methods or new more-efficient equipment
- Perform an economic evaluation to determine how well an energy saving opportunity can be integrated into the business plan

There are three phases in an energy audit, the first is to review data from energy bills and analyze to determine what energy is being consumed and how it varies with time.

The second phase deploys an audit team to conduct a walk-through inspection of the facility. Each physical system is observed and reported. After the plant has been surveyed, an energy balance is developed to account for the energy used in the facility. Once all energy sources are identified and quantified, analysis of alternatives can begin. The final step of phase two is to propose changes to equipment, processes or operations to achieve energy cost savings.

The third and final phase is implementation. Where the facility manager and the energy manager agree on specific energy savings goals and initiate some of the recommended actions to achieve those goals.

Included in this initiative is the setup of a monitoring system to determine how well each goal is being achieved. This will also show which initiatives have been successful and which have not.

This represents the first pass of an audit cycle which should then be repeated with the energy team working alongside the operation to achieve savings and maintain them.

XPS has been working closely with clients for several years with their collective efforts resulting in tens of millions of dollars in savings. A similar approach can be used for all sources of energy including oil and natural gas. Recently, XPS resources have received training as a Certified Energy Manager and can facilitate an energy audit of your operation.

Contact Ron Bose C.Eng., P.Eng., C.E.M., at ron.bose@xps.ca for more information on Energy Management Programs

Using Mineralogy to Support Copper Deportment Analysis

WEATHERING OF A NEAR SURFACE CU DEPOSIT RESULTS IN ALTERATION OF PRIMARY CU SULPHIDES TO A SUITE OF SECONDARY MINERALS.

One of two QEMSCANs at XPS

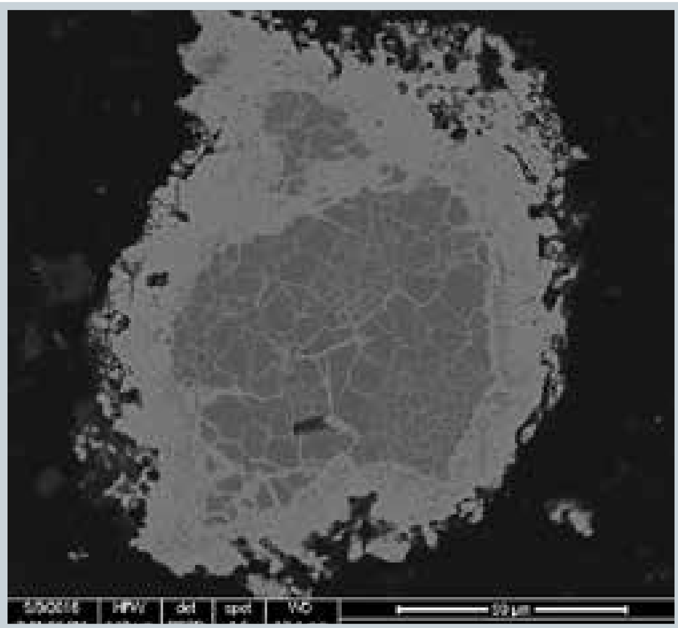
The use of sequential or diagnostic Cu assays for speciation of Cu minerals is the standard and most cost effective tool used by exploration and mining companies, but carries some risk depending on the mineralogical makeup and textures of an ore. The use of mineralogy to support the sequential assay method and to verify the mineralogical proxies is best practice in these situations.

TThe assay method uses a series of digestions with water, sulphuric acid and NaCN to dissolve minerals in a progressively aggressive leach. Each leach step is designed to remove specific phases which are separately assayed. Minerals that do not dissolve will report to the final leach residue and are considered refractory. Because the different Cu minerals require different processing routes, it is critical to have an understanding of the mineralogy when assessing the effectiveness of a particular metallurgical process.

A set of 60 samples from an Australian deposit was submitted for mineralogical assessment. Sequential assays were available to compare to the results. The deposit consists of an oxide zone, a transition and a sulphide zone. Mineralogy consists of combinations of Native Cu, Cu carbonate, Cu oxide and Cu silicate, chalcocite, chalcopyrite, bornite, pyrite and non-sulphide gangue.

The mineralogical assessment involved measurement of unsized samples by QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscope) and XRD (X-ray Diffraction).

The fine grained textures in the deposit are challenging for an automated system to produce high confidence data. Artefacts produced by scanning an electron beam across mineral boundaries can result in poor quality data if care is not taken to set up a detailed Species Identification Protocol (SIP) and to meticulously scrutinize the boundary identifications during the data processing stage. Thin chalcocite rims at pyrite grain boundaries will produce x-rays with varying concentrations of Cu, Fe and S as the electron beam traverses between the two minerals, and can be falsely identified as either bornite or chalcopyrite rather than the true pyrite or chalcocite.



Example of chalcocite rimming a pyrite particle and along internal grain boundaries. X-ray analysis can falsely identify a chalcocite-pyrite boundary as chalcopyrite or bornite. Careful review of data is required.

Once the data is processed, the modal mineralogy and a Cu deportment which produces a breakdown of the total Cu into the various minerals, can be used as a comparison to the sequential Cu assay. The study concluded that sequential assays are a reasonable proxy for mineralogy but with a few exceptions. When composites contained pyrite, the kinetics of the sequential assay increased, so that some of the Cu associated with the chalcocite leached early. The result could lead one to misinterpret chalcocite mineralization as Cu oxide, Cu carbonate or chrysocolla. The work also showed composites with very high levels of chalcocite leached early, and those with high levels of cuprite/tenorite leached late.

The highest confidence information is produced by employing multiple techniques, according to need. While sequential Cu assays and the use of proxies to determine mineralogy are the most cost effective method of defining Cu orebodies, a regular cross check of assays with mineralogical measurements in support of those assays is best practice. The combination of data from various methods provides geologists and metallurgical engineers with a better understanding of the variability in an ore and ensures that the proxies used for both orebody modelling and metallurgical interpretations are accurate.

XPS has performed this approach for clients and has the installed equipment and expertise to support full Cu deportment in ores and concentrates.

Contact Lori Kormos, P.Geo., at lori.kormos@xps.ca for more information on this unique method and its application

DEVELOPMENT TRAINING

'Foxboro DCS Comprehensive Integrated Control (2100C)' at XPS

RECENTLY, XPS FACILITATED A 'COMPREHENSIVE INTEGRATED CONTROL' COURSE – FOR THE FOXBORO IA DCS (DISTRIBUTED CONTROL SYSTEM) IN COLLABORATION WITH SCHNEIDER ELECTRIC.

The course benefited both XPS Process Control and Sudbury Integrated Nickel Operations: Strathcona Mill, Sudbury Smelter; as well as the Glencore Zinc Kidd operations.

The training was well attended by 6 participants from maintenance and process control development. The course covered the current mesh network hardware overview, feedback and cascade control configuration, feed forward, ratio control blocks followed by 'CALC' block configuration and best practices. The course finished with adaptive control, sequence block configuration, subroutines and a look at the new, next generation 'Foxboro Evo' configuration tool with the latest Field Control Processor FCP280.

Attendee feedback included,

"Instructor took time to help individuals that were less familiar with the Foxboro IA."

"Course layout was very informative."

Leo Moramarco with course participants

FCP280 Redundant IA Controllers

For your process training needs, please contact Kabir Ahmed, M.Sc., P.Eng. at kabir.ahmed@xps.ca

XPS – In the Consulting and Testing Business for 10 years!

2017 MARKS 10 YEARS SINCE XPS WAS CONVERTED FROM A CORPORATE RESEARCH AND DEVELOPMENT CENTRE TO AN AUTONOMOUS BUSINESS.

XPS started as a corporate research group, FTC, funded by Falconbridge Ltd., who were acquired by Xstrata PLC in 2007 and then Glencore in 2013.

Since 2007, XPS has been working collaboratively and developing innovative solutions for our internal and external clients.

Over the last 10 years, we have managed and worked on over 2,500 projects in the area of mineral processing, quantitative mineralogy, materials technology, process control and plant support. We have worked with clients from over 25 countries around the globe and have maintained a reputation for quality work and excellent value.

XPS has retained all the process expertise, relationships, plant and project experience from the previous organizations. We have evaluated and field tested some of our process concepts in our own Glencore plants and as a result have practical solutions to complex technical problems.

We are proud to have reached this milestone and thank all of past clients for their confidence in using our services.

XPS Process Mineralogy

The Process Mineralogy Group at XPS has evolved from the model first developed at the Falconbridge Technology Center (FTC) in 1997. The group consists of Mineral Processing and Mineral Science expertise in one integrated group. We have the benefit of experienced mineral processing engineers working side-by-side with talented geoscientists to solve complex mineral processing problems and strengthen the understanding of metallurgical performance by integrating ore characterisation and/or Geomet studies.

In all mineral processes, it's the **minerals and not the assays** that react and respond! Once a mineral processing engineer understands, quantitatively, the mineralogy, the liberation and the mineral chemistry, mineral processing optimisation and flowsheet development is much easier!

XPS Mineral Science

XPS Mineral Science has over 20 years experience with QEMSCAN technology and currently operates two Quanta 650s, one of which is a Field Emission instrument. Since the inception of XPS in 2007, the group has undertaken analysis of more than 5,000 plant, lab and ore samples totaling more than 40,000 polished section measurements and ½ billion particles measured and quantified. The combination of QEMSCAN technology and the CAMECA Electron Microprobe technology, in the same lab, is unique to the industry. The Microprobe capabilities allows for very accurate assessment of mineral chemistry, QEMSCAN calibration, element deportment and complete assessments of over 99.9% of all mineral species in the sample. In addition to the QEMSCAN and Microprobe technology, XPS has an X-Ray Diffractometer (XRD) and all the associated sample preparation equipment and technician expertise to prepare the best polished sections in the world. The most recent addition to the suite of capabilities is XPS Laser Ablation services to determine solid solution precious metal concentrations within sulphides, arsenides and oxides with detection limits at the ppb level. *(See Article XPS Bulletin Summer 2016)*.

Although the Mineral Science group was originally set up to support mineral processing operations, the group also contributes to many projects in the Extractive Metallurgy group (PyroMet and HydroMet) so the synergies at XPS are fully realized *(See XPS Bulletin Issue 14 Summer 2015)*. The group also leads Ore Characterisation and GeoMet studies, assesses environment samples and other materials not associated with mineral processing.

All this equipment requires experience in interpretation of data and efficient use of iDiscover Software. The XPS Mineral Science team has over 45 man-years experience and can transform vast amounts of data into information, cost effectively. Truly a winning combination!

Contact Lori Kormos, P.Geo., at lori.kormos@xps.ca or Mika Muinonen, MASc., P.Eng., at mika.muinonen@xps.ca

XPS Mineral Processing

The Mineral Processing group is led by experienced mineral processing engineers and technologists with plant, lab and business experience. We have expertise in separation processes including flotation, leaching, gravity and magnetic separation. Our experienced team of mineral processing engineers and technologists can execute batch tests, locked cycle tests and mini pilot flotation pilot plant tests to evaluate flowsheet concepts and deliver grade/recovery data and design basis to our clients. *(See XPS Bulletin Issue 12 Summer 2014)* XPS Mineral Processing engineers and technologists also work hand in hand with Mineral Science resources to develop, design and optimise mineral processing flowsheets to maximise economic value.

What distinguishes XPS Mineral Processing expertise is the plant experience. We bring practical solutions to our flowsheet decisions; understand and can manage risk in circuit complexity and when necessary, contribute to start-up and risk mitigation strategies. *(See XPS Bulletin Issue 13 – Winter 2015)*

Contact: Gregg Hill, Ph.D., at gregg.hill@xps.ca or Mika Muinonen, MASc., P.Eng. at mika.muinonen@xps.ca

XPS Extractive Metallurgy

The Extractive Metallurgy group at XPS continues to be a major resource for our internal and external clients around the world. We develop strategic processes for the economic extraction of metal value from ores, concentrates and intermediates by pyrometallurgical and hydrometallurgical methods.

The XPS Extractive Metallurgy team has a strong technical background tempered by years of practical experience at operations around the globe. The extractive roasting of ores in the laboratory is a good example of XPS drawing on a technical knowledge base spanning several decades with reinforcement from world class equipment at diameters from 50 to 300mm. *(See XPS Bulletin Issue 15 – Winter 2015)*

To complement the lab and pilot capabilities, our expertise in the use of Thermo Gravimetric Analysis (TGA) and various modelling tools such as FactSage, Simusage, ComSol, MetSim among others, shorten the time of most test programs and make full use of precious available samples.

The group works collaboratively and synergistically with the other XPS business groups to find solutions to problems such as refractory wear and process instability. Our plant experience helps determine what is needed for operating and mechanical stability and we use this experience to recommend changes in practice in operating smelters to increase throughput, improve metal production and increase operating time. All these factors are critical in low metal price cycles and essential when metal prices are rising to maximise cash flow.

Contact Graeme Goodall, P.Eng., Ph.D. at graeme.goodall@xps.ca or Mika Muinonen, MASc., P.Eng. at mika.muinonen@xps.ca

XPS Materials Technology

The Materials Technology group at XPS is known around the globe for their expertise in plant inspections, maintenance support, materials testing, failure analysis and failure prevention. Over the last 20 years, this group has performed over 1,000 failure analyses on equipment from mines, mills, smelters and metallurgical plants the world over. The Ma-

terials Technology Group brings value to your operations through Asset Integrity Management at the development and implementation stages of capital projects and on through the full equipment life cycle. The objective is to maximise return on assets and minimize business risks by improving the reliability of critical equipment.

Sulphuric acid plants in smelters in Sudbury, Rouyn Noranda, New Brunswick, Chile and now Australia and Kazakhstan have engaged the group to guide maintenance, replace and repair strategies, along with, perform life cycle assessments of key pieces of process equipment.

The group has grown to 5 engineers and 1 laboratory technologist over the last few years to meet demand. *(See this XPS Bulletin Announcements)* Our new employees bring operating and maintenance experience from other industries and Ni High Pressure Acid Leach (HPAL) processes and also offer significant industrial and academic knowledge in corrosion and strategies for risk mitigation.

In the end, its our industrial experience, working with maintenance and operating personnel and our exposure to real plant problems that ultimately make us most effective.

Contact Wilson Pascheto, M.Eng., P.Eng., at wilson.pascheto@xps.ca or Dan Falcioni, P.Eng. at dan.falcioni@xps.ca

XPS Process Control

Whether it's working from the XPS Centre or onsite at various operations around the world, the XPS Process Control team's proven approach delivers practical and robust solutions to our clients' plants.

The group is underpinned by key resources that have more than 60 years combined experience and using existing process control infrastructure to Measure, Control and Optimise processes or recommend process control upgrades and systems for new plants.

One of the key deliverables of the group is to use best practices to achieve operational performance excellence and results from our client's plants. To this end, for example, XPS has tuned or re-tuned over 1,000 loops and have reduced alarms by over 80% through strategic alarm rationalization.

The group has knowledge and expertise in all the major vendors' process control system technologies including Foxboro, ABB, Siemens and Delta V. We work with operations resources to design and implement control solutions or implement these solutions independently.

In the last 10 years, the group has evolved and among other products, is offering Plant Process Control Audit services that identify process control opportunities through use of best practices. We have identified opportunities and have implemented simple yet effective control strategies in plants in Kazakhstan, Chile, Peru and Canada.

Contact Alan Hyde, P.Eng. at alan.hyde@xps.ca or Phil Thwaites, BSc.(Eng.), ARSM, P.Eng., at phil.thwaites@xps.ca

Plant Support

The XPS Plant Support group is the most recent addition to the portfolio of services offered by XPS. Since 2011, XPS has been offering a range of services focusing on in-plant, hand-on technical assistance from metallurgical commissioning assistance to on-going plant optimisation, debottlenecking and troubleshooting.

The group consists of a team of experienced metallurgists with over 100 man years of operating experience and the proportional 'grey hair' that can work with operations and maintenance personnel to achieve metallurgical performance defined by the mineralogical ore entitlement. The group will bring in expertise from the other XPS groups such as materials technology and process control to achieve a Type 1 Start-Up... all this available in-house.

XPS Plant Support has played a key role in several plant start-ups in the Yukon, Northern Ontario, New Brunswick and Northern Michigan at Lundin's Eagle Mine. *(See XPS Bulletin Issues 12 and 13)*. We have worked with operations in southern Europe, northern Finland, East and West Africa.

XPS is available to help your operation during start-up, commission and optimize.

Contact Dominic Fragomeni, P.Eng. at dominic.fragomeni@xps.ca or Gord Marrs, P.Eng., at gordon.marrs@xps.ca

XPS KNOWS ALUMINUM

Not a single person in the modern world could go about their day without the products derived from our extractive metallurgy operations.

FROM THE STEEL REBAR HOLDING TOGETHER HOUSES TO THE ALUMINUM IN THE BEVERAGE CANS WE SEE EVERY DAY, PRIMARY METALS ARE ALL AROUND US, HIDDEN IN PLAIN SIGHT.

This ubiquity is a double edged sword, we as society constantly rely on metals, but we rarely appreciate their value.

Aluminum producers are constantly seeking ways to lower costs, reduce waste, and enhance product quality. Energy represents a key aspect of competitiveness, contributing roughly a third or more to the cost of producing aluminum from raw materials. Smelting is a priority area both because of its high energy use (per kilogram of aluminum produced) and undesirable greenhouse gas by-products (carbon dioxide and other carbon-based gases).

Primary aluminum is produced in smelters where pure metal is extracted from impure aluminum oxide (alumina) by the Hall-Héroult process. The reduction of alumina into liquid aluminum takes places at around 960°C in a cryolite salt bath using high intensity direct electrical current. This takes place in electrolytic cells or pots, where carbon cathodes form the bottom of the pot. Carbon anodes are held at the top of the pot and are consumed during the process, reacting with the oxygen coming from the alumina.

There are two main types of aluminum smelting technology: Soderberg and Prebake. The principal difference between the two is the type of anode used. Soderberg technology uses a continuous anode which is delivered to the pot in the form of a paste and which bakes to a hardened state in the cell itself. Prebake technology uses multiple anodes in each cell, which are baked in a separate facility and attached to rods that suspend the anodes in the cell. New anodes are exchanged for spent anodes, with the remaining anode "buts" being recycled into new anodes. Most primary aluminum production facilities use a variant of prebake technology called point fed prebake, which uses multiple in-cell feeders and other computerized controls for precise addition of alumina to the pot, which improves energy efficiency while reducing emissions, dust and raw material use.

There are many ways the primary aluminum production is addressing the challenges facing the industry today. Reducing the electricity consumption of the smelter is a clear, and critical priority in a highly competitive industry. The Extractive Metallurgy group at XPS understands the needs of the industry and can work with you to improve this critical metric.

Other challenges facing the industry where XPS can deliver value:

- Development of inert anode technology to improve energy efficiency and reduce direct CO_2 equivalent emissions
- Process control to eliminate anode effect occurrences, reduce fugitive PFC emission and improve anode baking
- Improving resource efficiency – adapting primary aluminum processes to lower grade raw materials and reducing solid waste by converting aluminum process waste into usable feedstock/products
- Reduce air emissions – improve total fluoride emissions by developing better sensors and measurements for fugitive fluoride emission evaluation

In terms of process optimisation, shifting to more flexible electricity consumption patterns to support the development of renewables-based grid mixes is an important

Continued on page 11 ➤

Materials Performance in Hydrometallurgical Plants

MATERIAL SELECTION FOR PIPING, VESSELS AND TANKS IS AN IMPORTANT PHASE IN A PLANT CONSTRUCTION PROJECT.

Once the plant is in operation, the performance of the materials selected is an important factor in measuring the plant availability and has a direct impact on safety, reliability and production objectives. It is therefore essential to have the adequate material for the required service and process conditions. The material selection process requires an in depth analysis of the life cycle of the equipment, the ore type and chemistry and planning for a contingency in the process conditions.

The challenge is therefore to account for unknown, but not totally unpredictable, factors when selecting material of construction for piping, tank and vessels.

Is it corrosion? Is it erosion? Or is it corrosion erosion?

Answering the questions above would facilitate, to a large extent, the material selection process.

Knowing that we are facing an identified corrosion mechanism, the selection of the material can easily be done by choosing a performing material, based on laboratory testing, field confirmation, availability, and industry experience and expertise.

In the case of erosion, the same approach can also be done. The selection of the adequate material will follow a systematic approach.

When it comes to corrosion erosion, the selection is not straight forward anymore. Is the fluid more erosive than it is corrosive? Should the selection process favour a more corrosion resistant material over erosion resistant material?

It is therefore very important to understand the damage mechanisms occurring in the pipe, vessel or tank. One material that would perform very well in a corrosive environment might not perform well in the presence of erosive particles within the fluid. Moreover, when a change in the process conditions occurs, where for example the corrosiveness of the fluid has increased from the original design conditions, the material performance can be compromised. Another example could be the morphology of the erosive particles, going from a lesser erosive to a more aggressive erosive type.

Should the process conditions adapt to the material originally selected?

The material selection must be done in a way that the process would run without any risk to safety, reliability and production. This is achieved by an exhaustive analysis of the process conditions, evaluating the material life cycle cost, taking into account the potential process changes, upsets and ore body variations.

An example of this situation is changes in process conditions presented in a high pressure acid leaching (HPAL) nickel / cobalt plant.

In the nickel laterite process, sulphuric acid is used to dissolve the desired metals from the ore into a solution, at high temperature, under high pressure. The acidic leached slurry is then neutralized, using calcium oxide and separated from the undesired non-dissolved ore. The refinery process consists of separating the dissolved metals and recovering the desired nickel and cobalt.

The first separation is performed by precipitating the dissolved metals with hydrogen sulfide. The introduction of hydrogen sulfide adds a challenge to the material selection. The material must be carefully selected in each part of the process to tailor the reactants and the process conditions.

In the refining process, hydrogen sulphide, calcium oxide, hydrogen, liquid ammonia, nitric acid, oxygen, sulphuric acid are some of the chemicals used and each one of them possess different material requirements.

This process description does not reflect all the various steps in the process where the acidity type and level are constantly changing, along with the types of particles in the slurry.

When a change in the ore chemistry happens, such an increase of an impurity that was not accounted for during the design process, refining is adjusted to maintain the same level of nickel and cobalt recovering rates. This adjustment can be translated into more sulphuric acid consumption or more hydrogen sulfide in the reactor vessel. The materials originally selected must then be able to adapt to this new factor and changing process environment.

Aerial view of the Ambatovy nickel-cobalt HPAL and refinery, in Madagascar

How can one predict a change in a process happening in the future?

This task relies on a continuous collaborative work between the geologists, extractive metallurgists, process control and materials engineers.

From the design phases, to the commissioning and plant operations, these groups must maintain a permanent communication channel to ensure the safety, reliability and overall operation excellence.

The role of the material engineer is therefore to be informed, to seek information, collect data, analyze, and ensure the adequate material is selected for the process conditions for today and tomorrow.

XPS has significant experience in design, operation and maintenance support of HPAL plants from pilot testing to operation. This expertise exists from pilot plant operations to full scale operating plants.

Contact Umugaba Seminari, M.Eng., P.Eng. at umugaba.seminari@xps.ca for further details on materials selection for varying process condition.

XPS KNOWS ALUMINUM *(continued from page 9)*

objective. Extending the life span of pots and improving understanding and control of the bath chemistry stand out as high priority areas. Production optimisation should take greater benefit from automation, sensors and IT development, as already used in downstream process. Reduction of environmental impact must focus on fluoride emissions as well as on solid waste such as Spent Pot Linings (SPL). XPS is uniquely positioned to promote the handling of these solid waste products in other sectors through cross-sectoral projects and industrial symbiosis.

XPS now has the expertise and the facilities to work collaboratively with the primary aluminum production industry. We are connected to a vast network of technical and operational knowledge that is available to overcome challenges and add value for our clients. With our combined experience in mineral processing, extractive metallurgy, materials characterisation, and process control, XPS is well suited for the detailed metallurgical test work required to successfully meet the needs of the aluminum industry.

Please contact Neivi Andrade, ing., Ph.D. at neivi.andrade@xps.ca for more information on XPS aluminum expertise.

XPS is very pleased to announce...

BEN VANDEN BERG HAS JOINED THE MINERAL SCIENCE GROUP AS A PROGRAM GEOSCIENTIST


BEN VANDEN BERG

Ben graduated from the University of British Columbia with a B.Sc. in Geology in 2002 and is a registered Professional Geoscientist in Ontario.

He has over 14 years of experience in the field of mineralogy, primarily with the Exploration Geology group at Vale. While there he supported Canadian and International sulphide, nickel laterite, PGE, IOCG type, porphyry copper and unconformity uranium ore exploration programs through petrographic and SEM studies and field mapping/ sampling campaigns.

Ben will work closely with future clients to deliver quantitative mineralogical data in support of ore characterisation, plant audits and process optimisation programs.

Please contact Ben for mineral science services at ben.vandenberg@xps.ca

NEIVI ANDRADE HAS JOINED THE EXTRACTIVE METALLURGY GROUP AS PROGRAM ENGINEER


NEIVI ANDRADE

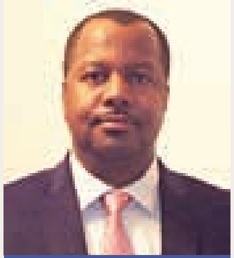
Neivi holds a Ph.D. from McGill University with B.Eng and M.Eng degrees from the Instituto Technologico de Saltillo in Mexico. Her primary speciality is the metallurgy of aluminium and its alloys. She is registered as a professional engineer in Quebec.

Neivi has over 10 years of experience in the metallurgical industry, most recently with the Rio Tinto Iron & Titanium technology centre in Sorel-Tracy. A trilingual metallurgist with industry experience in aluminium, titanium, ilmenite, iron and custom slags; Neivi brings technical competencies and experience running R&D projects at large pilot scale.

Neivi brings strong technical skills and professional experience to expand and complement the capacity of the XPS Extractive Metallurgy Group. Her ability to work with operations and technologists/ technology personnel is clearly recognised.

Contact Neivi for extractive metallurgy projects and support at neivi.andrade@xps.ca

UMUGABA SEMINARI HAS RETURNED TO MATERIALS TECHNOLOGY GROUP AS A SENIOR MATERIALS ENGINEER


UMUGABA SEMINARI

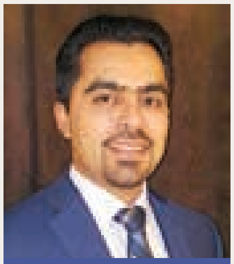
Umugaba holds a M.Sc. and B.Sc. in Metallurgical Engineering from McGill University and Ecole Polytechnique in Montreal. His primary speciality is in failure analysis, risk based assessment, asset integrity management, inspections of equipment, life cycle assessment and product development.

Umugaba has 10 years experience with materials technology, product development and inspections with Atlas Copco, Xstrata Process Support, Agrium Fertilizer Division and was recently Pressure Vessels and QA/QC Welding Specialist with Ambatovy Project in Madagascar.

Umugaba returns to XPS bringing strong technical skills, interpersonal and professional experience to expand and complement the capacity of XPS Materials Technology Group. His ability to combine his advanced knowledge of plant operational challenges and the ability to work closely work with maintenance, operations and technologists/ technology personnel is clearly recognised.

Contact Umugaba for your materials technology needs at umugaba.seminari@xps.ca

MAYSAM MOHAM HAS JOINED THE MATERIALS TECHNOLOGY GROUP AS AN ENGINEER IN TRAINING


MAYSAM MOHAM

Maysam holds a Ph.D. in Materials Engineering from University of British Columbia with B.Eng and M.Eng degrees in Materials Engineering from Chamran University and Sharif University of Technology in Iran. His primary speciality is the assessment and mitigation of corrosion in industrial environments.

Prior to receiving his Ph.D., Maysam worked in industry as a Materials Engineer, NDT Engineer and Corrosion Engineer for GoStar National Inspection Company and the Parsian Gas Refining Company. Maysam brings excellent academic knowledge with several years of industrial experience to the XPS team.

Maysam brings strong technical skills and professional experience to expand and complement the capacity of the XPS Materials Technology Group. His ability to combine his advanced knowledge of corrosion and work closely with operations and technologists/ technology personnel is clearly recognised.

Please contact Maysam for materials technology services at maysam.moham@xps.ca

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