XPS BULLETIN
ISSUE 18 – SUMMER 2017

IN THIS ISSUE

➤ XPS will be attending Metsoc COM2017 in Vancouver, B.C., Aug. 27-30, 2017.

Come by and visit our Booth at location 23 on the Trade Show Floor

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

The XPS Centre – 20 Years Young!

THE 10TH ANNIVERSARY OF XPS ALSO COINCIDES WITH THE 20 YEAR ANNIVERSARY OF THE XPS CENTRE

In the last edition of the XPS Bulletin (Issue 17 – 10th Anniversary Edition) we highlighted the 10 Anniversary of XPS as an autonomous technology business within Glencore, responding to client needs in over 25 countries around the world. The 10th Anniversary of XPS also coincides with the 20 Year Anniversary of the XPS Centre (formerly the Falconbridge Technology Centre - FTC) in Falconbridge, Ontario.


FML Lab (Thornhill, circa 1978)

XPS Centre Milestones

- 1952 – Falconbridge Metallurgical Laboratories founded in Thornhill, Ontario
- 1957 – FML expanded to accommodate metallurgy groups
- 1968 – Computer mainframe installation
- 1970 – Two Story expansion to accommodate new product development along with electron microprobe technology
- 1984 – FML moves to Falconbridge, Ontario and becomes MTC
- 1994 – Engineering and construction starts on new $18M Falconbridge Technology Centre (FTC) now the XPS Centre
- 1997 – Official opening of FTC
- 2007 – XPS Expert Process Solutions is formed and FTC renamed to XPS Centre


Old Metallurgical Technology Centre – Falconbridge, Ontario

The history of the world class XPS Centre would not be complete without first reviewing the history of FTC. The story begins in the late 1940's when the Falconbridge President, Dr. H.J. Fraser conceived an idea of a central research laboratory for Falconbridge Nickel Mines. The original property and building located in Thornhill, Ontario was acquired and remodelled in 1952 and Falconbridge Metallurgical Laboratories (FML) was formed to satisfy an immediate need for quality control methodologies. The building was expanded several times to accommodate metallurgy groups, focused upon both sulphide and laterite ores and concentrates. Physical metallurgists played a major role in the late 1950's to provide a scientific base for competitive sales and promotion of Falconbridge products and development of new alloys.

After several expansions the group had grown to over 70 scientists, engineers, chemists, technicians and technologists. In 1984, the Thornhill facility was amalgamated with laboratory facilities in the town of Falconbridge to form the Metallurgical Technology Centre (MTC).

Fast forward to 1994, when the company began a $35M construction project which included an $18M, 2-story, 73,000 sq. ft. world class technology centre, now known as the XPS Centre. The XPS Centre was

Continued on page 7 ➤

Lithium from the Canadian Shield

LITHIUM MINING IS A CANADIAN GROWTH INDUSTRY, WITH CANADIAN HARD ROCK DEPOSITS OFFERING SOME DISTINCT ADVANTAGES FOR HIGH-TECH LITHIUM MARKETS.

The battery industry has continued to push the envelope for product purity, especially with respect to control of magnesium and iron contamination. Historically the majority of commercial lithium has been obtained from brines and evaporitic deposits; however, brine sources are typically magnesium rich, and purification must be achieved hydrometallurgically.

Figure 1 – Pakeagama Lake (PAK) Spodumene

Figure 2 – Pakeagama Lake (PAK) Spodumene (UIZ) High Grade Zone

Mineral sources of lithium (spodumene $LiAlSi_2O_6$, or petalite $LiAlSi_4O_{10}$) have the advantage of containing no iron or magnesium, and are frequently hosted within rocks that also contain minimal iron and magnesium. As a result of this, hard rock lithium deposits which were historically considered to be economically disadvantageous relative to brine lithium resources have now emerged as attractive sources of exceptionally pure lithium materials. Mineral sources of lithium from the Canadian shield have come into their own.

XPS is proud to be working with Frontier Lithium (TSX.V: FL) in the development of the Pakeagama Lake (PAK) lithium project. Located 175 km north of Red Lake, the PAK project contains over 8 million tonnes of ore at ~1.8% Li_2O equivalent. The project anticipates the initial stage production of about 1,000 tpd of ore into a lithium concentrate containing over 7% Li_2O. Photos of the ore and ore zone arshown in Figures 1 and 2.

The upgrading task involves separation of spodumene from associated quartz and feldspars, as well as removal of trace diluents and contaminants. Crushed ore is upgraded by dense media separation (DMS) and is subjected to desliming and gravity separation (Ta recovery) followed by flotation for removal of micas and associated fluorine; separation of spodumene from gangue silicates (quartz and feldspar); reverse flotation for the removal of phosphates and tourmaline; and finally, wet high-intensity magnetic separation (WHIMS) for the reduction of iron to exacting specifications (<0.1% Fe_2O_3).

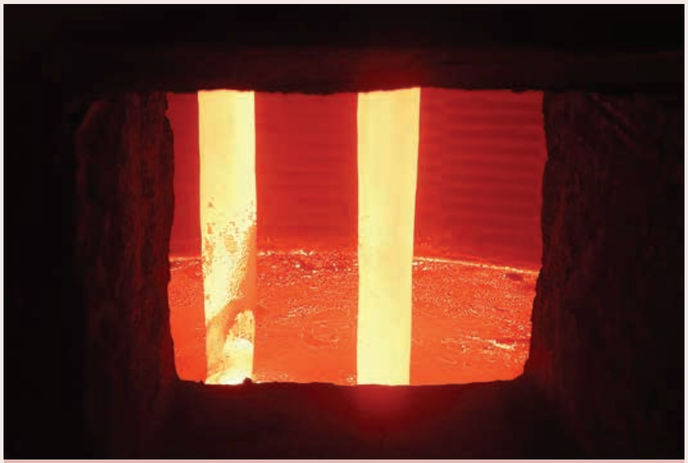
Development of the flowsheet has relied upon a combination of past industrial practice, mineralogical characterization by QEMSCAN, and laboratory testing of ore samples from the PAK deposit. Since the success of the project revolves around exacting control and reduction of potential contaminants, rigorous quality control methodologies are a key to project success.

The flotation products from the PAK project are suitable for sale into the glass industry, which will make up the initial market for concentrates; however, XPS will continue to work with Frontier Lithium in downstream development for the conversion of lithium concentrate into chemical products. Lithium concentrate will be converted through decrepitation, acid baking and leaching/precipitation to produce battery grade lithium carbonate and or hydroxide products. Frontier Lithium intends to spearhead the production of high quality battery grade lithium within Northern Ontario, establishing our region as a significant Canadian contributor to clean energy technology. XPS is extremely proud to be involved with Frontier Lithium in this groundbreaking and challenging project.

For more information, please contact gregg.hill@xps.ca

Cool pictures in Hot Places!

FREQUENTLY AT XPS WE GET ASKED TO SOLVE PROBLEMS WITHOUT KNOWN SOLUTIONS, BUT NORMALLY THEY ARE NOT IN THE FIELD OF PHOTOGRAPHY.



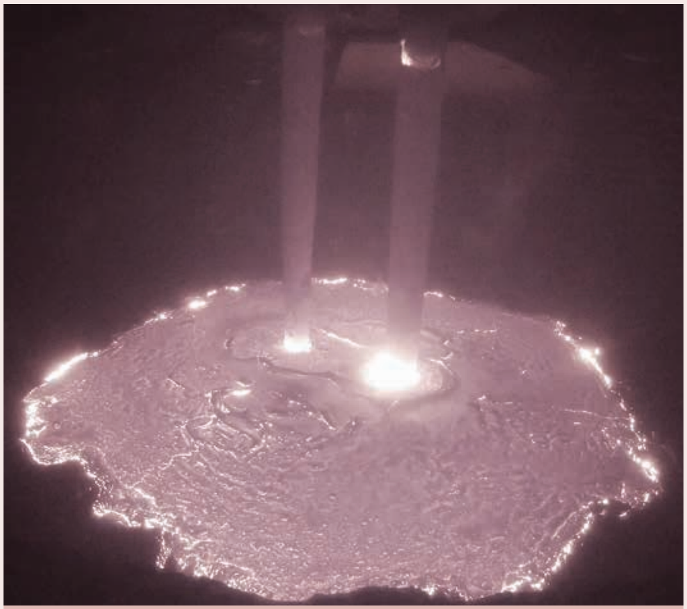
Looking at the access port into the furnace

Recently the extractive metallurgy group was asked for assistance in taking pictures in a very inhospitable place – the interior of a 1000°C furnace. The setup needed to be portable to accommodate test work. The camera needed to operate for 2-3 hours and it also had to fit in a suitcase to be taken on a plane. Finally, the access port was only ~20cm on each side.

There are many advantages of XPS's location in Sudbury, but one unexpected bonus is that the local glass suppliers keep high temperature ceramic window for wood fireplaces in stock year-round. However, glass alone will not keep a camera from cooking to a plastic pool when it's in a hot location. Water cooling could keep the camera cool, but water is generally avoided in metallurgical furnaces due to the risk of leaks and explosions. We decided to use a Vortex cooler, an innovative solid state device that uses counter current flows of rapidly spinning air to generate a hot and a cold fraction from a regular supply of compressed air. With cooling capacities in excess of 2900 W and temperatures adjustable to < -5°C, we were optimistic we could compensate for the conductive heat load and the immense radiation.

The video camera used was a GoPro Session 5, a small cubic video camera about 3cm per side. With the option to shoot in high definition at 1080 P or even 4K, the lack of manual zoom was compensated for with digital enhancement. Furthermore, the wide angle of the camera allowed a large amount of the interior to be imaged. Even better, the camera could be sealed in the cooled enclosure and operated remotely via android or iOS smartphone app. Live images were available up to 4m from the enclosure adding a useful degree of safety and convenience.

The GoPro looking through the fire-rated glass



Still image captured inside a 1000°C furnace using a GoPro in a custom, air cooled enclosure.

We're not sure if this is the hottest place a Go Pro has been used, but it must be near the top of the list. At the end of the day, some good old fashioned engineering to mitigate the heat-load and an off-the shelf camera got the job done.

For more information about applications of the XPS Pyro Cam, contact Graeme Goodall at graeme.goodall@xps.ca

The Problem with Pyrrhotite

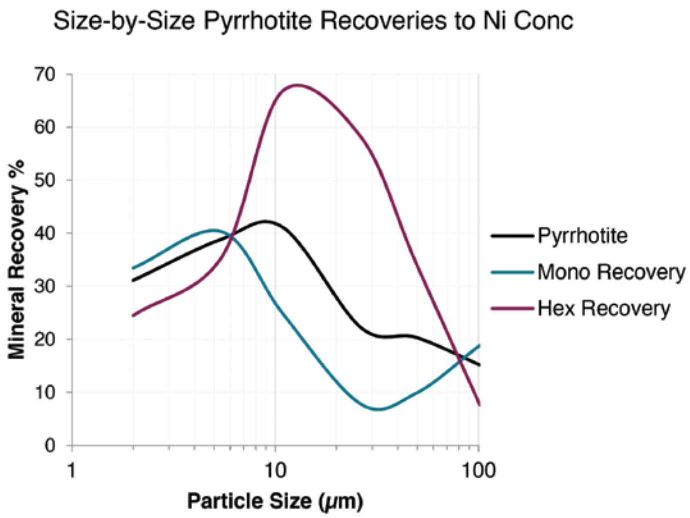
DO YOUR ORES CONTAIN PYRRHOTITE?

In many base metal concentrators, the presence of this Fe sulphide can have a negative impact on metallurgy and in some cases can wreak havoc on the economics of an operation. XPS is an industry leader in understanding and minimizing the effect of pyrrhotite on metallurgical performance.

Ore minerals in base metal sulphide deposits are often mixed with sulphide gangue which must be removed by flotation in order to produce a saleable concentrate. In NiCu orebodies, the sulphide gangue is predominately pyrrhotite, whereas in Cu, CuZn, PbZn deposits, both pyrite and pyrrhotite can be present.

The degree to which the process is affected by pyrrhotite includes not just the overall pyrrhotite content, but also the ratio of pyrrhotite to economic mineral(s) and the ratio of monoclinic to hexagonal pyrrhotite. XPS has extensive experience and has refined the X-Ray Diffraction (XRD) technique to quantitatively determine the amount of hexagonal versus monoclinic pyrrhotite.

Historically, pyrrhotite rejection has been successful by using appropriate reagents, pulp density, Eh control all play a role in improving selectivity of the economic mineral vs. pyrrhotite. However, the factors listed above tend to be successful on the monoclinic variety and have less of an impact on the hexagonal polytype. Therefore, special attention must be made to ores that contain hexagonal pyrrhotite and measurement of the ratio between the two polytypes is required in order to design a rejection strategy in the flotation circuit.



XRD Determination of Monoclinic versus Hexagonal Pyrrhotite

XPS has undertaken size-by-size mineralogical analysis of 5 different base metal concentrators processing both Ni and Zn orebodies along with extensive flotation testing to identify the behavior of the two varieties of pyrrhotite. Results are remarkably consistent across the different base metal concentrators and indicate that the hexagonal form not only has stronger flotation kinetics than does the monoclinic variety, but that the particle size has an impact on its recovery.

At XPS, measurement of the ratio between hexagonal and monoclinic pyrrhotite is done by X-ray diffraction using a calibration curve developed using a variety of polytype mixtures. Mineralogical measurement is the first step in diagnosing pyrrhotite dilution. Developing an appropriate flotation strategy based on the information then becomes a streamlined process.

If you are experiencing low concentrate grades or have had to accept higher losses in order to maintain a target grade, contact XPS. The experienced group of geoscientists and mineral processing engineers can help diagnose the issue and work with you to resolve the problem.

Contact Lori Kormos, Principal GeoScientist at lori.kormos@xps.ca

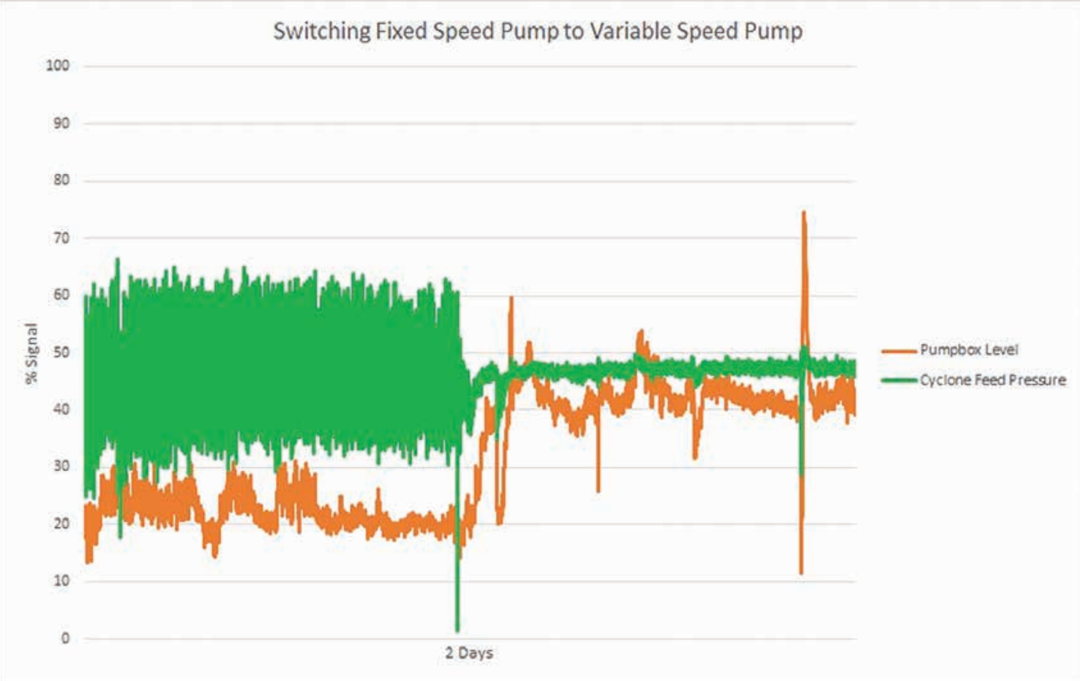
Using VFDs to Adapt to Different Operating Conditions

WHEN METALLURGICAL PROCESSING PLANTS ARE DESIGNED AND BUILT, EQUIPMENT SPECIFICATION AND SELECTION IS USUALLY TAILORED TO MEET THE MAXIMUM EXPECTED OPERATING CONDITIONS.

This can present challenges when operating at turndown conditions unless some means of adjusting equipment performance can be incorporated. In new plant designs, Variable Frequency Drives (VFDs) are often applied to rotating equipment such as slurry pumps to match the pump characteristics to the process duty. This technology was either not available or prohibitively expensive when many older plants were designed, and plant performance can suffer at turndown conditions. However, as shown by the example below, retrofitting VFDs to existing pumps can provide significant benefits.

A typical ball mill grinding circuit closed by cyclones was equipped with fixed speed cyclone feed pumps, one operating and one standby. Performance was good at high mill feed rates, but as shown in the left half of the graph below, at reduced feed rates the cyclone feed pressure was very unstable. The fixed pump capacity made it impossible to maintain sufficient head in the pumpbox, resulting in pump surging. This was confirmed in the plant, with cyclic variations observed in the cyclone overflows, as well as audible cycling in the pump noise and vibration.

The right hand side of the graph shows the improved performance obtained when running an identical pump equipped with a VFD, operating at reduced speed to maintain an appropriate pumpbox level. The benefits were estimated as a potential for up to 0.5% additional pay metal recovery in flotation from a more consistent flotation feed flow and quality, as well as energy savings of up to 8% from the reduced pump speed and improved efficiency.



Improved stability of cyclone feed pressure when switching from fixed speed cyclone feed pump to VFD pump at reduced speed.

To explore opportunities to reduce variability in your plant performance,
contact Alan Hyde, Principal Engineer XPS Process Control at alan.hyde@xps.ca

Materials Selection for SO_2 Handling Equipment

- Corrosion Assessment

XPS Materials Technology Lab

The XPS Materials Technology Laboratory located at the XPS Centre is the only materials testing and failure analysis laboratory in Northern Ontario. The main focus of the laboratory group is root cause failure analysis (RCFA), materials testing and materials characterizations. Materials testing techniques are used to support materials selection in the design stage of capital projects and also for quality control during materials procurement, equipment fabrication and construction. RCFAs are employed to determine the root causes of equipment failures such as boilers, refractories, autoclave parts, tanks, pipes and mechanical parts (gears, bearings, shafts, bolts, etc.) to implement mitigation alternatives for failure prevention.

Upfront testing is crucial in the determination of a materials performance in a given environment. Too often are decisions made in material selection without the proper testing completed, resulting in significant revenue loss from failure, and, in some instances, environmental and safety hazards. Our testing expertise in the areas of corrosion and wear can help mitigate these risks of equipment failures.

XPS Materials Technology Laboratory is equipped with various analytical and materials characterization techniques including:

- Microstructural characterization: Scanning electron microscopy (SEM), Energy dispersive x-ray spectroscopy (EDS), X-ray diffraction (XRD) and optical & stereo microscopies
- Mechanical properties evaluation: hardness, microhardness, impact, cold crushing, etc.
- Corrosion testing: Long term exposure immersion tests, potentiodynamic and cyclic potentiodynamic polarizations, linear polarization, galvanostatic and potentiostatic, electrochemical impedance spectroscopy (EIS), etc.
- Wear and Erosion Testing: Dry-sand rubber wheel abrasion, wet-sand rubber wheel abrasion, abrasive wear resistance of cemented carbides and slurry abrasivity testing.
- Furnaces for high temperature testing including refractory materials.
- Physical testing such as Differential Scanning Calorimeter (DSC) and Thermogravimetric Analysis (TGA)

Materials selection for a SO_2 gas handling equipment

Due to acid generation, corrosion is one of the main concerns in SO_2 gas handling equipment. XPS Materials Technology Laboratory was requested to evaluate materials and technology options for a new sulfur handling system. The evaluation is based on sound material engineering practices including literature review, electrochemical lab testing, benchmarking of other sites and expected future equipment integrity / risk. The design life is assumed to be 20 years as it is typical with most acid plant equipment.

For proper materials selection, the most important parameters are temperature, solution acidity, halide contents and redox potential. Considering these parameters, five alloys (Fe-based and Ni-based) were selected to be tested in the laboratory. These alloys are named as *Alloy A* through *Alloy E*.

These alloys were tested at two different conditions as following:

- **Condition 1:** Representing the upper limit halite content of the operating solution
- **Condition 2:** Simulating a possible feed change (higher halite) and higher SO_2 gas strength to the plant (lower pH).

For this project, Cyclic Potentiodynamic Polarization (CPP) tests were used according to ASTM G61-86. Figure 1 shows the electrochemical setup used for corrosion testing.

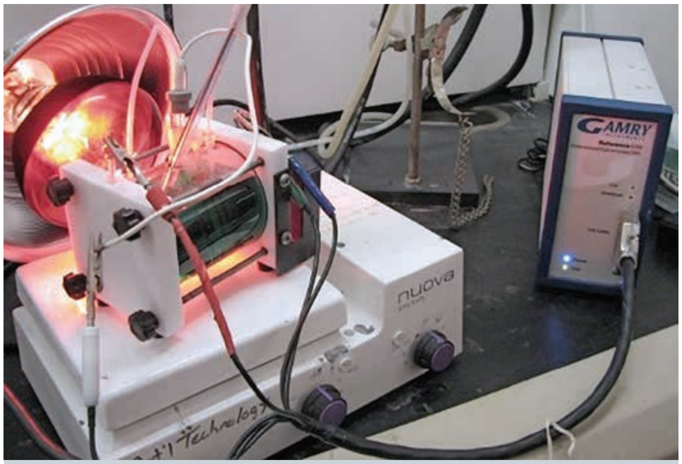


Figure 1 – Electrochemical setup used for corrosion testing

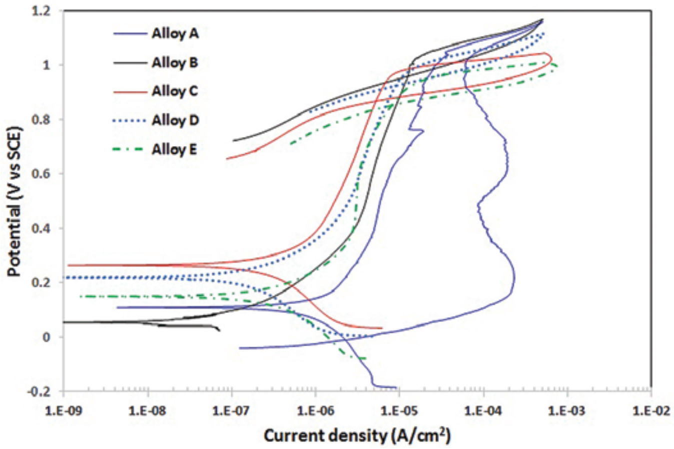


Figure 2 – Cyclic potentiodynamic voltammograms of the alloys at Condition 1

As an example, the cyclic voltammograms obtained at condition 1 are shown in Figure 2. An alloy is susceptible to pitting corrosion if a positive hysteresis loop is formed in the backward direction scan of a CPP test and also pits are observed on the tested coupon.

The large hysteresis loop of *Alloy A* indicates high susceptibility of this alloy to pitting corrosion at condition 1. This was verified by the optical microscopy images of this alloy after the CPP test (Figure 3(a)).

Optical microscope inspection after CPP tests showed no obvious pitting on the other coupons, except *Alloy B* tested at condition 1 that showed signs of what appears to be pitting (Figure 3 (b)). The hysteresis loops in most of the results could be attributed to the transpassive dissolution (Cr(III) oxide dissolution) and/or oxygen evolution reaction (OER).

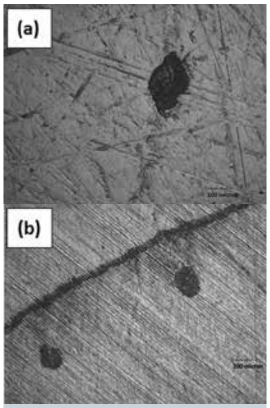


Figure 3 – Optical images of the pits formed on Alloy A (a) and Alloy B (b) after CPP tests at Condition 1

Corrosion rates of the alloys were determined according to the ASTM G102 – 89 and by modelling of the potentiodynamic results. The obtained results showed corrosion rates lower than 1 mpy for all the alloys except *Alloy A* at condition 1 (3.2 mpy) and *Alloy E* at condition 2 (1.1 mpy).

In this project, we performed corrosion testing on different alloys in different solutions to provide a materials selection baseline for a new SO_2 off-gas handling equipment. Using a combination of CPP tests, interpretation of results and optical microscopy inspection, XPS can determine the best alloys for specific operating conditions and what level deviations will contribute to excessive corrosion rates and ultimately failure. In this project, *Alloy C* and *Alloy D* are viable options for this application. Since the costs are comparable, a final decision between these two alloys should be made based on risk.

For more information on the XPS Materials Lab, contact Maysam Moham, Materials Engineer at maysam.moham@xps.ca

THE XPS CENTRE – 20 YEARS YOUNG! *(continued from page 1)*

XPS Centre 2017

officially opened on Sept 5th, 1997 and houses all the laboratory and pilot plant facilities of XPS, the Analytical Lab and administrative offices of Glencore's Sudbury Integrated Nickel Operations. The building remains a world class facility with benchtop and continuous pilot plants in Mineral Processing, Extractive Metallurgy, Materials Technology and Mineral Science and houses technologies such as Thermo-Gravimetric Analysis, QEMSCAN, MicroProbe and XRD. Although the XPS Centre was originally conceived as an R&D facility, XPS offers operations and project development support using known technologies and proprietary practices along with developing new innovative technologies to its valued clients.

The XPS Centre barely shows its 20 year vintage. Its unique colour scheme, corresponding to metals in solution, is maintained by a dedicated group of employees, technicians and support building contractors. Floor space and equipment assignments are adjusted to accommodate clients needs while maintaining an ergonomic and safe work environment.

XPS is pleased to be based at this amazing facility and welcomes all of its clients to visit the XPS Centre to discuss how this world class equipment, facility combined with XPS expertize can add value to your operation and project.

For more details on XPS and its facilities and capabilities, please see www.xps.ca

XPS is very pleased to welcome Mr. Nicolas Lazare to the XPS Management Team as Manager, Process Control

NICOLAS JOINS XPS FROM KONIAMBO NICKEL SAS IN NEW CALEDONIA, WHERE SINCE 2012, HE PLAYED A KEY ROLE IN THE START-UP AND COMMISSIONING.

NICOLAS LAZARE

Nicolas replaces Phil Thwaites who retired earlier this year after 37 years of dedicated service to Glencore, Falconbridge and Kidd. We would like to thank Phil for his many contributions to the organization and pleased that he will be available in future for on-going support of XPS and Glencore.

Nicolas joins XPS from Koniambo Nickel SAS in New Caledonia, where since 2012, he played a key role in the start-up and commissioning. Nicolas held roles of PCS and Metrology Head and most recently Process Control Department Head where he managed a team of 14 engineers and technicians in commissioning the control and DCS architecture, plant automation, functional safety, instrumentation, metrology, PIMS and CEMS.

Prior to joining KNS, Nicolas held roles of increasing responsibility with Society Le Nickel (SLN) Eramet as HMI Project Leader and then Automation Division Head at their integrated ferronickel plant in Noumea, New Caledonia. Nicolas has significant plant operating experience and has demonstrated strong leadership, technical, communication and strategic planning skills that will complement his experienced team of process control engineers and be synergistic with the other technical groups at XPS and at client operations around the world.

Nicolas is a graduate of South Pacific University in Noumea where he received an Associates Degree in Mathematics in 2000 and an Engineering Degree in Automation and Industrial Data Processing from ESIA (now Polytech Savoie) in France in 2003. He has certifications in ABB, Rockwell Automation, iFIX, HIMA, Multiple Industrial Network Protocols and PIMS (OsiSoft) among other relevant skills and training..

Please join me in welcoming Nicolas, his family to XPS and Sudbury.

Dominic Fragomeni
Vice President, XPS

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

6 Edison Road
Falconbridge, ON P0M 1S0 Canada

tel: +1 705 699 3400, ext. 3401
fax: +1 705 699 3431

dominic.fragomeni@xps.ca

If you would like to receive a copy of the XPS Bulletin, please email your details to info@xps.ca