# Mining Minerals Research Cluster

# Corrosion Projects

The **Mining Minerals Research Cluster** was a four-year program of projects focused on corrosion issues affecting the potash mining industry in Saskatchewan. The projects, conducted at the Universities of Saskatchewan and Regina, focused on developing insight into specific corrosion modes while engaging highly qualified people (HQP). There were four projects in the program.

**Project 1:** **Slurry Erosion-Corrosion**
**Principal Investigator:** Dr. Richard Evitts, Dept of Chemical & Biological Engineering, USASK

Equipment in potash facilities are prone to degradation due to slurry erosion (mechanical degradation) and corrosion. This project, using a combination of laboratory experimentation (a new test facility was created) and computer modelling, was conducted to understand failure modes when both erosion and corrosion were present. The results of this work have been published and the test facility for erosion-corrosion specimen testing is available for industry use. The outcomes for this project include:

- Testing facility, "Potash Corrosion Research Center", developed for erosion-corrosion, stress corrosion cracking, pitting experiments – available for testing. Testing facility includes:
  - Test loop with novel loading system for solids; can test elbows, flat specimens, electrodes
  - Developed internal cathodic protection system to test for interaction of erosion and corrosion
  - New technique for measuring corrosion rates in situ

Richard Evitts, Glynn Kennell and Akindele Odeshi (L-R) demonstrate the corrosion test loop. *Photo courtesy of the University of Saskatchewan.*

- Empirical relationships for erosion-corrosion in a 90° bend, corrosion rate/cathodic protection current, salts concentration/corrosion rate developed; critical pitting temps for various metals determined
- Test results were documented in 3 academic journal articles, 3 conference proceedings, and 3 conference presentations papers
- Engaged and trained 17 HQP during project including 2 PhD and 3 M.Sc. students (w/ Project 2)

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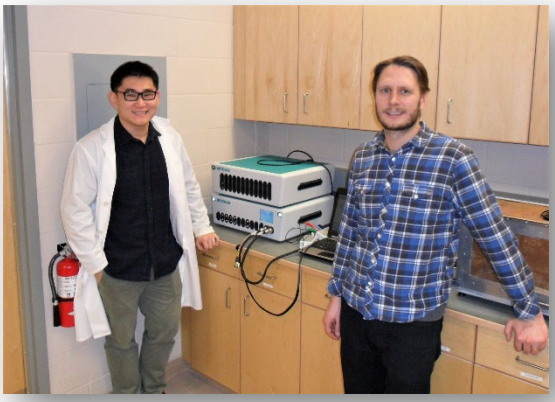
**Project 2:** **Stress Corrosion Cracking**
**Principal Investigator:** Dr. Ike Oguocha, Dept of Mechanical Engineering, USASK

Stress corrosion cracking (SCC) damage is a persistent problem in potash processing facilities. This project investigated SCC of selected corrosion resistant alloys in a potash environment using a variety of tests. The project also investigated the effects of boronizing heat treatment on specific alloys. Boronizing surface treatment is used to improve hardness, corrosion and wear resistance of metallic alloys. A method for boronizing steels within the laboratory was developed. The outcomes for this project include:

- Testing facility, "Potash Corrosion Research Center", developed for erosion-corrosion, stress corrosion cracking, pitting experiments – available for testing (w/ Project 1)
- Final Report to iMii – with specific recommendations for potash facilities
- Engaged and trained 16 HQP during project including 2 PhD and 3 M.Sc. students (w/ Project 1)

**Project 3:** **Concrete Corrosion**
**Principal Investigators:** Dr. Andrew Grosvenor and Dr. Ian Burgess, Dept of Chemistry, USASK

Concrete degradation in potash mills is due to harsh in-plant conditions such as high temperatures, standing and flowing water and high chloride concentrations. Corrosion of reinforcing steel bar (rebar) is one of the most common causes of concrete degradation. This project evaluated corrosion in polymer coated rebar using both traditional laboratory and synchrotron techniques. It was determined that commercially available fusion-bonded epoxy (FBE) rebar outperformed all samples. Site instructions for careful handling, inspection and repair of polymer coated rebar is expected to reduce concrete degradation (e.g. spalling, etc.) if implemented. A synchrotron technique, micro-XRF (x-ray fluorescence)-XANES (x-ray absorption near edge spectroscopy), was found to be particularly effective for studying the corrosion of polymer coated metals. The outcomes for this project include:



Vince Guo (L) and Burke Barlow of the Concrete Corrosion Project.
*Photo courtesy of the University of Saskatchewan.*

- White Papers produced: "Concrete corrosion and mitigation at potash mine and mill operations" (July 2017), "Review: Chloride Induced Reinforced Concrete Protection Strategies in the Potash Industry" (August 2017)
- Final Report with specific recommendations around concrete rebar coatings and rebar installation in concrete
- Developed synchrotron method (hard x-ray spectromicroscopy) for polymer coated metals (see between polymer and metal surface) – available for use to industrial partners
- Results from studies documented in 5 refereed academic journal articles
- Engaged 4 HQP (1 PhD student, 2 PDFs, 1 research associate) during project

**Project 4:** **Corrosion Inhibitors**

**Principal Investigator:** Dr. Amy Veawab, Dept of Environmental Systems Engineering, URegina

This project evaluated various chemical treatments to mitigate corrosion in potash solution mining and processing plants. Different corrosion inhibitors were evaluated for effectiveness in corrosion control, environmental impact, impact on plant operations and effect on potash products. Two corrosion inhibitors, with satisfactory corrosion inhibition performance and insignificant impact on final potash products, were recommended for corrosion control in potash solution mining. The outcomes for this project include:

- Final Report "MMRC – Corrosion Reduction: Corrosion Inhibitors" - with specific recommendations for two effective corrosion inhibitors
- Engaged and trained 2 HQP (2 M.A.Sc. students) during project


Amy Veawab (L) and Ramasamy Thamilarasan demonstrate corrosion inhibitor testing equipment. *Photo courtesy of the University of Regina.*

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| **Program Duration:** | **2015 – 2019** |
| **Program Costs:** | **$2,459,000** |
| Funding Contributors | |
| IMII & Industry Partners: | $1,072,000 |
| Western Economic Diversification: | $915,000 |
| NSERC | $339,000 |
| Mitacs | $133,000 |

**Principal Researchers:**

University of Saskatchewan:

- Richard Evitts
- Andrew Grosvenor
- Ian Burgess
- Ikechukwuka Oguocha
- Akindele Odeshi

University of Regina:

- Amy Veawab

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