<table>
<thead>
<tr>
<th>ROOM</th>
<th>MONDAY, AUGUST 16, 201</th>
<th>TUESDAY, AUGUST 17, 201</th>
<th>WEDNESDAY, AUGUST 18, 201</th>
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<tbody>
<tr>
<td>(Delta Hotel)</td>
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<td>PM (14:00 to 17:30)</td>
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<td>General I</td>
<td>Deposit Geology &amp;</td>
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<td>Mineralogy - Relevance</td>
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<td>to Mining and</td>
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<td>Advances</td>
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<td>Battleford</td>
<td></td>
<td>(Page 23)</td>
<td>(Page 45)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>(Page 61)</td>
</tr>
<tr>
<td>William Pascoe</td>
<td>Mining I</td>
<td>Mining II</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Page 25)</td>
<td>(Page 37)</td>
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</tr>
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<td></td>
<td>(Page 47)</td>
<td>(Page 57)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Page 59)</td>
</tr>
<tr>
<td>Adam Ballroom</td>
<td>PLENARY SESSION</td>
<td>Uranium Processing -</td>
<td>Uranium Processing -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improvement to Operations</td>
<td>New Projects</td>
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<td>(Page 33)</td>
</tr>
<tr>
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<td>Uranium Processing - SX &amp; Tailings</td>
</tr>
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<td>(Page 27)</td>
<td>(Page 45)</td>
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<td>(Page 37)</td>
<td>(Page 49)</td>
</tr>
<tr>
<td></td>
<td>Reactor Designs and</td>
<td></td>
<td>Uranium Processing - Ion Exchange</td>
</tr>
<tr>
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<td>Decommissioning /</td>
<td>Uranium Processing -</td>
<td>(Page 55)</td>
</tr>
<tr>
<td></td>
<td>Regulatory Requirements</td>
<td>General Processing</td>
<td></td>
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<tr>
<td></td>
<td>&amp; Expectations I</td>
<td>(Page 31)</td>
<td>(Page 57)</td>
</tr>
<tr>
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<td></td>
<td>(Page 39)</td>
<td>(Page 59)</td>
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<td>(Page 67)</td>
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<td>Uranium Processing -</td>
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<td>Regulatory Requirements</td>
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<td>&amp; Expectations II</td>
<td>Solvent Extraction</td>
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<td>(Page 45)</td>
<td>(Page 65)</td>
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<td>Refining/Conversion</td>
<td>Uranium Fuel</td>
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<tr>
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<td>Manufacture I</td>
<td>Safety Advances and</td>
</tr>
<tr>
<td></td>
<td>(Page 29)</td>
<td>(Page 41)</td>
<td>Best Practices I</td>
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</tbody>
</table>

**Poster Session**, Monday, August 16 @ Sheraton Cavalier Hotel in the Foyer. Judging from 17:30 to 18:00
CONFERENCE GUIDE INDEX

Schedule of Events ................................................................. Cover
Technical Program at-a-glance .................................................. Cover
Sponsors and co-sponsors ......................................................... Cover
Welcome to the Conference ..................................................... 2
Conference Organizing Committee ........................................... 3
President’s Message ................................................................... 4
General Information ................................................................... 6
  Conference Venue................................................................. 6
  Registration and Tickets ....................................................... 6
  CIM Membership .................................................................... 6
  Presenters’ Guidelines .......................................................... 6
Tradeshow Exhibitors ............................................................... 7
Short Course .............................................................................. 9
Industrial Tours ......................................................................... 10
Poster Session .......................................................................... 11
Delegates Social Program ........................................................ 12
Other MetSoc Conferences ....................................................... 15
MetSoc Board of Directors 2009-2010 ....................................... 16
CIM Council 2010-2011 ............................................................ 17
Hydrometallurgy Section of MetSoc of CIM ............................. 18
Hydrometallurgy Awards ........................................................ 19

Technical Program (Monday, Aug. 16 to Wednesday, Aug. 18)

**Monday, Aug. 16**
- Plenary Session (08:00 to 12:00) ........................................ 21
- PM Sessions [14:00 to 17:30] ............................................... 23

**Tuesday, Aug. 17**
- AM Sessions (08:00 to 12:00) ............................................. 33
- PM Sessions [14:00 to 17:30] ............................................... 45

**Wednesday, Aug. 18**
- AM Sessions (08:00 to 12:00) ............................................ 55
- PM Sessions [14:00 to 17:30] ............................................... 67

*Room names are listed on the Technical Program Schedule @ a glance on the cover page.*

Authors Index ........................................................................... 73
Maps ......................................................................................... 77
WELCOME TO THE CONFERENCE

On behalf of the organizing committee, we welcome you to URANIUM 2010, the 3rd International Conference on Uranium, which is also the 40th Hydrometallurgy meeting of the Metallurgical Society of the Canadian Institute of Mining, Metallurgy and Petroleum. Our theme, “The Future is U”, accurately describes the state of the uranium industry as we know it today.

U2010 conference is indeed an international conference with over 400 delegates from 26 countries. The conference features an exceptional line-up of plenary, luncheon, banquet and keynote speakers from the leaders of the uranium industry, academia and governments. Over 170 papers and posters covering various topics in the uranium fuel cycle are presented in the plenary and 25 sessions over three days. The tours to the state-of-the-art mines and mills in the Northern Saskatchewan, the short course on the uranium processing, the trade show and the poster session added further strength to the this international conference.

We thank the organizing committee for working hard over the last three years to put this outstanding conference together. We thank all of the authors who took the time to prepare their papers and presentations, and to the session chairs for reviewing the papers. In addition, we would like to recognize and thank all of our financial sponsors, and the support of our non-financial sponsors.

Again, welcome to U2010. Take time to connect and network with fellow participants, renew your friendship or form new lasting friendships in the years to come, and have fun along the way as well.

Ed Lam, Cameco
Chair

John Rowson, AREVA
Co-Chair

Engin Özberk, Cameco
Honorary Chair
Photos not available:

Ron Molnar, Short Course – Mining/ Milling Chair
Brigitte Farah, Registration & Arrangements Chair
Ronona Saunders, Publication and Technical Program Coordinator
Catherine Thibault, Registration and Customer Service
PRESIDENT’S MESSAGE

On behalf of the entire MetSoc Board of Directors, it is my privilege to welcome you to the 3rd International Conference on Uranium and the 40th Annual Hydrometallurgy Meeting. I would personally like to extend a warm welcome to our delegates who have come from faraway places to be with us in Saskatoon.

Met Soc is grateful to Ed Lam and his entire committee for organizing this conference, which promises to be a very exciting event. The conference includes technical presentations on all aspects of uranium processing, industrial tours, exhibits, a poster session, and a short course. I would like to take this opportunity to express MetSoc’s appreciation to all of our corporate and non-financial sponsors.

Finally, I would like to give thanks to all the authors and delegates for attending U2010. I wish you all a professionally rewarding, personally fulfilling and socially enjoyable conference. I invite as well all delegates to take part in the NAEMC (North American Extractive Metallurgy Council) survey http://www.metsoc.org/NAEMC/Introduction.asp. We need your opinion on the future direction of Extractive Metallurgy in North America. For more information, please see our ad in the delegate booklet. I hope to see you at the 49th Conference of Metallurgists (COM 2010) taking place this October in Vancouver, Canada’s newest Olympic City.

Nathan M. Stubina
President, Metallurgical Society of CIM

Sincerely,

Nathan M. Stubina
Barrick Gold Corporation Canada
President, Metallurgical Society of CIM
3500 de Maisonneuve Blvd West, Suite 1250
Westmount, Quebec, Canada
H3Z 3C1

www.metsoc.org
Introducing the
North American Extractive Metallurgy Council (NAEMC)

The leaders of these Societies recognize that for a stronger future we need to **work together**. We are committed to offering better services to members of the extractive metallurgy community.

**Who**
NAEMC consists of three members from each of the societies: TMS (The Minerals, Metals and Materials Society), SME (Society for Mining Metallurgy and Exploration), and CIM/MetSoc (The Metallurgical Society of CIM).

**What**
NAEMC’s purpose is to improve communication and strengthen collaboration between TMS, SME, and MetSoc of CIM.

**Why**
To better serve our community, by offering superior networking opportunities, by optimizing symposia in North America and providing exceptional professional education services to our membership.

**You the Member**
What are your expectations from NAEMC? NAEMC will be asking you to fill in a short survey. This will be made by email, on our websites or at an upcoming conference. Please take the time to provide your feedback – this effort is being done to help the membership of our societies.

To fill out our survey now: [www.surveymonkey.com/s/naemc](http://www.surveymonkey.com/s/naemc)

For more information, contact

**www.metsoc.org**
Nathan Stubina: metsoc@cim.org

**www.tms.org**
Tom Battle: tbattle@midrex.com

**www.smenet.org**
D.R. Nagaraj: D.R.nagaraj@cytec.com
CONFERENCE VENUE
All events will take place at the Delta Bessborough Hotel with the exception of the lunches and the Conference banquet which will take place at the Sheraton Cavalier Hotel.

Both hotels are located across one another for convenient access to the conference no matter your location.

**Sheraton Cavalier hotel**
612 Spadina Crescent East, Saskatoon
S7K 3G9
1-800-325-3535 or direct at 1-306-652-6770

**Delta Bessborough hotel**
601 Spadina Crescent East, Saskatoon
S7K 3G8
1-888-890-3222 or direct at 1-306-683-6935

SECURITY
You must wear your badge at all times.

REGISTRATION AND TICKETS
Registration Desk will be open at the **Delta Bessborough Hotel** on the following hours:

- **Saturday, August 14**, 07:00 – 09:00 Short Course Registration Only
- **Sunday, August 15**, 16:00 – 20:00
- **Monday, August 16**, 07:00 – 17:00
- **Tuesday, August 17**, 07:00 – 17:00
- **Wednesday, August 18**, 07:00 – 12:00

CIM MEMBERSHIP
The CIM annual membership dues are $150 (Canadian funds). As a CIM member you will receive the monthly CIM Magazine and the CIM Journal which contains, among other things, MetSoc articles and news.

Delegates who register as non-members will automatically receive a complimentary membership for the upcoming year.

INTERNET
Delegates can access their email and the Internet in the bedrooms or in the public spaces of the hotel. You must ask at the front desk for a wi-fi code. The access is free of charge.

PRESENTERS’ GUIDELINES
Presenters are required to supply their presentation file in their presenting ROOM at least 1.0 hour PRIOR THE SESSION START TIME. Conference Staff will be in all technical rooms for the duration of the conference to assist you with this process. Presentation files should be on a CD Rom or USB memory stick.

AIRLINE INFORMATION
Below are some of the airlines that serve the Saskatoon International Airport.

<table>
<thead>
<tr>
<th>Airline</th>
<th>Reservations</th>
<th>General</th>
</tr>
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<tbody>
<tr>
<td>Air Canada</td>
<td>1-888-247-2262</td>
<td>1-800-225-2525</td>
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<tr>
<td>Delta</td>
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<td>1-800-538-5696</td>
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<td>WestJet</td>
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DELEGATE LIST
Please visit our website at www.metsoc.org/u2010 to view who is pre-registered for the conference.
ACTIVATION LABORATORIES - BOOTH 06
Activation Laboratories Ltd. has been a global leader in analytical services for over 20 years. We are a primary laboratory for analytical geochemistry and are at the forefront of emerging services like Metal Speciation, Laser Ablation High-Resolution ICP/MS and Mineral Liberation Analyser. Accredited to ISO 17025 for specific registered tests.
1336 Sandhill drive, Ancaster, Ontario, Canada
Tel. 905-648-9611 Email: stacy@actlabsint.com, www.actlabs.com

AREVA - BOOTH 02
AREVA supplies solutions for carbon-free power generation. As the global nuclear industry leader, AREVA’s 50,000 employees cover every stage of the fuel cycle, nuclear reactor design and construction, and related services. The group is also expanding considerably in renewable energies – wind, solar, bioenergies, hydrogen and storage.
925 Brock Road, Pickering, Ontario, Canada L1W 2X9
Tel.: 905-421-2600, www.arevacanada.ca

BRUKER AXS INC - BOOTH 03
Bruker AXS offers a complete portfolio for Elemental Analysis. Our innovative solutions enable a wide variety of customers in the metal industry, automotive industry, chemistry, pharmacy, and semiconductor industry to elevate their business into new levels of quality and process control.
5465 East Cheryl Parkway, Madison, WI, USA
Tel.: 608-276-30118, Email: alexander.seyfarth@bruker-axs.com

CAMECO - BOOTH 01
Cameco is one of the world’s largest uranium producers accounting for about 16% of the world’s production from its mines in Canada and the US. Our leading position is backed by about 500 million pounds of proven and probable reserves and extensive resources. Cameco holds premier land positions in the world’s most promising areas for new uranium discoveries in Canada and Australia as part of an intensive global exploration program. Cameco is also a leading provider of processing services required to produce fuel for nuclear power plants, and generates 1,000 MW of clean electricity through a partnership in North America’s largest nuclear generating station located in Ontario, Canada.
2121 – 11th Street West, Saskatoon, Saskatchewan, Canada S7M 1J3
Tel.: 306-956-6200 Fax: 306-956-6201, Email: Ed_Lam@cameco.com, www.cameco.com

CHAMCO - BOOTH 08
CHAMCO is a modular packager of pumping and compression equipment to the energy, mining and utility markets. CHAMCO modules: compressed air system, fire pump system, fuel pump station, barles, floating pump station.
8900 Venture Avenue, Calgary, Alberta, Canada
Tel.: 403-777-1204, Email: jcampbell@chamco.com, www.chamco.com

GOLDER ASSOCIATES - BOOTH 10-11
Golder Associates is an employee-owned, global group of companies specializing in ground engineering and environmental services. From 160 offices worldwide, our 7,000 employees work with clients who want to manage their environmental and engineering activities in a technically sound, economically viable and socially responsible manner.
1721 8th Street East, Saskatoon, Saskatchewan, Canada S7H 0T4
Email: Tessa_Schellenberg@golder.com, www.golder.com
HATCH - BOOTH 04-05
For 50 years Hatch has been serving the world’s mining industry with feasibility studies; design for greenfield and brownfield facilities, enabling technologies, global procurements, project and construction management, commissioning, maintenance management, and on-site operational services. Within our Mining & Metals sector, Hatch provides services to the Uranium Industry via our mining, processing, infrastructure, energy and environmental practices.

201 - 121 Research Drive, Saskatoon, SK Canada S7N 1K2
Email: sbedrossian@hatch.ca, www.hatch.ca

PICO ENVIROTEC INC - BOOTH 09
Portable gamma ray spectrometer systems, and other geophysical exploration systems.

222 Snidercroft Road
Concord, Ontario, Canada, L4K 2K1
Tel.: 905-760-9512 Email: mgw@picoenvirotec.com, www.picoenvirotec.com

STANTEC - BOOTH 07
Engineering and Project Management Services. Stantec, founded in 1954, provides professional consulting services in planning, engineering, architecture, interior design, landscape architecture, surveying, environmental sciences, project management, and project economics for infrastructure and facilities projects. Continually striving to balance economic, environmental, and social responsibilities, we are recognized as a world-class leader and innovator in the delivery of sustainable solutions. We support public and private sector clients in a diverse range of markets, at every stage, from initial concept and financial feasibility to project completion and beyond.

1760 Regent Street, Sudbury, Ontario, Canada P3E 3Z8
Tel.: (705) 566-6891 Fax:(705) 566-5589, Email: david.loken@stantec.com, www.stantec.com
The course curriculum will take the participant through the uranium processing flow sheet from mineralogy, its influence on treatment route choices to hydrometallurgy to product recovery including refining and conversion. Course participants will gain valuable insights into the technologies applied to and issues involved in dealing with milling effluents and wastes and environmental compliance requirements and trends, both in Canada and in other jurisdictions. Uranium processing specific health and safety considerations will also be covered. A principal key objective of this course is to familiarize participants with the current state of the art in uranium recovery in the various technical areas. The emphasis will be on pragmatic approaches to dealing with real issues.

**DAY 1 - Saturday, August 14th**

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- Uranium Mineralogy & Implications for Processing Options (Gerhard Heinrich, Cameco)
- Comminution and Pre-concentration (SAG milling, ore sorting etc.) (Chuck Edwards, AMEC)
- Leaching Technologies (chemistry, acid, base, pressure, atmospheric other buy not in situ) and Liquid/Solid Separation (Chuck Edwards, AMEC)
- In-situ Leaching (Larry, Reiman, Cameco)
- Solution Purification I - SX Chemistry and Important Considerations (Gary Kordosky, Cognis)
- Solution Purification II - SX Equipment Options and Choices (Gary Kordosky, Cognis)
- Solution Purification III - IX from solution (from ISL) and RIP (Mikhail Michalenko, Purolite)
- Product Recovery from Solution (ppt’n etc.) (Bruno Courtaud, AREVA)
- Industry Trends in Extractive Metallurgy (John Goode, Aurora)

**DAY 2 - Sunday, August 15th**

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<td>Lunch</td>
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- Byproduct Management I - Liquid Effluent Treatment (Brett Moldovan, Cameco)
- Byproduct Management II - Solid Wastes, Tailings (Brett Moldovan, Cameco)
- Refining and Conversion (Andrew Oliver, Cameco)
- Environmental Compliance Strategies and Trends (Canada as base case with reference to other jurisdictions, US, Australia, other U producers) (Arden Rosaasen, AREVA)
- U-specific H&S Issues (Radiological monitoring and protection in the mine, mill, refinery, issues, solutions, trends) (Dale Huffman, AREVA)
TOUR 1: MCARTHUR RIVER MINE / KEY LAKE URANIUM PROCESSING MILL TOUR
(Sunday, August 15th)

Meet in the Delta Hotel lobby: 06:45
Expected arrival at Delta Hotel: 19:00
A light continental breakfast will be served on the airplane.
Lunch is sponsored by McArthur River Mine.

Do not forget your photo identification.
Dress attire: Wear slacks (no dresses, capris, shorts or skirts) and comfortable, flat, closed toe shoes. A jacket is recommended. Cool, wet weather, with muddy conditions could be encountered. Cameras or camera cell phones are allowed at the sites but cannot be taken into the solvent extraction area at Key Lake due to the explosion hazard.

Visit two of the world’s important uranium mines and metallurgical processing operations. You will fly to northern Saskatchewan to experience a land of lakes and pristine wilderness and tour these state-of-the-art facilities to gain a better understanding of the challenges of mining and milling of high-grade uranium ore.

McArthur River Mine
The McArthur River uranium mine operated by Cameco Corporation is located 620 kilometers north of Saskatoon, Saskatchewan. McArthur River is the world’s largest, low-cost uranium producer, accounting for about 14% of world uranium production in 2008.

Key Lake Uranium Processing Mill
Key lake is home to the largest, high-grade uranium mill in the world. Originally built to handle the high-grade, open pit deposits discovered on site in 1975, the Key Lake mill began processing even higher grade ore from McArthur River in 1999. Key Lake is located 570 kilometres north of Saskatoon, Saskatchewan and is operated by Cameco.

TOUR 2: CANADIAN LIGHT SOURCE TOUR
(Thursday, August 19th)
Departure from Delta Hotel: 09:00
Expected return at the Delta: 10:30
www.lightsource.ca


A Leading Light for Mining and Environmental Research
Canada’s national synchrotron laboratory, the Canadian Light Source, is a powerful tool for research related to effectively extracting resources from the earth while protecting the environment. Using powerful magnets and radio frequency waves the synchrotron accelerates electrons to nearly the speed of light, producing intense light beams for probing matter with unprecedented precision.

The Canadian Light Source can answer questions at every stage of the resource cycle: from exploration and metals recovery, to tailings management, remediation and environmental monitoring, research at Canada’s synchrotron is leading the way.
The Poster Session will take place on Monday, August 16th. Poster paper presentations provide an excellent opportunity for learning about current research projects, encourage interactive discussion and showcase the work of researchers and graduate students.

The poster session will be on display on Monday, August 16th at the Sheraton Cavalier hotel in the foyer. The students Posters will be judged officially from 17:30-18:30 that evening. You can post your poster on Monday as of 7am. Those students with posters will be competing for cash prizes.

Saskatchewan Research Council is sponsoring the cash prize of $500.
DELEGATES SOCIAL PROGRAM

SUNDAY, AUGUST 15

OPENING RECEPTION - Sponsored by Areva & Cameco
17:30 to 19:00
Delta Hotel - Adam Ballroom

All delegates are invited to attend the Opening Reception sponsored by our Premier sponsors, Areva and Cameco on Sunday evening, August 15th. Come and enjoy a complimentary drink and hors d’oeuvres while you renew old acquaintances and meet new friends. The evening will also feature a welcome by Donald J. Atchison, The Mayor of Saskatoon, and Tim Gitzel, President, Cameco Corporation.

MONDAY, AUGUST 16

AN EVENING UNDER THE STARS - Sponsored by Golder Associates
19:00 to 21:00
Delta Hotel - Gardens

Join your friends and colleagues for an evening under the stars! This event sponsored by Golder Associates is open to all conference delegates with reserved tickets. This evening will be held under the tent in the gardens of the Delta Bessborough on August 16th.

TUESDAY, AUGUST 17

HYDROMETALLURGY SECTION BUSINESS LUNCHEON - Sponsored by March Associates Inc.
12:00 to 14:00
Sheraton Hotel - Ballroom

The Hydrometallurgy Section of MetSoc of CIM will conduct its Annual Business Meeting and present the Student awards on August 17th. The lunch will also feature guest speaker Peter Mackinnon, President, University of Saskatchewan. Tickets and reservations are required.

CONFERENCE BANQUET - Sponsored by Wardrop & NRT
19:00 to 22:00
Sheraton Hotel - Ballroom

Enjoy a cocktail at the Banquet Reception, which starts at 18:00.

The Hydrometallurgy Section of MetSoc of CIM and the organizing committee, invite the delegates to the conference banquet on August 17th. We thank both Wardrop and Northern Resource Trucking for their contribution to this event with the sponsorship of the entertainment and the wine.

That evening the Hydrometallurgy Section will present the Hydrometallurgy Awards for 2010. The evening will feature unique entertainment. Tickets and reservations are required.
CALL FOR PAPERS

50th Anniversary

COM 2011
CONFERENCE OF METALLURGISTS
MONTREAL, QC
OCTOBER 2–5, 2011

CANADIAN METALLURGY —
CELEBRATING HISTORY AND POISED FOR THE FUTURE!

Technology & Innovation Themes:

Met Soc

www.metsoc.org/com2011
Mark your Calendar! C’est un rendez vous!
Come Visit Canada’s Olympic City!

COM2010
VANCOUVER, BC
CONFERENCE OF METALLURGISTS | OCTOBER 03 - 06, 2010

TECHNICAL PROGRAM THEMES
LEAD ZINC • LIGHT METALS • MATERIALS • REFRACTORIES
• ENVIRONMENT • AEROSPACE • MINERAL PROCESSING

A host of SHORT COURSES and a variety of INDUSTRIAL TOURS
complimenting the technical program are scheduled.

Limited spaces available for the METALS TRADE SHOW
BOOK NOW!
Other Upcoming MetSoc Conferences and co-sponsored Conferences

2010

October 03-06 - **49th Conference of Metallurgists COM2010** – held in conjunction with Lead Zinc 2010
MetSoc & TMS Co-sponsored event
Vancouver, British Columbia, Canada
www.metsoc.org/com2010/index.asp

October 03-05 - **TITANIUM 2010**
Gaylord Palms Resort and Convention Center
Kissimmee, Florida, U.S.A.
www.titanium.org/Category.cfm?CategoryID=251

October 17-21 - **MS & T** (Materials Science & Technology 2010 Conference & Exhibition)
Houston, Texas, U.S.A.

October 24-27, 2010 – **MEMO** Maintenance Engineering / Mine Operators’ Conference
Sudbury, Ontario, Canada
www.cim.org

2011

February 27-March 03 - **TMS 140th Annual Meeting & Exhibition, MetSoc Co-sponsored Event**
San Diego, California, U.S.A.
http://www.tms.org/meetings/annual-11/AM11home.aspx

February 27-March 03 – **Chloride 2011 at the 140th Annual Meeting & Exhibition MetSoc Co-sponsored Event**
San Diego, California, U.S.A.
http://www.tms.org/meetings/annual-11/AM11home.aspx

May 21-25- **MONTREAL 2011 CIM Conference & Exhibition**
Montreal, Quebec, Canada
www.cim.org

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Perth, Western Australia

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http://www.emc.gdmb.de/

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MetSoc of CIM events
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2012

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The Hydrometallurgy Section’s focuses in the principles and practice of extraction of metals from ores or concentrates and their subsequent transformation into useable forms by means of environmentally sound aqueous processes.

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The Sherritt Hydrometallurgy Award
The Sherritt Hydrometallurgy Award was established in 1976 by Sherritt Gordon Mines Limited to recognize significant contribution in the field of hydrometallurgy. **The 2010 recipient is David G. Dixon.**

David G. Dixon is a Professor in the Department of Materials Engineering at the University of British Columbia in Vancouver, Canada. He received his B.Sc. in Chemical Engineering in 1986 and his Ph.D. in Metallurgical Engineering in 1992, both from the University of Nevada at Reno. He joined the UBC faculty in 1993 as Assistant Professor and Junior Industrial Research Chair in Hydrometallurgy, and received promotion to Associate Professor with tenure in 1999. Dr. Dixon has published widely in the field of hydrometallurgy and holds two U.S. patents on novel flash letdown devices for pressure leaching circuits, and several national and international patents for GalvanoxTM, a novel pyrite-catalyzed atmospheric leaching process for copper concentrates. His research interests include mathematical modeling of heap leaching and bioleaching processes, the design and analysis of leaching reactors, sulfide mineral leaching kinetics and electrochemistry, and the development of novel hydrometallurgical processes for the recovery of copper and nickel.

The Gordon M. Ritcey Award
The Gordon M. Ritcey Award was established in 2004 in honour of a Canadian hydrometallurgist whose accomplishments, particularly in the field of solvent extraction, are known throughout the world. This award recognizes outstanding scholarship in the pursuit of a graduate degree in hydrometallurgy.

**The 2010 recipient is Ilya Perederiy of the University of Toronto.**

CIM Awards

The CIM Fellowship
The CIM Fellowship recognizes members who have distinguished themselves through outstanding contributions to the mining, metallurgical and petroleum industries. A CIM Fellow can place “FCIM” after his or her name when deemed appropriate.

**The 2010 recipients are Daniel Ashman, Hubert King, Ronald Molnar, Bert Wasmund, Zhenghe Xu.**
Monday, August 16, 2010 AM
Room: Adam Ballroom

Co-chaired: Jerry Grandey and Engin Özberk

8:00 OPENING OF THE PLENARY SESSION
Engin Özberk, Vice President, Innovation and Technology Development, Cameco Corporation

8:10 THE FUTURE IS U
Gerald W. Grandey, Chief Executive Officer, Cameco Corporation

8:35 AREVA’S VISION IN CANADA AND THE WORLD
Roger Alexander, President and CEO, AREVA Canada Inc.

9:00 ADDRESS TO DELEGATION
Zhou Zhenxing, Chairman, CGNPC Uranium Resources Co., Ltd. of China

9:25 SASKATCHEWAN’S VISION FOR URANIUM SUPPLY AND NUCLEAR ENERGY
Honourable Bill Boyd, Minister of Energy and Resources, SK

10:00 Coffee Break

10:15 URANIUM 2009: RESOURCES, PRODUCTION AND DEMAND
Robert Vance, Nuclear Energy Analyst, OECD Nuclear Energy Agency

10:40 THE ROLE OF REGULATORY ORGANIZATIONS IN MAKING THE ‘FUTURE IS U’
M. Binder, President, Canadian Nuclear Safety Commission

11:05 URANIUM INDUSTRY
Chief Tammy Cook-Searson, President of Kitsaki Management Limited Partnership

11:30 ADDRESS TO DELEGATION
Galymzhan Pirmatov, Vice-President, Finance, National Atomic Company, "Kazatomprom” JSC
14:00 Paper 5791- Keynote Speech
URANIUM OCCURRENCES AND EXPLORATION EXPERIENCE IN INDIA
A. Chaki
Atomic Minerals Directorate for Exploration and Research, India

The history of the uranium industry in India is briefly reviewed. The efforts of exploration in a number of important uranium provinces, such as the Singhbhum Shear zone, Cuddapah basin, Mahadek basin, Bhima basin, North Delhi Fold Belt and Kaladgi basin, are outlined. Though India had been an early starter in uranium exploration, it slightly lagged behind to cope with the emerging new technologies in mineral exploration, mainly because of the technological isolation. In the new millennium, there is a major shift in India’s uranium exploration strategy from conventional exploration techniques to “technology intensive” exploration. With the large pool of human resources along with the new technology-intensive exploration program, India will achieve self-sufficiency in uranium in the near future.

14:30 Paper 4794
ON THE BRAZILIAN URANIUM PRODUCTION AND DEMAND: SCENARIOS FOR THE NEXT 20 YEARS
R.A.S Villegas and L.A. Gomiero
Indústrias Nucleares do Brasil - Unidade de Concentrado de Urânia, Brazil

The Brazilian government announced in 2007 its plans to reactivate the nuclear program. As a result of this decision, a new nuclear power plant is already being built and there are studies dealing with, among other activities, the building of 5 to 9 new ones until the end of 2030. Such increase of the country’s uranium demand affects INB, the Brazilian state company that’s in charge of uranium supply. This paper describes scenarios predicted to impact the Brazilian nuclear industry for the next years and the INB’s plans to meet the country’s needs in terms of uranium exploration and production.

15:00 Paper 4855
AUSTRALIA’S URANIUM: RECENT EXPLORATION, RESOURCES AND MINE DEVELOPMENTS
A.D. McKay, I.B. Lambert and L.J. Carson
Geoscience Australia, Australia

Uranium exploration expenditure in Australia reached a record level of A$220.5 million in 2008, which had subsequently declined to A$179.6 million in 2009. Recent discoveries include: Ranger 3 Deeps east of Ranger open pit and Thunderball project in the Northern Territory, and Pepegoona and Yadglin sandstone hosted deposits in South Australia. Australia's Reasonable Assured Resources recoverable at costs of ≈US$80/kg uranium at December 2009 are estimated (preliminary) to be 1,224,000 tonnes of uranium, 5% higher than the estimate for December 2008. Recent developments at Olympic Dam mine, Four Mile in situ recovery project, Ranger mine, and Honeymoon, Oban and Yeelirrie projects are discussed.

15:30 Coffee Break

16:00 Paper 4872
URANIUM MINING AND MILLING IN AUSTRALIA - AN OVERVIEW
J. Battista and H. Jones
Golder Associates Pty Ltd, Australia

Uranium mining in Australia has a chequered history. This paper reviews the development of the Australian uranium production industry from the 1930s to the present day. It outlines the geology of the various deposits and the mining and metallurgical techniques used to extract the uranium. The industry is and has been profoundly affected by government policies and the paper considers the roles of the federal, state and local governments. The influence of public opinion on nuclear issues and the effects current and historical policies of various governments have had on uranium production are outlined. Despite heavy restrictions placed on it, Australia’s uranium mining industry has maintained its place as one of the world’s largest producers. This paper also provides an outline of where the industry in Australia may be headed in future.
16:30 Paper 4913
THE FUTURE OF URANIUM IN CANADA
P. Van Vliet, et al.
Canadian Society for Senior Engineers, Canada
Van Vliet Consulting, Canada

This paper examines issues relating to the future of uranium in Canada. It outlines the need for increased base-load electrical power generation to reach Canada’s full economic potential of the resource sector. It outlines international comparisons, with emphasis on wind power generation as part of the energy mix of energy sources. It examines a broad overview of options and nuclear power; addressing the nuclear industry’s safety as well as the unfounded continuing public fear of radiation. It also addresses nuclear waste management and disposal and the environmental assessment work done, leading up to the current Nuclear Waste Management Organization (NWMO).

17:00 Paper 4762
URANIUM FROM PHOSPHATE ROCK. AN UP-DATE
F. Habashi
Department of Mining, Metallurgical, and Materials Engineering, Laval University, Canada

Phosphate rock of sedimentary origin contains on the average 0.01% uranium. At an annual world production of phosphate rock of 130 millions tons this represents a potential source of about 13,000 tons uranium. Because the mining and processing of phosphate rock is already financed by the existing phosphate fertilizer industry, the cost of the uranium as a by-product should not be great. Before the discovery of rich uranium deposits this source was developed on industrial scale. The production of phosphoric acid by sulfuric acid process is at present facing the problem of disposal of gypsum; about 1.5 tons of gypsum is produced per ton of rock processed. This material contains all the radium originally present in the rock which results from the radioactive decay of uranium. As a result, phosphogypsum contains about 0.03 mg Ra/t or 30 pCi/g. The recovery of uranium from this source and the advantages of using nitric acid are discussed. The possibility of applying in-situ, heap and vat leaching to phosphate rock is emphasized.
Demand for reliable, affordable energy will continue to grow as lesser developed countries aspire for standards of living closer to that of developed nations. Society now also realizes the environmental costs of various forms of energy and electricity production. Increasingly, nations are turning to nuclear power to contribute clean, reliable and affordable electricity. Cameco has aggressive growth plans to increase uranium supply to the nuclear industry in order to meet this growing demand. This presentation will provide an overview of Cameco’s current and future uranium supply portfolio including existing operations, projects under development and projects under evaluation.

Northern Saskatchewan comprises an area of about 350,000 km² and boasts some of the world’s largest known high-grade uranium deposits. The successful mining of these deposits, however, cannot be accomplished without overcoming technical challenges. Not only is the high grade of the uranium ore challenging, but mining methods need to be developed to deal with groundwater at very high pressures, and ground conditions that vary substantially from excellent to wholly unconsolidated clays and sand. This paper discusses the various mechanisms of inflows at the three of the Cameco Corporation Mines in Northern Saskatchewan. The risk of inflows is quantified in terms of unique challenges from hydrogeologic conditions, rockmass integrity, and uncertainty in geologic conditions. Mitigation strategies in case of an inflow are also briefly described. The paper concludes by addressing the impact of institutional rules (corporate standards) on minimizing, monitoring, and controlling the probability and/or impact of unexpected inflows.

The objective of this research is to determine how freezing affects weak rock mass behaviour with direct application to the jet boring mining method at Cigar Lake. The Cigar Lake project is a prospective high-grade uranium property in northern Saskatchewan currently under remediation to restore underground workings after water inflows occurred in 2006 and 2008. The deposit, up to 16 m thick, comprises a mixture of massive pitchblende, clay and sand and is overlain by thick zones of sandy clay, unconsolidated sand, and altered sandstone. Above and below the orebody, the rock mass shows variations in porosity and permeability due to fracturing and alteration. Artificial ground freezing will be implemented to support the weak rock associated with the orebody and minimize the potential for a significant water inflow while mining the ore. A material testing program was completed on drill core to provide data that will verify or improve upon previous designs for the stability of the behaviour of frozen ground above the jet-bored cavities.

The team will discuss the innovative methods to locate the source of inflow and steps taken to remediate it.
In a world where underground mining is more commonly deeper than 5,000 ft., and 8,000-10,000 ft is becoming less extraordinary, new techniques and technologies are in demand to reverse the trend of increasing costs per ton mined. So when a company using their own internal engineering, project and operating resources achieve a true technical first, and moves from concept, through research and development, to successful implementation at the pace of regular production, this is an important event. While the technological details of how the inflow into the flooded Cigar Lake Mine was identified and sealed are tantalising, the value lies in reviewing the repeatability of how to achieve this kind of extraordinary result, which raises people-in-team related questions like; how were they led? How did the working environment get created and sustained that allowed the team to operate in a consistently innovative mindset? How did they maintain a pace that relegated research, development and testing to a pace which is common in a regular operating function? How was the risk of these new techniques and technologies evaluated in a timely and effective manner that was considered normal rather than abnormal, and did not retard the pace of the team progress? If repeatable in regular team project and operating environs, then challenging and improving accepted mining methods, practice and technologies could become the norm rather than the exception.
The Key Lake mill located approximately 570 km north of Saskatoon, Saskatchewan, Canada and is currently the world’s largest primary producer of uranium producing 8.5 million kg U3O8/year. The feed to the Key Lake mill currently originates from the McArthur River mine, an underground mine located approximately 80 kilometres north of the Key Lake mill. The McArthur River mine, located within the Athabasca Basin, is the world’s largest high-grade uranium deposit with proven and probable reserve, as of December 31, 2009 of 152 million kg U3O8. Approximately 1,300 people are employed at Key Lake and McArthur River of which 51% of the workforce are residents of Saskatchewan’s north. The mine site and mill are remote and employees commute via air travel to and from the sites from Saskatoon, Saskatchewan as well as communities throughout northern Saskatchewan. Employees work a 7-day in/7-day out work rotation and reside in permanent camps during the work week at the mine and mill.

REVITALIZING THE WHITE MESA URANIUM-VANADIUM MILL

R. Robison1, D. Read1, A. Vien1, P. Malm1, C. Barlow2
1Metso Minerals Canada Inc.
2Denison Mines (USA) Corp.

The White Mesa Mill (WMM) began operating in 1980 as a regional processing mill owned by Energy Fuels Nuclear, Inc. Original mill design was for 656,000 Mtpa of U ore producing 1,250 Mtpa of U3O8 concentrate. Sustained market downturns delayed facility upgrades during most of the 1980s and 1990s. The new owners of WMM, Denison Mines, elected to advance the regional mill concept in 2007 with the modernization of these facilities. This paper details the decisions taken in the plant revitalization, choice of leading-edge instrumentation, motor controls, process automation and training, with some example benefits from process control stabilization.

HEAP-LEACHING OF LOW-GRADE URANIUM ORE AT SOMAIR: FROM LABORATORY TESTS TO PRODUCTION OF 700 TONNES U PER YEAR

N. Durupt and J.J. Blanvillain
AREVA NC

In 2006, SOMAIR decided to increase the uranium production by 50% using heap leaching for the treatment of low grade ores. These ores, which come from different ores with various properties, have been studied in four steps:

- Lab tests: to compare the ores (characterization, acid consumptions, recovery).
- Column tests on an average sample: to define significant parameters for a feasibility study.
- Column tests on specific samples: to optimize recovery for each ore and identify problems of percolation due to the clays.
- Pilot tests in large boxes (stalls): to validate process parameters.

Uranium production by heap leaching started commercially in July 2009.

EVALUATION OF A NEW MILLING PROCESS FOR THE CAETITÉ-BRAZIL URANIUM ORE

L.A. Gomiero1, H. M. Lima1 and C.A. Morais2
1Indústrias Nucleares do Brasil S/A- INB
2Centro de Desenvolvimento da Tecnologia Nuclear – CDTN/CNEN

The Caetité-Brazil uranium facility produces about 400 tonnes/year of U3O8 from an ore averaging 0.29% U3O8. The steps of the process consist of: ore crushing, heap leaching with sulphuric acid, U separation and purification by solvent extraction with a tertiary amine followed by stripping with a sodium chloride solution and precipitation as ammonium diuranate and then product drying. A change in the milling process is being evaluated in order to increase the production as well as uranium recovery. Heap leaching will be replaced by conventional tank agitated leaching of the – 590 µm ground ore slurry in a sulphuric acid medium. The replacement of the stripping reagent is also being considered.
The modern uranium mill generates a vast amount of raw data from various sources including control systems, operator logsheets, assay results and environmental monitoring, which is frequently stored in separate databases. Implementation of software at the McClean Lake mill that includes an integrated, web-based view of these multiple and disparate data sources has provided better tools in the effort to manage this "data load", and extract the information required to enhance process understanding and support the continuous improvement and decision making processes. This paper outlines the opportunities, challenges, and milestones of this software project.

Considering the recent global upsurge in uranium production activity, in 2008 the IAEA re-launched its Uranium Production Site Appraisal Team (UPSAT) program with emphasis on the holistic review of uranium production cycle activities. The review is built around an international panel of uranium industry experts put together by the IAEA. Each UPSAT panel is specific to the requirements and terms of reference for its review. The Terms of Reference are drawn up jointly by those requesting the review and the relevant IAEA technical staff. In January 2010 the first UPSAT review was undertaken at Indústrias Nucleares do Brasil’s uranium operation in Caetité, Brazil. In this paper we describe the philosophy, planning, execution and outcomes of this first UPSAT review, and discuss the possible benefits of hosting a review for future potential UPSAT clients.
**REFINING/CONVERSION**

**Monday, August 16, 2010 PM**
Room: Kelsey

**14:00 Paper 5605**
**SPRINGFIELDS FUELS – TECHNOLOGY AND CAPABILITIES**
M. R. Gornall and D. G. Eaves
Springfields Fuels Ltd, UK.

This paper describes the technologies applied and capabilities of Westinghouse’s Springfields facility in the UK. The site has been involved in the front end of the nuclear fuel cycle for over sixty years yet has some of the most modern manufacturing facilities for UF6 and nuclear fuel. The current capabilities at Springfields include UO3 to UF6 conversion, natural and enriched uranium residue recovery, reconversion of natural and enriched UF6 to UO2, fuel fabrication of Advanced Gas-cooled Reactor (AGR) and Light Water Reactor (LWR) products, the export of UO2 intermediates and the potential to utilise reprocessed uranium feedstock. These processes are supported by an extensive analytical and technical knowledge base.

**14:30 Paper 5576**
**MINIMIZING THE RISK AND IMPACT OF URANIUM HEXAFLUORIDE PRODUCTION**
D.R. Clark1 and T. W. Kennedy2
1Camco Corporation, Port Hope Conversion Facility, Canada
2Camco Corporation, Major Projects Division, Canada

 Cameco Corporation’s Port Hope conversion facility, situated on the shore of Lake Ontario in the Municipality of Port Hope, Ontario, Canada, converts natural uranium trioxide (UO3) into uranium dioxide (UO2) or natural uranium hexafluoride (UF6). Conversion of UO3 to UF6 has been undertaken at the Port Hope conversion facility since 1970 and is currently carried out in a second-generation plant licensed to annually produce 12,500 tonnes U as UF6. Consistent with Cameco’s vision, values and measures of success, Cameco recognizes safety and health of its workers and the public, protection of the environment, and the quality of our processes as the highest corporate priorities. Production of UF6 in a brownfield urban setting requires a commitment to design, build and maintain multiple layers of containment [defence-in-depth] and to continually improve in all operational aspects to achieve this corporate commitment. This paper will describe the conversion processes utilized with a focus on the cultural, management and physical systems employed to minimize the risk and impact of the operation.

**15:00 Paper 5380**
**DEPLETED URANIUM PROCESSING AND FLUORINE EXTRACTION**
S.T. Laflin
International Isotopes Inc., USA

Since the beginning of the nuclear era, there has never been a commercial solution for the large quantities of depleted uranium hexafluoride generated from uranium enrichment. In the United States alone, there is already in excess of 1.6 billion pounds (730 million kilograms) of DUF6 currently stored. INIS is constructing a commercial uranium processing and fluorine extraction facility. The INIS facility will convert depleted uranium hexafluoride and use it as feed material for the patented Fluorine Extraction Process to produce high purity fluoride gases and anhydrous hydrofluoric acid. The project will provide an environmentally friendly and commercially viable solution for DUF6 tails management.

**15:30 Coffee Break**

**16:00 Paper 4780**
**URANIUM REFINING WITHOUT SOLVENT EXTRACTION**
A. Bhowmik, P. Shanmugavelu, D. Dhavamani, A. Agrawal, S. Sarkar and T.K.Bera
Chemical Technology Group, Bhabha Atomic Research Centre, India

Uranium Refining is the process by which undesirable neutron absorbing elements such as Boron (B), Gadolinium (Gd), Dysprosium (Dy), Cadmium (Cd), Europium (Eu), Samarium (Sm) and other metals (Fe, Ni, Co, Ca, Mg etc.) are removed from the yellow cake. Generally, uranium refining is carried out by solvent extraction process, by using organic extractant such as Tri-n butyl phosphate (TBP) diluted with Kerosene. This process generates significant volume of nitrate bearing liquid waste and degraded organic. In order to eliminate the use of hazardous organic and anhydrous ammonia for uranium refining, altogether, a new process using hydrogen peroxide for selective precipitation of uranium from uranyl nitrate solutions has been developed. The precipitate is filtered and washed with DM water to obtain product meeting nuclear purity standards as per ASTM C–753–04. The product is spray dried and calcined to obtain uranium oxide. This process is simple as it integrates refining and precipitation process together. The new process is more environment friendly.
Uranium tetrafluoride, UF₄, is produced at the Port Hope conversion facility by the reaction of uranium dioxide, UO₂, with hydrogen fluoride in a wet process. Two of the important parameters for UF₄ quality control of this process are the water content and the unreacted UO₂ content. Water content is typically measured by weight loss during heating, while UO₂ content is determined by measuring the ammonium oxalate insoluble content. A procedure was developed using thermal gravimetric analyses to simultaneously determine the water content by weight loss and the unreacted UO₂ content through weight gain after oxidation.
Molten Salt Reactors were chosen as one of the six Generation IV reactors due to their numerous advantages in terms of overall safety, low cost potential, minimal long lived waste and superior resource utilization. These reactors are typically thought of as operating on the thorium to 233U cycle. However, all these advantages and still more are also true of simplified designs that employ no fuel processing and run off Low Enriched Uranium while requiring only a small fraction the uranium needs of LWR or CANDU designs. This paper will review the great potential of this often overlooked mode of operation and introduce new proposed designs.

The CANDU reactor has proven to be a strong performer in both the Canada, with 22 units constructed in Ontario, New Brunswick and Quebec, as well as in Argentina, Korea, Romania and China where a further nine units are operating and two in the planning stage. The average lifetime capacity factor of the CANDU reactor fleet is 89%. The last seven CANDU projects in Korea, China, and Romania have been completed on budget and on schedule. CANDU reactors have the highest uranium utilization efficiency measures as electricity output per ton of uranium mined. The CANDU fuel channel design using on-power fuelling and a heavy water moderator enables flexible fueling options – from the current natural uranium option to burning uranium recovered from used LWR reactor fuel and even a thorium-based fuel. AECL and the CANDU reactor are poised to participate in the worldwide construction at least 250 new reactors over the next 20 years.

The global nuclear power forecast, the North American outlook and the effect of nuclear power growth on greenhouse gas emissions in North America will be discussed. The construction of Generation III reactors will replace aging power plants and, further, add capacity that is environmentally sustainable. The outlook for Generation IV reactors also may significantly improve the environmental balance after 2030, both in electrical markets, waste reduction, and in non-traditional markets such as process heat.
The Australian Government policy is to ensure that uranium mining, milling and rehabilitation is based on world best practice standards. A best practice guide for in situ recovery (ISR) uranium mining has been developed to communicate the Australian Government’s expectations with a view to achieving greater certainty that ISR mining projects meet Australian Government policy and consistency in the assessment of ISR mine proposals within multiple government regulatory processes. The guide focuses on the main perceived risks; impacts on groundwaters, disposal of mining residues, and radiation protection. World best practice does not amount to a universal template for ISR mining because the characteristics of individual ore bodies determine the best practice.

Ranger Uranium Mine operates under an Authorisation issued by the Northern Territory Government. In addition, the site is regulated by a set of Environmental Requirements attached to the uranium export permit issued by the Australian Government Department of Resources, Energy and Tourism. A Heap Leach facility proposed for the site could result in a third approval being issued, in accordance with the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). Finding the correct balance to regulate the mine in light of these approvals will be a challenge for the range of stakeholders involved in regulation and oversight of this operation.
There are fifteen accepted types of uranium ore deposits and at least forty subtypes readily identified around the world. Each deposit type has a unique set of geological characteristics which may also result in unique processing implications. Primary uranium production in the past decade has predominantly come from only a few of these deposit types including: unconformity, sandstone, calcrete, intrusive, breccia complex and volcanic ones. Processing implications can vary widely between and within the different geological models. Some key characteristics of uranium deposits that may have processing implications include: ore grade, uranium and gangue mineralogy, ore hardness, porosity, uranium mineral morphology and carbon content. Processing difficulties may occur as a result of one or more of these characteristics. In order to meet future uranium demand, it is imperative that innovative processing approaches and new technological advances be developed in order that many of the marginally economic traditional and uneconomic non-traditional uranium ore deposits can be exploited.

Among the uranium deposits in the Karoo sandstones of southern Africa, those in the Escarpment Grit Formation at Mutanga are particularly attractive because uranium occurs as uranyl phosphate rather than refractory oxides or silicates. The fluvial Escarpment Grit sandstones unconformably overlie the late Permian lacustrine Madumabisa Mudstone and are conformably overlain by the early Triassic fluvial Interbedded Sandstone and Mudstone Formation. The Mutanga deposits contain resources of 1.99 million lb. measured, 5.82 million lb. indicated and 13.2 million lb. inferred U3O8 at ≥286 ppm. The deposits are suitable for open-pit mining, and acid heap leaching. Meta-autunite, as pore-filling crystals, and fracture/grain coatings, is the predominant uranium mineral, with minor brannerite and coffinite. The autunite likely formed from uranyl ions, oxidized and teached from primary uranium minerals following post-Karoo fault uplift, precipitated with dissolved phosphate and possibly concentrated following the Permian-Triassic extinction.

CSIRO is undertaking advanced mineralogical and elemental characterisation studies of low-grade and refractory Australian uranium deposits. Of particular interest are the calcrite-type uranium deposits of Western Australia. These deposits are found in playa lake sediments and channels which drain a uranium-rich source. The primary uranium mineral is carnotite. The ore is highly friable and is usually found in association with clayey and calcareous minerals, such as gypsum, dolomite and halite. This paper aims to provide a better understanding of the characteristics and formation of these calcrite-type uranium deposits to assist in the development of new and improved processing routes.

The Uranium Province of Lagoa Real is located in the mid-south region of Bahia State, Brazil. Uranium, occurring mainly in the form of uraninite, is the only economic mineral commodity. The region has been explored for uranium since 1971 and 35 anomalies were detected, distributed over 1200 km2. Seven are classified as deposits, accounting for reasonably assured resources of 100,000 tonnes of U3O8. This paper describes the geological aspects of the area, the exploration and mining activities done so far by the state company INB and the perspectives for the near future, when an increase in the country’s uranium demand is expected.
NON-TRADITIONAL URANIUM EXPLORATION TARGETS IN SOUTH AUSTRALIA
M.C. Fairclough¹, T. Wilson¹, T. Dhu¹, G. Gouthas¹, P. Heath¹, S.A. Bosman² and C.D. Card²
¹Geological Survey Branch, Primary Industries & Resources, South Australia
²Saskatchewan Ministry of Energy and Resources, Canada

South Australia hosts two of Australia’s three operating uranium mines with another two anticipated to begin production in the near future. Traditionally exploration has largely focused on Iron oxide copper gold + uranium (c.f. Olympic Dam style) or sandstone-hosted (c.f. Beverley style) uranium targets. However, due to the ubiquitous uranium anomalism through the Mesoproterozoic crystalline basement in eastern South Australia, process-driven target generation indicates high potential for contemporary hybrids of different types, as well as younger unconformity-related or calcrete-hosted deposits. Translation of key mineralising processes into mappable criteria allows innovative targeting strategies to be developed for explorers in Greenfield areas.

AGPAITIC NEPHELINE SYENITES FROM THE ILIMAUSSAQ COMPLEX, SOUTH GREENLAND; AN IMPORTANT NEW URANIUM ORE TYPE
J. L. Mair
Greenland Minerals and Energy Limited

The Ilimaussaq Intrusive Complex in south Greenland is a layered alkaline igneous body that is predominantly comprised of agpaitic nepheline syenites. The Complex is now recognized as containing vast resources of uranium in polymetallic ores that are also strongly enriched in rare earth elements (REEs) and zinc. Uranium and REEs are dominantly hosted in phosphate minerals with a minor proportion hosted in zirconium silicate minerals. Equivalent ores are yet to be mined for uranium anywhere in the world; however, studies are well advanced in confirming a process route to economically extract uranium. The Ilimaussaq Complex is considered the world’s type-locality for agpaitic rocks. Formation of the complex is attributed to four successive pulses of magma. Resources defined to date include 192 million lb. of U₃O₈ at 350 ppm within an overall resource of 282 million lb. of uranium oxide at a grade of 280 ppm. With scope for several other similar sized resources within complex, the overall potential resource is of immense global significance. Metallurgical studies to date indicate that uranium can be successfully extracted from black lujavrites via an alkaline pressure leach method. There is also scope to beneficiate ores as uranium and REEs are hosted in specific mineral groups. Phosphate minerals can be effectively concentrated by froth floatation and uranium-bearing silicate minerals can be concentrated by gravitational methods. Studies indicate that REEs can be extracted from the residue following the alkaline leach process by a dilute hydrochloric acid wash, with REEs then precipitated in the form of a REE concentrate.

DISSOLUTION-PRECIPITATION PROCESSES ON THE SURFACE OF URANYL-MINERALS
M. Schindler
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Understanding dissolution-precipitation processes on the surface of uranyl minerals is crucial for predictive modeling of U mobility in the subsurface. In order to understand how pH and type of cation in solution may affect these processes, dissolution experiments were performed on mainly single crystals of seven different uranyl-minerals. Uranyl mineral basal surface microtopography, micromorphology, and composition were examined prior to, and after dissolution experiments on micrometer scale specimens using Atomic Force Microscopy, Scanning Electron Microscopy, and, X-ray Photoelectron Spectroscopy. Surface precipitation of the following phases was observed: (a) a highly-hydrated uranyl-hydroxy-hydrate in ultrapure water; (b) a Na-uranyl-hydroxy-hydrate in Na₂CO₃ solutions (pH = 10.5); (c) Ba- and Pb-uranyl-hydroxy-hydrates in Ba-HCl and Pb-HCl solutions of pH 2; (d) a (SiOₓ(OH)₄-2x) phase in solutions of pH 2 (only on silicates) and sulfate-bearing phases in solutions of pH 2 (only on sulfates). These results suggest that thin coatings form on the surface of almost all uranyl minerals independent of pH and composition, affecting hereby the dissolution of the underlying mineral and thus the release of U and other radionuclides to the environment.
In 2009 AREVA became the world’s 1st uranium producer. Historically, since the closure of all uranium mines in France, AREVA’s production was essentially coming from Canada and Niger. Most recently intense development in Kazakhstan contributed to AREVA’s ascension to its current leading position. AREVA’s production will continue to increase in Kazakhstan, in Canada and in Niger and preparations are under way for the launch of production in Namibia. AREVA plans to remain a major player in the long term, with its aggressive exploration program across the world. This is particularly true here in Canada with world-class projects such as Shea Creek in the Western Athabasca Basin and Kiggavik in Nunavut that will add during the coming decades to AREVA’s flagship state of the art uranium mill at McClean Lake and its participation in the two world largest uranium high-grade projects, the McArthur River mine and the Cigar Lake project scheduled for start-up in 2013.

8:30 Paper 4745
QUANTIFYING THE EFFECT OF LOCALIZED DEPRESSURIZATION ON A DEEP UNDERGROUND OREBODY AT THE McARTHUR RIVER MINE THROUGH CROSS HOLE HYDRAULIC TESTING AND GROUNDWATER MODELLING
H. Liu1, R. Bashir2,3, S. Axen1, J. Hatley1 and G. Murdock4
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2Golder Associates Ltd., Canada
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4Cameco Corporation, Canada

The McArthur River mine in northern Saskatchewan is the largest single producer of uranium in the world. Most of the ore is extracted by raisebore mining methods at depths of 530 to 600 m below ground surface where pore pressures in the fractured host sandstone are on the order of 5 MPa. Currently, ground freezing is used to isolate the ore from ground-water sources. Localized depressurizing of the freeze drifts is being considered to increase their ground-stability. Cross-hole flow and shut-in tests in eight NQ-size coreholes were conducted in the basement rock that is adjacent to a fault contact with the overlying 500 m thick sandstone unit. The hydrogeologic parameters of basement rock in the vicinity of a freezing drift were obtained. A 15% to 25% reduction of pore pressure over a 25 m distance was observed within a three-hour test period. A detailed three-dimensional groundwater flow model was constructed to replicate the pore pressure measured in the coreholes. The pore pressure distribution simulated from the model provides the hydrogeologic input for geotechnical engineers to evaluate ground-stability and assess whether additional active depressurizing should be conducted.

9:00 Paper 4751
BOXHOLE MINING AT McARTHUR RIVER
H. Goetz, V. Madenga and J. Callin
Cameco Corporation, McArthur River Operation, Canada

Raisebore mining is the current production method at Cameco’s McArthur River Operation. This mining method requires access development both above and below the ore zone. In areas of the mine, where access above the mining block is difficult, it is proposed to extract the ore by Boxhole mining from below. A test mining program commenced in 2009 at McArthur River to demonstrate the viability of this new mining method. This paper provides a description of the Boxhole mining method and summarizes the results obtained during the first year of testing.

9:30 Paper 4814
OVERCOMING THE GEOTECHNICAL CHALLENGES OF DRIFT DEVELOPMENT AT THE UNCONFORMITY OF THE ATHABASCA BASIN
S. T. Yameogo and J. Hatley
Cameco Corporation, McArthur River Operation, Canada

Rock mechanics literature has documented the challenges, failures and successes of tunnelling through weak rocks. Cases usually deal with low RMR rock masses or high stresses in a fractured zone. With the combination of 5 MPa water pressure, 14 RMR ground with clay infillings and ground freeze walls, the case of the 510-8225N development drift at McArthur River is certainly much more challenging, especially when high grade uranium production is at stake. The article explains the excavation and the ground control techniques that were used to overcome the challenges of development at the Unconformity in the Athabasca Basin.
A RELIABILITY-BASED DESIGN PROCEDURE FOR MINE DEWATERING SYSTEMS
R. Bashir 1, 2, S.A. Imran 3 and J.F.A. Hatley 4
1 Golder Associates Ltd.
2 Department of Civil & Geological Engineering, University of Saskatchewan
3 Water Quality Modeling & Monitoring, NRC Center for Sustainable Infrastructure Research
4 Cameco Corporation

The presence of groundwater in the form of large aquifers can have an important influence on investment decisions for underground mines. The design for such mines requires development of special mining methods, and mine dewatering infrastructure to avoid hazards during shaft sinking and underground development. The costs associated with mine drainage control and mine dewatering systems (MDS) are relatively small compared to the huge consequential losses that can occur in case of an uncontrolled inflow and subsequent flooding of the mine. The design of MDS needs consideration of accurate prediction of the maximum uncontrolled inflow rate, availability of the system during an uncontrolled inflow while the inflow is mitigated, and decision on pumping system technology to have capability to operate under water. The research presented in this paper provides a theoretical framework for a reliability-based design procedure which takes into account the uncertainty in the estimate of the maximum uncontrolled inflow, performance of the system during the period of an uncontrolled inflow and a methodology to decide on appropriate pumping technology considering the reliability of the system and available underground storage. The reliability-based mine design procedure integrates the ideas of Effective Reserve and Hydraulic Reliability Index to come up with a unified methodology for design of Mine Dewatering Systems.

GEOMECHANICAL ASSESSMENT FOR DRIFT AND CHAMBER DEVELOPMENT IN THE ATHABASCA BASIN
S. T. Yameogo
Cameco Corporation, McArthur River Operation, Canada

Much has been said about the methodology of geomechanical design in underground excavations. However, the geological, hydrogeological and geotechnical complexities encountered at the production horizons in the Athabasca Basin commanded a novel approach in geomechanical assessment and the design of underground openings. Geologists and mining engineers at Cameco McArthur River have been able to establish a practical methodology that goes beyond conceptual approaches. In this paper, the author describes the original challenges and unique approach in the geomechanical assessment for access drift and extraction chamber development.
Joint Venture Inkai, owned by Cameco Corporation and KazAtomProm, is located in Kazakhstan and represents one of the world’s richest uranium deposits that would be suitable for extraction by in-situ recovery methods using a strong acid leach. This property has undergone the transition from exploration to development to fully operational as of late 2009, with the completions of surface processing facilities with a capacity of 2000 tU per year, and the further development of wellfields. This presentation will highlight the history of the test leach results at Inkai, the early experiences of wellfield development and performance improvement, and the design, construction, commissioning and operations of the processing facilities.

Aurora Energy Resources Inc. is proposing to build and operate a 10,000 t/d process plant to produce 97 million pounds of U3O8 over a seventeen-year project life from deposits in coastal Labrador. This paper summarizes the testwork, generally done by SGS Mineral Services in Lakefield, Ontario, and the economic studies that support flowsheet selection. The selected flowsheet includes SAG and ball milling, acid leaching using air/SO2 as an oxidant, and resin-in-pulp (RIP) extraction of uranium from the leached slurry. Other unit operations examined include ore sorting, heap leaching, liquid-solid separation, solvent extraction, and nanofiltration for eluate upgrading. We also review the extensive programs of environmental testwork and studies that were completed.

In April 2009, production began at the Kayelekera uranium in Malawi, Africa. The mine is owned by Paladin Energy Limited, through its subsidiary Paladin Africa Limited. The mill employs standard unit operations to crush, grind and acid leach uranium ore grading 0.11% U3O8. Soluble uranium is recovered and purified using resin-in-pulp technology with strong acid elution. Hydrogen peroxide is used to precipitate uranyl peroxide. Sulfuric acid is generated on site.

Imouraren is a sedimentary uranium deposit (total → 150 000 tU, average U ~ 0.08 %), located in Niger (~100 km from Agadez). Uranium mineralization is trapped in sandstones and is widely oxidized (uranotyle, metatuyamunite), but a part remains reduced (pitchblende, uraninite). The sandstones have a peculiar mineralogical assemblage (analcite partly chloritized) which can affect uranium recovery. Several acid heap leaching tests have been completed to determine the most suitable process parameters. Microscopic studies and XRD analysis performed on fresh ore and on leached residue highlight the complex behavior of uranium and the associated mineralogical families during the tests.

Midwest is a unique uranium deposit with exceptionally high arsenic content. The ore body is located 17 km west of the McClean Lake operation. The McClean Lake mill will be modified to process Midwest ore and handle solid wastes from the Midwest water treatment plant. This paper describes the modifications required of the McClean Lake mill, process challenges associated with treatment of the arsenic, and the possibility of recovering nickel and cobalt as a by-product. It also reviews the complexity in the design of the Midwest water treatment facility which incorporates reverse osmosis technology with conventional physical-chemical water treatment.
Toro Energy Ltd. has identified a resource of 20.2 million tonnes at a grade of 548 ppm U3O8 at Wiluna, Western Australia. Calcrete and clay delta formations host the uranium mineral carnotite. Initial studies indicate a mining operation is technically, environmentally and commercially viable. Increase in demand for uranium and a change in State Government policy on uranium mining have lead Toro to proceed with a bankable feasibility study and commence approvals with State and Federal Governments. This paper discusses how Toro arrived at the decision to utilise alkaline heap leach, a process not widely used, and how it is being developed.

The uranium deposits of Elkon district are located in the south of Republic of Sakha Yakutia. Deposits contain about 6% of the world known uranium resources: 342 409 tonnes of in situ or 288 768 tonnes of recoverable RAR + Inferred resources. Most significant uranium resources of Elkon district (261 768 tonnes) were identified within five deposits of Yuzhnaya zone. The uranium grade averages 0.15 %. Gold, silver and molybdenum are by-products. Principal resources are proposed to be mined by conventional underground method. Location, shape and dimensions of uranium orebodies are primarily controlled by NW-SE oriented and steeply SW dipping faults of Mesozoic age and surrounding pyrite-carbonate-potassium feldspar alteration zones. Country rocks are Archean gneisses. Deposits are of metasomatic geological type. Principal mineralization is represented by brannerite. The Yuzhnaya zone is about 20 km long. It was explored by underground workings and drill holes. Upper limit of orebodies is at a depth of between 200 m and 500 m. Depth persistence exceeds 2,000 m. Uranium mining enterprise Elkon was established in November 2007. It is a 100% Atomredmetzoloto (ARMZ) subsidiary. The planned producing capacity is up to 5000 Mt U/year. It will perform the entire works related to uranium mining, milling, ore sorting, processing and uranium dioxide production. Technology of ore processing assumes primary radiometric sorting, thickening, sulphide flotation for gold concentrate extraction, subsequent autoclave sulphuric-acid uranium leaching from flotation tails and uranium adsorption onto resin, roasting and heap leaching for uranium from low grade ores, cyanide leaching of gold. Due to a considerable abundance of brannerite, the ore is classified as refractory. Elkon development include 4 main stages: feasibility study and infrastructure development (2009-2011), mine and mill construction (2012-2015), pilot production (2013-2015), mine development and achieving full capacity production (2016-2024).
8:00 Paper 4779
CONSIDERATIONS FOR URANIUM EXTRACTION PROCESS PLANT DESIGN
C. Edwards
AMEC Americas Limited

Uranium process plant design offers a wide variety of potentially feasible options that include equipment, processes and procedures used in the past, in use now, and that could be considered for future use. Process design options should be selected to reduce costs, improve efficiencies, effect safer operations, and lessen environmental impacts. This paper suggests concepts for consideration in selecting equipment, processes and procedures for uranium process plant design through the whole operation from ore intake to final product preparation.

8:30 Paper 4935
EFFECT OF REAGENT PARAMETERS ON RECOVERY OF SOUTH AFRICA URANIUM ORE
A. S. Afolabi¹, E. Muzenda² and R. Sigwadi³
¹Department of Civil and Chemical Engineering, University of South Africa, South Africa
²Chemical engineering Technology Department, University of Johannesburg, South Africa
³SGS Lakefield Research Africa (Pty) Limited, South Africa

The effects of leach parameters to determine the variability of reagents consumption on a uranium ore was investigated in this work. The effects of time, temperature, sulphates, and acid consumption on the rate of dissolution of the comminuted uranium ore samples were also studied. It was found that 77% dissolution of uranium was achieved after 8 hours at temperature 30°C. The addition of ferric sulphate at 30°C showed a decrease in acid consumption from 79.32 to 32.32 kg/t as well as decrease in the MnO₂ consumption from 21.03 to 15.06 kg/t. At elevated temperature of 60°C a higher acid consumption of 100 kg/t was realized and this is attributed to the fact that other acid consuming minerals were leached at this temperature. Maximum uranium dissolution of 89.37% was achieved after 24 hours and the acid consumption was 31 kg/t with a MnO₂ addition of 24.26 kg/t.

9:00 Paper 4777
URANIUM PEROXIDE PRECIPITATE DRYING TEMPERATURE RELATIONSHIPS
C. "Chick" Rodgers and B. Dyck
 Cameco Corporation

Cameco Corporation is in the process of revitalizing the mill at its Key Lake operation in northern Saskatchewan. The current Key Lake process employs ammonia stripping and ammonia precipitation. As part of the revitalization, the company is considering installing strong acid stripping in solvent extraction as used at its Rabbit Lake operation. This change would lead to using hydrogen peroxide for uranium precipitation. As part of the process evaluation, tests were carried out to study how changes in the temperature of an indirect fired dryer affected the properties of uranium peroxide (yellowcake) precipitate. This paper discusses the results of the test work, including the relationships between drying temperature and the following:

9:30 Paper 4831
A NEW PROCESS FOR URANIUM PRECIPITATION – INCREASING BULK YELLOWCAKE DENSITY
B. Courtaud, F. Auger, and J. Thiry
AREVA NC – Service d’Etudes de Procédés et d’Analyses (SEPA), France

Uranium plants are generally located quite far from conversion plants, resulting in high transport costs. One way of reducing such costs involves putting more uranium in each drum by increasing the final product’s bulk density, which can be achieved via mechanical compaction of the powder and/or improved precipitation. For most of its plants, AREVA has adopted the latter approach, involving a new precipitation process applicable to all kinds of yellowcake produced (via uranates, uranium peroxide, etc.) that achieves bulk density of 3 for soda urinate, for example, instead of the 1.5-2 density available via conventional processes. At present, this process is being undertaken on an industrial scale and will become the norm for precipitation processes at all AREVA U plants. In addition to producing dense yellowcake, the process also delivers a product with no fines, a spherical particle shape (which allows for high-quality powder flow) and superior post-precipitation filterability.

10:00 Coffee Break
THE USE OF ENGINEERED MEMBRANE SEPARATION® (EMS®) TECHNOLOGY FOR RADIONUCLIDE SEPARATIONS
L. Lien
HW Process Technologies, Inc.

Engineered Membrane Separation® (EMS®) technology has been applied successfully in the nuclear industry for many years for both processing and environmental applications. Radionuclides do not harm polymeric UF membranes or Thin-Film Composite membranes. In addition, these polymeric membranes are stable in both strong acid and strong base solutions, and are therefore well suited to concentrate radioactive nuclides effectively from process or waste water applications. The range of specific applications for EMS® technology include separating uranyl sulfate and nitrate from acids, fractionation of radionuclides from boron in reactor moderation water, and the removal of radionuclides from contaminated ground water sources.

POTENTIAL APPLICATION OF MOLECULAR RECOGNITION TECHNOLOGY (MRT) FOR EXTRACTION AND RECOVERY OF RHENIUM AND MOLYBDENUM FROM URANIUM LIQUORS
N.E. Izatt, R.L. Bruening, S.R. Izatt, and J.B. Dale
IBC Advanced Technologies, Inc., USA

Many uranium ores contain molybdenum and rhenium at very low concentrations. Molybdenum and rhenium have a close geochemical association. Rhenium is a relatively high value metal with a number of established, growing applications. The incentive to recover rhenium at some point in the uranium extraction flow sheet has become significant. Recovery of rhenium, molybdenum, and uranium from various feed solutions using molecular recognition technology (MRT) is described. Examples are also provided.

MICROBES: URANIUM MINERS, MONEY MAKERS, PROBLEM SOLVERS
A.L. Williamson1,2, R. Payne3, F. Kerr4, S. Hall2, and G.A. Spiers1,2
1MIRARCO, Canada
2Laurentian University, Canada
3Pele Mountain Resources Inc., Canada

Bioleaching, the microbial dissolution of minerals, is potentially useful in exploiting a variety of ore deposits, including the lower-grade uraniferous quartz-pebble conglomerate beds of the Quirke Syncline, Elliot Lake, Ontario. The metabolism of chemolithotrophic bacterium Acidithiobacillus ferrooxidans is dependent on its ability to derive energy and reducing power from the oxidation of ferrous iron. The characteristics of this bacterium, in particular the ability to oxidize both iron and sulphur with an associated high tolerance of low acidity, allow the organism to contribute significantly to bioleaching processes. Under ideal conditions, A. ferrooxidans promotes the oxidation of iron-containing sulphide ore materials, breaking their crystal structure and promoting the dissolution of iron, base metals, as well as uranium, rare earth elements and associated elements of toxicological interest such as arsenic and selenium. The current study documents an overview of the recovery of uranium and rare earth elements to solution, plus investigates the acid generating potential of the solid residues from a series of environmentally controlled, biologically-mediated uranium ore extraction experiments. The findings will be used in the design of larger scale bioleaching experiments to further assess the potential for success of bioleaching as a metallurgical extraction technique potentially leading to minimum maintenance decommissioning strategies for the ore deposits of the Quirke Syncline.
Nuclear power is experiencing a renaissance and stable growth all over the world and is emerging as one of the leading options for meeting the ever increasing demand for electricity, avoiding greenhouse gas emissions and global warming. Presently, some 437 Nuclear Power Reactors are in operation in 30 countries with total installed power of ~370 GWe, generating ~14.5% of global electricity. According to the projection of the International Atomic Energy Agency (IAEA), the installed nuclear power is likely to be in the range of 748 GWe by 2030.

Natural Uranium is the basic raw material for nuclear fuel. It contains U235, the only fissile isotope in nature, and U238 which could be transmuted in a reactor to man-made element Plutonium, which has Pu239 and Pu241 fissile isotopes. Light Water Reactor (LWR) system is most common and account for nearly 90% of the operating nuclear power reactors, followed by the Pressurized Heavy Water Reactor (PHWR) system which contribute to some 6%. The LWRs and PHWRs use Low Enriched Uranium (LEU) containing up to 5% U235 and natural uranium (0.7% U235) as fuel respectively, in the form of high density uranium oxide pellets. Nuclear power reactor and fuel cycle activities go hand in hand. The front end of uranium fuel cycle consists of exploration and mining of uranium ores, their milling, purification and refining to UO3, conversion to natural UO2 powder for fabricating PHWR fuel and to UF6 followed by U235 enrichment (up to 5%) and conversion to LEU di-oxide powder for LWR fuel. The UO2 powder is subjected to pelletization, sintering and center less grinding to obtain fuel pellets which are encapsulated in zirconium alloy cladding tubes to form fuel pins that are subsequently clustered to form fuel assemblies. The major challenges in front end of uranium fuel cycle are meeting the growing annual demand of uranium, increasing fuel burn up and ensuring high performance and zero defect of fuel.

The present paper summarizes the recent development in the front and back end of uranium fuel cycle, highlighting the fuel development activities for thermal and fast reactors.
density functional theory is used in this calculation. The total energy technique is implemented to investigate changes in the lattice constants. The ab-initio calculations predict a 36-38% increase in the volume per uranium atom when transforming from UO2 to U3O8, which agrees very well with experimental data. The implication of this prediction on the linear expansion and fragmentation of fuel is discussed. The calculated elastic constants of urania are in good agreement with experiments. The predicted mechanical properties of UO2 and U3O8 are compared.

10:00 Coffee Break

10:30 Paper 4864

MODELLING OF THE TETRAVALENT URANIUM OXALATE PRECIPITATION IN A VORTEX REACTOR AT STEADY STATE

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3CERFACS, France
4Commissariat à l’Energie Atomique et aux Energies Renouvelables, Nuclear Energy Division, Reactor Studies Department, France

Oxalic precipitation is usually applied to process radioactive wastes or to recover actinides from a multicomponent solution. Precipitation reactions being highly sensitive to many operation parameters, the computer simulation appears to be a very effective tool to forecast the evolutions of the system subjected to various operating conditions. This study focuses on the tetravalent uranium oxalate precipitation modelling which combines population balance and hydrodynamics. The objective of this work is to show how flow pattern inside the precipitator can have a noticeable effect on the precipitate properties.

11:00 Paper 5925

FUEL FABRICATION ACTIVITIES FOR POWER REACTORS IN INDIA – PRESENT AND FUTURE PROSPECTS

J. Raigiri Narayana
Nuclear Fuel Complex, India

Based on the initial developmental works and pilot plant studies carried out at Bhabha Atomic Research Centre (BARC), Mumbai, the Nuclear Fuel Complex (NFC) was established as an industrial unit during early 1970s to manufacture fuel assemblies and reactor core structural for PHWRs and BWRs. The Plants consisting of Uranium and Zirconium streams process raw materials in form of Magnesium Di-Uranate (MDU) and Zircon Sand respectively to fabricate finished fuel assemblies. Presently, 17 PHWRs and 2 BWRs are operating in India, generating about 4340 MWe of electricity. The reload fuel assemblies for all these Reactors are manufactured at NFC in addition to the reactor structural like Coolant Channels and Calandria Tubes. In tune with the decision of the Department of Atomic Energy to set-up twelve PHWRs of 700 MWe capacity, NFC has embarked on expansion programme to manufacture fuel for all these Reactors. In addition, the plans are afoot to set-up fuel fabrication facilities for catering to the needs of large number of imported Light Water Reactors (LWRs), in collaboration with the fuel manufacturers abroad. The Paper highlights the present scenario and the future plans for fabrication of nuclear fuel assemblies for both indigenously built and imported Reactors.

11:30 Paper 5367

PLUTONIUM ROCK-LIKE OXIDE FUEL (ROXF) SYSTEM, THEIR ONCE-THROUGH BURNING AND USAGE

A. E. Mohamed Mohamed
Brno University of Technology, Czech Republic

The ROXf is a kind of inert matrix fuel U238-free matrices, it has a high plutonium transmutation capability. The ROXf consists of chemically stable phases of fluorite ‘stabilized ZrO2 or ThO2 and spinel MgAl2O4. In this fuel, PuO2 is solidified in a fluorite phase. With U238-Free matrices, a large part of the plutonium can be burned after irradiation in conventional LWRs. The spent ROXf consists of natural analogous geologically stable phases, and is disposed directly as high level wastes ‘HLWs’ after about 50 years cooling. From the high plutonium burn up rate and the high stability of the fuel, the ROXf-LWRs system has proliferation resistance and environmental safety. Characteristics of two types of ROXf, Zr-ROX and Th-ROX with weapons-Pu, in an LWR core arrangement are evaluated by cell burn up calculations and 2-D core calculations using the SRAC code system and JENDL-3 nuclear library. In an LWR of moderator to fuel volume ratio = 1.9, which corresponds to current PWRs, Pu transmutation rates with the two types of ROXf are large enough and more than 80% and 99% of Pu and Pu239, respectively, can be burned. The calculated kinetic parameters indicate less moderate characteristics of ROX cores, especially with Zr-ROX. The fertile Th232 in Th-ROX works like U238 in the UO2 fuel, making kinetic parameters more moderate and reactivity drop due to burn up smaller than that Zr-ROX. The neutron capture of Th232 to generate U233, causes the safeguards problem. Thus, the characteristics of Zr-ROX as a typical example, were investigated in this study
Over the past 60 years of uranium process development only a few commercial uranium plants have adopted a pressure leaching process in their flowsheet. The selection of acid versus alkaline pressure leaching is related to the uranium and gangue mineralogy. Tetravalent (U+4) uranium has to be oxidized to hexavalent (U+6) uranium to be soluble. Refractory tetravalent uranium requires higher temperature and pressure, as practised in pressure leaching, for conversion to soluble hexavalent uranium. This paper chronicles the history of these uranium pressure leaching facilities over the past 60 years, with specific details of each design and operation.

Coffinite (USiO₄) is the second most important uranium ore mineral behind uraninite. Accurate analysis of naturally occurring coffinite is usually extremely difficult as it commonly exists as very fine grains. As coffinite is an alteration product of uraninite and is part of the largest uranium mineral group (uranil silicates) a greater understanding of the fundamental properties is important to continuing to improve current processes for extracting uranium from this mineral. In this study synthetic coffinite was prepared using a hydrothermal method and characterised using X-ray Diffraction, Scanning Electron Microscopy and Fourier Transform Infrared Spectroscopy. Batch sulphuric acid dissolution of the prepared synthetic coffinite was conducted at a temperature of 150 °C. It was found that > 94 % coffinite dissolution occurred under the following conditions; [U] = 100 mg/L, 2 h, Fe³⁺:Fe²⁺ = 1:10 and [H₂SO₄] = 5, 15, 100 and 200 g/L.

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9:30 Paper 4857
THE EFFECT OF VARIOUS HALIDES ON THE DISSOLUTION OF SYNTHETIC URANIUM DIOXIDE (UO2)
R. Ram, F. Charalambous, J. Tardio and S. Khargava
Advanced Materials and Industrial Chemistry group,
School of Applied Sciences, RMIT University, Australia

The naturally occurring mineral tetravalent uraninite (UO2) is one of the major raw products used to produce nuclear fuel grade uranium. Increasing demand for uranium has led to significant interest in improving the efficiency of UO2 dissolution, particularly from complex, low grade uranium ores. In this study the influence of F- and Cl-, [Fe3+] and oxidation reduction potential on UO2 dissolution were investigated. F- was found to have a significant effect on UO2 dissolution under the conditions studied, with a significant decrease in UO2 dissolution occurring with increasing F- concentration. [Fe3+] also was found to have a significant effect on UO2 dissolution. The mechanism of UO2 dissolution under different conditions is also discussed.

10:00 Coffee Break

10:30 Paper 4906
CHARACTERISATION AND DISSOLUTION STUDIES ON VARYING FORMS OF BRANNERITE
F.A. Charalambous, R. Ram, J. Tardio and S.K. Bhargava
Advanced Materials and Industrial Chemistry group,
School of Applied Sciences, RMIT University, Australia

Brannerite is commonly referred to as refractory uranium mineral as it is usually highly resistant to acid leaching. There is however widely varying literature data on brannerite leaching, with some studies reporting that brannerite leaching can be achieved under relatively mild conditions. The differences observed for brannerite leaching are most likely due to the high degree of variation in the composition and structure observed in natural brannerites. These aspects of brannerite chemistry however are not very well understood due to a lack of fundamental research. The aims of this study were to investigate and develop methods for synthesising brannerites of varying composition and to investigate the effects of composition on brannerite leaching in acidic conditions.

11:00 Paper 4841
THE DETERMINATION OF SELENIUM AND MOLYBDENUM DISTRIBUTION IN URANIUM ORE AND MILL SOLIDS
G. Heinrich1, K. Kyser2, D. Chipley2 and E. Lam1
1Innovation & Technology Development – Research Centre, Cameco Corporation
2Department of Geological Sciences and Geological Engineering, Queen’s University

The distributions of molybdenum and selenium in solid compounds in uranium ores and mill streams were studied. The methodology consisted of LA-ICP-MS analysis of mineral grains and of physical sample separation and subsequent characterization of the mineral concentrates by chemical analyses and X ray diffractometry followed by correlation of the assay data. Results of the study indicated that selenium and molybdenum in the ore samples were not only present in sulphides, but to an even greater extent in phyllosilicates and uraninite, whereas in mill solids, they were absent in gypsum and likely adsorbed on iron hydroxides.

11:30 Paper 4800
BIOMINERAL PROCESSING OF HIGH APATITE CONTAINING LOW GRADE INDIAN URANIUM ORE
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1MEF Division, National Metallurgical Laboratory (CSIR), India
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Microbial species isolated from source mine water, primarily an enriched culture of Acidithiobacillus ferrooxidans was employed for bio-leaching of uranium from a low-grade apatite rich uranium ore of Narwapahar Mines, India while varying pH, pulp density (PD), particle size, etc. The ore (0.047% U3O8), though of Singhbhum area (richest deposit of uranium ores in India), due to presence of some refractory minerals and high apatite (5%) causes a maximum 78% recovery through conventional processing. Bioleaching experiments were carried out by varying pH at 35°C using 20%(w/v) PD and ≤76 µm size particles resulting in 83.5% and 78% uranium bio-recovery at 1.7 and 2.0 pH in 40 days as against maximum recovery of 46% and 41% metal in control experiments respectively. Finer size (<45 µm) ore fractions exhibited higher uranium dissolution (96%) in 40 days at 10% (w/v) pulp density (PD), 1.7 pH and 35°C. On increasing the pulp density from 10% to 20% under the same conditions, the bio-recovery of uranium fell down from 96% to 82%. The higher uranium dissolution during bioleaching at 1.7 pH with the fine size particles (<45 µm) can be correlated with increase in redox potential from 598 mV to 708 mV and the corresponding variation of Fe(III) ion concentration in 40 days.
Joachimsthal in Saxony was an important silver mining district since the Middle Ages when around the 1770s production started to decrease and the mining town was about to become a ghost town. It was at that time that Martin Heinrich Klaproth (1743-1817) a pharmacist in Berlin who later became a professor of chemistry at the Royal Mining Academy, discovered that the black mineral in the ore can be used to give glass a brilliant yellow color with green fluorescence when added to the molten batch. He was also convinced that this mineral must have contained a new metal. This discovery coincided with the discovery in 1781 of a new planet in the solar system by his compatriot William Herschel who had immigrated to England in 1757 and called the planet Uranus. Hence Klaproth named the new metal “uranium” to honor his compatriot. In 1789 he was able to isolate a black heavy solid from the ore which he thought to be the new metal. Since that time uranium started to play a dominant role in the history of civilization that will be told briefly.

The IAEA’s programmes encompass all aspects of the uranium production cycle, (UPC). The IAEA collaborates with member states to organize training activities, workshops and technical meetings that promote good practices in UPC. The present paper presents an international, interactive and web based initiative, UPNET, Uranium Production Network for Education and Training. Ramp-up of uranium production to 2030 will see new mines starting with lower grade resources after 25 years of UPC stagnation. Many emerging operations are based in countries with limited skills and experience. Constraints with people who can teach, train and consult are expected. Good practices in UPC by qualified personnel can help develop economically viable operations and avoid environmental legacies which have characterized many uranium mining projects in earlier times. Creation of an international network for training and education in UPC would be a substantial step forward in resolving the rising demand for skilled personnel. Developing contacts with potential participants and contributors has begun. A meeting of specialists is planned to promote a vision, framework and structure of the network; meanwhile development of the systems at IAEA that will carry the network has begun and these will be configured to suit UPNET as well as other networks that serve topics across IAEA’s Nuclear Fuel Cycle program.

Uranium production is cyclic and for most of the past 25 years it has been at a low point. The price increase that began in 2003 has steadied now after reaching record values in 2007; but exploration is now surging ahead – in 2009 we saw at least three new mines commence production. But the personnel to support all these activities, both operators and regulators, are a dwindling and ageing group with few replacements available and few young people entering the industry over the past 25 years. The skills shortages we are experiencing cover a wide variety of disciplines. How is the global uranium industry going to cope with the staff needs for the expansion that is happening? Both operators and regulators face a crisis. This paper examines the current situation and discusses options for the future.
extraction. Research students are also provided with extensive training on how to conduct research safely using radioactive materials. The research programs are undertaken in RMIT’s new EPA approved, low level radiation laboratory which has been dedicated to research projects on uranium processing. An extended overview of both of these new programs will be presented. This program is unique in Australia and is designed to address the issue of skill shortage in the ever growing Uranium industry world wide. International collaborators in this program will be most welcomed.

16:30 Paper 4750
CANADA’S MMP (MAINTENANCE MANAGEMENT PROFESSIONAL) EDUCATION AND CERTIFICATION PROGRAM
Norman Clegg¹ and Vince Rae²
¹Plant Engineering & Maintenance Association of Canada (PEMAC), Canada
²Fuel Services Division, Cameco, Canada

PEMAC (Plant Engineering and Maintenance Association of Canada) is a national not for profit association providing global leadership, education and certification in world class maintenance, reliability and physical asset management practices. This presentation will introduce the MMP (Maintenance Management Professional) education and certification program and its 8 Modules. You will see the learning elements and learning outcomes of each of the 8 Modules which are delivered through selected colleges, institutes and universities across Canada using in-class, on-site and live, on-line formats in both official languages.

17:00 Paper 4752
THE IAEA ACTIVITIES SUPPORTING IMPLEMENTATION OF BEST PRACTICE IN URANIUM PRODUCTION CYCLE
J. Slezak
International Atomic Energy Agency, Austria

Since the International Atomic Energy Agency’s foundation in 1957, the Agency has had an increasing interest in uranium production cycle (UPC) developments. Recent activities cover tasks on uranium geology & deposits, exploration, mining & processing including environmental issues. The two projects titles are (1) Updating uranium resources, supply and demand and nuclear fuel cycle databases and (2) Supporting good practices in the UPC in particular for new countries. Based on the recent experience, one of the new activities is focused at human resources development to improve application of best practice called Uranium Production Cycle Network (UPCNet).
14:00 Paper 5893 Keynote Speech
URANIUM INDUSTRY OF INDIA: A PERSPECTIVE
R. Gupta
Uranium Corporation of India Ltd., India

This paper presents a brief outline of the uranium industry in India. In particular, the mining, ore processing and tailings management technologies used in operations of the Uranium Corporation of India Ltd. (UCIL) are described. Challenges to meet the increasing demand of uranium and to expand the nuclear energy sector are outlined. Future prospects, including indigenous efforts and overseas opportunities, are explored.

14:30 Paper 4756
URANIUM MINING IN THE CZECH REPUBLIC
B. Michálek¹, O. Babka² and A. Grmela², ³
¹DIAKO, state enterprise, Division GEAM, Czech Republic
²VŠB-Technical University of Ostrava, Czech Republic
³ATH- University of Bielsko-Biała, Poland

Until the mid-nineties of the last century, uranium mining belonged to important industries in the Czech Republic and, the Czech Republic occupied a leading position in the world in the production of uranium concentrate. A considerable phasing out of this industry in the first half of the nineties in the last century led to the closure of almost all underground uranium mines; at present they are decommissioned and flooded. Mining operations are performed in only one underground mine in the deposit of Rožná with the expected cessation of mining by the year 2015. The present-day home production of uranium meets only 45% of the demand of the Czech nuclear power industry and is secured from three sources, namely from the production of the deposit of Rožná, from the treatment of mine waters flowing from closed underground uranium mines and from the remediation of the rock environment of the deposit of Stráž. With the proven reserves of more than 100,000 t of natural uranium not mined at present, the Czech Republic still represents a potentially significant uranium producer.

15:00 Paper 4893
INNOVATIVE USE OF A MIST ELIMINATOR IN MINE VENTILATION
K. Boyko¹ and T. Smith²
¹Nordmin Engineering Ltd., Canada
²Cameco Corporation, Canada

The McArthur River Operation recently installed an upcast mine ventilation system to increase its total mine ventilation capacity. During commissioning, the amount of water discharged by the new system exceeded that which is normally observed in similar installations. Operation of the system was suspended, and a study was conducted to determine to most effective technology to significantly reduce or remove this water from the saturated air stream. A chevron-type mist eliminator was designed and installed to strip the water from the air, such that the condensate could be appropriately managed in the mine effluent treatment system.

15:30 Coffee Break

16:00 Paper 4894
UNDERGROUND MINING OF THE LOWER 163 ZONE THROUGH GROUNDWATER DRAINAGE AT THE EAGLE POINT MINE
D. M. Robson¹, R. Bashir ², ³, J. Thomson³, S. Klemmer³, A. Rigden¹
¹Rabbit Lake Operation, Cameco Corporation, Canada
²Golder Associates Ltd., Canada
³Dept. of Civil and Geological Engineering, University of Saskatchewan, Canada

The Eagle Point Mine is part of the Cameco Rabbit Lake Operation. The mine produces uranium ore using the long-hole, vertical and horizontal retreat mining method. The majority of the mine workings are under Wollaston Lake and cementitious grouting is used as one of the water control measures. Historical groundwater table in the mining area was close to ground surface. The Lower 163 Zone encompasses an estimated 4.2 million pounds U₃O₈ geological resource that was not considered feasible to mine due to the expected groundwater flows in the area. Cross-hole testing was conducted to better understand the groundwater flow through various geologic units. A local depressurization test was conducted to assess the potential for lowering the water table. Following testing an active depressurization was conducted to lower the groundwater table below the planned mining areas. This resulted in safe and drier mining conditions and allowed for the successful extraction of the ore body.
Many methods of geohazard risk management have been developed for various applications, including for mining industries and protection of highway infrastructure. The most common instrumentation used for management of geohazards is vibrating wire piezometers, slope inclinometer casings, strain gauges, and weather stations (a partial list). Monitoring requirements for instrumentation typically depends on the potential risk of a monitoring site. Alternatives for monitoring vary from occasional manual monitoring to sensors connected with near real-time monitoring capability and alarms that automatically distribute notifications to defined individuals. This paper describes a few common geohazard risk management methods used in the mining industry, the monitoring options that are available, and some considerations when developing monitoring plans.
The PAREX code has been developed since the 1990s by CEA and AREVA to describe the PUREX process implemented in the French fuel reprocessing plants. It enables the calculation, either in steady or transitory states, of the behaviour of the different elements of interest at each process step. The highly customized structure of the software allowed the implementation of various phenomenological models describing solvent extraction systems dedicated to uranium purification from crude ore to spent fuel. After qualification of the implemented models, the code was used to perform the design of flowsheets, for safety demonstration analysis or for operational assistance.

ON STREAM ANALYZER, ONE MORE TOOL IN OUR TOOL BOX
B.A. Just and M.J. Galbraith
AREVA Resources Canada Inc. Canada

The AREVA Resources Canada Inc. McClean Lake uranium processing facility experienced serious operational challenges in handling crud formation. In order to assist in troubleshooting the performance of the Solvent Extraction circuit, the company purchased and installed an On Stream Analyzer (OSA). This presentation will share the benefits and challenges encountered with the commissioning of the OSA. It will also elaborate on unexpected benefits beyond solvent extraction.

THE SIMPLE SOLUTIONS CONCEPT: A USEFUL APPROACH TO ESTIMATE DEVIATION FROM IDEALITY IN SOLVENT EXTRACTION
C. Sorel and V. Pacary
CEA, Nuclear Energy Division, Radiochemistry & Processes Department, Chemistry of Separation Processes Service, France

The solvent extraction systems devoted to uranium purification from crude ore to spent fuel involve concentrated solutions in which deviation from ideality can not be neglected. The Simple Solution Concept based on the behaviour of isopiestic solutions has been applied to quantify the activity coefficients of metals and acids in the aqueous phase in equilibrium with the organic phase. This approach has been validated on various solvent extraction systems such as trialkylphosphates, malonamides or acidic extracting agents both on batch experiments and counter-current tests. Moreover, this concept has been successfully used to estimate the aqueous density which is useful to quantify the variation of volume and to assess critical parameters such as the number density of nuclides.

URANIUM SOLVENT EXTRACTION CIRCUITS: OPERATIONAL CHALLENGES AND ADJUSTING TO UNIQUE PROCESS CONDITIONS
J. Bender1, M. Virnig1, A. Nisbett1, P. Crane2, M. Mackenzie3 and K. Dudley4
1Cognis Corporation, Mining Chemicals Technology, USA
2Cognis Australia Ltd., Mining Chemicals Technology, Australia
3Consultant, Murdoch Mackenzie, Australia
4Consultant, KDHC Pty Ltd, South Australia

Uranium solvent extraction (USX) is a mature technology that was first successfully employed in the 1950s. It involves the use of a tertiary amine in a diluent to extract uranyl sulfate anions. USX processing and the quality of the product can be affected by impurities in the leach liquor. These impurities can also interfere with the chemical or physical aspects of the SX process. Ore mineralogy will dictate the quantity and type of impurities that will be present in the resulting leach liquor. While the transfer of the majority of impurities into the final product is undesirable, an additional concern is that they can negatively affect routine plant operations. Because the extraction mechanism is a simple ion-pairing, there is a competition between any anions for protonated amine. The relative selectivity of an anion and its concentration in the pregnant leach solution (PLS) dictate the degree of extraction. For a plant to run optimally, it is essential that the composition of the incoming feed is determined. It is important to acknowledge that each operation is somewhat unique, and that the pregnant leach solution generated from leaching will be influenced by the ore and gangue mineralogy, site water quality, and water balance issues specific to that site. Therefore, the information and philosophy outlined in this article serve to provide a generic approach that can be potentially applied and adapted to any site or project.
Mined uranium (U) ore often contains relatively high concentrations of elements (other than uranium) that may be deleterious to the environment. These include molybdenum (Mo) and selenium (Se), which are liberated from uranium oxides and associated sulphide minerals during milling processing. A critical environmental concern in the U mining industry is the possibility of long-term mobilization of elements such as Mo and Se from tailings deposited in in-pit tailings facilities to regional groundwater systems. In this study, x-ray absorption spectroscopy (XAS) was used to study the molecular speciation of these elements of concern (EOC) in samples from the Deilmann Tailings Management Facility (DTMF) at Key Lake in northern Saskatchewan, Canada. An understanding of Mo and Se speciation will help to characterize their long-term stability and evolution in the mine tailings. Results indicate Mo exists mainly as molybdate (+6 oxidation state) and Se exists mainly as selenite (+4 oxidation state). Linear combination fitting (LCF) analysis of the Mo K-edge XANES spectra on tailings samples using standard reference compounds suggests various proportions of NiMoO₄ and CaMoO₄ complexes as well as molybdate adsorbed onto ferrihydrite.

The Deilmann Tailings Management Facility (DTMF), located in Key Lake, Saskatchewan, has been in operation since 1996. Geochemical analyses of porewaters collected between 2004 and 2009 from three corehole locations indicate the DTMF is characterized by two geochemically distinct tailings from processing of uranium ores from either Key Lake (Deilmann ore) or the McArthur River uranium deposit. The Deilmann porewaters have significantly higher As, Mo, Se, and SO₄ concentrations compared to the McArthur porewaters. Geochemical modeling indicates that ferrihydrite, gypsum, and Ca-arsenate minerals are the predominant phases controlling porewater concentrations of these elements. The long-term stability of these phases and their potential effect on the surrounding environment are discussed.
Tuesday, August 17, 2010 PM
Room: Kelsey

14:00  Paper 5368
**LICENSING APPROACH FOR LOW ENRICHED URANIUM**
P. Desiri
*GE Hitachi Nuclear Energy Canada Inc., Canada*

The newly designed Advanced CANDU® Reactor technology utilizes enriched uranium as the fuel source. GE Hitachi Nuclear Energy Canada Inc (GEH-C) has partnered with AECL to develop and manufacture this enriched fuel. As part of this program, GEH-C required a licence to manufacture low enriched uranium fuel. A project description for the manufacture of low enriched uranium fuel bundles was first submitted to the CNSC in May of 2007. The hearing for both the licence amendment and environmental assessment was held January 13, 2010 and an amended licence was granted Feb 15, 2010. Several challenges were encountered during the licensing process, particularly in regards to the public consultation aspects of the project. This paper will summarize the approach taken to obtain a licence to produce low enriched uranium fuel at enrichments up to 5%. It will include the technical requirements, as well strategies to overcome various licensing challenges.

14:30  Paper 5403
**TRANSITIONING TO LARGE VOLUME ENRICHED FUEL MANUFACTURE**
A. Pant¹, M. Longinov² and W. Newmeyer²
¹Cameco Fuel Manufacturing, Canada
²Nuclear Safety Associates, Canada

Cameco Fuel Manufacturing (CFM) has a long history of low enriched uranium (LEU) fuel manufacture for development and specialty applications. The recent LVRF initiative necessitated extending the protocols used for small scale manufacture so that large volume production of the ~ 1% enriched material could be safely deployed in accordance with regulatory guidelines. This paper will discuss some of the technical and cultural changes that were initiated in order that a successful transition could be effected. In particular, the unique manner in which criticality safety principles were developed and embedded in the mind-set of the personnel as well as the robustness of the engineering design will be discussed.

15:00  Paper 5377
**DESIGN AND DEVELOPMENT OF AN AUTOMATED URANIUM PELLET STACKING SYSTEM**
B.S. Riess and S.B. Nokleby
*University of Ontario Institute of Technology, Canada*

A novel design for an automated uranium pellet stacking system is presented. This system is designed as a drop-in solution to the current production line to enhance the fuel pellet stacking process. The three main goals of this system are to reduce worker exposure to radiation to as low as reasonable achievable (ALARA), improve product quality, and increase productivity. The proposed system will reduce the potential for human error. This single automated system will replace the two existing pellet stacking stations while increasing the total output, eliminating pellet stacking as a bottleneck in the fuel bundle assembly process.

15:30  Coffee Break

16:00  Paper 5378
**AUTOMATED FUEL INSPECTION**
J. Vanderlaan and S.B. Nokleby
*University of Ontario Institute of Technology, Canada*

A proposed method of applying high-speed, non-destructive testing (NDT) technologies to the inspection process of U02 (uranium dioxide) fuel pellets is presented. The scanning process examines each pellet individually for correct surface roughness and any surface imperfection or defects. Three inspection technologies are investigated: laser scanning of surface roughness, 2D laser scanning, and vision systems. The complete circumferential surface inspection of the pellet can be achieved using a combination of these three technologies.

16:30  Paper 5458
**ROLE OF CRYSTAL MISORIENTATION IN THE FROMATION OF THE INTERLINKED HYDRIDE CONFIGURATION IN ZIRCALOY-4**
W. Qin¹, N.A.P. Kiran Kumar² and J.A. Szpunar¹
¹Department of Mechanical Engineering, University of Saskatchewan, Canada
²Department of Metals and Materials Engineering, McGill University, Canada

The formation of δ hydride in Zircaloy-4 has been studied using electron backscatter diffraction. Both intra-granular and inter-granular hydrides were observed. The intra-granular hydrides platelets prefer to interlink each other and form a chain-like configuration. Based on thermodynamic model, the formation mechanisms of the interlinked structure were analyzed. We found that the misorientation of two adjacent grains and the tensile stress near the tips of hydride platelets are the key factors affecting the appearance of the interlinked structure.
Re-orientation of hydrides platelets along the radial direction during reactor operation adversely affect the mechanical properties and may lead to failure of the cladding tube. Until now many factors have been reported as being responsible for the hydride re-orientation along the radial direction. In the present study, texture inhomogeneity along radial direction is investigated and is considered as one of the main factors responsible for hydride reorientation. Texture of the top and bottom layers of Zircaloy-4 and E110 alloy was measured using X-ray diffraction and electron back-scattering diffraction (EBSD) techniques. Texture results obtained by X-ray diffraction technique was used to compare the texture inhomogeneity in Zircaloy-4 and E110 alloy. Kearn’s f parameter was used to calculate differences in thermal expansion coefficients at different thickness layers in both alloys. The stress generated by differences in thermal expansion can contribute to hydride re-orientation and cracking of the fuel cladding. Zircaloy-4 texture is more inhomogeneous than E110 alloy texture.
Strategically located within the Uravan Mineral Belt District of western Colorado, the Piñon Ridge Project is the first new uranium mill being proposed for construction in the United States in over 25 years. In 1992, dramatic changes to the US regulatory environment for uranium ore processing occurred making regulatory compliance an increased challenge for a new facility. Proposed as a uranium and vanadium milling operation with an ultimate capacity of 6.3 million tonnes, the mill will receive ore from a number of mines in the region. The project includes design and licensing of a uranium/vanadium processing facility, tailings cells, evaporation ponds, and ore stockpile pads. The focus of this paper is to provide an overview of the current US regulations, how the regulations have evolved in the recent past, and how these regulations were applied to design of the mill facilities. A status update on the project is also provided, with the mill license application submitted to the Colorado Department of Public Health and Environment (CDPHE) in November 2009.

The Canadian Nuclear Safety Commission (CNSC), under the Nuclear Safety and Control Act (NSCA), regulates all nuclear facilities and nuclear related activities in Canada. The enhanced environmental protection mandate under the NSCA has led to reassessment and subsequent requirements for significant process changes to effluent treatment systems at existing uranium mining and milling operations. Waste rock and tailings from the mining and milling operations must also be carefully managed to minimize potential adverse environmental effects during operations and for the long term. This paper will review the regulatory processes used in Canada for uranium mining and milling operations and the design practices used and specific examples of effluent treatment and tailings and waste-rock management systems in Saskatchewan.
The Saskatchewan Ministry of Environment recognizes uranium mining as an important contributor to Saskatchewan’s economy. The environmental performance of the industry is closely monitored, often with significant process. The Saskatchewan Ministry of Environment has embarked on a visionary restructuring of its regulatory framework from conventional command and control to a result-based regulatory framework. This new regulatory framework will provide for: establishing clear environmental protection and resource management objectives; the streamlining of the environmental acts and regulations; development of an environmental code; reliance on qualified persons; enhanced compliance and enforcement tools; the elimination of many permits; and greater certainty in environmental assessment decisions. Results-based regulation promises to deliver enhanced environmental protection with less process.
LESSONS FROM THE PAST: A LITERATURE REVIEW OF THE RESIN-IN-PULP PROCESS FOR THE URANIUM INDUSTRY

B. McKevitt and D. Dreisinger
University of British Columbia, Department of Materials Engineering, Canada

In the 1950s, the resin-in-pulp (RIP) process was a hot topic for uranium research around the world. Several design methodologies were tested, and a few were implemented on a commercial scale. Many thought that RIP would dominate as the process of choice for uranium recovery; however, in the Western World, other processing routes replaced RIP. Recently, RIP is once again being proposed as a potential processing option for uranium. This paper provides a literature review of the development of the RIP process from the 1950s to today.

THE RECOVERY OF URANIUM FROM ACID LEACHED ORE USING RESIN-IN-PULP TECHNOLOGY

S. Leung¹, L. Heymann¹ and D. King²
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²Aker Solutions Australia Pty Ltd., South Australia

Ion exchange resins have been used extensively in the past to extract uranium from aqueous solutions. This was done by contacting relatively clean solutions with resin beads in a conventional resin column. An expensive liquid-solid separation step ahead of the ion exchange circuit is required to provide the clean solutions. When dealing with uranium ores that are difficult to filter or settle, it has been found that resin-in-pulp (RIP) provides a more economical treatment path. Aker Metals, a division of Aker Solutions Canada Inc. has been involved in the design of two such plants and, in each case, has found RIP to be an acceptable low cost solution to these difficult ores. This paper will compare the Capital and Operating costs of a 3500 tonne per day acid leach uranium plant using the more conventional CCD-SX route with those for a RIP circuit. Treatment options designed to mitigate resin loss by breakage and fouling will be discussed. An overview of current projects using this approach will be given.

RIP STUDIES AT AREVA: R&D AND APPLICATIONS FOR NIGER AND CANADA PROJECTS

Yuanbing Ling¹,², Nicolas Durupt¹ and Nicola Banton²
¹AREVA-SEPA [Service D’études de Procédés et Analyses], France
²AREVA Resources Canada Inc., Canada

Cominak in Niger owns a large stock of high grade fines which cumulated originally from underground mining discharge water. This ore is too fine to be treated with the current process because it readily blocks the cloths of the belt filters. Cominak plans to build a Resin-In-Pulp (RIP) plant. The RIP technology permits to recover U values without filtration. Some bench scale studies (at AREVA-SEPA) and two trial campaigns (on site) had been successfully conducted to implement the RIP process, which further allows, from economic point of view, a positive feasibility evaluation. As part of the Kiggavik Project managed by Areva Resources Canada [ARC], AREVA-SEPA is also being actively involved in developing a practical, cost-effective and environmentally sound process flowsheet. RIP technology has drawn significant attention due to the relatively low water consumption and capital cost. SEPA’s experience with RIP technology together with the newer and better-performance resins makes this technology a viable choice. Three pilot campaigns have been accomplished at SEPA, which is believed to be of great help to reduce technical risk as well as capital risk in the decision making for Kiggavik project.
A significant expansion project is under way at KATCO’s Torkuduk In Situ Recovery (ISR) operation to increase uranium production to about 4000 tU/year. Higher flows and lower uranium concentration are expected in the rich solutions coming from the well fields. Therefore, extra adsorption and elution columns and modified operating conditions are required to deal with the increased demand for uranium transfer from the ISL solutions to the eluate solution, which goes to the uranium precipitation section. Resin adsorption and elution performance have been interpreted and projected by using Mc-Cabe-Thiele equilibrium diagrams. The resin load, the adsorption mass transfer coefficient, the adsorption zone height and the eluate concentration have been estimated for the expected changing operating conditions associated to the future mine plan. This information has allowed to improve the present operation results and to define the main process design criteria for the expansion project.

In-situ leach uranium mines frequently extract other metals of value from the ore body. Some mines in Texas and New Mexico extract substantial quantities of moly and rhenium, while Colorado plateau and Wyoming mines may co-extract vanadium in the leach solutions. In many cases, the recovery of the secondary metal oxoanions could add significantly to the revenue of the mine. The opportunity to add secondary metal values to the top line of operating mines is limited by the availability of effective ion capture resins that will recover molybdenum, rhenium, or vanadium from in-situ leach solutions. Ion exchange columns that are manufactured with interstitial polymer networks (Spiderwebs) suspended between silica particles have enhanced rates of equilibration with solutions flowing through the Spiderweb. When the Spiderweb-like polymer networks are modified with metal-selective chelating agents, highly metal-selective columns are prepared that strongly bind uranium and the secondary metals of interest. We report tests of enhanced uranium and molybdenum extraction from both pregnant and barren ISL solutions. The captured metals can then be separately eluted from the columns with a variety of acidic or basic reagents.
GPS-BASED GAMMA EXPOSURE RATE SITE CHARACTERIZATION: LICENSING AND RADIATION PROTECTION ADVANTAGES
R. Meyer, Tetra Tech Inc. USA

While regulatory licensing guidance for uranium mine licensing has not been updated to specify high-density gamma radiation characterization of a site, such technology is in current use. For example, gamma scan maps are incorporated in recent U.S. in situ recovery license applications. In the long run, a site with thorough pre-operational gamma mapping will encounter a smoother license termination process. An understanding of exposure rates can also inform radiation protection planning. We present pre-licensing and remedial action examples from a number of our projects worldwide. Our purpose is to encourage uniform and updated site characterization procedures.

CLIMATE CLASSIFICATION AND QUANTIFICATION FOR COVER DESIGN IN COLD ENVIRONMENTS
J. Stianson, D.G. Fredlund and T. McArthur
Golder Associates Ltd., Saskatoon, Canada

The decommissioning of uranium tailings facilities often requires the design of a suitable cover system. In cold climatic environments there is a portion each year that can be considered to be “inactive” while the remainder of the year can be considered to be “active”. There are numerous engineering design assumptions required when analyzing both the “active” and the “inactive” portions of the year. Cover systems are subjected to complex boundary conditions and are comprised of materials with highly nonlinear soil properties. This paper describes the challenges associated with the preparation and the analysis of a multi-year climatic database for the design of a cover system in cold environments. The paper also explains how climate can be classified and how observed variations from one year to the next can be taken into consideration in cover design. The results of climatic records at mine sites are used to illustrate conditions that need to be taken into consideration when designing soil cover systems.
Some of the past uranium production operations have caused extensive environmental problems. The lack of appropriate regulatory framework in addition to the fact that environmental issues were not conveniently addressed in the operations contributed to this situation. Nowadays, this situation has changed dramatically and lessons learned from the past have led to the implementation of responsible operations from both environmental and social perspectives. Involvement of different stakeholders in the decision making process turned out to be a mandatory issue in many countries. With the so called “Renascence of Nuclear Power” new production sites will come into play. The sustainability of the uranium industry will depend on the adoption of good practices in these operations under a life-cycle perspective. The recently launched IAEA initiative – the ENVIRONET is aimed at contributing to expedite the transfer of experience amongst its members. It brings together private and state-owned companies, research institutes, and governmental organizations providing a forum for information and experience exchange. Sharing of practical experience is to be addressed by means of training courses and workshops. In addition to this long distance training and educational material will be made available. This paper will present the ENVIRONET and describe how networking can contribute to the implementation of sustainable and responsible uranium production operations worldwide.
THE FATE OF ENTRAINED HYDROCARBON MATERIALS IN THE MCCLEAN LAKE OPERATION MILL TAILINGS

K.A. Hughes, C. Rinas, R. Frey and J. Rowson
AREVA Resources Canada Inc., Canada

Under the oxidizing conditions of the McClean Lake Tailings Management Facility (TMF) hydrocarbons entrained on the surface of tailings material from mill processes are gradually converted to soluble bicarbonate ion. This has been observed to be a process occurring over approximately three years likely encouraged by the presence of a microbiological community within the tailings mass and in the water column. A recent tailings sampling campaign has provided evidence that bicarbonate ion is participating in the conversion of gypsum to calcite. In older tailings, equilibrium with calcite appears to be controlling the terminal bicarbonate ion concentration.

THE POTENTIAL ARSENIC RETENTION ROLE OF Ca-Fe(III)-AsO4 COMPOUNDS IN LIME NEUTRALIZED CO-PRECIPITATION TAILINGS

L. Becze1, M.A. Gomez1, V. Petkov2, J.N. Cutler3 and G.P. Demopoulos1
1McGill University, Department of Mining and Materials Engineering, Canada
2Central Michigan University, Department of Physics, USA
3University of Saskatchewan, Canadian Light Source Inc., Canada

Arsenic is a major contaminant in a number of high grade uranium ores mined in Northern Saskatchewan. Upon processing of these ores by hydrometallurgical processes, arsenic reports to aqueous waste solutions from which arsenic(V) is removed by co-precipitation with iron(III). This process results in the generation of a mixture of poorly crystalline arsenate-bearing phases and gypsum. Based on laboratory investigations there exists the potential upon reaction of the disposed iron(III)-arsenate phases and gypsum to lead to Ca-Fe(III)-AsO4 association resembling the mineral yukonite. In this paper the laboratory synthesis, characterization and solubility investigation of yukonite is reviewed and the implications of its formation in U-mill tailings as an arsenic control phase are discussed.

THE TRANSFORMATION OF FERRIHYDRITE UNDER A RANGE IN pH (2-10) AND TEMPERATURE (25-100°C)

S. Das, M.J. Hendry and J. Essilfie-Dughan
University of Saskatchewan, Canada

Ferrihydrite, a form of iron in mill tailings, is a dominant sorption complex for elements of concern (EOC) such as arsenic (via adsorption or co-precipitation) within uranium mine tailings at the Key Lake Operation. As ferrihydrite is unstable under oxic conditions, and can undergo dissolution and subsequent crystallization to hematite and goethite over time, the impact of crystallization on the long-term stability of EOC within tailings needs to be investigated. Here, studies were undertaken to assess rates of pure ferrihydrite recrystallization in relatively dilute aqueous solutions which serve as baseline for upcoming studies that more closely simulate uranium mine tailings solutions. The results are also used to assess the impacts of recrystallization on porewater concentrations of sorbed sulfate and arsenate. At present, these preliminary results indicate the rate of crystallization is controlled by solution pH, temperature, and reaction time.

MINERALOGICAL CHARACTERIZATION OF ARSENIC, IRON, AND NICKEL IN URANIUM MINE TAILINGS USING XAS AND EMPA

Joseph Essilfie-Dughan1, M. Jim Hendry1, Jeff Warner2 & Tom Kotzer1,3
1Department of Geological Sciences, University of Saskatchewan, Canada
2Canadian Light Source Inc. University of Saskatchewan, Canada
3 Cameco Corporation, Canada

In northern Saskatchewan, Canada, high-grade uranium ores and the resulting tailings can contain high levels of arsenic (As), iron (Fe), and nickel (Ni). An environmental concern in the uranium mining industry is the long-term stabilization of these elements of concern (EOCs) within tailings management facilities thereby mitigating their transfer to the surrounding groundwater. Characterization of these As-, Fe- and Ni-bearing minerals and complexes must be carried out to evaluate their solubility and long-term stability within the tailings mass. Synchrotron-based bulk x-ray absorption spectroscopy (XAS) has been used to study the speciation of these EOCs in mine tailing samples obtained from the Deilmann Tailings Management Facility (DTMF) at Key Lake, Saskatchewan. Electron microprobe analysis (EMPA) and synchrotron-based micro-focussing x-ray fluorescence mapping and absorption spectroscopy (µXRF; µXAS) have also been employed to study spatial distribution and speciation at the micron scale. Comparisons of K-edge absorption spectra of tailings...
samples and reference compounds indicate the dominant oxidation states of As, Fe, and Ni in the mine tailings samples are +5, +3, and +2, respectively, largely reflecting their deposition in an oxidized environment and complexation within stable oxic phases. Backscattered electron (BSE) images of the tailings from the electron microprobe indicate the presence of gypsum/lime nodules surrounded by metallic rims mainly consisting of As, Fe, and Ni. µXRF elemental mapping confirms these EPMA results. µXAS collected within the metal-bearing rims indicates As and Fe is present mainly in the +5 and +3 oxidation state, respectively.

10:00 Coffee Break

10:30 Paper 4907
ARSENIC CONTROL IN PROCESS TAILINGS: CONTINUOUS CO-PRECIPITATION OF AS(V) WITH IRON SULPHATE MEDIA
R. Daenzer, R.J. De Klerk and G.P. Demopoulos
McGill University, Department of Mining and Materials Engineering, Canada

Arsenic constitutes a serious environmental problem for the mineral processing industries. The removal of high concentrations of arsenic in the case of uranium milling process effluents is done by adjusting the iron to arsenic molar ratio to four (MFetot/MAss=4) and subsequently neutralizing with slaked lime in a continuous coprecipitation (CCPTN) circuit. This paper investigates the production of arsenic-bearing phases through CCPTN from simulated waste process effluents and their long term stability at accelerated conditions. In particular, special attention is given to a two stage continuous reactor set-up. Moreover, the effect of a fraction of total iron as ferrous iron and the presence of co-ions such as nickel and aluminum on the stability of the products was investigated.

11:00 Paper 5502
AGING OF REDUCED ARSENIC MINERALS IN URANIUM MILL TAILINGS AT THE McCLEAN LAKE OPERATION
C. Rinas, J. Rowson, R. Frey and K. Hughes
AREVA Resources Canada Inc., Canada

The primary arsenic minerals in the uranium ore processed at the McClean Lake Operation are rammelsbergite, niccolite and gersdorffite. During processing, a large fraction, typically (80 - 95%), of these reduced minerals is oxidized and dissolves primarily as As5+ in the leachate solution. In the tailings preparation circuit the dissolved As5+ is precipitated as a poorly crystalline form of the mineral scorodite. Following subaqueous deposition in the tailings management facility, a temporal rise and fall in arsenic pore water concentrations has been observed. This is due to the oxidation of the residual quantities of reduced arsenic minerals initially present in the tailings sediment. The XANES (x-ray absorption near edge spectrometry) technique has shown that As1- is gradually oxidized to As3+ and then finally to As5+ in the tailings sediment. This oxidation process results in a temporary accumulation of As3+ in solution and is the source of the rise and fall in arsenic concentration observed.

11:30 Paper 5522
IDENTIFICATION OF POORLY CRYSTALLINE SCORODITE IN URANIUM MILL TAILINGS
R. Frey1, J. Rowson1, K. Hughes1, C. Rinas1 and J. Warner2
1AREVA Resources Canada Inc., Canada
2Canadian Light Source Inc., University of Saskatchewan, Canada

The McClean Lake mill, located in northern Saskatchewan, processes a variety of uranium ore bodies to produce yellowcake. A by-product of this process is an acidic waste solution enriched in arsenic, referred to as raffinate. The raffinate waste stream is treated in the tailings preparation circuit, where arsenic is precipitated as a poorly crystalline scorodite phase. Raffinate neutralization studies have successfully identified poorly crystalline scorodite using XRD, SEM, EM, XANES and EXAFS methods, but to date, scorodite has not been successfully identified within the whole tailing solids. During the summer of 2008, a drilling program sampled the in situ tailings within the McClean Lake tailings management facility. Samples from this drilling campaign were sent to the Canadian Light Source Inc. for EXAFS analysis. The sample spectra positively identify a poorly crystalline scorodite phase within the McClean tailings management facility.
Wednesday, August 18, 2010 AM
Room: Battleford

8:00 Paper 5119
INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION: RECOMMENDATIONS RELEVANT TO THE URANIUM INDUSTRY
C.H. Clement
International Commission on Radiological Protection, Canada

The International Commission on Radiological Protection (ICRP) is an independent, international organization that advances for the public benefit the science of radiological protection, in particular by providing recommendations and guidance on all aspects of protection against ionizing radiation. This presentation touches on aspects of The 2007 Recommendations of the ICRP, a fundamental document that lays out the system of radiological protection for all exposure situations and types, and focuses on other recent publications relevant to the uranium industry. Of particular relevance are the 2009 ICRP Statement on Radon and the accompanying report on lung cancer risk from radon.

8:30 Paper 5158
UNIQUE RADIATION PROTECTION DESIGN FOR PROCESSING HIGH GRADE URANIUM ORES AT THE MCCLEAN LAKE MILL
K. Stewart
AREVA Resources Canada Inc., Canada

Rich uranium deposits in northern Saskatchewan are coming into production and will last for the next few decades. The combination of high ore grades and increasingly stringent radiation protection regulations require complex mill design features far different from those for conventional uranium mills. The McLean Lake mill, which has operated since June 1999 with production rates averaging 4 million lbs of U3O8 annually, has been expanded to receive uranium ore slurry with nominal feed grades up to about 20% U3O8 and production rate of up to 24 million lbs annually. The mill design ensures that workers are separated from radioactive ore being processed through the use of slurry handling and processing systems that are enclosed and has several state-of-the-art shielding and ventilation features that protect workers against external gamma radiation and airborne radioactive materials (radon progeny and radioactive dusts). This paper discusses the unique design of the AREVA’s McClean Lake mill.

9:00 Paper 5176
RISKS FROM EXPOSURE TO RADON AT HOME OR AT WORK
Douglas B. Chambers and Ronald H. Stager
SENES Consultants Limited, Canada

This paper examines the risks associated with exposure to radon decay products through estimation of lifetime excess absolute risks (LEAR) per WLM for selected epidemiological risk projection models from miner studies and pooled residential radon studies applied to the ICRP 103 reference populations. The mSv per WLM was calculated using the total detriment per Sv factor. The effect of smoking was considered based on application to Canadian mortality data by smoking status. There was a large variation in the risk per WLM and dose conversion factor depending on the smoking histories which vary substantially between individuals and over time.

9:30 Paper 5501
EPIDEMIOLOGICAL EVIDENCE AND RADIATION PROTECTION
R. Lane and P. Thompson
Canadian Nuclear Safety Commission, Canada

Objective scientific information should be the basis for understanding the health effects of uranium on workers and members of the public so stakeholders can make informed decisions about radiation protection. The Canadian Nuclear Safety Commission has participated in several recent epidemiological studies of the health effects of uranium workers and people living near uranium processing facilities. This presentation will discuss the findings, studies conducted elsewhere, international scientific consensus, gaps in knowledge, and plans for international collaborative studies. Finally, it will discuss the importance of epidemiological evidence for radiation protection and provide examples of how information has been communicated to stakeholders for evidenced-based decision making.

10:00 Coffee Break
10:30  Paper 4918  
SOLUBILITY OF RADIONUCLIDES IN SIMULATED LUNG FLUID  
G. Tairova¹, M. Boucher¹, K. Toews², M. Ioffe¹, J. Takala², M. Murchie¹, Engin Ozberk²  
¹Innovation and Technology Development, Cameco Corporation, Canada  
²SHEQ System, Cameco Corporation, Canada  
The objective of this work was to assign FMS (fast, moderate and slow) absorption types to site-specific radionuclides found at various Cameco facilities. Kinetics studies of dissolution of various uranium-bearing samples in simulated lung fluid were carried out. Dissolution parameters were determined and the samples were assigned to the FMS absorption types. A software program was developed for the determination of dissolution parameters. The assignments were based on criteria established in the International Commission on Radiological Protection (ICRP) Publication 71. The assignments were used to determine the internal radiation dose for workers.

11:00  Paper 5344  
EVALUATION OF CONTENTS OF THE URANIUM SERIES RADIONUCLIDES IN THE ENVIRONMENTAL MEDIA AND LOCAL FOODS AT THE RESIDENTIAL AREA CLOSE TO THE RUSSIAN URANIUM MINE FACILITY  
N.K. Shandala¹, S.M. Kiselev¹, S.V. Akhromelev¹*, E.A. Khohlova², E.G. Metlyaev¹ and A.A. Filonova¹  
¹Federal Medical Biophysical Centre, Russia  
²Regional Management 107, FMBA of Russia, Russia  
The goal of this study is to carry out comprehensive environmental and hygienic examination of the Health Protection Zone and the location area of the Priargunskiy production mining and chemical association and to assess health conditions of miners. The media under examination were: common air, soil, vegetation, and water. Contents of natural radionuclides - 238U, 232Th, 226Ra, 210Po, and 210Pb have been determined. Concentrations of other chemicals have also been determined in common air. Radionuclide migration levels and accumulation coefficients of uranium series have been determined. Medical and dose information has been collected and verified to evaluate health conditions of miners.
Wednesday, August 18, 2010 AM
Room: Kelsey

8:00 Paper 4764
RECENT TRENDS IN SELENIUM REGULATION AND MANAGEMENT
A. Sobolewski
AMEC, Vancouver, Canada

Selenium is a contaminant encountered at uranium mines. When discharged into water, it can build up in the food chain and become toxic to egg-laying fish and shorebirds. This presentation reviews recent developments in its regulation, management and treatment. Selenium will soon be regulated on the basis of its concentration in fish or bird eggs, not its dissolved concentrations, which challenges managers trying to establish acceptable discharge limits. Information supporting this change will be discussed. Recent developments to manage and treat selenium will also be reviewed, emphasizing new chemical and biological treatment processes applicable at uranium mines and mill sites.

8:30 Paper 5116
SELENIUM AND MOLYBDENUM REMOVAL FROM CONTAMINATED MILL PROCESS EFFLUENT: CAMECO KEY LAKE OPERATION
Key Lake Operation, Cameco Corporation, Canada

The mill effluent treatment, Bulk Neutralization circuit in the Cameco Key Lake Operation was modified in 2008 to enhance the removal efficiency of selenium (Se) and molybdenum (Mo) from the mill process water. This modification was completed in part due to increased knowledge of the effects these elements have on biota. In addition, legacy effects from the historical operation of the Key Lake mill in regards to Se and Mo were shown to have an effect on the regional biota in the downstream receptors. This was a challenging initiative as there was no off the shelf technology available and the removal process had to be incorporated into an existing (brownfield) process. These modifications have resulted in significant reduction in the concentration of these elements in the mill effluent. The removal efficiency for Se and Mo has increased to 85% and 96%, respectively. As a result, concentrations of Se and Mo are now consistently less than 0.02 mg/L and 0.6 mg/l. This paper will provide detail on the hydrometallurgical removal mechanisms and process modifications required in the Key Lake effluent treatment circuit to remove these elements to trace levels.

9:00 Paper 4919
REMOVAL OF SELENIUM FROM SMITH RANCH-HIGHLAND EFFLUENT
G. Tairova1, E. Lam1, L. Reimann2, J. Clay3, A. Rose3, R. Hembree3 Mike Murchie1
1Innovation and Technology Development, Cameco Corporation
2Cameco Resources Inc., USA
3Cameco Resources Smith Ranch-Highland Operation, USA

Bench-scale experiments were carried out to investigate a number of potential methods of selenium removal from purge water obtained from Cameco Resources Smith Ranch-Highland (SRH) operation. Test results indicated that the concentration of selenium in the effluent was consistently reduced to below the 0.1 mg/L target using a down flow column with fixed-bed active media. Based on the results of the bench-scale experiments, pilot studies were successfully carried out on site. A commercial-scale plant was built and commissioned in September 2009. To date, more than 75,000 m3 of water have been successfully treated.

9:30 Paper 4874
URANIUM DEVELOPMENTS – AQUATIC RISK ASSESSMENT AND MANAGEMENT
P.M. Chapman
Golder Associates Ltd, Burnaby, Canada

Risks to aquatic receiving environments from uranium developments fall into three categories: physical (habitat change); chemical (e.g., uranium, selenium, total dissolved solids, metals including vanadium and magnesium); and radiological. Although all categories of risk need to be managed, chemical risks are the most significant and are typically chronic rather than acute. For instance, selenium toxicity is primarily manifested as reproductive impairment due to maternal transfer, resulting in embryotoxicity and teratogenicity in egg-laying vertebrates. Risk is best assessed using a site-specific weight of evidence approach focused on ecosystem services. Risk management should be based on both risk assessment and adaptive monitoring.

10:00 Coffee Break
Ranger Uranium Mine is undergoing an environmental impact statement assessment process to develop a Heap Leach facility to treat low grade ore on site. The facility is proposed to be located in the relatively unimpacted Gulungul catchment within the Ranger Project Area which itself is surrounded by, but excluded from, the World Heritage listed Kakadu National Park. The Supervising Scientist Division (SSD) acts to ensure the downstream environment is protected from mine-related impacts. To achieve this SSD will develop a leading practice monitoring program for Gulungul Creek to monitor potential impacts to this catchment from the Heap Leach facility.

This study was carried out with the objective of understanding the spatial and temporal variation in groundwater level and uranium concentration in Peddagattu and Seripalli areas of Nalgonda district, Andhra Pradesh, India where uraninite deposit occur. Mining of uraninite from this deposit is proposed to commence in near future. From March 2008 to November 2009 groundwater samples were collected from forty five wells. Groundwater level in wells was recorded during sampling. The samples were analyzed for the uranium concentration using laser fluorimeter. The uranium concentration in the groundwater of this region ranges from 0.2 ppb to 118.4 ppb. About 20.61% of the groundwater samples had uranium concentration about the standards set by USEPA (30 ppb). The comparison between groundwater level and uranium concentration in groundwater shows that the uranium concentration increases with raise in groundwater table. This pattern of relationship indicates the effect of water table fluctuation between the weathered and fractured granites on concentration of uranium. In the event of opening up of mining activity in this region care has to be taken to look into this pattern of relationship for proper and effective management of groundwater quality.
In the solvent extraction of uranium the three most commonly encountered operational problems are:

1. The transfer of impurities on the loaded organic,
2. Poor phase separation, and
3. Crud formation.

The chemistry and physics associated with these problems are discussed and suggestions are made as to how circuit design and operating procedures can alleviate these challenges.

Two types of equipment are used in the industry for solvent extraction (SX) of U: mixer-settlers (MS) and columns. Currently the only published type of columns applied in U SX is the Bateman Pulsed Columns (BPC). These columns have been applied for extraction of U for more than 13 years in Olympic Dam plant in Australia and in recent years were also introduced to additional plants in Australia and South Africa. Other plants are using MS of various types. The columns are currently used in the extraction battery only. For stripping and scrubbing only MS are currently used. Although pilot tests prove that the pH gradient required in the stripping may be successfully obtained in the BPC, they have not yet been applied in the industry. The paper compares the extraction and stripping in both types of equipment, regarding the capital cost, operating costs and operating conditions. The capital cost of the BPC is lower by 33-40%, depending on the size of the plant and the quality of the ore. The operating costs with the BPC are slightly lower, due to smaller losses of solvent. From operating point of view the BPC has the ability to recover from phase inversion and precipitation of yellow cake without the need to shut down the plant, if the problem is addressed within a few minutes.

A chemical property model was built for the process of stripping uranium from a loaded solution of a tertiary amine in kerosene with sulphuric acid. A combination of two software packages, OLI (OLI System, Inc) and IDEAS (Andritz Automation, Inc.) were used to develop a speciation-based thermodynamic model of the multi-stage counter-current process. Equilibrium constants for the reactions between uranium and sulphuric acid species were calculated by fitting to experimental data from different publications. The model was able to accurately predict most of the stripping process parameters (number of contacts, concentration of uranium in both phases, acid consumption, etc) in a wide range of process conditions. It was shown that the existing thermodynamic data alone is sufficient to design and optimize complicated uranium recovery processes.

Historically, recovery of uranium from high grade (>400 ppm U) leach solutions (PLS) was done by solvent extraction (SX), while low grade feed was treated by ion exchange (IX). Significant improvement in the SX technology, especially with large pulsed columns instead of mixer-settlers (MS), has now made the SX more attractive for PLS with U below 100 ppm. Recently Bateman carried out three test work programs for direct SX of low grade (<100 ppm) U PLS, using BPC pulsed columns for extraction and MS for stripping and scrubbing. In all 3 cases the results prove that the direct SX is overall more economical that any combination of IX and SX. Based on these results, two industrial plants, in South Africa and Australia, were erected.
10:30  Paper 4747
INFLUENCE OF THE CHEMICAL DEGRADATION OF TRIOCTYLAMINE DISSOLVED IN N-DODECANE MODIFIED WITH TRIDECANOL ON URANIUM EXTRACTION PROCESS IN A PLANT LOCATED IN NIGER
A. Chagnes¹ and G. Cote¹, B. Courtaud², N.P. Syna² and J. Thiry²
¹Chimie Paristech – Ecole Nationale Supérieure de Chimie de Paris (ENSCP), France
²AREVA NC – Service d’Etudes de Procédés et d’Analyses (SEPA), France

Solvent losses in hydrometallurgical applications of liquid-liquid extraction are of great concern. In our earlier studies, we reported the chemical degradation of a solvent containing tri-n-octylamine extractant and 1-tridecanol modifier dissolved in kerosene. This solvent extractant is used for the recovery of uranium from sulfuric acid media in a plant located in Niger. Our studies have showed that tri-n-octylamine is degraded into dioctylamine via a radical mechanism due to the presence of Vanadium (V). Dioctylamine influences the kinetics of degradation of the extraction solvent and induces the formation of cruds in the presence of Molybdenum (VI). This paper will focus on the impact of dioctylamine on the solvent extraction operation of a uranium production plant.

11:00  Paper 5145
CRUD SEPARATION AND SX OPTIMIZATION AT KEY LAKE
T. Saruchera, J. Jarvi, and B. Moldovan
Cameco Corporation, Key Lake Operation, Canada

The Key Lake mill processes a combination of high grade uranium ore and uranium-bearing mineralized waste from the McArthur River Mine. The mill uses solvent extraction for recovery and purification of uranium. Crud is an ongoing challenge to all SX circuits. Technical personnel at the Key Lake mill have gained an understanding of the mineralogical and hydrometallurgical origin of this crud. Further, mill processes have been modified to reduce crud formation. Finally, on-going R&D is in progress to further reduce the impact that crud has on mill efficiency. These aspects will be presented in greater detail.

11:30  Paper 5625
CRUD TREATMENT WITH 3 PHASE CENTRIFUGE IN HEAP LEACH URANIUM PROCESS
T. Hartmann
GEA Westfalia Separator Process GmbH, Germany

The presence of crud represents a permanent challenge for solvent extraction in the hydro-metal Uranium industry. The crud forms in the settlers of SX extraction. The crud is a stable emulsion which slowly spreads along the phase boundary between the aqueous and organic phase. Spreading of this intermediate phase is determined by the following influencing factors. Wind blows dust into the open settlers, some suspended solids coming with the pregnant leach solution (PLS) and wrong design of the mixers cause stable emulsions. Metallic solid residue is likewise responsible for the growth rate of the crud at the above-mentioned phase boundary. The crud can significantly impair the efficiency of hydro-metal extraction because the phase boundary between the aqueous and organic phases assumes substantial proportions, and the settlers cannot react flexibly. In a chain reaction, all settlers connected in series become infected with crud. The transfer of organic phase to the electrowinning [EW] cell can cause ‘cathode burn’. The entrainment of electrolyte into the extraction stage can result in loss of pH control in the extraction circuit which will cause a drop in extraction efficiency. On the other hand, entrainment of the organic in the raffinate will result in organic losses to the leach circuit. Continuous treatment of the crud is extremely effective and reliable with a 3-phase separating solid bowl centrifuge. All three phases are separated distinctly from one another. All associated process steps exhibit a steady uniform efficiency. The main benefit for the customer is that process fluctuations in the extraction process will no longer occur. The 3-phase separating solid bowl centrifuge consists of an axial solid-wall bowl. The solid-wall bowl has a cylindrical section for simultaneous separation and clarification of the aqueous and organic liquid phase and a conical section for efficient solids dewatering. The 3-phase feed suspension is fed into the solid bowl centrifuge through the feed tube and enters the separation chamber through the distributor. The scroll conveys the solids to the solids discharge.
14:00 Paper 4904
ELECTROKINETIC DEWATERING OF URANIUM MINE TAILINGS
J.Q. Shang¹, Y. Xu¹, A. R. Fernando², E.K. Lam²
¹Department of Civil and Environmental Engineering, The University of Western Ontario, Canada
²Innovation & Technology Development - Research Centre, Cameco Corporation

Bench-scale experiments are carried out to evaluate electrokinetic (EK) dewatering of two tailings samples from uranium mines in Northern Saskatchewan. The study includes characterization of tailings, measurement of electrokinetic permeability (ke), and electrokinetic enhanced gravity dewatering. It is found that tailings containing clay minerals respond well to EK dewatering. Significant EK flow is generated, which can be further enhanced by pH adjustment at anodes. The key parameters, such as density, electrical conductivity, pH, and mineral composition of tailings play dominant roles in the effectiveness of EK dewatering, which should be considered in the design for field applications.

14:30 Paper 4836
ELECTRICAL RESISTANCE HEATING FOR THAWING OF FROZEN URANIUM TAILINGS
C. Melis, P. Landine and T. Kotzer
Cameco Corporation, Canada

The Rabbit Lake In-Pit Tailings Management Facility contains frozen layers of tailings due to sub-aerial deposition during the successive winters. Thawing is required to ensure full consolidation of the tailings prior to closure and to regain disposal space presently occupied by ice. Electric resistance heating (ERH), which has been used to heat soil for bitumen extraction and remediation of volatile contaminants, was evaluated as a thawing mechanism. Two bench-scale experiments were performed wherein ERH was tested on about 0.3 cubic metres of frozen tailings frozen to a minimum of -2°C. Thawing occurred in both experiments with negligible geochemical effects, demonstrating the viability of ERH as a tailings thawing mechanism.

15:00 Paper 4840
TRANSPORT AND DEPOSITION OF THICKENED URANIUM TAILINGS
E. Paulsen
AREVA Resources Canada, Inc., Canada

The McClean Lake operation has experienced several problems relating to the thickened tailings disposal system. These include issues relating to segregation, inadequate pumping capacity, and unstable pipeline operation. Segregation in the tailings management facility is of particular importance since it negatively impacts the long-term containment of arsenic and the consolidation of the tailings solids. These issues have direct implications on the regulatory requirements of the operation. As a result several initiatives relating to tailings thickening, transport, and deposition were proposed and implemented. This paper presents an audit of the existing tailings transport system based on the rheological requirements of homogeneous tailings as well as the proposed changes and preliminary results of this study.

15:30 Coffee Break

16:00 Paper 4868
CAMECO ENGINEERED TAILINGS PROGRAM: LINKING APPLIED RESEARCH WITH INDUSTRIAL PROCESSES FOR IMPROVED TAILINGS PERFORMANCE
T.G. Kotzer
Cameco Corporation, Canada

Mine tailings at Cameco’s operations are by-products of milling uranium ore having variable concentrations of uranium, metals, oxyanions and trace elements or elements of concern (EOC). Cameco has undertaken an Engineered Tailings (ET) program to optimize tailings performance and minimize environmental EOC impacts, regardless of the milled ore source. Applied geochemical and geotechnical tailings research is key within the ET program. In-situ drilling and experimental programs are used to understand long-term tailings behaviour and help validate source term predictions. Within this, the ET program proactively aids in the development of mill-based processes for production of tailings having improved long-term stability.
Tailings from a uranium mine have been tested to improve the dewatering properties and final weight percent (wt%) solids of the neutralized tailings. The objectives were to maximize water recovery due to the scarcity of water in the project area and to produce a suitable cemented paste fill to minimize ore dilution underground in order to maximize the head grade to the mill. The applicability of the controlled neutralization process, in which gypsum would precipitate as crystalline particles thereby improving the dewatering properties of the tailings through the use of a deep bed paste thickeners was tested. The acid leach slurry samples used were obtained from the end of the leaching circuit, before uranium recovery and lime neutralization. The tests conducted indicated that the controlled neutralization process greatly reduced the volume of neutralization precipitates which typically results in a higher final density and wt% solids. Additionally, it improved the dewatering (filtration) properties of the material. Controlled neutralization also reduced the amount of sulphate in the solution close to that of its saturation limit, which would reduce the amount of scaling that could occur during full scale applications and would increase the recyclability of the water back to the process. Deep bed paste thickening also improved the final wt% solids of the underflow. The test work demonstrated that it was possible, at the bench scale level, to improve final density and recover additional water. The increase in the filterability of the material provided a good indication that further increase in wt% solids and water recovery could be obtained in full scale applications. Unconfined Compressive Strength (UCS) tests improved for samples with reduced gypsum concentrations. While the strength achieved remained low, there was a substantial increase. Although further studies are required, neutralization of uranium tailings under controlled conditions to form gypsum as crystalline particles and/or reduce the gypsum content could possibly provide a viable option in the preparation of suitable paste material.
DECOMMISSIONING II

Wednesday, August 18, 2010 PM
Room: William Pascoe

14:00 Paper 5096
BEAVERLODGE MINE CLOSURE CURRENT CHALLENGES AND OPPORTUNITIES
M. Webster, J. Alonso and J. Jarrell
Cameco Corporation, Canada

Beaverlodge mine and mill facilities operated from 1952 until 1982. Site decommissioning was completed in 1985 and a transition monitoring/maintenance phase followed. As described in this paper, although some properties have recently been transferred into Saskatchewan’s newly established institutional control program, most properties remain in transition phase, originally envisioned to last 10 years. Reclamation/decommissioning expectations were initially established, but over time societal and regulatory expectations and regulatory processes have changed. Cameco recently established a management framework to guide potential remedial activities which has been accepted by regulatory agencies. The framework seeks to balance current decommissioning expectations with the presence of legacy issues and past close-out agreements, ultimately relying on benefit-cost evaluation to determine final acceptance criteria for sites.

14:30 Paper 5091
ENVIRONMENTAL CLEAN-UP OF THE EAST GERMAN URANIUM MINING LEGACY: DISCUSSION OF SOME KEY EXPERIENCES MADE UNDER THE WISMUT REMEDIATION PROGRAM
M. Paul and S. Mann
WISMUT GmbH, Germany

Since 1991 the Wismut environmental remediation project is one of the largest mine closure projects worldwide, entailing the rehabilitation of the former Soviet-East German uranium mining industry. The legacy of forty years of intensive uranium mining in East Germany enclosed a vast variety of radioactive contaminated sites and objects, including five underground mines and more than 3,700 ha of contaminated areas with ca. 500 million m³ of solid radioactively contaminated material. The multi-disciplinary remediation approach has developed robust solutions by ensuring rigorous site evaluations and impact assessments focused on key processes. Having realized more than 80 % of the remediation work to be performed, the paper highlights selected results and discusses key experiences gained, both from a technical and non-technical perspective.

15:00 Paper 4863
REMEDIATING THE SOUTH ALLIGATOR VALLEY URANIUM MINING LEGACY
M. Fawcett¹ and P. Waggitt²
¹ Fawcett Minesite Rehabilitation Services, Australia
² International Atomic Energy Agency, Austria

In late 1950s and early 1960s 13 uranium mines operated in the South Alligator Valley of Australia’s Northern Territory. Once sales contracts had been filled the mines were abandoned and no remediation took place. In the 1980s the valley was designated as part of Stage 3 of the adjacent World Heritage-listed, Kakadu National Park. Proposals for remediation were only seriously put forward when the land was returned to the traditional Aboriginal owners, the Gunlom Land Trust, in 1996. Although they leased the land back so it would remain a part of Kakadu National Park the traditional Aboriginal owners required remediation to be complete by 2015. This paper tells the story of the development and implementation of the remediation process from the start of planning in 1998 to completion in 2009; and finally it describes the development of stakeholder relationships and the initial plans for long term stewardship.

15:30 Coffee Break

16:00 Paper 5373
REMEDIATION OF WISMUT’S URANIUM TAILINGS PONDS AT SEELINGSTÄDT, GERMANY
U. Barnekow, T. Metschies and M. Paul
WISMUT GmbH, Germany

As part of its mine closure program Wismut GmbH is remediating the Uranium tailings ponds Culmitzsch and Trünzig covering 3.6 km² pond area including approximately 104 Mill m³ tailings. From 1960 till 1990 tailings were discharged into tailings ponds erected in a densely populated area. Contaminant leakage from the tailings enters the surrounding aquifers and the receiving streams. Dry remediation in situ started with first securing measures in 1991 and will last till 2020. The paper presents the conception for the entire remediation of the tailings ponds, the actual remediation status achieved to date and an outlook to the future.
Golder Associates Ltd. (Golder) provided overall radiological direction and assistance to the client in planning for the remediation of a Calciner Room which had once operated as the final stage of a uranium processing circuit. Afterwards, Golder provided operational radiation protection services during the remediation work. The project was somewhat unusual in that the contaminated steel from within the Calciner Room was recycled. In addition, the presence of concentrated uranium within the process equipment required stringent radiation protection measures beyond those normally employed for such remediation. This part of the project was completed successfully with worker radiation exposures well below the regulatory dose limits and with the effective protection of the environment.
14:00  Paper 4809  
**TRANSLATION OF ENVIRONMENTAL LEADERSHIP OBJECTIVES INTO ROUTINE PROJECT EXECUTION FOR THE URANIUM MINING INDUSTRY**  
J.Breker¹, T.Studer¹, N.Voykin¹, B.Berg¹, and W.Scott²  
¹Cameco Corporation, Canada  
²Wardrop Engineering, Thunderbay, Canada  

Cameco Corporation (Cameco) aligns its social and environmental responsibilities with its vision, mission and values. Environmental Leadership is established as a corporate objective that emphasizes the triple-bottom-line and a systematic approach to understanding environmental, social and economic issues, risks and opportunities. These are ingrained in the project culture, systems and processes and used to influence solutions derived by the project teams to achieve Cameco’s objectives. This paper traces the organizational objectives from the early stages of a project through to implementation and turn over to Operations. A case study is used to demonstrate how an asset is influenced by Cameco’s strategy.

14:30  Paper 5583  
**EFFECTIVE INTEGRATION OF ENVIRONMENTAL LEADERSHIP AND ENVIRONMENTAL MANAGEMENT SYSTEMS WITHIN CAMECO’S MINING DIVISION**  
K. Nagy and S. Borchardt  
Cameco Corporation, Canada  

To support the implementation of its integrated Safety, Health, Environment & Quality (SHEQ) Policy, Cameco has undertaken an environmental leadership initiative with the goal of moving beyond regulatory compliance and significantly reducing environmental impacts in five key areas: air emissions, treated water quality and quantity, energy use and greenhouse gas emissions, and waste generation. To ensure environmental leadership becomes routine business practice, it was necessary to integrate the initiative into Cameco’s programs and management systems at the corporate and operational levels. Operations-based environmental leadership strategies and action plans have since been developed, as well as a corporate reporting system to monitor Cameco’s environmental performance.

15:00  Paper 5097  
**ADVANCES IN CANADIAN URANIUM MINE ENVIRONMENTAL MONITORING PROGRAMS**  
Cameco Corporation, Canada  

By world mining standards, the uranium sector is relatively small, with limited sector-specific standards upon which environmental performance can be evaluated. To fill this gap, environmental monitoring programs have expanded, largely driven by new environmental effects monitoring and environmental assessment program requirements. Much more emphasis is now being placed on evaluating environmental interactions with the near-field receiving environment – both through more sophisticated field monitoring and effects-based modelling. End-of-pipe effluent objectives can now be reverse engineered from these effects-based monitoring and modelling results. This presents new challenges for mine operators and new tools that promote more engaging stakeholder discussions.

15:30  Coffee Break

16:00  Paper 5345  
**COMPREHENSIVE STUDY OF THE ENVIRONMENTAL CONDITIONS AND HEALTH OF WORKERS AT THE RUSSIAN URANIUM MINING AND MILLING FACILITY**  
N.K. Shandala¹, S.M. Kiselev¹, S.V. Akhromeev¹, E.A. Khohlova ², E.G. Metlyaev¹, A.A. Filonova¹  
¹Federal Medical Biophysical Centre, Russia  
²Regional Management 107, FMBA of Russia, Russia  

The goal of this study is to carry out comprehensive environmental and hygienic examination of the Health Protection Zone and the location area of the the Priargunskiy production mining and chemical association and to assess health conditions of miners. The media under examination were: common air, soil, vegetation, and water. Contents of natural radionuclides - 238U, 232Th, 226Ra, 210Po, and 210Pb have been determined. Concentrations of other chemicals have also been determined in common air. Radionuclide migration levels and accumulation coefficients of uranium series have been determined. Medical and dose information has been collected and verified to evaluate health conditions of miners.
<table>
<thead>
<tr>
<th>Name</th>
<th>Page</th>
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<tbody>
<tr>
<td><strong>A</strong></td>
<td></td>
</tr>
<tr>
<td>Abhilash</td>
<td>44</td>
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<tr>
<td>Afolabi, A.S.</td>
<td>39</td>
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<tr>
<td>Agrawal, A.</td>
<td>29</td>
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<tr>
<td>Akhromeey, S.V.</td>
<td>62, 71</td>
</tr>
<tr>
<td>Alexander, R.</td>
<td>21</td>
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<td>Alonso, J.</td>
<td>69</td>
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<td>Alonso, J.</td>
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<td>Aral, H.</td>
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<td>Archambault, D.P.</td>
<td>30</td>
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<td>Ashley, F.</td>
<td>53</td>
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<td>Auger, F.</td>
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<td>Awati, A.B.</td>
<td>31</td>
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<td>Axen, S.</td>
<td>35</td>
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<td>Babka, O.</td>
<td>47</td>
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<td>Backham, L.</td>
<td>37</td>
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<td>Banton, N.</td>
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<td>Barlow, C.</td>
<td>27</td>
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<td>Barnekow, U.</td>
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<td>Bashir, R.</td>
<td>25, 35, 36, 47</td>
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<td>Batchelor, L.A.</td>
<td>30</td>
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<td>Bazin, K.</td>
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<td>59</td>
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<td>37</td>
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<td>Bellino, M.</td>
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<td>Belyk, C.L.</td>
<td>33</td>
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<td>Bera, T.K.</td>
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<td>Berg, B.</td>
<td>71</td>
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<td>Bergbusch, P.</td>
<td>63</td>
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<td>Bertrand, M.</td>
<td>42</td>
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<tr>
<td>Bharadwaj, B.</td>
<td>27, 63</td>
</tr>
<tr>
<td>Bhargava, S.K.</td>
<td>43, 44, 45</td>
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<tr>
<td>Bhattacharjee, S.</td>
<td>41</td>
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<td>Bhowmik, A.</td>
<td>29</td>
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<td>Binder, M.</td>
<td>21</td>
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<td>Blanvillain, J.J.</td>
<td>27</td>
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<td>Borchardt, S.</td>
<td>71</td>
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<td>Bosman, S.A.</td>
<td>34</td>
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<td>Boucher, M.</td>
<td>62</td>
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<td>Boyd, B.</td>
<td>21</td>
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<td>Boyko, K.</td>
<td>47</td>
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<td>Boytsov, A.</td>
<td>38</td>
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<td>Breker, J.</td>
<td>71</td>
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<tr>
<td>Breus, S.</td>
<td>37</td>
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<tr>
<td>Brindha, K.</td>
<td>64</td>
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<tr>
<td>Broczkowski, M.E.</td>
<td>41</td>
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<td>Brown, J.A.</td>
<td>37</td>
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<td>Bruening, R.L.</td>
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<td>Brykala, M.</td>
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<td>Buchalter, E.</td>
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<td>Burling, S.</td>
<td>43</td>
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<td>Bush, M.</td>
<td>32</td>
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<tr>
<td>Bush, M.</td>
<td>64</td>
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<tr>
<td>Bustos, S.</td>
<td>56</td>
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<td><strong>C</strong></td>
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<td>Cadden, A.</td>
<td>57</td>
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<td>Callin, J.</td>
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<tr>
<td>Card, C.D.</td>
<td>34</td>
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<tr>
<td>Carson, L.J.</td>
<td>23, 32</td>
</tr>
<tr>
<td>Chagnes, A.</td>
<td>66</td>
</tr>
<tr>
<td>Chaki, A.</td>
<td>23</td>
</tr>
<tr>
<td>Chambers, D.B.</td>
<td>61</td>
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<tr>
<td>Chapman, P.M.</td>
<td>63</td>
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<tr>
<td>Charalambous, F.</td>
<td>44</td>
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<tr>
<td>Chipley, D.</td>
<td>44</td>
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<tr>
<td>Chmielewski, A.G.</td>
<td>41</td>
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<tr>
<td>Clark, D.R.</td>
<td>29</td>
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<tr>
<td>Clay, J.</td>
<td>63</td>
</tr>
<tr>
<td>Clegg, N.</td>
<td>46</td>
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<tr>
<td>Clement, C.H.</td>
<td>61</td>
</tr>
<tr>
<td>Cook-Searson, T.</td>
<td>21</td>
</tr>
<tr>
<td>Cote, G.</td>
<td>66</td>
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<td>Courtaud, B.</td>
<td>39, 66</td>
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<td>Crane, P.</td>
<td>49</td>
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<tr>
<td>Cutler, J.N.</td>
<td>59</td>
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<td><strong>D</strong></td>
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<td>Daenzer, R.</td>
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<td>Das, S.</td>
<td>59</td>
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<td>De Klerk, R.J.</td>
<td>60</td>
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<td>de Matos, E.C.</td>
<td>33</td>
</tr>
<tr>
<td>Demopoulos, G.P.</td>
<td>59, 60</td>
</tr>
<tr>
<td>Dent, A.</td>
<td>26</td>
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<td>Deptula, A.</td>
<td>41</td>
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<td>Desiri, P.</td>
<td>51</td>
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<td>Dhavamani, D.</td>
<td>29</td>
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<td>Dhu, T.</td>
<td>36</td>
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<td>Dinh, B.</td>
<td>49</td>
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<td>Dixon, B.</td>
<td>26</td>
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<td>Dombrose, E.</td>
<td>38</td>
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<td>Dreisinger, D.</td>
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<td>Ducros, F.</td>
<td>42</td>
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<td>Dudley, K.</td>
<td>49</td>
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<td>Durupt, N.</td>
<td>27, 55</td>
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<td>Dyck, B.</td>
<td>39</td>
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<td>Eaves, D.G.</td>
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<td>Eberhardt, E.</td>
<td>25</td>
</tr>
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<td>Edwards, C.</td>
<td>28, 39</td>
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<tr>
<td>Elango, L.</td>
<td>64</td>
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<tr>
<td>England, K.</td>
<td>71</td>
</tr>
<tr>
<td>Essilfie-Dughan, J.</td>
<td>50, 59</td>
</tr>
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<td><strong>F</strong></td>
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<tr>
<td>Fainerman-Melnikova, M.</td>
<td>56</td>
</tr>
<tr>
<td>Fairclough, M.C.</td>
<td>34</td>
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<tr>
<td>Fawcett, M.</td>
<td>69</td>
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<tr>
<td>Fernando, A.R.</td>
<td>67</td>
</tr>
<tr>
<td>Filas, F.</td>
<td>53</td>
</tr>
<tr>
<td>Filonova, A.A.</td>
<td>62, 71</td>
</tr>
<tr>
<td>Fraser, K.S.</td>
<td>43</td>
</tr>
<tr>
<td>Fredlund, D.G.</td>
<td>57</td>
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<td>Name</td>
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<td>Fredlund, M.D.</td>
<td>68</td>
</tr>
<tr>
<td>Frey, R.</td>
<td>59, 60</td>
</tr>
<tr>
<td>Galbraith, M.J.</td>
<td>28, 49</td>
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<tr>
<td>Ganguly, C. (Tona)</td>
<td>41</td>
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<td>George, G.</td>
<td>50</td>
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<td>Goetz, H.</td>
<td>35</td>
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<td>Gomez, M.A.</td>
<td>59</td>
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<td>Gomezio, L.A.</td>
<td>23, 27</td>
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<td>Goode, J.R.</td>
<td>37</td>
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<td>Gornall, M.R.</td>
<td>29</td>
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<tr>
<td>Gouthas, G.</td>
<td>34</td>
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<td>Grandey, G.W.</td>
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<td>Grant, S.</td>
<td>27</td>
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<td>Grinbaum, B.</td>
<td>65</td>
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<td>Grmela, A.</td>
<td>47</td>
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<td>Grover, R.B.</td>
<td>31</td>
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<td>Gunning, C.</td>
<td>53</td>
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<tr>
<td>Gupta, R.</td>
<td>47</td>
</tr>
<tr>
<td>Habashi, F.</td>
<td>24, 45</td>
</tr>
<tr>
<td>Hackl, R.</td>
<td>33</td>
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<td>Hall, S.</td>
<td>40</td>
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<tr>
<td>Hammen, J.P.</td>
<td>56</td>
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<tr>
<td>Hammen, R.F.</td>
<td>56</td>
</tr>
<tr>
<td>Hartmann, T.</td>
<td>66</td>
</tr>
<tr>
<td>Hatley, J.F.A.</td>
<td>35, 36</td>
</tr>
<tr>
<td>Heath, P.</td>
<td>34</td>
</tr>
<tr>
<td>Heinrich, G.</td>
<td>44</td>
</tr>
<tr>
<td>Hembree, R.</td>
<td>63</td>
</tr>
<tr>
<td>Hendry, M.J.</td>
<td>50, 59</td>
</tr>
<tr>
<td>Heyman, L.</td>
<td>55</td>
</tr>
<tr>
<td>Hiadun, D.</td>
<td>37</td>
</tr>
<tr>
<td>Hughes, K.A.</td>
<td>59, 60</td>
</tr>
<tr>
<td>Imran, S.A.</td>
<td>36</td>
</tr>
<tr>
<td>Ioffe, M.S.</td>
<td>41, 62</td>
</tr>
<tr>
<td>Izatt, N.E.</td>
<td>40</td>
</tr>
<tr>
<td>Izatt, S.R.</td>
<td>40</td>
</tr>
<tr>
<td>Jarrell, J.</td>
<td>69, 71</td>
</tr>
<tr>
<td>Jarvi, J.</td>
<td>63, 66</td>
</tr>
<tr>
<td>Jones, H.</td>
<td>23</td>
</tr>
<tr>
<td>Just, B.A.</td>
<td>49</td>
</tr>
<tr>
<td>Kaulard, J.</td>
<td>57</td>
</tr>
<tr>
<td>Kennedy, T.W.</td>
<td>29</td>
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<tr>
<td>Kenny, D.</td>
<td>38</td>
</tr>
<tr>
<td>Kerr, F.</td>
<td>40</td>
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<tr>
<td>Kerr, W.</td>
<td>33</td>
</tr>
<tr>
<td>Khargava, S.</td>
<td>44</td>
</tr>
<tr>
<td>Khohlova, E.A.</td>
<td>62, 71</td>
</tr>
<tr>
<td>King, C.</td>
<td>26</td>
</tr>
<tr>
<td>King, D.</td>
<td>55</td>
</tr>
<tr>
<td>Kiran Jumar, N.A.P.</td>
<td>51, 52</td>
</tr>
<tr>
<td>Kiselev, S.M.</td>
<td>62, 71</td>
</tr>
<tr>
<td>Klemmer, S.</td>
<td>47</td>
</tr>
<tr>
<td>Ko, K.</td>
<td>63</td>
</tr>
<tr>
<td>Kotze, M.</td>
<td>65</td>
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<tr>
<td>Kotzer, T.G.</td>
<td>50, 59, 67</td>
</tr>
<tr>
<td>Kryst, K.</td>
<td>41</td>
</tr>
<tr>
<td>Kuyucak, N.</td>
<td>68</td>
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<tr>
<td>Kyser, K.</td>
<td>44</td>
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<tr>
<td>Labelle, M.</td>
<td>68</td>
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<tr>
<td>Lada, W.</td>
<td>41</td>
</tr>
<tr>
<td>Laflin, S.T.</td>
<td>29</td>
</tr>
<tr>
<td>Lam, E.K.</td>
<td>44, 63, 67</td>
</tr>
<tr>
<td>Lamarque, N.</td>
<td>42</td>
</tr>
<tr>
<td>Lambert, I.B.</td>
<td>23, 32</td>
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<tr>
<td>Landine, P.</td>
<td>67</td>
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<tr>
<td>Lane, R.</td>
<td>61</td>
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<tr>
<td>Lebaigue, O.</td>
<td>42</td>
</tr>
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<td>LeBlanc, D.</td>
<td>31</td>
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<tr>
<td>LePoudre, D.C.</td>
<td>48</td>
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<td>Leung, S.</td>
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<td>Lien, L.</td>
<td>40</td>
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<td>Lieu, A.</td>
<td>63</td>
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<td>Lima, H.M.</td>
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<td>Ling, Y.</td>
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<td>Liu, H.</td>
<td>35</td>
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<td>Longinov, M.</td>
<td>51</td>
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<td>Mackenzie, J.M.W.</td>
<td>65</td>
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<td>Mackenzie, M.</td>
<td>49</td>
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<td>Madenga, V.</td>
<td>35</td>
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<td>Mair, J.L.</td>
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<td>Mann, S.</td>
<td>69</td>
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<td>Martin, V.</td>
<td>35</td>
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<tr>
<td>McArthur, T.</td>
<td>57</td>
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<tr>
<td>McKay, A.D.</td>
<td>23, 32</td>
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<td>McKee, M.</td>
<td>53</td>
</tr>
<tr>
<td>McKeivitt, B.</td>
<td>55</td>
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<td>McNamara, K.</td>
<td>25</td>
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<td>Mehta, K.D.</td>
<td>44</td>
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<td>Melis, C.</td>
<td>67</td>
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<tr>
<td>Metlayaev, E.G.</td>
<td>62, 71</td>
</tr>
<tr>
<td>Metschies, T.</td>
<td>69</td>
</tr>
<tr>
<td>Meyer, R.</td>
<td>57</td>
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<tr>
<td>Michælek, B.</td>
<td>47</td>
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<td>Modolo, G.</td>
<td>41</td>
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<tr>
<td>Mohamed, A.E.M.</td>
<td>42</td>
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<tr>
<td>Moldovan, B.</td>
<td>27, 63, 66</td>
</tr>
<tr>
<td>Monken-Fernandes, H.</td>
<td>58</td>
</tr>
<tr>
<td>Montuir, M.</td>
<td>49</td>
</tr>
<tr>
<td>Morais, C.A.</td>
<td>27</td>
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<tr>
<td>Morrison, K.F.</td>
<td>53</td>
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<td>Murchie, M.P.</td>
<td>41, 62, 63</td>
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<tr>
<td>Murdock, G.</td>
<td>35</td>
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<tr>
<td>Murphy, K.M.</td>
<td>54</td>
</tr>
<tr>
<td>Muzenda, E.</td>
<td>39</td>
</tr>
</tbody>
</table>
# Author Index

<table>
<thead>
<tr>
<th>Name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nagy, K</td>
<td>71</td>
</tr>
<tr>
<td>Nair, R.N</td>
<td>64</td>
</tr>
<tr>
<td>Neuburger, D</td>
<td>25</td>
</tr>
<tr>
<td>Newmeyer, W</td>
<td>51</td>
</tr>
<tr>
<td>Nguyen, T.T.</td>
<td>37</td>
</tr>
<tr>
<td>Nisbett, A</td>
<td>49</td>
</tr>
<tr>
<td>Nokleby, S.B.</td>
<td>51</td>
</tr>
<tr>
<td>Oberth, R</td>
<td>31</td>
</tr>
<tr>
<td>Olczak, T</td>
<td>41</td>
</tr>
<tr>
<td>Ożberk, E</td>
<td>21</td>
</tr>
<tr>
<td>Pacary, V</td>
<td>49</td>
</tr>
<tr>
<td>Pakalnis, R</td>
<td>25</td>
</tr>
<tr>
<td>Palkovits, F</td>
<td>68</td>
</tr>
<tr>
<td>Panasiuk, S.V.</td>
<td>65</td>
</tr>
<tr>
<td>Pandey, B.D.</td>
<td>44</td>
</tr>
<tr>
<td>Pant, A</td>
<td>51</td>
</tr>
<tr>
<td>Paul, M</td>
<td>69</td>
</tr>
<tr>
<td>Paulsen, E</td>
<td>67</td>
</tr>
<tr>
<td>Paulsen, K</td>
<td>63</td>
</tr>
<tr>
<td>Payne, R</td>
<td>40</td>
</tr>
<tr>
<td>Petkov, V</td>
<td>59</td>
</tr>
<tr>
<td>Piche, J</td>
<td>27</td>
</tr>
<tr>
<td>Pickering, I</td>
<td>50</td>
</tr>
<tr>
<td>Pirmotov, G</td>
<td>21</td>
</tr>
<tr>
<td>Plasari, E</td>
<td>42</td>
</tr>
<tr>
<td>Pownceby, M</td>
<td>33</td>
</tr>
<tr>
<td>Priestley, D</td>
<td>68</td>
</tr>
<tr>
<td>Primeau, P</td>
<td>68</td>
</tr>
<tr>
<td>Qin, W</td>
<td>51</td>
</tr>
<tr>
<td>Rae, V</td>
<td>46</td>
</tr>
<tr>
<td>Raigiri Narayana, J</td>
<td>42</td>
</tr>
<tr>
<td>Ram, R</td>
<td>44</td>
</tr>
<tr>
<td>Ray, L</td>
<td>44</td>
</tr>
<tr>
<td>Read, D</td>
<td>27</td>
</tr>
<tr>
<td>Reid, S.J.</td>
<td>30</td>
</tr>
<tr>
<td>Reimann, L</td>
<td>63</td>
</tr>
<tr>
<td>Remple, G.A.</td>
<td>28</td>
</tr>
<tr>
<td>Rey, S</td>
<td>56</td>
</tr>
<tr>
<td>Reynolds, H.S.</td>
<td>43</td>
</tr>
<tr>
<td>Riess, B.S.</td>
<td>51</td>
</tr>
<tr>
<td>Rigden, A</td>
<td>47</td>
</tr>
<tr>
<td>Rinas, C</td>
<td>59, 60</td>
</tr>
<tr>
<td>Rincon, M</td>
<td>56</td>
</tr>
<tr>
<td>Ring, R</td>
<td>43</td>
</tr>
<tr>
<td>Robertson, E</td>
<td>71</td>
</tr>
<tr>
<td>Robison, R</td>
<td>27</td>
</tr>
<tr>
<td>Robson, D.M.</td>
<td>47</td>
</tr>
<tr>
<td>Rodgers, C. (Chick)</td>
<td>39</td>
</tr>
<tr>
<td>Rose, A</td>
<td>63</td>
</tr>
<tr>
<td>Roussel, H</td>
<td>49</td>
</tr>
<tr>
<td>Rowat, J</td>
<td>57</td>
</tr>
<tr>
<td>Roworth, M</td>
<td>25</td>
</tr>
<tr>
<td>Rowson, J</td>
<td>59, 60</td>
</tr>
<tr>
<td>Sarkar, S</td>
<td>29</td>
</tr>
<tr>
<td>Saruchera, T</td>
<td>63, 66</td>
</tr>
<tr>
<td>Schindler, M</td>
<td>34</td>
</tr>
<tr>
<td>Schnell, H</td>
<td>56</td>
</tr>
<tr>
<td>Schryer, D</td>
<td>53</td>
</tr>
<tr>
<td>Schwartz, L</td>
<td>65</td>
</tr>
<tr>
<td>Schwarz, G</td>
<td>53</td>
</tr>
<tr>
<td>Scott, W</td>
<td>71</td>
</tr>
<tr>
<td>Shandala, N.K.</td>
<td>62, 71</td>
</tr>
<tr>
<td>Shang, J.Q.</td>
<td>67</td>
</tr>
<tr>
<td>Shanmugavelu, P</td>
<td>29</td>
</tr>
<tr>
<td>Shaw, S.A.</td>
<td>50</td>
</tr>
<tr>
<td>Sigwadi, R</td>
<td>39</td>
</tr>
<tr>
<td>Simon-Coll, Y</td>
<td>56</td>
</tr>
<tr>
<td>Sležak, J</td>
<td>45, 46</td>
</tr>
<tr>
<td>Smith, T</td>
<td>47</td>
</tr>
<tr>
<td>Sobolewski, S</td>
<td>63</td>
</tr>
<tr>
<td>Soldenhoff, K</td>
<td>56</td>
</tr>
<tr>
<td>Sorel, C</td>
<td>49</td>
</tr>
<tr>
<td>Southworth, F.H.</td>
<td>31</td>
</tr>
<tr>
<td>Spence, J</td>
<td>26</td>
</tr>
<tr>
<td>Spence, G.A.</td>
<td>40</td>
</tr>
<tr>
<td>Stager, R.H.</td>
<td>61</td>
</tr>
<tr>
<td>Stanley, R</td>
<td>33</td>
</tr>
<tr>
<td>Steele, R</td>
<td>26</td>
</tr>
<tr>
<td>Stewart, K</td>
<td>61</td>
</tr>
<tr>
<td>Stianson, J</td>
<td>57</td>
</tr>
<tr>
<td>Studer, T</td>
<td>71</td>
</tr>
<tr>
<td>Syna, N.P.</td>
<td>66</td>
</tr>
<tr>
<td>Szpunar, B</td>
<td>41</td>
</tr>
<tr>
<td>Szpunar, J.A.</td>
<td>41, 51, 52</td>
</tr>
<tr>
<td>Tairova, G</td>
<td>62, 63</td>
</tr>
<tr>
<td>Takala, J</td>
<td>62</td>
</tr>
<tr>
<td>Tamrakar, P.K.</td>
<td>44</td>
</tr>
<tr>
<td>Tardio, J</td>
<td>43, 44</td>
</tr>
<tr>
<td>Thiry, J</td>
<td>39, 66</td>
</tr>
<tr>
<td>Thomas, K.G.</td>
<td>43</td>
</tr>
<tr>
<td>Thompson, P</td>
<td>61</td>
</tr>
<tr>
<td>Thomson, J</td>
<td>47</td>
</tr>
<tr>
<td>Toews, K</td>
<td>62</td>
</tr>
<tr>
<td>Tremblay, M</td>
<td>63</td>
</tr>
<tr>
<td>Turner, K</td>
<td>64</td>
</tr>
<tr>
<td>Van Vliet, P</td>
<td>24</td>
</tr>
<tr>
<td>van Zyl, D</td>
<td>68</td>
</tr>
<tr>
<td>Vance, R</td>
<td>21</td>
</tr>
<tr>
<td>Vanderlaan, J</td>
<td>51</td>
</tr>
<tr>
<td>Vien, A</td>
<td>27</td>
</tr>
<tr>
<td>Villegas, R.A.S.</td>
<td>23, 33</td>
</tr>
<tr>
<td>Virmig, M</td>
<td>69</td>
</tr>
<tr>
<td>Voykin, N</td>
<td>71</td>
</tr>
<tr>
<td>Wagjitt, P</td>
<td>28, 45, 69</td>
</tr>
<tr>
<td>Warner, J</td>
<td>59, 60</td>
</tr>
<tr>
<td>Wattinne-Morice, A</td>
<td>37</td>
</tr>
<tr>
<td>Wawszczak, D</td>
<td>41</td>
</tr>
<tr>
<td>Name</td>
<td>Page</td>
</tr>
<tr>
<td>--------------------</td>
<td>------</td>
</tr>
<tr>
<td>Webster, M.</td>
<td>69</td>
</tr>
<tr>
<td>Williamson, A.L.</td>
<td>40</td>
</tr>
<tr>
<td>Wilson, T.</td>
<td>34</td>
</tr>
<tr>
<td>Wittrup, M.B.</td>
<td>54</td>
</tr>
<tr>
<td>Xu, Y</td>
<td>67</td>
</tr>
<tr>
<td>Yameogo, S.T.</td>
<td>35, 36</td>
</tr>
<tr>
<td>Yeo, G.</td>
<td>33</td>
</tr>
<tr>
<td>Yesnik, L.</td>
<td>27</td>
</tr>
<tr>
<td>Zheng, J.</td>
<td>63</td>
</tr>
<tr>
<td>Zhenxing, Z.</td>
<td>21</td>
</tr>
</tbody>
</table>
Sheraton Cavalier Hotel Saskatoon
612 Spadina Crescent East, Saskatoon, Saskatchewan S7K 3G9 - Phone: 306-652-6770 Fax: 306-224-1739

Windows Restaurant - Our brand new, refreshingly modern, river view restaurant, offering a tantalizing menu for all tastes.
Hours of Operations: ext.3159
Monday – Friday: 6:30am – 10:30pm / Saturday: 7:00am – 10:30pm / Sunday: 7:30am – 10:30pm

Room Service Hours of Operations: ext.50
Monday – Wednesday: 6:30am – 11:00pm / Thursday: 6:30am – 11:30pm
Friday: 6:30am – 12:00midnight / Saturday: 7:00am – 12:00midnight / Sunday: 7:30am – 11:00pm

Carver’s Steakhouse - Saskatoon’s premier steakhouse featuring the finest beef and vintages from an unparalleled wine list
Hours of Operations: ext.3317
Monday – Sunday: 5:30pm Reservations recommended.

6Twelve – Our stylish, urban lounge with a unique appetizer menu and extensive martini selection
Hours of Operations: ext. 3329
Monday - Tuesday: 11:30am - 12:00am / Thursday: 11:30am - 12:30am / Friday: 11:30am - 1:00am / Saturday: 1:00pm - 1:00am / Sunday: 3:00pm -10:30 pm

River Country Recreation Complex - A twisting, turning adventure in the water! Enjoy our two giant waterslides, large main pool, children’s pool, hot tubs and licensed snack bar.
Hours of Operations: ext.3328
Monday - Friday: 10:00am - 10:00pm / Saturday – Sunday: 9:00am - 10:00pm

Fitness Center – Unwind in our modern fitness facility. Open 24 hours

How to Dial:
Room to Room: 7 and the room number
Local Calls: 9 and the phone number
Long Distance Calls: 9 (area code) and the seven digit number
International Calls: 9 (country code) (area code) and the phone number

The Link:
24-Hour Access to Internet and Printing

Internet Information:
Complimentary High Speed in all guest rooms and Wireless in the Lobby. Fees apply to all Catering Spaces.

Local Hospital:
Royal University Hospital / 103 Hospital Drive / Ph: 655-1000 / 1.0 km0.6 miles (24hr ER)

Nearest 24 Hour Pharmacy:
Shoppers Drug Mart / 2410 – 22nd Street W. / Ph: 382-5050 / 5.0 km3.1 miles

Nearby Pharmacy Open Until Midnight:
Shoppers Drug Mart / 1210 7th Ave. N & 33rd St. / Ph: 653-0882 / 2.0 km1.2 miles

Nearest Dry Cleaner & Shirt Laundry:
Custom Cleaners / 321 4th Avenue N. / Ph: 665-0155 / Approx. 5 blocks

Nearby Coin Operated Laundry:
Off Broadway Laundromat & Drycleaning / 8358 Broadway Avenue / Ph: 244-1344 / Approx. 10 blocks

Local Full Service Fitness Centre:
YMCA / 25 22nd Street E. / Ph: 652-7515 / Approx. 7 blocks (ymcasaskatoon.org)
California Fitness / 611 4th Avenue N. / Ph: 244-4000 / Approx. 12 blocks (caffi.ca)

Local Full Service Spas:
Paramount / 702 2nd Ave N / Ph: 242-0017 / 1.6 km0.9 miles (paramountdayspa.com)
Angles Salon Spa / Midtown Plaza / Ph: 653-4247 / 5 blocks west (anglesalonspa.com)
Edgewater Spa / 611 University Drive (just across the Broadway Bridge) / Ph: 978-8111 / 1.2 km0.7 miles
(Mon, Tue, Fri, Sat: 9-6; Wed, Thu: 9-9)

Local Shopping Mall:
Midtown Plaza / 201 – 1st Avenue S. / 125 stores and services / Ph: 653-8844 / Approx. 4 blocks
(Hours: Mon, Tue & Sat: 9:30 am – 5:30 pm; Wed, Thu & Fri: 9:30 am – 9:00 pm; Sun 11:00 am – 5:00 pm)

Local Shopping Areas:
Downtown Area: Numerous retail stores, coffee shops and restaurants within walking distance.
Broadway District: 100+ merchants are located on or near Broadway Ave. (just across the Broadway Bridge – 5 blocks).

Local Electronic Store:
The Source by Circuit City / Midtown Plaza / Ph: 384-7704

Local Movie Complex:
Galaxy Cineplex / 347 2nd Avenue S. / Ph: 664-5060 / 0.7 km0.4 miles / approx. 5 blocks
Sheraton Cavalier Hotel Saskatoon
612 Spadina Crescent East, Saskatoon, Saskatchewan S7K 3G9 - Phone: 306-652-6770 Fax: 306-224-1739

.....Continued

Nearest Grocery Store:
Uptown Market / 23rd St & 2nd Ave / Mon-Sat: 7:30am—8:00 pm
Extra Foods / 906 Broadway Ave / Ph: 242-4764 / 1.7 km/1 mile

Nearby Health Food Store:
Herbs ‘N’ Health Foodport / #3 – 1005 Broadway Avenue / Ph: 664-1070 / 1.5 km/0.9 miles / Approx. 12 blocks

Nearby Museums & Galleries:
The Diefenbaker Canada Centre / 101 Diefenbaker Drive, U of S / Ph: 966-8384 / 1.6 km/1.0 miles
Ukrainian Museum of Canada / 910 Spadina Crescent E. / Ph: 544-3800 / Approx. 4 blocks
Glen Scrimshaw Art Gallery / 245 – 3rd Avenue S. / Ph: 668-2226 / Approx. 4 blocks
Mendel Art Gallery / 950 Spadina Crescent E. / Ph: 975-7610 / Open Daily 9 – 9 / Approx. 6 blocks (Relocating Nov 2010)

Locations of Interest:
Meewasin Valley Trail / 21 km of riverbank trails within the city / Ph: 665-6888 / (you can start just across the street)
Saskatoon Forestry Farm Park & Zoo / 1903 Forestry Farm Park Drive / Ph: 975-3382 / 8.0 km/5.0 miles
The Berry Barn / 830 Valley Road / Ph: 978-9797 / 20.0 km/12.4 miles
Western Development Museum / 2610 Lorne Avenue S. / Ph: 931-1910 / 8.0 km/5.0 miles

Local Golf Courses: (See Front Desk for More)
Willows Golf Club / 382 Cartwright St. / Ph: 956-1100 / 6.0 km/3.7 miles
Moon Lake Golf & Country Club / 905 Valley Road / Ph: 382-5500 / 20 km/12.4 miles

Local Bars & Night Clubs: (All bars close at 2 am)
6 Twelve Lounge / Hotel Lobby / ext. 3329
Staqatto Piano Bar / 416 21st Street E. / Ph: 244-8877 / (Around the corner)
Scratch / 215 2nd Ave S / Ph: 477-3070 (3 blocks west)
Barking Fish Tavern / 154 – 2nd Avenue S. / Ph: 665-2220 (3 blocks west)
O-Shea’s Irish Pub / 222 – 2nd Avenue S. / Ph: 384-7444 (3 blocks west)
Winston’s English Pub & Grill / 243 21st Street E. / Ph: 374-7468 (3 blocks west)
Hose & Hydrant Brewing Co. / 612 – 11th Street E. / Ph: 477-3473 / (just off Broadway Avenue)
Lydia’s / 650 Broadway Avenue / Ph: 652-8595 (Live music)
The Yard & Flagon Pub / 718 Broadway Avenue / Ph: 653-8883

Restaurants:
24-Hour: Olympia Family Restaurant / 120 – 2nd Avenue N. / Ph: 244-1513 (pg. 1418 yellow pages)
Asian: Red Pepper Restaurant / 145-3rd Avenue S. / Ph: 477-1977 (pg. 1414 yellow pages)
Szechuan Kitchen / 835E Broadway Ave / Ph: 664-8668 (pg. 1374 yellow pages)
California: Earl’s Restaurant & Lounge / 610 2nd Avenue N. / Ph: 664-4606 (earls.ca)
Octane Restaurant / 410 – 22nd Street E. / Ph: 956-0026
Casual: Jake’s on 21st / 307 21st Street E / Ph: 373-8383 (jakeson21st.ca)
Souleio Foods / 265 3rd Ave. S / Ph: 979-8102 (souleio.ca)
Mulberry’s Bakery Café & Pub / 124 3rd Avenue N / Ph: 664-4911 (mulberries.ca)
Spadina Freehouse / 608 Spadina Crescent E. / Ph: 668-1000 (thefreehouse.com)
Chinese: Ming’s Kitchen / 534 – 2nd Avenue N. / Ph: 664-3141 (pg. 1386 yellow pages)
Coffee Houses: Starbucks / 167A 2nd Avenue S. / Ph: 665-9901
The Living Room / 733 Broadway Avenue / Ph: 244-1070
East Indian: Taj Mahal Restaurant / 6-157 2nd Avenue N / Ph: 978-2227 (tajmahalsaskatoon.ca)
Fine Dining: Carver’s Steakhouse (Located in the Sheraton Cavalier Hotel) / Ph: 652-8292
Mr. Rio’s / 706 Idylwyld Dr N / Ph: 664-1923
French: Calories Bakery & Restaurant / 721 Broadway Avenue / Ph: 665-7991 (calorierestaurants.com)
Truffes Bistro and Patisserie / 230 21st Street E. / Ph: 373-7779
Weckeria / 616 10th Street E. / Ph: 933-9600 (weckeriarestaurant.ca)
Greek: Kououki Taverna / 119 3rd Ave. N / Ph: 244-4777 (koutouktaverna.ca)
Italian: Chianti’s Cafe & Restaurant / 102 Idylwyld Drive N / Ph: 665-8466 (chianticafe.ca)
Taverna Italian Restaurant / 219 – 21st Street E. / Ph: 652-6366
Japanese: Samurai / 601 Spadina Crescent E. / Ph: 683-6926
Otowa / 227 2nd Ave S. / Ph: 651-3888 (pg. 1416 yellow pages)
Mexican: Las Palapas / 910 Victoria Ave. / Ph: 244-5556 (laspalapas.ca)
La Bamba / #3 – 1025 Boychuk Dr. / Ph: 242-2622 (labambarestaurant.ca)
Amigos Cantina / 632 – 10th Street E. / Ph: 652-4912 (amigoscantina.ca)
Steak/Seafood: Carver’s Steakhouse (Located in the Sheraton Cavalier Hotel) / Ph: 652-8292 / ext. 3317
John’s Steakhouse / 401 – 21st Street E. / Ph: 244-6384 (johnsaskatoon.com)
Tusq / 416 – 21st Street E. / Ph: 244-8877 (tusq.ca)
Sushi: Fuzion Sushi & Deli Bar / #2 – 100 2nd Avenue S. / Ph: 244-2005
Sushiro Sushi Bar / 737 Broadway Avenue / Ph: 665-5557 (sushiro.com)
Vegetarian: Saskatoon Asian Restaurant / 136 2nd Avenue N. / Ph: 665-5959 (Menu has over 30 vegetarian items)
Sheraton Cavalier Saskatoon Hotel
612 Spadina Crescent East  Saskatoon, Saskatchewan  S7K 3G9 Canada
T (306) 652 6770  F (306) 244 1739  sheraton.com/saskatoon

MAIN LEVEL
Conference Centre

Key
Room 1: South Room
Room 2: West Room
Room 3: Center Room
Room 4: East Room
Room 5: Conference Foyer

Room 1 & 2: Sheraton South-West
Room 3 & 4: Sheraton Centre-East
Room 1,2,3 & 4: Sheraton Ballroom
E: Guest Elevator
what the world needs

clean, reliable energy

the world needs energy
Our world consumes energy every day. As global energy requirements increase over the long term, we must meet that demand in a sustainable way.

ergy needs nuclear
Energy consumers respect the environment and see the impact of dramatic shifts to our planet’s thermostat. One way to reduce greenhouse gases is a clean electricity source – nuclear.

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AREVA Resources Canada, with its head office in Saskatoon, is one of the world’s leading uranium exploration, mining and milling companies. With its nuclear and renewable energy programs, AREVA is committed to supplying ever cleaner, safer and more economical energy to the world.

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First AREVA 5 MW wind turbine installed in the first German offshore wind park Alpha Ventus.

...builds wind power generators such as this one in the North Sea.