AIPG 50th Anniversary Conference

Geology Serving Society

Program

Energy Independence, Mineral and Water Resources, and Geologic Education

October 23-26, 2013
Broomfield, Colorado
Exhibitors

- AMEC Environment & Infrastructure, Inc.
- American Geosciences Institute (AGI)
- Association for Women Geoscientists
  - Colorado Mining Association
  - Climax Molybdenum
  - Crystals Unlimited
- Environmental Systems Research Institute
  - FMC Environmental Solutions
    - Geotemps, Inc.
    - In-Situ, Inc.
- Liberty Mutual Insurance Company
  - Old Dead Things, LLC
  - The Wright Group
  - Zonge International, Inc.

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- RBC Wealth Management

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- The Wright Group

Break Sponsor
- Modern Litho Printing

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AIPG Section Sponsors

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Student Poster Contest Sponsor — Colorado
Lunch Sponsor — Arizona • Michigan • Pennsylvania
Break Sponsor — California • FAPG/Florida
- Georgia • Illinois/Indiana • Minnesota
- Missouri • New Mexico • South Dakota • Virginias • Wisconsin
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Congratulations!!!
AIPG 2013 Awardees

Ben H. Parker Memorial Medal
Jonathan G. Price, CPG-07814
Reno, Nevada

Martin Van Couvering Memorial Award
Robert A. Stewart, CPG-08332
Avon, Connecticut

John T. Galey, Sr. Memorial Public Service Award
Scott W. Tinker, CPG-10564
Austin, Texas

Award of Honorary Membership
William J. Siok, CPG-04773
Thornton, Colorado
Welcome!

The organizing committee and the Colorado AIPG Section would like to welcome each of you to Broomfield, Colorado and the 50th Annual American Institute of Professional Geologists Meeting. Whether you flew into Denver’s state-of-the-art DIA airport, drove across the High Plains from the East, or came over the Continental Divide from the West, we sincerely thank you for making the trip. The theme for this year’s meeting is Geology Serving Society: Energy Independence, Mineral and Water Resources, and Geologic Education. We are bringing geologists together from across the nation and from across a broad spectrum of geologic professions; oil and gas, mineral exploration, resource development, environmental compliance and remediation, and energy fuels. The diverse program and technical sessions, coupled with the wide-ranging diversity of the field trips, will ensure that there will be plenty of interesting information for all of the meeting attendees. Technical sessions are open to all registrants.

We have a diverse group of co-sponsors for this year’s annual meeting. These included the Denver Regional Exploration Geologists’ Society (DREGS), The Grand Junction Geological Society (GJGS) and the Rocky Mountain Association of Environmental Professionals (RMAEP). Each of these groups brings its own culture and interests to the Annual Meeting and are welcomed sponsors and participants in the event.

Many people have worked quite diligently for several years to put together this meeting. The AIPG headquarters staff; Cathy Duran, Wendy Davidson and Executive Director, Bill Siok have all worked long hours planning this event. In addition to the headquarters staff, the Planning Committee has been working over a year assembling the program and vetting the technical sessions. Planning Committee members include Larry Cerrillo, Dr. Larry Anna, Dr. Jim Burnell, David Abbott, Sue Abbott, Tom Cavanaugh, Ed Baltzer, John Galey, Cindy Cason, Graham Closs and Dick Nielsen. They are a very talented group of people and every one of them is an accomplished geologist. It has been a pleasure working with them.

Again, welcome to Colorado and welcome to the 50th Annual Meeting of the AIPG. Please participate to your fullest in the program offerings and try to stay on for a few days to take advantage of the change of seasons and Colorado’s colorful display.

Sincerely;
Matthew J. Rhoades, CPG, RG
50th Annual Meeting Chairman
### AIPG Active Charter Members

Adolf U. Honkala, CPG-7 *
Dorman N. Farmer, CPG-16
William H. Kay, CPG-26
Jay Glenn Marks, CPG-48
Joseph G. Wargo, CPG-54
Hugh W. Dresser, CPG-57
Robert J. Weimer, CPG-98 *
John M. Sweet, CPG-126
Wyman Harrison, CPG-134
William V. Knight, CPG-153
John H. Dolloff, CPG-180
James A. Barlow Jr., CPG-199
Ben H. Parker Jr., CPG-212
Erwin L. Single, CPG-247
William J. Wayne, CPG-250
Thomas R. Marshall Jr., CPG-270
David R. Martin, CPG-271
William E. Long, CPG-293 *
James A. Martin, CPG-294
Wolfgang E. Elston, CPG-301
Eugene Aleshin, CPG-307
Willard E. Cox, CPG-321 *
Robert E. Long, CPG-338
Charles E. Melbye, CPG-344
Theodore D. Sheldon, CPG-353
James H. Williams, CPG-374 *
Thomas L. Grose, CPG-379
Peter T. Flawn, CPG-430
Robert D. Cowdery, CPG-537
Willard J. Classen Jr., CPG-524
Richard D. Hagni, CPG-549
William J. Lemay, CPG-574
Ernest E. Russell, CPG-579
Ernest K. Lehmann, CPG-583
M. Dean Kleinkopf, CPG-593
John G. Troster, CPG-596
Thomas E. Kelly Jr., CPG-625
Glen L. Faulkner, CPG-635 *
Frank L. Stanonis, CPG-636 *
Ben Donegan, CPG-648
Kay C. Havenor, CPG-673
Verne E. Dow, CPG-732

* Members in Attendance (as of 10/2/2013)
## Daily Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Wednesday October 23</th>
<th>Thursday October 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>7:30 am-5:00 pm Centennial Foyer</td>
<td>7:30 am-5:00 pm Centennial Foyer</td>
</tr>
<tr>
<td>Breakfast (open to all registrants)</td>
<td>7:00 am-8:30 am Taproom &amp; Terrace</td>
<td>7:00 am-8:30 am Interlocken Ballroom BCD</td>
</tr>
<tr>
<td>Technical Sessions (open to all registrants)</td>
<td>8:30 am-5:00 pm (see pg 12 for the detailed schedule)</td>
<td></td>
</tr>
<tr>
<td>Morning Break (open to all registrants)</td>
<td>10:00 am-10:30 am Interlocken Ballroom BCD</td>
<td></td>
</tr>
</tbody>
</table>
| Lunch (open to all registrants) |                                                           | 11:45 am-1:00 pm Interlocken BCD Keynote Speaker | John Harpole  
Mercator Energy  
Littleton, CO |
| Afternoon Break (open to all registrants) | 2:40 pm-3:10 pm Interlocken Ballroom BCD |                                               |
| Reception (open to all registrants) | 6:30 pm-8:30 pm Interlocken Ballroom BCD |                                               |
| Purchased Field Trips & Guest Trips | See page 6 for Details | See page 6 for Details                      |
| Awards Dinner (all welcome with additional fee) | 6:00 pm-8:30 pm Centennial Ballroom |                                               |

### Front Cover Photos

1. Red Rocks, Photo Courtesy of Bob Ash and Visit Denver
2. Rocky Mountain National Park, Photo Courtesy of Bruce Boyer and Visit Denver

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2013 AIPG 50th Anniversary Conference-Geology Serving Society
## Daily Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registration</strong></td>
<td>7:30 am-5:00 pm</td>
<td>7:30 am-3:00 pm</td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Centennial Foyer</td>
<td>Centennial Foyer</td>
</tr>
<tr>
<td><strong>Breakfast</strong></td>
<td>7:00 am-8:30 am</td>
<td>7:00 am-8:30 am</td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Interlocken Ballroom BCD</td>
<td>Centennial Ballroom</td>
</tr>
<tr>
<td><strong>Technical Sessions</strong></td>
<td>8:00 am-4:30 pm</td>
<td></td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>(see pg 18 for the detailed schedule)</td>
<td></td>
</tr>
<tr>
<td><strong>AIPG Executive Committee/Advisory Board Meetings</strong></td>
<td>8:00 am-5:00 pm</td>
<td></td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Private Dining Room</td>
<td></td>
</tr>
<tr>
<td><strong>Exhibits</strong></td>
<td>9:00 am-5:00 pm</td>
<td></td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Interlocken Ballroom BCD</td>
<td></td>
</tr>
<tr>
<td><strong>Morning Break</strong></td>
<td>9:40 am-10:10 am</td>
<td>10:00 am-10:30 am</td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Interlocken Ballroom BCD</td>
<td>Garden Foyer B</td>
</tr>
<tr>
<td><strong>Lunch</strong></td>
<td>11:50 am-1:00 pm</td>
<td>12:00-1:00 pm</td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Interlocken BCD</td>
<td>Aspen</td>
</tr>
<tr>
<td><strong>Keynote Speaker</strong></td>
<td>Ian Miller</td>
<td></td>
</tr>
<tr>
<td><strong>Denver Museum of Nature &amp; Science</strong></td>
<td>Denver, CO</td>
<td></td>
</tr>
<tr>
<td><strong>Afternoon Break</strong></td>
<td>2:40 pm-3:10 pm</td>
<td>3:00 pm-3:30 pm</td>
</tr>
<tr>
<td>(open to all registrants)</td>
<td>Interlocken Ballroom BCD</td>
<td>Garden Foyer B</td>
</tr>
<tr>
<td><strong>Popcorn and a Movie</strong></td>
<td>4:45 pm-6:15 pm</td>
<td></td>
</tr>
<tr>
<td>“Switch” (open to all registrants)</td>
<td>Interlocken BCD</td>
<td></td>
</tr>
<tr>
<td><strong>Feature Length Documentary on Global Energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Purchased Field Trips &amp; Guest Trips</strong></td>
<td>See page 7 for Details</td>
<td>See page 7 for Details</td>
</tr>
</tbody>
</table>
## Program at a Glance

### Wednesday October 23, 2013

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>7:30 am-5:00 pm</td>
</tr>
<tr>
<td><em>Field Trip — Cripple Creek &amp; Victor Open Pit Large Surface Gold Mine Tour</em></td>
<td>8:00 am-6:00 pm</td>
</tr>
<tr>
<td><em>Field Trip — Henderson Molybdenum Underground Mine Tour</em></td>
<td>8:00 am-5:00 pm</td>
</tr>
<tr>
<td><em>Field Trip — General Shale Brick Plant and Quarry Tour</em></td>
<td>8:00 am-3:30 pm</td>
</tr>
<tr>
<td><em>Field Trip — Front Range Geology and Tectonic Setting</em></td>
<td>8:00 am-5:00 pm</td>
</tr>
<tr>
<td><em>Field Trip — Dinosaurs of the Front Range and Their Geologic Setting</em></td>
<td>8:45 am-4:45 pm</td>
</tr>
<tr>
<td>Welcome Reception — Exhibit Area Open</td>
<td>6:30 pm-8:30 pm</td>
</tr>
</tbody>
</table>

### Thursday October 24, 2013

<table>
<thead>
<tr>
<th>Event</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration</td>
<td>7:30 am-5:00 pm</td>
</tr>
<tr>
<td>Technical Sessions (see Technical Session Schedule on pg 12)</td>
<td>8:30 am-5:00 pm</td>
</tr>
<tr>
<td><em>Guest Trip — Front Range Foot Hills Tour Including Red Rocks, Lookout Mountain, and Buffalo Bill's Museum and Grave</em></td>
<td>8:30 am-4:00 pm</td>
</tr>
<tr>
<td>Exhibits Open — Interlocken Ballroom BCD</td>
<td>9:00 am-5:00 pm</td>
</tr>
<tr>
<td><em>Guest Trip — Celestial Seasonings Tour, Lunch at Dushanbe Tea House and Shopping in Boulder (lunch on your own)</em></td>
<td>10:00 am-4:00 pm</td>
</tr>
<tr>
<td>Foundation of the AIPG Meeting — Boardroom (open to all registrants)</td>
<td>4:00 pm-5:00 pm</td>
</tr>
<tr>
<td>AIPG Awards, Dinner and Entertainment (all welcome with additional fee)</td>
<td>6:00 pm-8:30 pm</td>
</tr>
</tbody>
</table>

*All field trips/guest trips will depart and return to the Omni Interlocken Resort from the Garden Level East Entrance (take stairs down located near the registration desk).*
| **Friday**  
| **October 25, 2013** | **Saturday**  
| **October 26, 2013** |
|---------------------|---------------------|
| **Registration**   | **Registration**   |
| Centennial Foyer   | Centennial Foyer   |
| 7:30 am-5:00 pm    | 7:30 am-3:00 pm    |
| **Technical**      | **AIPG Executive** |
| Sessions (see **Session Schedule on pg 18**) | Committee Meeting *(open to all registrants)* |
| 8:00 am-4:30 pm    | Private Dining Room |
|                    | 8:00 am-12:00 noon |
| **Guest Trip — Rocky Mountain Arsenal National Wildlife Refuge Tour and Butterfly Pavilion (lunch & entrance to the Butterfly Pavilion on your own)** | **Field Trip — The Consequences of Living with Geology: A Model Field Trip for the General Public** |
| 8:00 am-4:45 pm    | 8:00 am-4:00 pm    |
| **Guest Trip — Downtown Denver to Museums Old and New (lunch on your own)** | **Field Trip — The Central City-Idaho Springs Au-Ag Mining District** |
| 9:00 am-4:00 pm    | 8:00 am-5:00 pm    |
| **Exhibits Open — Interlocken Ballroom BCD** | **Field Trip — Pleistocene and Recent Floods of the Big Thompson River Drainage, Northern Colorado** |
| 9:00 am-5:00 pm    | 8:00 am-5:00 pm    |
| **Exploratory Meeting for Possible AIPG Fellows Program** | **Field Trip — The Geology, Mineralogy, and Mining History of the Leadville District** |
| Interlocken Ballroom BCD | 8:00 am-6:00 pm |
| 2:15 pm-2:45 pm    |                    |
| **Popcorn and a Movie — “SWITCH” Feature Length Documentary on Global Energy (open to all registrants)** | **AIPG Advisory Board Meeting (open to all registrants)** |
| Interlocken Ballroom BCD | Private Dining Room |
| 4:45 pm-6:15 pm    | 1:00 pm-4:30 pm    |
|                    |                    |
| **AIPG 2013-2014 Joint Executive Committee Meeting & Business Meeting (open to all registrants)** | **AIPG 2013-2014 Joint Executive Committee Meeting & Business Meeting (open to all registrants)** |
|                    | Private Dining Room |
|                    | 4:30 pm-5:00 pm    |
Technical Sessions

Thursday, October 24, 2013  8:30 am-10:00 am

Interlocken Ballroom BCD

Plenary Session

• Welcome
  Matthew Rhoades, CPG, 2013 Conference Chairman

• 2013 AIPG President
  Ronald Wallace, CPG

• New Reserves in an Old Field, the Niobrara Resource Play in the Wattenberg Field, Denver Basin, Colorado
  Dr. Steve Sonnenberg, CPG, Colorado School of Mines, Golden, CO

• Marketing Hydraulic Fracturing
  Amy Oliver Cooke, Independence Institute, Denver, CO

El Dorado Canyon-Photo Courtesy of Visit Denver
### Technical Sessions

**Thursday, October 24, 2013**  
10:30 am-11:45 am

#### Session 1A - Interlocken A

**Resource Development**

- Moderator - Larry Cerrillo, CPG, CO

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30-</td>
<td><strong>Federal Issues Affecting the Oil and Natural Gas Industry in the West</strong></td>
</tr>
<tr>
<td>10:55-</td>
<td>Kathleen Sgamma, Western Energy Alliance, CO</td>
</tr>
<tr>
<td>10:55-</td>
<td><strong>Mining - Energy Security and Independence for the World</strong></td>
</tr>
<tr>
<td>11:20-</td>
<td>Stuart Sanderson, Colorado Mining Association, CO</td>
</tr>
<tr>
<td>11:20-</td>
<td><strong>The Dynamics of the Uranium Market in a Growing Nuclear Industry</strong></td>
</tr>
<tr>
<td>11:45-</td>
<td>Jim Graham, NFC Consulting LLC and Anatolia Energy Ltd, CO</td>
</tr>
</tbody>
</table>

#### Session 1B - Centennial F

**Geologic Hazards**

- Moderator - Edward Baltzer, CPG, CO

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30-</td>
<td><strong>Avalanches: An Enigma for People and Industry</strong></td>
</tr>
<tr>
<td>10:55-</td>
<td>Dale Atkins, American Avalanche Association, CO</td>
</tr>
<tr>
<td>10:55-</td>
<td><strong>Active Volcanism in Kamchatka and Hawaii</strong></td>
</tr>
<tr>
<td>11:20-</td>
<td>Steven Anderson, University of Northern Colorado, CO</td>
</tr>
<tr>
<td>11:20-</td>
<td><strong>Innovative Landslide Repair Concepts, Including the Use of Ballistic Soil Nails for Shallow Landslide and Erosion Mitigation</strong></td>
</tr>
<tr>
<td>11:45-</td>
<td>Justin Jones, GeoStabilization Int’l., CO</td>
</tr>
</tbody>
</table>

#### Session 1C - Interlocken BCD

**State Geologist Panel**

- Moderator - Bill Siok, CPG, CO

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30-</td>
<td><strong>Jonathan Price, CPG, NV State Geologist Emeritus</strong></td>
</tr>
<tr>
<td>10:30-</td>
<td><strong>Scott Tinker, CPG, TX State Geologist</strong></td>
</tr>
<tr>
<td>10:30-</td>
<td><strong>David Wunsch, MEM, DE State Geologist</strong></td>
</tr>
</tbody>
</table>

**Luncheon Keynote Speaker**

John Harpole, Mercator Energy, CO  
The Future of Natural Gas in the U.S.

Interlocken Ballroom BCD  
11:45 am-1:00 pm
### Technical Sessions

**Thursday, October 24, 2013 1:00 pm-2:40 pm**

#### Session 2A - Interlocken A

**Hydrology**
- **Moderator** - Larry Cerrillo, CPG, CO
- **1:00-1:25**
  - *Keystone Heights, Florida: The Search for NEW Water*
  - Peter Schreuder, CPG, Schreuder, Inc., FL
- **1:25-1:50**
  - *Interaction of Groundwater and Surface Water in the Williston and Powder River Structural Basins*
  - Jennifer Bednar, U.S. Geological Survey, SD
- **1:50-2:15**
  - *Aquifer Storage - Opportunities in the Lost Creek Basin, Colorado*
  - Ralf Topper, CPG, Colorado Division of Water Resources, CO
- **2:15-2:40**
  - *The Heterogeneous Conejos Aquifer in the Eastern San Juan Mountains of Rio Grande County, Colorado*
  - Robert Kirkham, CPG, GeoLogical Solutions, CO

#### Session 2B - Centennial F

**Mining**
- **Moderator** - Jim Burnell, CPG, CO
- **1:00-1:25**
  - *The Hermosa Ag Project, Santa Cruz County, Arizona — An Update*
  - Thomas Bidgood, MEM, MineMappers LLC, CO
- **1:25-1:50**
  - *Rare-Earth Elements and the Bear Lodge Project, Wyoming*
  - Donald Ranta, CPG, Rare Element Resources Ltd., CO
- **1:50-2:15**
  - *Major Silver Districts of the Western United States: Their Relative Importance to Current and Past North American Silver Production*
  - Paul Hohbach, CPG, Coeur d’Alene Mines Corp., ID
- **2:15-2:40**
  - *The Cresson Mine - The Past, Present and Future of Colorado’s Largest Gold Mining Operation*
  - Timothy Brown, Cripple Creek and Victor Gold Mining Company, CO
<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:00</td>
<td>David Abbott, CPG, CO</td>
<td>Imaging and Modeling Large-Scale Laramide Thrust Detachment: Results From the NSF-EarthScope Bighorn Project, with Implications to Hydrocarbon Resource Plays</td>
</tr>
<tr>
<td>1:25</td>
<td>Eric Erslev, University of Wyoming, CO</td>
<td>A Rotated Block Complex Located Between Large Strike-slip Faults in Colorado’s Northern Front Range</td>
</tr>
<tr>
<td>1:50</td>
<td>Matthew Rhoades, CPG, Consultant, CO</td>
<td>The Late Eocene Castle Rock Conglomerate Fluvial System and Newly Documented Tributary Streams, East-Central Colorado</td>
</tr>
</tbody>
</table>

**Silent Auction**

**Bidding Ends Friday at 1:30 pm**

**Auction Winners will be Announced During the Afternoon Break**
### Technical Sessions

#### Thursday, October 24, 2013 3:10 pm-4:50 pm

<table>
<thead>
<tr>
<th>Session 3A - Interlocken A</th>
<th>Oil &amp; Gas Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moderator - <strong>Larry Anna</strong>, CPG, CO</td>
<td></td>
</tr>
<tr>
<td>3:10- U.S. Oil Shale – An Important Domestic Energy Resource</td>
<td>Tracy Boyd, National Oil Shale Association, CO</td>
</tr>
<tr>
<td>3:35- <strong>Secondary Containment</strong> - Regulations and <strong>Best Management Practices</strong></td>
<td>Beth Powell, New Pig Corporation, PA</td>
</tr>
<tr>
<td>3:35- <strong>POGO – GOLD ALL OVER!!</strong> - New Deposits, Updated Exploration Model, and Current Thoughts</td>
<td>David Larimer, Sumitomo Metal Mining Pogo LLC, AK</td>
</tr>
<tr>
<td>4:00- <strong>A Day in the Life of a Barrel of Water</strong></td>
<td>Robin Watts, Linde, TX</td>
</tr>
<tr>
<td>4:00- <strong>Lessons Learned in Shale Development Water Management and Treatment</strong></td>
<td>CDM Smith, TX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 3B - Centennial F</th>
<th>Alaska Mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moderator - <strong>Jim Burnell</strong>, CPG, CO</td>
<td></td>
</tr>
<tr>
<td>3:10- <strong>Fort Knox, Alaska</strong></td>
<td></td>
</tr>
<tr>
<td>3:35- Chris Ekstrom, CPG, Fairbanks Gold Mining, Inc., AK</td>
<td></td>
</tr>
<tr>
<td>3:35- <strong>POGO – GOLD ALL OVER!!</strong> - New Deposits, Updated Exploration Model, and Current Thoughts</td>
<td>David Larimer, Sumitomo Metal Mining Pogo LLC, AK</td>
</tr>
<tr>
<td>4:00- <strong>The Pebble Cu-Au-Mo Deposit, Alaska: An Update on Geologic Investigations</strong></td>
<td>Paul Jensen, CPG, Pebble Limited Partnership, AK</td>
</tr>
<tr>
<td>4:25- <strong>The Greens Creek Deposit, An Exploration Overview 1973-Present</strong></td>
<td>Rob Davidson, Hecla Greens Creek Mining Co., AK</td>
</tr>
</tbody>
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2013 AIPG 50th Anniversary Conference-Geology Serving Society
Technical Sessions

Thursday, October 24, 2013  3:10 pm-4:50 pm

Session 3C - Interlocken BCD

Environmental

• Moderator - Stephanie Jarvis, SA, IL

3:10 - Pump and Treat as a Remedy: Perhaps It Works
Gerald Kirkpatrick, CPG, Environmental Standards, Inc., PA

3:35 - After All
Gerald Kirkpatrick, CPG, Environmental Standards, Inc., PA

3:35 - TDS: Natural or Anthropogenic, The Results of an Optimization Study on a Groundwater Pump and Treat System
Todd Knause, CPG, Stanley Consultants, IA

4:00 - Of an Optimization Study on a Groundwater Pump and Treat System
Todd Knause, CPG, Stanley Consultants, IA

4:00 - In-Situ Design Considerations of Using Various High pH Activators for Sodium Persulfate
Gary Cronk, JAG Consulting Group, CA

4:25 - Evaluating Electromigration and Electroosmotic Remediation of Road Salt Contamination in Soils
Brent Huntsman, CPG, Terran Corporation, OH

Supporting Conference Organizations

Denver Region Exploration Geologists’ Society (DREGS)

Grand Junction Geological Society (GJGS)

Rocky Mountain Association of Environmental Professionals (RMAEP)

Thank You for Your Support!
### Technical Sessions

**Friday, October 25, 2013  8:00 am-9:40 am**

<table>
<thead>
<tr>
<th>Session 4A - Interlocken A</th>
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<tbody>
<tr>
<td><strong>Geocopia</strong></td>
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<tr>
<td>Moderator - <em>Larry Anna</em>, CPG, CO</td>
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<tr>
<td>8:00- <strong>Geothermal Heat Flow Determinations in Colorado and on Mars</strong>  Paul Morgan, Colorado Geological Survey, CO</td>
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<tr>
<td>8:25- <strong>Used Fuels Disposition in the United States</strong>  Larry Stetler, CPG, SD School of Mines and Technology, SD</td>
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<tr>
<td>8:50- <strong>New Suspected Kimberlite: Northern Colorado</strong>  Stephanie Gallegos, Metropolitan State University of Denver, CO</td>
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<tr>
<th>Session 4B - Centennial F</th>
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<tr>
<td><strong>Mining</strong></td>
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<tr>
<td>Moderator - <em>Jim Burnell</em>, CPG, CO</td>
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<tr>
<td>8:00- <strong>Carbonate Geochemistry of Yorke Peninsula, South Australia</strong>  Keryn Wolff, SA, University of Adelaide, South Australia</td>
</tr>
<tr>
<td>8:25- <strong>20 Years After: A Brief Update on the Study of Telluride Deposits</strong>  Bruce Geller, Colorado School of Mines Geology Museum, CO</td>
</tr>
<tr>
<td>9:15- <strong>Is the Concept of the Colorado Mineral Belt the Best Way to Understand the Distribution of Epithermal Ore Deposits in Colorado?</strong>  Matthew Morgan, Colorado Geological Survey, CO</td>
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</table>
Technical Sessions

Friday, October 25, 2013  9:40 am-10:10 am

Poster Session

New Suspected Kimberlite: Northern Colorado
Stephanie Gallegos, Metropolitan State University of Denver, CO

Limitations of GIS in Mapping Papyrus Along the Egyptian Nile River
Eve Iversen, Iowa State University, IA

Managing Geopolitical Risk in the Mining Industry
Andrew Katen, Geopolitical Risk Analyst, CO

Passive Treatment of Contaminants Using Sustained-Release Oxidants: Laboratory, Modeling and Field Scale Efforts
Troy Lizer, Carus Corporation, IL

A Paleoenviromental Analysis of the Middle Devonian Gravel Point Formation, Western Michigan
Joseph Mohan, Central Michigan University, MI

Ferrous Sulfate Effects on High pH Soils
Taylor Sting, PM Environmental/Michigan State University, MI

Carbonate Geochemistry of Yorke Peninsula, South Australia
Keryn Wolff, SA, University of Adelaide, South Australia

Poster Presenters will be Available at their Posters Friday During the Morning Break

Interlocken Foyer  9:40 am-10:10 am

Student Poster Contest Results will be Announced Friday During the Afternoon Break
Technical Sessions

Silent Auction

Be Sure to Stop by the Centennial Foyer and Bid on Your Favorite Items!!

All proceeds go to the Foundation of the AIPG

2013 AIPG 50th Anniversary Conference—Geology Serving Society
# Technical Sessions

## Session 5A - Interlocken A

### Professional / Legal

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>10:10</td>
<td>Making Effective Geologic Presentations</td>
<td>Robert Stewart, CPG, ARCADIS U.S., Inc., CT</td>
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<tr>
<td>10:35</td>
<td>Handshake Deals and Bar Napkin Agreements-The Strategic Use and Risks of Preliminary Agreements</td>
<td>Anne Weber, CPG, Weber Law Firm, CO</td>
</tr>
<tr>
<td>11:00</td>
<td>Managing Geopolitical Risk in the Mining Industry</td>
<td>Andrew Katen, SA, Geopolitical Risk Analyst, CO</td>
</tr>
<tr>
<td>11:00</td>
<td>The Milestone Solution Potash Mine-A World Class Project in the Making</td>
<td>Greg Vogelsang, Western Potash Corp, Canada</td>
</tr>
</tbody>
</table>

## Session 5B - Centennial F

### Mining / Industrial Minerals

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Title</th>
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<tbody>
<tr>
<td>10:10</td>
<td>Impact of Hydrocarbon Development on Industrial Mineral Availability in Eastern Ohio</td>
<td>Mark Wolfe, Ohio Division of Geological Survey, OH</td>
</tr>
<tr>
<td>11:00</td>
<td>The Often Overlooked Use of Polarized Light Microscopy in the Mining Industry</td>
<td>Daniel Linder, CPG, RJ Lee Group Inc., PA</td>
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</tbody>
</table>
## Session 5C - Pine

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Presenter</th>
<th>Location</th>
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<tbody>
<tr>
<td>10:10-</td>
<td>Recent Trends and Prevention for a Significant Occupational Hazard for Scientists and Engineers and Other Field Workers: Coccidioidomycosis: (Valley Fever)</td>
<td>James Jacobs, CPG, Clearwater Group, CA</td>
<td>10:35</td>
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<tr>
<td>10:35-</td>
<td>History of the Naval Industrial Reserve Ordnance Plant (NIROP) National Priority List Site, Fridley, Minnesota</td>
<td>Harvey Pokorny, CPG, NAVFAC MW, IL</td>
<td>11:00</td>
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<tr>
<td>11:00-</td>
<td>Soil Gas Investigation at a Buried Drum Disposal Site Used to Aid in the Remedial Design of an SVE Well Remediation Network</td>
<td>David Heidlauf, ENVIRON International Corp., IL</td>
<td>11:25</td>
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<tr>
<td>11:25-</td>
<td>Water Well “Problems” in Areas of Unconventional Resource Developments: Appearances are Deceiving and Solutions are Many’</td>
<td>John Fontana, Vista GeoScience, CO</td>
<td>11:50</td>
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### Luncheon Keynote Speaker

**Ian Miller, Denver Museum of Nature & Science, CO**

*Digging Snowmastodon: Discovering an Ice Age World in the Colorado Rockies*

Interlocken Ballroom BCD 11:50 am-1:00 pm
Friday, October 25, 2013  
1:00 pm-2:40 pm

**Session 6A - Interlocken A**

**Professional**

- **Moderator** - David Abbott, CPG, CO

1:00- Developing a Competencies Profile for the Profession of Geoscience for Canada - A Snapshot of the Start of a Journey
Oliver Bonham, Geoscientists Canada, Burnaby, BC

1:25- 'Non-Geo' Skills and Perspectives - An Essential Basis, Alongside 'Geo-Skills', for Effective and Ethical Professional Practice in the Geosciences
Ruth Allington, European Federation of Geologists, United Kingdom

1:50- Educational and Professional Standards for a Global Profession: Introducing Information Developed as Part of the IUGS Task Group on Global Geoscience Professionalism Website
Barbara Murphy, CPG, Clear Creek Associates, AZ

2:15- Know the Assumptions Underlying a “Best Practice”
David Abbott Jr., CPG, Consulting Geologist LLC, CO

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**Session 6B - Centennial F**

- **Moderator** - Tom Cavanaugh, CPG, CO

1:00- Rare-Earth Elements in Uraninite - Breccia Pipe Uranium District Northern Arizona, USA
Karen Wenrich, CPG, Economic Geologist, CO

1:25- Black Range Minerals Limited and Ablation
Patrick Siglin, CPG, Black Range Minerals Limited, CO

1:50- Permitting the Piñon Ridge Uranium and Vanadium Mill
Frank Filas, Energy Fuels Resources (USA) Inc., CO

2:15- Strategies for Uranium Exploration & Development in Uravan Mineral Belt, Montrose County, Colorado - Nuvemco, LLC
Tom Cavanaugh, CPG, AMEC Environment & Infrastructure, CO
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<tr>
<th>Time</th>
<th>Session</th>
<th>Presenter</th>
<th>Institution</th>
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<tr>
<td>1:00</td>
<td>Controls on Slope Erosion at Badlands</td>
<td>Larry Stetler</td>
<td>South Dakota School of Mines and Technology, SD</td>
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<td>1:25</td>
<td>National Park</td>
<td>David Noe</td>
<td>Colorado Geological Survey, CO</td>
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<td>1:25</td>
<td>STATEMAP Geologic Mapping in Colorado - Reaping Many Benefits</td>
<td>Willy Lynch</td>
<td>Esri, CO</td>
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<tr>
<td>1:50</td>
<td>“Clancy Mining’s” ArcGIS Online GIS Platform Solution for Geoscientific Data Management, Analysis and Collaboration</td>
<td>Jared Shank</td>
<td>Wright State University, OH</td>
</tr>
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Friday, October 25, 2013 1:00 pm-2:40 pm

Session 6C - Pine

Mapping

• Moderator - Matthew Rhoades, CPG, CO

2013 AIPG 50th Anniversary Conference-Geology Serving Society
## Technical Sessions

### Session 7A - Interlocken A

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>3:10</td>
<td>The Three G's: Geohazards, Geology and Groundwater, a Case Study of</td>
<td>Peter Barkmann, CPG, Colorado</td>
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<td>What Went Wrong and What we Might Learn in Jefferson County,</td>
<td>Geological Survey, CO</td>
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<tr>
<td>3:35</td>
<td>Bangladesh Responds to Rising Sea Levels by Raising Sea Dike</td>
<td>Barney Popkin, CPG, ADB-Ban</td>
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<td>Embankments</td>
<td>Coastal Towns Infrastructure</td>
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<td>4:00</td>
<td>The Grapevine Hill Fault: A New Local Fault Discovered During</td>
<td>George Davis, CPG, Missouri</td>
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<td>Preliminary Geotechnical Exploration for Route Construction, US 50,</td>
<td>Department of Transportation, MO</td>
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<td>Osage Co., Missouri</td>
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### Session 7B - Centennial F

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<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>3:10</td>
<td>Early Mining History of the Carlin Trend 1874-1961 or How Small</td>
<td>Dean Heitt, CPG, Newmont Mining</td>
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<td>Mines Can Lead to Big Discoveries</td>
<td>Corporation, NV</td>
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<tr>
<td>3:35</td>
<td>Geology and Mineralization of the Exodus Gold Project, Eureka County</td>
<td>Joshua Townshend, Newmont Mining</td>
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<td>Nevada</td>
<td>Company, NV</td>
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<tr>
<td>4:00</td>
<td>Exploring Areas of Natural Acid Rock Drainage in Colorado</td>
<td>Matthew Sares, Colorado Division</td>
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<td>of Water Resources, CO</td>
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</tbody>
</table>
**Energy Issues**

**Moderator - Larry Anna, CPG, CO**

**3:10-3:35 Local and Regional Water Supply Planning to Evaluate and Manage Hydrofracking for Shale Gas Development**

Michael Lawless, CPG, Draper Aden Associates, VA

**3:35-4:00 Is the Oil and Gas Industry Really Unregulated?**

Doug Dennison, Bill Barrett Corporation, CO

**4:00-4:25 Quality Considerations for Baseline Sampling During Natural Gas Fracturing Activities**

Stephen Brower, Environmental Standards, Inc., PA

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**“Switch”**

Feature Length Documentary on Global Energy

Interlocken BCD 4:45 pm-6:15 pm
“Best Practices” are becoming an increasing part of professional geoscience practice. Failure to follow the “best practice” for a particular geoscience task can lead to charges of professional incompetence and malpractice. The problem is that the assumptions underlying a “best practice” are seldom provided and must be met in order for the “best practice” to be applicable to the task at hand. Several examples of deviations from or failures due to inappropriate use of a “best practice” will be provided including core splitting, testing for bentonite beds, high-grade sampling, and when fire assays are inapplicable will be discussed. When one deviates from a “best practice” one must carefully and fully explain in one’s report why the “best practice” was inapplicable and why the selected alternative practice employed provided a more scientifically suited solution to the task at hand in order to forestall allegations of professional incompetence. Indeed, knowing when a “best practice” is and is not applicable is demonstration of one’s professional competence.
‘NON-GEO’ SKILLS AND PERSPECTIVES - AN ESSENTIAL BASIS, ALONGSIDE ‘GEO-SKILLS’, FOR EFFECTIVE AND ETHICAL PROFESSIONAL PRACTICE IN THE GEO SCIENCES

Ruth Allington, European Federation of Geologists, United Kingdom, Barbara Murphy, AIPG, Isabel Fernandez-Fuentes, EFG, Oliver Bonham, Geoscientists Canada

The IUGS Task Group on Global Geoscience Professionalism (TGGGP) was launched at the 34th International Geological Congress in Brisbane (2012). The idea arose from a recognition by professional geoscience organisations that formation of an international network focusing on professionalism in geoscience in the service and protection of the public would be beneficial for three principal reasons:

• An international professional network:
Sharing of good practice in regulating the geoscience professions through registration, licensure and the award of professional titles. Providing to individual members of professional geoscience organisations information about registration and licensure requirements in other jurisdictions, thereby fostering mobility of labour.

• A resource for early career geoscientists, educators and their students:
Providing information and guidance on non-academic career paths in geoscience to assist in improving the linkages between academia and applied geoscience both to ensure relevance of teaching and careers advice and to connect better societal needs (delivered by applied geoscientists) with research agendas.

• A resource for governments and other public institutions, other professionals and the general public:
Accessible information on the roles and responsibilities of professional geoscientists; the significance of their work for public safety and sustainable development; explanations of the meaning of their qualifications; ethical and conduct codes binding on members of professional geoscience organisations; and reasonable public expectations of the standards of their work and their accountability for it.

This contribution will first consider what we mean by a ‘professional geoscientist’ and argue that ‘professionalism’ is just as relevant and important to geoscientists working in education and research as it is in applied fields. It will go on to explore what ‘non-geo’ skills and perspectives transform a competent technical or scientific practitioner with geoscientific qualifications and training into a truly professional practitioner and how and why this is important. Examples of ‘non-geo’ skills that will be described and considered are:
‘NON-GEO’ SKILLS AND PERSPECTIVES - AN ESSENTIAL BASIS, ALONGSIDE ‘GEO-SKILLS’, FOR EFFECTIVE AND ETHICAL PROFESSIONAL PRACTICE IN THE GEOSCIENCES
(Continued)

Communication (appropriate to audience)
Collaboration (interdisciplinary especially)
Project management
Financial management and planning
Strategic planning/business planning
Adaptability in the face of new information/findings
Leadership/team building
Management (especially people)
Problem definition
Mediation/Negotiation/Dispute avoidance
Risk assessment

European Federation of Geologists (EFG), American Institute of Professional Geologists (AIPG), Geoscientists Canada, Geological Society of South Africa (GSSA), Australian Institute of Geoscientists (AIG), and El Colegio de Geólogos de Bolivia (College of Geologists of Bolivia)
ACTIVE VOLCANISM IN KAMCHATKA AND HAWAII

Dr. Steven Anderson, Department of Earth and Atmospheric Sciences, University of Northern Colorado, CO

A pair of volcanic eruptions in different regions of the world highlights the need for unique approaches, technology, and methodology in order to better understand the way these volcanoes work, and to better mitigate hazards associated with them. The ongoing, >30 year long eruption of Kilauea in Hawaii is located in a fairly accessible region with a nearby population center (Hilo, Hawaii). The main hazards associated with the effusive eruptions of basaltic lava are mainly centered on the loss of property, danger to tourists, and the long-term effects of the gas emissions on downwind residents. The monitoring necessary to assess these hazards involves detailed and automated studies of the eruption dynamics with equipment that can be accessed, repaired and updated frequently, such as seismometers, tilt meters, gas sensors, and visual observations. These ground-based techniques are supplemented by satellite and fixed-wing remote sensing collections using LiDAR, RADAR interferometry, and thermal cameras. In contrast, the ~2 year eruption of the andesitic volcano Kizimen in Kamchatka is located in one of the most remote places on the planet; an animal refuge more than 20km from the nearest dirt road and a 10 hour drive to the nearest sizeable population center, with no humans living close enough to be directly impacted by the eruption. The main hazards associated with the explosive eruptions of Kizimen are to aviation as the prevailing winds carry ash plumes over the heavily flown polar routes. The monitoring available to study this eruption relies almost solely on satellite remote sensing platforms, supplemented with an occasional fixed wing overflight, and include thermal and radar studies designed to provide topography and temperature. Despite the differences in approach to studying these two volcanoes, some similar skills are needed for both. The ability to work with large spatial databases are becoming the norm for all volcanic hazards studies, as is the need to apply fluid dynamics models to either the flow of lava, or the movement of atmospheric ash plumes. Quantitative skills that allow the geologist to use large datasets are key to future studies in this area.
AVALANCHES: AN ENIGMA FOR PEOPLE AND INDUSTRY

Dale Atkins, American Avalanche Association, CO

These days the public views snow avalanches as a danger for skiers, snowmobilers and other winter sportsmen. However, avalanche dangers can have a significant affect on industry and commerce. To solve avalanche problems requires a blend of science and art to manage risk and uncertainty, and this presentation will look at the unique characteristics of snow avalanches and their dangers.
THE THREE G’S: GEOHAZARDS, GEOLOGY AND GROUNDWATER, A CASE STUDY OF WHAT WENT WRONG AND WHAT WE MIGHT LEARN IN JEFFERSON COUNTY, COLORADO

Peter E. Barkmann, CPG and Annette Moore, Colorado Geological Survey, Denver, CO

Near-surface groundwater has lead to slope failure beneath an engineered retaining wall at the Rocky Mountain Metropolitan Airport (RMMA) in Jefferson County, Colorado. At the request of the Colorado Department of Transportation, Colorado Division of Aeronautics, the Colorado Geological Survey (CGS) responded by performing a comprehensive hydrogeologic investigation of the area to aid in mitigation efforts and to prevent future groundwater-related problems. The investigation entailed compilation of existing geologic data, review of pre-development and post-development aerial imagery, detailed topographic analysis, new borehole drilling, and water level monitoring. Results showed that the geology of the failure site already includes many features that could lead to natural slope failure: multiple terrace features, permeable gravel terrace deposits above less permeable bedrock, permeable bedrock sand overlying impermeable shale, and fault/fracture patterns in bedrock nearly parallel to terrace breaks. Indeed, prehistoric landslides can be found throughout the area in similar settings. Furthermore, historic cultural modifications enhanced slope failure potential by building on failure-prone slopes, removing natural low permeability cover, and redirecting surface runoff to potential recharge areas. This case study illustrates the importance of developing a comprehensive understanding of geologic conditions before designing and building major facilities.
INTERACTION OF GROUNDWATER AND SURFACE WATER IN THE WILLISTON AND POWDER RIVER STRUCTURAL BASINS

Jennifer M. Bednar, U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD, jbednar@usgs.gov

Groundwater availability in the Lower Tertiary and Upper Cretaceous aquifer systems in the Williston and Powder River structural basins is currently being assessed by the U.S. Geological Survey (USGS). The Williston basin is located in parts of North Dakota, South Dakota, and Montana in the United States and Manitoba and Saskatchewan in Canada. The Powder River basin is located in parts of Montana and Wyoming. Both structural basins are in the forefront of energy development, with an increased demand for both surface water and groundwater uses. As part of this study, the interaction between groundwater and surface water is being quantified. Estimates of base flow, gaining streams, sinking streams, and reservoir interactions have all been computed. Streamflow records from more than 300 streamgages available in the USGS National Water Information System database were used in conjunction with the hydrograph separation software, PART, developed by the USGS. To eliminate interference from natural and anthropogenic processes associated with measuring streamflow, only fall estimates of base flow were used in the study. A net balance approach was used along stream reaches where streamgages were located. Base-flow estimates from PART were compared to actual streamflow measurements. The streamflow estimates were used in the final quantification of the interactions. A water budget for each mainstem reservoir along the Missouri River was completed using data from the U.S. Army Corps of Engineers. Most of the streams in the study area are gaining flow from the aquifers, whereas the main-stem reservoirs are recharging or contributing water to the underlying aquifers.
THE HERMOSA SILVER PROJECT, SANTA CRUZ COUNTY, ARIZONA—AN UPDATE

Dr. Thomas Bidgood, MEM, Minemappers LLC, Arvada, CO

The Hermosa silver (Ag) project is located in the Harshaw and Patagonia Mining Districts in the Patagonia Mountains of Santa Cruz County, Arizona, approximately six miles southeast of the town of Patagonia. Mining in the Harshaw District dates from Spanish Colonial times, but is poorly documented before the 1870’s. Records from the late 1800’s through the mid-1900’s report production estimates of 150,000 tons, yielding approximately two million ounces of silver with by-product lead, copper and manganese. ASARCO controlled the property (called Hardshell) from 1940 until 2005 when it was purchased by Wildcat Silver Corporation. ASARCO exploration programs between 1940 and 1991 discovered thick deposits of manganese oxides containing silver, lead and zinc in a manto/replacement geometry.

The Hermosa Ag-Mn-Pb-Zn mineralization is a stratigraphically- and structurally-controlled, manto type replacement deposit formed at the contact between Permian carbonate rocks and overlying late-Cretaceous rhyolitic volcanic rocks. Five distinct rhyolitic volcanic units have been identified in the Cretaceous rhyolite volcanic package, and these units are correlated across the property and in drill holes. The deposit and its host rocks strike approximately east-west and dip ± 35° to the north. They do not appear to be significantly disrupted by post-mineralization faulting. The dominant alteration associated with the manto-type mineralization is an asymmetric envelope of pervasive and strong silicification, referred to in the past as “jasperoid.” Mineralization has been subdivided into three mineralized material types defined by gangue characteristics, lithological host and grade profiles: 1) upper silver zone—oxidized rhyolites overlying manto-style mineralization contains irregular patches and zones of veinlet-controlled hematite-limonite and sooty Mn-oxide with Ag mineralization, 2) manganese replacement zone with silica gangue—rhyolitic volcanic units dominated by black, sooty Mn-oxide and quartz-dominant gangue mineralogy and Ag mineralization, 3) manganese replacement zone with carbonate gangue—black, sooty Mn-oxide with calcite-dominant gangue mineralogy and Ag mineralization.

Wildcat Silver initiated a drilling campaign to define and classify the Hermosa mineralization in December, 2010. Supporting geological mapping, geochemical sampling and airborne geophysical exploration, and metallurgical testing was completed as well. Results of that program are the subject of an updated Preliminary Economic Assessment (PEA) on Hermosa completed in October 2012. Hermosa’s current measured and indicated resources are 194 million tonnes averaging 37.7 grams per tonne silver, for a total of 236 million ounces of silver and an inferred resource of 80 million tonnes averaging 30.9 grams per tonne silver for a total of 79 million ounces of silver. Pre-feasibility studies and permitting are ongoing.
DEVELOPING A COMPETENCIES PROFILE FOR THE PROFESSION OF GEOSCIENCE FOR CANADA – A SNAPSHOT OF THE START OF A JOURNEY

Oliver Bonham, Geoscientists Canada, Burnaby, BC; Kate MacLachlan, Association of Professional Engineers and Geoscientists of Saskatchewan, Regina, SK; Bruce Broster, Department of Geology, University of New Brunswick, Fredericton, NB; and Keith Johnson, Consultant, Toronto, ON

In September 2012, Geoscientists Canada received funding from Human Resources and Skills Development Canada’s Foreign Credentials Recognition Program for a 30 month project to carry out four interrelated initiatives in the area of admissions support for its members - the provincial/territorial professional bodies that regulate geoscience practice in Canada. The central and largest initiative involves the development of a competency profile for the geoscience profession.

Competencies are defined by the Canadian Information Centre for International Credentials as “a set of knowledge, skills and abilities obtained through formal or non-formal education, work experience or other means, required to perform an occupation at the point of entry to a profession”.

A key rationale for development of a competency profile is the move by other professions both in Canada and around the world, away from traditional credentials-based admissions assessments towards a system that is based on a combination of academic outcomes and practice skills.

The resulting profile will address both academic competencies as well as abilities necessary to undertake geoscientific practice work, independent of direct supervision. Development of the profile will follow an iterative process that includes (1) input from Subject Matter Experts who are practising geoscientists and who represent a diverse sampling of the profession, (2) extensive consultation and (3) validation procedures.

Subsequent work will determine specific indicators of proficiency related to each competency that an individual is expected to demonstrate in order to become a P.Geo. and suggest appropriate methodologies to assess competencies.
U.S. OIL SHALE – AN IMPORTANT DOMESTIC ENERGY RESOURCE

Tracy Boyd, Member, Board of Directors, National Oil Shale Association, Denver, CO

Oil shale in the Green River Formation in Colorado, Utah and Wyoming is a major domestic energy resource in the United States that can contribute to energy and national security.

Significant progress has been made in oil shale research and development during the past years in the United States. Commercial projects have operated for decades outside U.S. borders. Millions of tons of oil shale have been mined and millions of barrels of shale oil produced around the world, including from plants here in the U.S. The experience gained from these projects gives developers an important tool to advance technology toward commercialization.

A technological renaissance similar to that being experienced in shale gas and tight oil development is on the brink of occurring in oil shale. But, significant challenges face a developer hoping to build a commercial oil shale project in the United States. Lack of consistent U.S. Federal policy for leasing and regulation, similar to what already exists for other minerals and oil & gas, is restraining long term investment.

The presentation will discuss how shale oil is produced from oil shale, the status of U.S. oil shale projects, the political and regulatory hurdles facing the industry, the benefits that will occur from its commercialization, the correction of myths surrounding the industry, and the confusion that currently exists about oil shale vs. tight oil terminology.
QUALITY CONSIDERATIONS FOR BASELINE SAMPLING DURING NATURAL GAS FRACTURING ACTIVITIES

Stephen D. Brower, P.G. (sbrower@envstd.com); Rock J. Vitale, CEAC, CPC, Gerald Kirkpatrick, P.G., CPG, Environmental Standards, Inc., Valley Forge, PA

The practice of drilling and subsequent hydraulic fracturing for natural gas in the Marcellus and Utica Shale formations has received intense media and regulatory agency attention. Baseline domestic well sampling is performed as a regulatory requirement to establish groundwater quality prior to commencement of drilling (baseline conditions). The quality of this pre-drilling data is critical in establishing pre-existing conditions and naturally-occurring geochemical variations in groundwater. It is also critical to properly document anthropogenic impacts that may occur during the life-cycle of unconventional gas production activities. These data are an important component of community relations, demonstrating regulatory compliance and strategic business risk management for the development of the gas resource while at the same time properly documenting groundwater quality.

A groundwater sample quality-management program for baseline groundwater sampling is presented to describe a robust and defensible baseline sampling program. The quality-management program can include: a needs assessment; quality control documents (Standard Operating Procedures and Sampling and Analysis Plans); sample team training and field auditing; data review; and data management. Regulatory baseline sampling requirements for three states (Pennsylvania, Ohio, and West Virginia) are discussed highlighting the variability in regulatory requirements for both the Marcellus Shale and Utica Shale.

Two case studies are also presented that demonstrate where a robust quality program would have quickly identified the source of suspected contaminants (a diol compound and poly-aromatic hydrocarbons) encountered during groundwater investigations related to unconventional gas production activities.
THE CRESSON MINE
THE PAST, PRESENT AND FUTURE OF COLORADO’S LARGEST GOLD MINING OPERATION

Timothy R. Brown, Exploration Manager, Cripple Creek and Victor Gold Mining Company, Victor, CO

Gold has been produced from the Cripple Creek Mining District since its discovery in 1891. Historic production from underground mines and small, shallow surface mines is approximately 20 million ounces (622 tonnes) of gold. Recent gold production, since 1995, by the Cripple Creek and Victor Gold Mining Company (a wholly-owned subsidiary of AngloGold Ashanti, Ltd.) is nearly 4.5 million ounces (140 tonnes). Current reserves include 5.9 million contained ounces (184 tonnes) of gold while the exclusive resources include an additional 7.0 million ounces (218 tonnes). This puts the total district endowment at nearly 37 million ounces (1,164 tonnes) of gold. This endowment makes Cripple Creek one of the most important gold districts in the world. More importantly, exploration activities continue in the district and new resources may be discovered.

The district is located between the towns of Cripple Creek and Victor in central Colorado where the dominant geologic feature is a 34-28 Ma diatreme-intrusive complex hosted at the junction of four Precambrian rock units. The main portion of the complex is 6.4 km long, 3.2 km wide and consists of a heterolithic diatremal breccia that has been intruded by stocks, dikes and discordant breccias. Early volcanic and intrusive rocks include alkaline phonolites, trachytes, phonotephrites and tephriphonolites, followed by later lamprophyres. Evidence, such as deeply buried carbonized wood, also suggests significant vertical movement during magmatism. All rocks have undergone a complex magmatic history and abundant hydrothermal alteration that is primarily characterized by a strong, pervasive flooding of K-feldspar. Gold mineralization, dated between 27.8 Ma and 26.6 Ma, is hosted in all rock types as veins and disseminated ore bodies. The deposit is well known for its quartz-poor, gold telluride-rich styles of mineralization. In addition to the gold tellurides, primary ore minerals include native gold and native gold with pyrite. Silver is present but has minimal economic importance.

All ore is currently processed on the Valley Leach Facility where a dilute solution of sodium cyanide is percolated through the crushed rock. The gold goes into solution and this pregnant solution is collected and pumped to the recovery facility. The leach pad currently holds over 300 million tons of rock. It will be filled with ore tons in late 2015 when it reaches its capacity of 400 million tons. Annual gold production from the operation is approximately 260,000 ounces.
THE CRESSON MINE
THE PAST, PRESENT AND FUTURE OF
COLORADO’S LARGEST GOLD MINING
OPERATION
(Continued)

Exploration activities have successfully replaced depletion for sev-
eral years and sufficient reserves exist to justify to construction of a
second Valley Leach Facility. The construction of the second leach
pad, with a capacity of 218 million tons, is currently underway and
the first gold will be poured in 2016. In addition to this project, a
new mill is also under construction to process higher grade material
and to increase gold recoveries through a gravity circuit, flotation,
and CIP. This mill will process nearly 2.0 million tpa of higher grade/
lower recovery material that is intersected in the open pit mining
operations.
STRATEGIES FOR URANIUM EXPLORATION & DEVELOPMENT IN URAVAN MINERAL BELT, MONTROSE COUNTY, COLORADO – NUVMEMCO, LLC

Tom Cavanaugh, CPG, AMEC Environment & Infrastructure, Golden, CO

The Uravan Mineral Belt in southwest Colorado has over a hundred years of uranium and vanadium production history, through a series of boom and bust cycles based on demands for the respective metals. The minerals deposited in the Salt Wash fluvial sandstone member of the Jurassic Morrison Formation were easily recognized, with the best mines concentrated in an arcuate area named the “Uravan Mineral Belt” by the USGS in 1952. Radium was the boom mineral in the early 1900’s. Vanadium demands by the alloy-steel industry kept mining in the Belt through World Wars I and II. The WWII effort of the Manhattan Project, stimulation by the Atomic Energy Commission through 1970, and growth of nuclear energy industry helped the uranium-vanadium mining efforts in the Uravan Mineral Belt stay vibrant into the 1980’s. While the US electrical production from nuclear power has stabilized at about 19%, uranium fuel prices have been kept artificially low by foreign imports and the “Megatons to Megawatts” agreement with Russia to recycle weapons-grade, highly enriched uranium. Following the Three Mile Island incident in 1979, most of the US and especially the Uravan mining industry nearly died for 20 years.

In 2004, with rising prices for yellowcake, many historic properties were restaked and mines reevaluated. Nuvemco targeted and began acquiring properties with known resources and development potential. Their strategy was to find good mineable properties with:

- existing infrastructure – roads and power;
- dry mines in areas with potential for rehabilitation;
- high historic grades of both uranium and vanadium;
- and of course, an eye for wive’s tales and rumors of remaining resources.

Nuvemco has assembled a nearly contiguous block of 12,000 acres including private and public land, with properties that are mining ready to exploratory in status. Regulatory compliance and permitting have been challenging during this transitory time of uranium mining rules from the BLM and DRMS in Colorado. They now have two Section 112d permits, two Notices of Intent to explore (which include opening old portals and drilling), and a Section 110d permit to remove and process an old ore pile. In 2010-11 they began mining ore at their Last Chance and Blue Streak mines, trucking it to the White Mesa Mill near Blanding, Utah. Other mines were readied for operations, but price drops made production uneconomic. Nuvemco has kept mines in standby maintenance mode and continued exploration underground and by...
STRATEGIES FOR URANIUM EXPLORATION & DEVELOPMENT IN URAVAN MINERAL BELT, MONTROSE COUNTY, COLORADO – NUHEMCO, LLC
(Continued)

drilling. Colorado has recently approved Energy Fuel’s Piñon Ridge Mill which is less than a mile from two of Nuvemco’s most promising mines.

The presentation will peek at a historic mining district and follow Nuvemco’s mapping, permitting, exploration, mining, and future plans in the heart of Colorado’s Uravan Mineral Belt.
IN-SITU DESIGN CONSIDERATIONS OF USING VARIOUS HIGH PH ACTIVATORS FOR SODIUM PERSULFATE

Gary Cronk, JAG Consulting Group, Santa Ana, CA

The use of high pH is a very aggressive means of activating sodium persulfate and destroying a wide variety of VOC contaminants. Injection design approaches may vary due to the numerous chemicals used to create the high pH conditions. This paper discusses the design considerations for three alkaline chemical solutions that are most commonly used for in-situ injections.

Initially, a bench scale laboratory test is required to accurately determine the soil buffering capacity of the site soils. Testing of soils from over 15 sites has shown that soil buffering capacity can vary by 10-fold from site to site. Calcareous rocks and sediments typically have the highest buffering capacities. Maintaining the pH over 10.5 for at least 24 to 48 hours is a critical factor in determining the ultimate success of a high pH activation project.

The most commonly used chemical for creating high pH conditions is sodium hydroxide (caustic), because of the ease in injecting a liquid solution. Generally, a 25% concentration of sodium hydroxide is used. Field injection considerations include mixing the caustic and the persulfate at the well head instead of mixing tank. This will minimize the rapid decomposition of persulfate radicals that typically occurs when chemicals are combined in a mixing tank.

Another common high pH activation chemical is the use of Klozur CR, a branded chemical consisting of 50% calcium peroxide (the high pH activator) and 50% sodium persulfate. Due the high variability in soil buffering capacity, this chemical should be tested using different ratios of the active ingredients (60% to 40% versus 50% to 50%) to determine which mixture will best maintain the pH over 10.5 for at least 24 hours.

Lastly, when treating soils within a UST excavation, a solid alkaline chemical such as Hydrated Lime (calcium hydroxide) is preferred because it can easily be mixed (along with sodium persulfate) with the soil using an excavator. Care is required to minimize corrosion of excavation equipment during the soil mixing process.
THE GREENS CREEK DEPOSIT, AN EXPLORATION OVERVIEW 1973-PRESENT

Rob Davidson, Senior Geologist, Hecla Greens Creek Mining Company, Juneau, AK

The Greens Creek Mine is located 18 miles south-southwest of Juneau, Alaska on Admiralty Island. Camp and port facilities are located along the shores of Hawk Inlet while the portal, mill, and support offices are accessed via an 8-mile road up Greens Creek Valley.

Greens Creek is located within the Insular Belt of the North American Cordillera. This belt is dominated by the Wrangellia Superterrane which is composed of the Alexander and Wrangellia Terranes. Greens Creek is within the Admiralty sub-terrane of the Alexander Terrane. The Alexander Terrane represents an allochthonous late Proterozoic island arc. Late Triassic rifting along the eastern margin of the Alexander Terrane allowed for generation and deposition of a belt of Triassic rocks and initiated a significant metallogenic episode. These Triassic rocks stretch over 600 km from Annette and Gravina islands in the southeast to Mt. Henry Clay and Windy Craggy to the northwest, and due to their associated mineral occurrences, have been termed the Alexander Triassic Metallogenic Belt by Taylor and Johnson. A series of transitional features within the mineralized occurrences of this belt suggest a southward propagating rift as the setting for the deposition of these rocks and the mineralization they host.

Greens Creek is a polymetallic massive sulfide deposit containing significant Ag, Zn, Pb, and Au, with lesser Cu. Ores are classified as massive if they contain greater than 50% combined galena, sphalerite, and pyrite. These ores are further subdivided into base metal or pyritic units based upon the ratio of combined sphalerite and galena to pyrite. Ores containing less than 50% combined galena, sphalerite, and pyrite are termed white ores and are subdivided into carbonate, baritic, or siliceous units based upon gangue mineralogy. Mineralization is strataform in geometry and stratabound in location, occurring at or very near the contact of footwall phyllites and hangingwall argillites. The deposit is structurally complex with at least four periods of deformation, resulting in complicated folding and overturned stratigraphy, and one period of brittle faulting, which is manifested as two major fault zones within the mine. The mine produces 2,200 tons per day using overhand cut and fill as well as longhole stoping methods. Through conventional gravity and flotation processes the mill produces three concentrates (Pb, Zn, and bulk) along with Au/Ag products. As of the end of 2011, the deposit contained a total metal endowment of 320 million ounces of Ag, 2.64 million ounces of Au, 812 thousand Tons of Pb, and 2.08 million Tons of Zn.

Discovery of the Greens Creek Deposit dates to 1973, when the Pan-Sound joint venture initiated a large grass-roots exploration program within northern Southeast Alaska. That year they
recognized anomalous Zn and Cu in stream silt samples from Cliff Creek. During follow up the next year, a ferricrete kill zone known as the “Big Sore” was quickly recognized from the air. Soil sampling and geophysics delineated coincident anomalies and 134 claims were staked. In 1975 the first drill hole, collared just downhill from the “Big Sore” intercepted 89 feet of .123 opt Au, 5.77 opt Ag, 2.04% Pb, 8.03% Zn, and .43% Cu. Drilling proceeded rapidly and by 1978 mineralization had been delineated over 2,750 feet along strike. The following year drifting of an underground drill platform was begun and by 1980 the operator believed they had 3 million tons at 10-16 opt Ag, .1 opt Au, 7-10% Zn, 2-2.5% Pb, and .5% Cu. Feasibility studies were accomplished and production began at 1,100 Tons per day in 1989. The mineralization initially defined was termed the East Ore zone. Since then, underground drilling has followed mineralization down plunge, down dip and through major structures to define a total of eight zones of mineralization. Current exploration continues to be guided by these strategies. The Deep 200 South, Galagher, and a portion of the Deep Southwest Zones are open down plunge and are primary targets. The down dip extent of the mineralized horizon is often very poorly defined once several hundred feet beyond known mineralization. Current plans include several deep holes testing this under-explored volume of rock directly down dip of producing ore zones. As it was in 1989 when production began, the exploration potential at Greens Creek remains high.
THE GRAPEVINE HILL FAULT: A NEW LOCAL FAULT DISCOVERED DURING PRELIMINARY GEOTECHNICAL EXPLORATION FOR ROUTE CONSTRUCTION, US 50, OSAGE CO., MISSOURI

George H. Davis, CPG, Central Office Geologist, Missouri Department of Transportation, Jefferson City, MO

During the winter of 2010 and through the summer of 2011, a preliminary engineering soil survey was conducted for the relocation of Route U.S. 50 in Osage County, Missouri. This 6.2-mile survey of the geology and soils precedes construction and upgrade for two additional lanes for U.S. 50 as well as relocates the road to a less curved alignment, enabling higher speeds for motorists. In conjunction with this survey, four resistivity traverses were conducted to investigate the efficacy of using this geophysical method for planning the number and spacing of borings on the subject route. Faculty-supervised students from Missouri University of Science and Technology (MS&T, formerly the University of Missouri-Rolla) completed the resistivity traverses which were post-processed and interpreted by faculty of MS&T.

One major resistivity anomaly was identified during these traverses on a ridge known as Grapevine Hill. This feature was investigated by drilling three rock cores at the location of, and on either side of the identified anomaly. The locations of these borings were chosen due to their proximity to a planned bridge for a county road connector. Originally, this anomaly was thought to be a filled-sink deposit. Instead, the identification of a 20-foot offset in a key bed of the Jefferson City Formation from one side of the anomaly to the opposite side identified the feature as a fault. Comparison of the processed resistivity profile to another profile from a known faulted area confirmed this interpretation. The feature seems to fit within the areal geologic framework, but was previously unknown. The existence of this fault has been verified during construction.
IS THE OIL & GAS INDUSTRY REALLY UNREGULATED?

Doug Dennison, Bill Barrett Corporation, Silt, CO

Many media reports, testimony at public hearings, and other commenters frequently state that the oil and gas industry is unregulated or there are too many “loopholes” in the regulations that apply to the industry. This presentation will provide background on the myriad Federal, state, and local regulations applicable to the industry, with an emphasis on Colorado. In addition to discussing the current state of the regulatory environment, a discussion will be provided of impending or proposed regulations that may have a significant impact on the industry. The chronology and facts behind the so-called “Halliburton Loophole” and other often misunderstood and misquoted regulatory issues will also be provided.
FORT KNOX, ALASKA

Chris Ekstrom, CPG and Arne Bakke, Fairbanks Gold Mining, Inc., Fairbanks, AK

The Fort Knox gold mine near Fairbanks, Alaska, began commercial production in 1997. Through 2012, 5.6 M oz of gold have been produced through conventional open-pit mining methods, by both milling and heap-leach processes. Annual, seasonal exploration drilling programs for reserve addition have been conducted since 1997. These programs have been successful in refining the geological model and extending the mine life.

Gold mineralization is hosted within a Late Cretaceous (92 Ma) granitic complex. Gold occurs within, and along the margins of pegmatite vein swarms, quartz veins and veinlets, and quartz-filled shear zones. Weak to moderate development of vein-controlled potassic, albitic, sericitic, and argillic alteration styles are present. There is a strong geochemical correlation of gold with bismuth and tellurium. The overall sulfide content is low.

To date, a total of 925,853 feet of exploration drilling has been completed on the Fort Knox ore body. Total expense of the drilling programs is $54.7 million, with 40% of the drilling performed as PQ/HQ core, and 60% as reverse circulation. As of the end of year 2012, 9.88 million ounces of mineable reserves at $1,200 gold, and 1.38 million ounces of resource at $1,400, have been identified. Of the 9.88 million reserve ounces, 6.27 million ounces have been mined, with 3.61 million scheduled to be removed during the period from 2013 through 2020.
IMAGING AND MODELING LARGE-SCALE LARAMIDE THRUST DETACHMENT: RESULTS FROM THE NSF-EARTHSCOPE BIGHORN PROJECT, WITH IMPLICATIONS TO HYDROCARBON RESOURCE PLAYS

Eric A. Erslev and Karen Aydinian, Department of Geology and Geophysics, University of Wyoming; Kate C. Miller and Lindsay L. Worthington, Department of Geology and Geophysics, Texas A&M University; Anne F. Sheehan and William L. Yeck, Department of Geological Sciences, University of Colorado; Christine S. Siddoway and Megan L. Anderson, Department of Geology, Colorado College

Understanding Rocky Mountain deformation histories and mechanisms are critical to resource play exploration and production because the orientation and intensity of natural fractures typically determine the economic success of individual wells. The NSF-EarthScope-funded Bighorn Project was initiated in 2009 to determine the crustal geometry and kinematics of the Laramide Bighorn Arch by combining structural geology investigations of the upper crust with seismic experiments (BASE) imaging the entire crust. The integration of active and passive BASE experiments with gravity models shows that the seismically-determined Moho topography is independent of Laramide folding defined by pre-Laramide platformal strata. The lack of through-going Laramide faults cutting the Moho and the incompatibility of the NE-trending Moho high and the NW-trending Laramide arch necessitate a Laramide detachment in the middle crust at ~30 km depth. Thus, the Bighorn Arch is a large-scale detachment fold, which confirms that the Laramide orogen is a thick-skinned thrust orogen.

Regional Laramide ENE-WSW horizontal compression is generally indicated by abundant map-scale fold and fault patterns as well as data from slickensided minor faults. But on the steeply-dipping eastern flank of the arch, compression directions radiate away from the arch crest, from NNE-SSW on the northern plunge of the arch to ESE-WSW on the southern plunge of the arch. On the north plunge, variations in compression direction exceed permissible vertical axis rotations indicated by paleomagnetic investigations. The radiating pattern of compression directions is explained by an additional component of syn-Laramide gravity collapse of the Bighorn Arch.

This hybrid model of Laramide deformation in which ENE-WSW regional horizontal compression is partially modified by local gravitational collapse of the arches appears to make multi-stage, multi-directional models of Laramide regional compression unnecessary. Our model should also help predict basinal fracture patterns for both conventional and unconventional fracture plays, like the current Niobrara oil and gas resource plays.
PERMITTING THE PIÑON RIDGE URANIUM AND VANADIUM MILL

Frank Filas, Director Environmental and Regulatory Affairs, Energy Fuels Resources (USA) Inc., Lakewood, CO

The Piñon Ridge property was acquired in July 2007 by Energy Fuels Resources Corporation (Energy Fuels) as a future mill site for the company. The site is located in East Paradox Valley in western Colorado near the towns of Naturita and Bedrock, Colorado. Baseline studies, engineering design, and permitting began almost immediately after acquisition in August 2007. From a geologic and hydrogeologic perspective, the property was determined to be well suited for a modern mill because the natural conditions on site limited the potential for impacting ground water, surface water, and other media. The site is underlain by thousands of feet of salt and ground water is absent under most of the property. With the exception of an ephemeral drainage north of the site, the nearest surface water is located seven miles away. The site is also geomorphically stable, in a seismically stable area, and outside of any areas prone to flooding.

The mill design includes many engineering improvements compared to historic mills, which will minimize the potential for a release of pollutants to the environment. For example, stack emissions are controlled with bag houses and scrubbers, and the uranium drying facility, which historically had some of the highest air emissions, now consists of a zero-discharge vacuum system. Storage and processing areas and solutions lines are all equipped with secondary containment and leak detection systems. Disposal areas, including the tailings impoundment and evaporation ponds, are equipped with tertiary containment and leak collection and recovery systems. State regulations and our monitoring plans also require concurrent cleanup of any spills or releases that occur on site to minimize the potential for the spread of contamination.

Because of the proposed mill’s location on private land, very few federal permits were needed for the project, and it was not necessary to do an environmental analysis under the National Environmental Policy Act (NEPA). A Special Use Permit Application was submitted in July 2008 to Montrose County and was ultimately approved in September 2009. A 15-volume mill license application was then submitted to the Colorado Radiation Program of the Colorado Department of Public Health and the Environment (CDPHE) in November 2009. The agency decision to approve the license was issued in January 2011, and the license was issued with conditions in March 2011.

Both the Montrose County and CDPHE decisions were appealed by Sheep Mountain Alliance (SMA), a non-government organization (NGO) based in Telluride, Colorado that is generally opposed to natural resource development. The County’s decision was upheld in State District Court and the State Appellate Court. The State District Court upheld CDPHE’s license decision on 10 of the 11

Energy Fuels anticipates that uranium prices will rebound over the next few years due to anticipated supply and demand imbalances created by the construction and operation of new nuclear power plants. There are currently 435 nuclear power plant units in the world with 67 more units under construction. Of those under construction, 29 are located in China, 20 in Russia, and 7 in India. Furthermore, the Megatons to Megawatts Program will expire this year. This program supplied much of our low-enriched uranium for nuclear fuel over the past 20 years by converting high-enriched uranium taken from dismantled nuclear weapons. With increasing uranium prices, Energy Fuels is optimistic that the Piñon Ridge Mill can be financed and constructed within the next several years.
WATER WELL “PROBLEMS” IN AREAS OF UNCONVENTIONAL RESOURCE DEVELOPMENTS: APPEARANCES ARE DECEIVING AND SOLUTIONS ARE MANY

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Public concern is growing about water well problems such as adverse quality and productivity in areas of unconventional oil and gas development and, more generally, about the potential future risk to regional aquifer systems. When development occurs in populated areas, operators and regulators are frequently notified of complaints from water well owners suspecting that their water well is being damaged by development. The geology in the areas of unconventional resource developments, such as shales, tight sands and gas-saturated coals, is more likely to affect water quality in fresh water aquifers than in other regions. This is also the case with shallow uranium deposits. Hydrogeologists generally believe that increasing public hysteria about drilling and hydrofracturing practices damaging water supplies is unwarranted. What is coming to light is the existence of this naturally occurring “contamination” and other common water well problems.

Anthropogenic contaminant releases do occur and must be acknowledged, remediated, and prevented. However, water wells can become non-productive or their water quality degraded due to regional overuse of the aquifer, drought, bacterial or mineral well fouling, or the naturally limited life span of the well. Methane in a water well occurs naturally from bacteria, natural gas seeps, or the result of shales or coals present in some aquifers. Since methane occurs naturally and is not toxic, it is excluded from routine water quality tests of private wells. Some regulatory agencies require that nearby water wells be tested for methane and other constituents before oil & gas wells are drilled nearby. This testing can reveal the presence of pre-existing anomalous methane concentrations or other issues.

Fears about drilling and hydraulic fracturing are rapidly spreading as unconventional resources increasingly become targets for development. Many states in the USA have, or are now proposing, regulations to require baseline water testing and monitoring to address these concerns. In response, some industry associations are working closely with regulators to develop programs based on best practices. Such cooperative interaction could be a highly effective model to mitigate water-related concerns associated with global development of unconventional resources.

Uranium roll front deposits, another energy source, commonly form in shallow freshwater aquifers where dissolved oxidized uranium migrating with ground water flow encounters a naturally reduced environment, and the uranium and associated metals (e.g.}

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vanadium, molybdenum, etc) precipitate into an ore deposit. Where this happens, the ground water will contain high concentrations of dissolved uranium, radium, and radon gas. These same aquifers can be a ground water source for homeowners, farmers and ranchers. Routine water quality tests of domestic wells do not include these compounds, so they will likely not be discovered until a company develops the resource.

Prior to unconventional resource development, a proactive baseline testing program can head-off these problems with stakeholders. If, however, such testing is not done prior to development, forensic geochemical methods can typically distinguish the source as natural or anthropogenic, unless it's a natural seep from the same source as the developed resource.

Methods are presented to assist resource developers in the documentation of pre-existing environmental conditions and location of potential problem areas that can allow them to effectively address complaints. Procedures are outlined that will help operators protect themselves from potential legal action by regulators or civil law suits. These procedures include educating water well owners about common water well problems such as natural methane, natural or anthropogenic contamination, and proper well maintenance.
NEW SUSPECTED KIMBERLITE: NORTHERN COLORADO

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Kimberlite pipes are small in diameter, carrot shaped, geologically elusive, ultramafic igneous structures which penetrate the crust all the way from the mantle. They often occur in swarms, such as in the Colorado – Wyoming kimberlite district, are primary source rocks for diamonds, and are very difficult to detect. A heavily weathered kimberlite of approximately 400 ft² surface area is believed to exist in a road cut on County Road 45E and Highway 287, just North of Virginia Dale, Colorado, in a minor fault line. The outcrop consists of sparsely vegetated, clay-like soil yielding large amounts of greyish green to pinkish talc-like fragments with an increase of black, solid material at the outcrop fringes. The verified Moen kimberlite pipe is less than 1 mile to the west from the discovery site.

Simple physical tests as well as thin sectioning and PLM (Polarized Light Microscope) investigation confirms the presence of chlorite, a common decompositional mineral of ultra-mafic lithologies. This discovery is further verified by XRD (X-ray Diffraction) analysis, showing the definite presence of Mg-chlorite. Search for visible KIMs (Kimberlite Indicator Minerals) within soil samples through heavy mineral separation has yielded zircon and questionable ilmenite, but so far lacks garnet and diopside. However, thin sections of kimberlite edge sample show definite euhedral garnets of 30 to 50 microns in diameter. Geochemical testing through ICP (Inductively Coupled Plasma) shows low SiO₂ and elevated MgO and TiO₂ content for both soil and lithologic fragments, congruent with analysis of kimberlites in the vicinity. Unusual high Al₂O₃ amounts (> 15%) are most likely due to the heavy weathering of the pipe. Concentration plots of Ce/Nd as well as Zr/Nd approach the type II kimberlite classification. Preliminary XRF (X-ray Fluorescence) data on a lithologic fragment indicates the presence of Cr. Additionally, initial scans with the TIMA mineral analyzer has shown the presence of small (<10µm), low Ca pyrope garnets in thin sections of the black sample material, a strong indicator mineral of kimberlitic rocks.

While the discovery of a new kimberlite within the established State Line Kimberlite District is to be expected, the fact that this new pipe is publicly accessible is not. Thus this new openly available outcrop, when properly protected, would be a welcomed addition for educational purposes.
20 YEARS AFTER: A BRIEF UPDATE ON THE STUDY OF TELLURIDE DEPOSITS

Bruce Geller, Colorado School of Mines Geology Museum, 1310 Maple St., Golden, CO

This talk will focus on the developments in telluride deposit research that have occurred in the twenty years since the completion of my nine years of doctoral studies on them (Geller, 1993). The focus will be on un-oxidized telluride minerals — their occurrences, relationships to vanadium phases, and crystal chemistry. Many advances have been made in telluride research applying new tools and insights gained from previous investigators. This paper will attempt to summarize those results. Additionally, tellurium has become a more sought-after commodity, since its requirement in modern photovoltaic (PV) cells, versus less glamorous applications twenty years ago.

References
THE DYNAMICS OF THE URANIUM MARKET IN A GROWING NUCLEAR INDUSTRY

Jim Graham, NFC Consulting and Anatolia Energy Ltd., CO

New nuclear reactor construction programs continue today as the nuclear fuel cycle industry deals with the actual and perceived impact of an earthquake and tsunami in Japan two years after the event. We have seen the global nuclear industry continue to state their commitment to addressing improved safety standards in an already safe industry while meeting growing energy needs. Mr. Graham will provide a lively update of the nuclear fuel cycle industry today and will address numerous areas of concerns and will present "real" facts so the attendees can began to separate the truth from the age old media hype.
THE FUTURE OF NATURAL GAS IN THE U.S.

John Harpole, Mercator Energy, 26 W. Dry Creek Circle, Suite 410, Littleton, CO

The shale gas revolution has definitely caused the supply curve to move. When it becomes commonplace to drill a vertical well down two miles and continue on with a horizontal leg for an additional two miles, one begins to realize what the North American energy sector has accomplished.

The biggest question facing the industry now is whether or not the demand curve will also shift. The potential growth in four key areas of demand should answer that question. 1) Compressed Natural Gas (CNG)/Natural Gas Vehicles (NGV) 2) Industrial Demand 3) Utility Demand, i.e., conversion of electric generation from coal to natural gas and 4) Liquefied Natural Gas (LNG) exports.
SOIL GAS INVESTIGATION AT A BURIED DRUM DISPOSAL SITE USED TO AID IN THE REMEDIAL DESIGN OF AN SVE WELL REMEDIATION NETWORK

David Heidlauf, ENVIRON International Corp., Chicago, IL, Justine Petras, Michael Badding, Wayne Weber, and Bruce Kennington

A multi-phase soil gas investigation was conducted at a large, capped, buried drum disposal site. In excess of 100,000 drums of pesticide manufacturing waste were buried in trenches in three general disposal areas during a ten year period in the 1960’s and 1970’s. The waste disposal trenches were created using a bull dozer in generally sandy soils along ridge top areas. The waste disposal areas were formally capped in 1980 with earthen materials consisting of a grading layer, a two-foot compacted clay cap, and a six-inch topsoil layer. The landfill caps were further upgraded in 1997 with geo-composites to conform to RCRA landfill capping standards. The predominant volatile organic compound (VOC) present in the unconfined aquifer, underlying and emanating from the landfill disposal areas, is carbon tetrachloride. The average thickness of the vadose zone in the vicinity of the landfill disposal areas is approximately 90 feet. Contaminants released from the disposed waste have resulted in the notable presence of VOCs in the landfill waste; the native vadose zone sandy soils underlying the landfill disposal areas; and the groundwater, the surface water, ambient air, and indoor air in the vicinity of the landfill disposal areas.

An initial soil gas investigation in the landfill disposal area was conducted in 2008, which consisted of the installation and sampling of 74 soil gas probes situated in and adjacent to the capped disposal areas. Soil gas probes were screened at various depth intervals to allow for both the horizontal and vertical characterization of soil gas. Shallow (6 to 18 feet below ground surface (bgs)) soil gas probes were installed using direct push methods. Deeper nested soil gas probes (up to 88 feet bgs) were installed using rotosonic installation methods. Two rounds of soil gas samples were collected using summa canisters and analyzed for VOCs using EPA Method TO-15.

Carbon tetrachloride concentrations measured in the shallow vadose zone soil gas within and immediately adjacent to the landfill disposal areas were approximately 1,000 to 5,000 parts per million by volume (ppmv). In contrast, the carbon tetrachloride concentrations measured in the intermediate and deep portions of the vadose zone along the perimeter of the main landfill disposal area were in the single digit percentile range (i.e. 1% to 4% a.k.a. 10,000 to 40,000 ppmv). The 2008 soil gas data have been used to design a SVE pilot test for one of the smaller landfill disposal areas and to help justify the selection of an SVE remedy for the site.

A subsequent pre-design soil gas investigation phase was completed
SOIL GAS INVESTIGATION AT A BURIED DRUM DISPOSAL SITE USED TO AID IN THE REMEDIAL DESIGN OF AN SVE WELL REMEDIATION NETWORK
(Continued)

in early 2013 and consisted of the installation and sampling of 48 additional soil gas probes in the vicinity of the main landfill disposal area. The objective of the pre-design soil gas investigation was to better delineate the vertical and lateral extent of elevated carbon tetrachloride concentrations beyond the limits of the capped disposal areas which warrant SVE treatment. Using the pre-design soil gas data, off-cap SVE well field networks are being designed for those areas where the carbon tetrachloride soil gas concentrations exceed 3,000 ppmv. Nested SVE wells are being incorporated into the design to accommodate venting of the entire vadose zone thickness for both on-cap and off-cap areas.
EARLY MINING HISTORY OF THE CARLIN TREND 1874-1961 OR HOW SMALL MINES CAN LEAD TO BIG DISCOVERIES

Dean G. Heitt, CPG, Geology Manager - Underground Project Development, Newmont Mining Corporation, Elko, NV

In 1877, prospectors searching for riches in the Tuscarora Mountains north of the town of Carlin, Nevada, discovered silver – lead deposits in an area that would eventually become the Richmond Mining District. These discoveries were small and none would become producing mines; but they proved the area was worthy of prospecting. In the following years, other districts would be discovered including the Schroeder, Lynn, and finally the Bootstrap district. Discovery of placer gold by Joe Lynn in 1907 was the first significant gold find in the area but clearly not the last.

Between 1877 and 1961 these districts produced not only gold but copper, lead, silver, antimony, barite, turquoise, and even marble. When compared to other districts and camps in Nevada like Eureka, Tonopah, Goldfield, and Tuscarora the discoveries north of Carlin would seem insignificant in comparison. However, when these mines and discoveries were plotted on a map, combined with the previously known alignment of carbonate windows in the area, they provided an exploration model that would lead to the discovery of one of the largest gold camps in the world.
MAJOR SILVER DISTRICTS OF THE WESTERN UNITED STATES: THEIR RELATIVE IMPORTANCE TO CURRENT AND PAST NORTH AMERICAN SILVER PRODUCTION

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Major Silver Districts of the western United States range from the >1.0 billion ounce Coeur d'Alene District in Idaho to numerous, economically-important districts of Miocene and younger ages such as the Comstock Lode and Walker Lane deposits in Nevada. Butte, Montana, Aspen and Leadville, Colorado were also significant producers with > 100 million ounces of silver produced from these mines.

Mining of bonanza deposits created employment and great wealth in sparsely inhabited parts of western America. Newly discovered silver mines financed the Union during the American Civil War; built the city of San Francisco thereafter and enabled modern settlement of the northwestern United States. Silver mining helps to drive the economy of many western States today.

This presentation gives a visual overview of geographic locations, geological ages and deposit types of predominately silver-rich mines in the western United States. Three selected deposits – Coeur d'Alene District, Idaho, the Comstock Lode and Rochester deposits in Nevada, are discussed in some detail to highlight the great variety of host rocks types, structural settings and mineral alteration that emplaced silver lodes.

In the future, where would Geologists look to find new silver districts in the western United States? What types of geological settings are likely to produce a new Silver Valley?
EVALUATING ELECTROMIGRATION AND ELECTROOSMOTIC REMEDIATION OF ROAD SALT CONTAMINATION IN SOILS

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Used as a deicing agent for highways, secondary roads and parking lots, crushed halite (road salt) is an increasing non-point source of chloride (Cl\(^-\)) and sodium (Na\(^+\)) contamination to soil and groundwater throughout North America. Highest brine concentrations are released when wet weather drainage occurs at unsecured storage facilities. Due to the high solubility and mobility of Cl\(^-\) and Na\(^+\) in the saturated subsurface, groundwater recharge from infiltration of salinized runoff results in recalcitrant soil and aquifer contamination. Application of electrokinetic technology is one of the few in-situ methods of salt remediation from soils.

When subjected to induced DC electric fields, soil pore water moves toward the cathode via electroosmotic flow. Dissolved cations migrate towards the cathode and anions migrate towards the anode by electromigration. A series of anode and cathode extraction wells placed in contaminated soils can be used to separate and remove Cl\(^-\) and Na\(^+\), respectively. The efficiency of this removal process is dependent upon the electrical and geochemical characteristics of the soil.

A 2-dimensional analytical model was developed to simulate the electromigration and electroosmotic aspects of Cl\(^-\) and Na\(^+\) in soil. This model assumes a quasi-cylindrical configuration of electrodes with a center cathode surrounded by anodes. To validate the model, laboratory studies were completed using kaolin clay and calcareous glacial diamicton substrates with well-based electrodes in a hexagonal configuration. The rate and removal efficiency of sodium was measured. Study results were used to modify the model to better represent the lag time of sodium movement in the diamicton and to design a field pilot-scale remediation system.

This presentation will review the movement and fate of sodium chloride in the subsurface as related to the management and utilization of road salt. Also discussed will be the model simulations, the data obtained from the laboratory studies and the benefits of using electrodes in hexagonal placement patterns to represent extraction well networks in field pilot-scale remediation system design.
LIMITATIONS OF GIS IN MAPPING PAPYRUS ALONG THE EGYPTHIAN NILE RIVER

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Papyrus (Cyperus papyrus) has been harvested in Egypt since approximately 3000 BCE. I want to evaluate the reasons for the 20th Century decline in the species by mapping the original extent and current distribution of the species.

By examining how papyrus was reintroduced to the Pharaonic Village plantation on Jacob’s Island, Giza I want to determine what factors are necessary to reintroduce the plant to its former range. The extensive stands of papyrus both within the plantation and in recolonized areas acted as my verified ground truth which I used to compare other candidate sites.

The width of papyrus stands, even at the Pharaonic Village, are too thin to be resolved by remote sensing systems. Remote sensing cannot distinguish papyrus from other species based on spectral signature. Papyrus stands are very difficult to separate from other vegetation even on low-altitude photos. The final result is that current distribution limits must be established based on site examinations. The historical distribution will be an approximation based on primary and secondary literature describing the Nile River banks.
RECENT TRENDS AND PREVENTION FOR A SIGNIFICANT OCCUPATIONAL HAZARD FOR SCIENTISTS, ENGINEERS AND OTHER FIELD WORKERS: COCCIDIOIDOMYCOSIS: (VALLEY FEVER)

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When soil containing the fungus Coccidioides immitis in the arid regions of the southwestern United States is disturbed by anthropogenic activities, or natural causes such as wind, and earthquakes, microscopic fungal spores or arthroconidia (about 3 to 5 µm in size) can become airborne and lodged in the lungs of unsuspecting workers. Those who disturb soils in endemic areas by digging, drilling, trenching, and even driving vehicles may include geologists, archaeologists, wild land fire fighters, military personnel, construction staff for road building and excavation, and workers in the agricultural, mining, quarrying, and oil and gas industries. The environmental factors for the fungus growth are well understood. The Centers for Disease Control and Prevention reported Coccidioidomycosis (Valley Fever) cases in Arizona, California, Nevada, New Mexico and Utah from 1998 to 2011 increased almost ten-fold, although some case reporting variations exist due to the laboratory procedures used or documentation methods. Symptoms can include influenza-like illness such as cough, fever, chest pain, headache, muscle ache, rash and general fatigue, but some victims develop more severe or chronic pulmonary disease. The disease can be costly and debilitating, with nearly 75% of patients missing work or school due to their symptoms and 40% requiring hospitalization. Although no vaccines are available, aggressive dust control and appropriate respiratory protection reduces spore exposure of workers. The talk will focus on 1) the life cycle of the dimorphic soil-living fungus, 2) the saprophytic phase in soil to the invasive phase in entering the host, 3) the symptoms of the disease, as well as 4) the prevention strategies to protect field employees, including scientists and engineers.
THE PEBBLE CU-AU-MO DEPOSIT, ALASKA: AN UPDATE ON GEOLOGIC INVESTIGATIONS

Paul Jensen, CPG, Chief Geologist, Pebble Limited Partnership, 3201 C Street, Suite 604, Anchorage, AK

Over the past decade, scientists from all backgrounds have flocked to a remote corner of southwestern Alaska to study the world’s largest single undeveloped base and precious metal deposit. The Pebble Deposit, with a resource of over 80 Blbs of copper, 107 Moz of gold, and 5.6 Blbs of molybdenum, is truly a giant resource deserving the attention. Extensive scientific studies have been conducted by the USGS, academia and industry geoscientists, so that Pebble is now considered a well-understood type example for exploration in covered and glaciated terrains. The studies range from the use of 10 different partial leaching assaying methods on soil samples to measuring copper isotopes in surface waters. Typical genetic studies such as fluid inclusions, stable isotopes on alteration minerals and ore petrography using the SEM have also been employed to characterize the deposit. Tectonic, geophysical and magmatic evolution studies have all been completed. The age of mineralization has been characterized using a variety of frequently used methods including U-Pb, Ar-Ar and Re-Os. Indeed, the nature of Pebble has progressed so that we now have a well-defined template of understanding.

Though this template describes the deposit’s genesis and physical manifestation, and where we should look to find more, it does not necessarily bring the value of the deposit to fruition. There is a critical need for today’s geoscientists to develop the specialized skills required to respond to the challenges of responsibly developing ore deposits in today’s world. With higher grade, and near surface deposits having been largely discovered, and with the need to pay exceptional care to our environment, a different set of skills is necessary than what the typical college graduate enters the mining sector with. Geologists of the future will not meet society’s needs for metals by simply explaining alteration and leach capping or turning over every rock, looking for a hematite boxwork – they will need to be experts in the kinetics of sulfide oxidation and associated metal transport, geostatistics, geometallurgy and computer modeling. How many of our current graduates would know how to set up a sequential indicator simulation of a domainable variable for use in mill throughput or waste pile risk analysis, why one would want to, or even what that is? How many could predict the selenium concentration in pore waters from an exposed waste pile of known mineral concentrations? My experience is that there are very few geology graduates with these skill sets, and they are soon stretched beyond their ability to meet project needs within the consulting firms that hire them.

Given the impetus of NEPA, the science of managing ore deposits is still quite new, but tremendous strides have been made in our ability to effectively manage them. The science and tools have now been developed, I believe, to bring lower grade deposits to market,
THE PEBBLE CU-AU-MO DEPOSIT, ALASKA: AN UPDATE ON GEOLOGIC INVESTIGATIONS
(Continued)

and to raise the public's opinion of mining projects exponentially, but it will take time and thousands more competent earth scientists contributing to successful projects across the world. I acknowledge that many Universities have increased focus on environmental studies, but more preparedness to serve within the mining industry is needed. Industry-sponsored consortia such as AMIRA are tremendously beneficial in improving the technology of developing mineral deposits. Still, until these tools are widely taught in geoscience education, so that each deposit has the expertise it needs, we will effectively undermine the development of deposits we have worked so hard to discover.
INNOVATIVE LANDSLIDE REPAIR CONCEPTS, INCLUDING THE USE OF BALLISTIC SOIL NAILS FOR SHALLOW LANDSLIDE AND EROSION MITIGATION

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This presentation will focus on case histories of multiple landslides of various magnitude repaired using innovate Design/Build/Warranty contracting and technologies such as ballistic (or launched) soil nails, micropiles, hollow bar soil nail retention, GCS – IBS walls, and other techniques we employ. The case histories have a specific focus on landslides and severe erosion problems repaired on state and county roadways, AML sites, gas transmission pipelines, and energy/mine access roads.

Design/Build/Warranty contracting is particularly suited to landslide mitigation and severe erosion repair. This contracting approach combines designer and contractor into an integrated team able to respond quickly to unforeseen conditions and continued slope/slide movement before and during construction. During this portion of the presentation, multiple large landslides repaired using this contracting technique will be examined from initial site visit through stability modeling and design to construction techniques and challenges.

The second part of the presentation will outline new technologies for shallow landslide and severe erosion repair, including launched soil nails. Developed in Europe in the late 1980s to repair shallow landslides and severe erosion problems at a fraction of the time, cost, and environmental impact of traditional repair techniques, the technology was never successfully commercialized in Europe, and only recently gained momentum in the United States. Based on a multitude of successful installations in America after 2001, the use of launched nails has expanded to New Zealand, Canada, and Australia. A brief introduction to the principal design manual for ballistic soil nails – the Joint USFS/FHWA Engineering Manual EM 7170-12A/FHWA-FLP-93-003 (“Application Guide for Launched Soil Nails, Vol. 1”) will be included, along with a brief description of how launched nails can be designed using PC-based limit equilibrium and finite element slope stability analysis programs.
MANAGING GEOPOLITICAL RISK IN THE MINING INDUSTRY

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Geopolitical risks to natural resources development continue to grow and can be expected to accelerate in the coming decades. Although historically they most notably impact governments and the oil and gas industries, these risks also significantly influence minerals exploration and production. Energy and mining companies face similar and substantial challenges when engaged in international undertakings. Mining companies routinely apply conventional methodologies to mitigate geologic and financial risks. Now and in the future, they must also carefully consider and address political uncertainty. This paper explores various strategies that mining companies may want to consider to better manage these increasing risks.
THE HETEROGENEOUS CONEJOS AQUIFER IN THE EASTERN SAN JUAN MOUNTAINS OF RIO GRANDE COUNTY, COLORADO

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The early Oligocene Conejos Formation is the major bedrock aquifer in the mountainous part of Rio Grande County in south-central Colorado, yet until recently little was known about the hydrologic character of the aquifer in this area. In 2012 we conducted a reconnaissance-level hydrogeologic study of the aquifer for Rio Grande County in response to renewed interest in petroleum exploration and production in this area and concerns about its potential impact on the aquifer. Funding for the study was provided by a grant from the State Water Supply Reserve Account through the Rio Grande Basin Roundtable and Colorado Water Conservation Board.

The Conejos Formation ranges in age from about 35 to 30 Ma and is the oldest formation in the eastern part of the San Juan Volcanic Field. It includes a vent facies composed chiefly of andesite and dacite lava flows that were erupted from several mid-Tertiary stratovolcanoes; and a volcaniclastic facies consisting of mudflow, stream, and fan deposits. The formation was deposited prior to development of the Rio Grande Rift and was later east-tilted and locally broken by rift-related faulting associated with the San Luis Basin.

Between 1982 and 1990 sixteen oil wells were drilled in and near the study area to evaluate the hydrocarbon potential of the Laramide-age San Juan Sag, a structure formed in sedimentary rocks concealed beneath the younger volcanic rocks in the Conejos Formation. Only one well produced oil; others were plugged and abandoned after being drilled. Data from these wells and others located on the floor of San Luis Valley were used to prepare structure contour and isopach maps. Two new oil tests are proposed in the San Juan Sag. One well is located northwest of the town of Del Norte, and the second well is south of Del Norte.

Water-quality data was collected for forty-two water wells and springs during the study. Thirty-six water wells and springs within about one mile of the two new oil tests were analyzed for the recommended constituents in the Colorado Oil and Gas Association’s voluntary baseline ground water quality sampling program and also for ethylene and butane. Water samples from four deep domestic water wells were submitted for drinking water analysis, and analytical results for samples from two public water-supply wells in a subdivision were provided by the property owner’s association.
THE HETEROGENEOUS CONEJOS AQUIFER IN THE EASTERN SAN JUAN MOUNTAINS OF RIO GRANDE COUNTY, COLORADO (Continued)

The hydrologic character of the Conejos aquifer was evaluated using water well data in the Colorado Division of Water Resources online records. Other data useful for evaluating the hydrologic character of the aquifer was obtained from drill stem tests conducted in the oil wells and from petrophysical analysis of geophysical logs from the oil wells.

These data indicate the Conejos aquifer is highly heterogeneous and anisotropic. Available data provide evidence of deep circulation of ground water to depths of several thousand feet within the Conejos aquifer and perhaps in older underlying formations. Also, oil and gas naturally occur at shallow depths locally within the aquifer. There apparently are no highly impermeable formations that would serve to hydrologically separate the underlying petroleum-bearing reservoir and source rocks from the shallower fresh-water aquifers.
PUMP AND TREAT AS A REMEDY: PERHAPS IT WORKS AFTER ALL

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The technological limitations of groundwater pump and treat systems have long been examined by various groundwater scientists. US EPA has estimated that more than 100 federally financed superfund sites rely on pump and treat systems as the groundwater containment and cleanup remedy of choice. In addition, hundreds if not thousands of pump and treat systems are used for containing groundwater and protecting water supplies nationwide; few are truly anticipated to allow an aquifer to be restored to become a source of “useable drinking water.” As acknowledged by US EPA, the likelihood of restoration of an aquifer to potable use is slim, and the technology is best used to control the spread of a chemical plume; but there are many exceptions to this long-held belief; some rather remarkable.

This paper will examine the actual remedial efficacy of pump and treat systems at two sites in complex geologic settings in the fractured bedrock of Pennsylvania. At these two sites, the use of pump and treat technologies not only contained a groundwater plume, but either remediated or is effectively remediating the plume as well.

The first site is in the Stockton Formation of southeast Pennsylvania and is impacted by a volatile organic compound, present in such high concentrations that it exists as Dense Non-Aqueous Phase Liquid (DNAPL) more than 1,000 feet away from the DNAPL source area. The Stockton Formation is a Member of the Newark Super-group in the Triassic Basin of the Mid-Atlantic. After more than 15 years of pumping the impacted bedrock aquifer, a significant reduction in DNAPL plume size and compound concentrations can be demonstrated. Calibration of the model developed for the pump and treat remedy several years after its implementation indicated that the treatment system was performing as designed, not merely for containment of the DNAPL, but for remediation of the DNAPL plume as well.

The second site to be discussed is located in the Appalachian Overthrust Complex, and is located on a faulted anticline that includes highly weathered karst, terrain, fractured sandstones and shales. In this case, low-level concentrations of chlorinated ethenes were identified in groundwater. Over the lifetime of pump and treat operations, chlorinated compound concentrations decreased from levels exceeding MCLs to concentrations at or below MCLs. During pump and treat system optimization work, US EPA determined that the treatment system was so effective, that cleanup of the plume was complete and that system operations could be terminated.
TDS: NATURAL OR ANTHROPOGENIC THE RESULTS OF AN OPTIMIZATION STUDY ON A GROUNDWATER PUMP AND TREAT SYSTEM

Todd Knause, P.G., CPG, Stanley Consultants, Coralville, IA

A groundwater pump and treat system was installed downgradient of several evaporation ponds to address potential releases of process water as a result of the deterioration of the high density polyethylene (HDPE) liners. After five years of operation the state regulatory agency requested an optimization study be conducted on the existing system. The purpose of the study was to ascertain whether the existing groundwater extraction system is operating at capacity, is containing the total dissolved solids (TDS) plumes onsite, and to determine whether an offsite upgradient source of TDS is migrating onto the site. The results of the study indicated the system needs modifications in order to contain the TDS impacted groundwater from leaving the site.

Modifications to the groundwater pump and treat system resulted in an increase in flow rates, the radii of influence, and the capture zones. More importantly, TDS concentrations are decreasing in the downgradient wells and at an adjacent creek monitoring station. The study also found TDS concentrations increasing in the upgradient monitoring wells indicating a potential offsite source is impacting the site. Or is it the result of the ongoing drought and/or the local hydrogeology that is degrading the water quality in the shallow aquifer?
Geologic and hydrogeologic characteristics play an extremely important role in site characterization and remediation at environmentally-impacted sites. Among other influences, the composition of bedrock and overburden soil directly influences groundwater geochemistry and determines whether an aquifer is aerobic or anaerobic and what the buffering capacity of groundwater might be. In addition, there may be naturally occurring regulated compounds present in soil or groundwater, such as arsenic, that must be assessed. Physical features such as faults and joints in bedrock have a direct influence on contaminant fate and transport.

Groundwater geochemistry is also strongly influenced by the presence of regulated substances. For example, oxidation-reduction potential and dissolved oxygen concentrations can be directly influenced by contaminants and it is well documented that alkalinity typically increases in biologically active dissolved contaminant plumes. For these reasons, among others, it is critical to fully characterize and understand the subsurface geologic conditions in order to effectively design a remedy.

Two case studies from projects in the mid-Atlantic region are presented to provide specific examples of how the geologic/hydrogeologic characteristics had a significant influence on either site characterization or remediation at a contaminated property. These case studies include:

1. Chlorinated Solvent Bioremediation in North-Central Pennsylvania. Groundwater and soil at a project site in north-central Pennsylvania are impacted with chlorinated ethenes resulting from an historical dry cleaner release. Based on the results of two pilot-scale studies, an in-situ engineered bioremediation program was implemented to address dissolved-phase volatile organic compounds (VOCs) in groundwater. The bioremediation program involved the injection of an emulsified vegetable oil (EVO) substrate, combined with a source area soil vapor extraction (SVE) system as part of an integrated remediation approach. The fermentation process enhanced by the EVO injections resulted in a significant decrease in groundwater pH resulting in an unfavorable acidic environment for the VOC-degrading bacteria. Although a decrease in groundwater pH was expected, the low buffering capacity of the shallow groundwater aquifer required ongoing buffering injections and pH management throughout the course of the project.
Abstracts

GEOLOGIC AND HYDROGEOLOGIC SETTING INFLUENCES ON CONTAMINATED SITE CHARACTERIZATION AND REMEDIATION (Continued)

2. Groundwater Fate and Transport at a Former Landfill in Central Pennsylvania. A structurally controlled contaminant plume was identified and an optimized groundwater remedy that better accounted for the site geology and underlying structural geology was developed. The site is located on the eastern limb of a complex anticline influenced by a nearby thrust sheet of the Appalachian fold and thrust belt. Ultimately, it was determined that major changes to the original pump and treat remedy were necessary to effectively address the contamination in a karst limestone faulted against a lower permeability formation.
POGO – GOLD ALL OVER!!! - NEW DEPOSITS, UPDATED EXPLORATION MODEL, AND CURRENT THOUGHTS

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The Pogo property is located on the Goodpaster River 150 km south east of Fairbanks Alaska. The claim property represents nearly 1,200 state mining claims and covers approximately 50,000 acres. The property is underlain by highly deformed mid-amphibolite grade, sillimanite-bearing paragneiss and orthogneiss (mid-Paleozoic) of the Lake George sub-group from the Yukon-Tanana terrane. The Pogo Deposit sits in the middle of the “Tintina Gold Belt”, which represents a region of similar type “Intrusion Related Gold Deposits” associated with mid-Cretaceous felsic intrusions.

The Liese zone represents the current mining focus of the Pogo deposit (5 Moz Au). This zone comprises three (possibly more?) “stacked”, massive quartz shear ± sulfide-gold veins. From shallow to deepest, these veins have been designated L1, L2 and L3. Vein thickness varies from 1’ to 10’ and can locally swell up to 40’ thick.

Studies of the Liese Zone suggest similarities between “Liese type mineralization” and other Intrusion Related Gold deposits of interior Alaska. There is a strong association between bismuth and gold (~3.5:1, R² 0.89), tellurium and gold (0.89:1, R² 0.9), and a very weak correlation with arsenic and gold (R² 0.30). Lead isotope studies support fluid sources from magmatic origins, and sulfide analyses group with feldspars from 107Ma intrusions. Modes and occurrences of gold in the Liese zone are as follows by precedence: 1. Au⁺ as inclusions in arsenopyrite (FeAsS) ~100µm+ to 1 µm (fineness 980-900). 2. Au⁰ inclusions in quartz, 1mm to 1 µm (fineness 930-850). 3. Au⁰ composite intergrowths with Bi-Te+/−S minerals in quartz. 4. Invisable Au, less than 1 µm inclusions to solid-solution atomically bound Au in loellingite (FeAsS) and “low arsenic” arsenopyrite (ASP, with composition Fe₆₆As₃₂S₃₅). Paragenetically, the earliest mineral assemblage is loellingite + pyrrhotite and arsenopyrite found as inclusions in arsenopyrite, (“high arsenic” arsenopyrite with composition Fe₆₆As₃₂S₃₅). Later assemblages include arsenopyrite + pyrite (arsenopyrite compositions varying from 35 to 33 at% As) associated with trace amounts of sphalerite (Fe,ZnS), magnetite (Fe₃O₄), rutile (TiO₂), chalcopyrite (CuFeS₂), scheelite (CaWO₄), and molybdenite (MoS₂). Throughout the Liese zone, we suggest that the initial formation was a higher temperature, low fS² fluid that formed under “disequilibrium conditions”, followed by lower temperature higher fS² fluids. Mineral assemblages with these fluid pulses are consistent with rapidly-changing “magmatic” fluid pulses as opposed to a prolonged “metamorphic” fluid source.

Through the last couple of years, exploration activities have focused on identifying, targeting, and drilling near mine prospects. Located ~2.5 miles east of the Liese zone, the 4021 prospect is coming along...
POGO – GOLD ALL OVER!!! - NEW DEPOSITS, UPDATED EXPLORATION MODEL, AND CURRENT THOUGHTS
(Continued)

as a 440+ Koz Au (inf) deposit. Focused infill drilling commenced in 2010 and continued through 2012. Gold in the 4021 prospect is hosted in two stacked, shallow dipping (north) quartz veins (thickness between 5' and 0.5'), hosted in granitic gneiss. Lead isotope of sulfides and metal ratios (Bi:Au = 2:1) suggest mineralization in 4021 is related to Liese zone mineralization and may represent the distal expression of the system.

The North zone deposit is located north of the Liese zone on the adjacent ridge. These are two (possibly 3?) sub-vertical dipping quartz veins that strike NNW and appear to intersect/interact with the L1 vein of the Liese Zone. To date, North Zone veins one and two represent an inferred resource of 396 Koz Au. Bismuth to gold ratios (3.5:1) and electron microprobe analysis of selected arsenopyrite samples are very similar to the Liese zone. Gold and loellingite inclusions are frequently observed in arsenopyrite with compositions identical to arsenopyrite1 of the Liese zone (at% As 35.5). Potentially, the sub-vertical orientation and near identical mineralogy of the North Zone may represent a feeder zone for ore forming fluids into the Liese Zone.

The newly discovered East deep prospect was the main effort of drilling for the 2011 exploration season. This body is located under the ridge just north of the Liese zone. A quartz-diorite dike (94 Ma, post dates mineralization) spatially separates the East Deep prospect from the Liese zone. The E1 vein has a similar orientation and superficially has the same mineral assemblages as the Liese zone. Further petrographic and analytical analysis is in progress. To date, the E1 vein represents a inferred resource of 1.5M oz Au. During the drilling of the 2011 season, it was discovered that a smaller, shallower vein exists above the E1. This was recently modeled as the E0.5 vein and is pending resource evaluation. Every indication suggests that the East Deep vein is the same structure as the Liese zone and has been cut off (and possibly off set vertically) with the intrusion of the quartz diorite down the Liese Creek fault. To date, the total extent of the East Deep area remains unknown. Mineralization limits have been established in the east and south, but the resource remains open to the west and north!

The three above mentioned deposits, by no means represent the limit of mineralization on the Pogo property. Through the years we have identified over eight other prospects that require investigations. With limited time available for exploration activities in interior Alaska, planning and resource prioritization become the decisive factor in successful exploration activities at Pogo. It has taken many years to understand the mineralization we have identified and it will take many more to fully understand the full potential of the Liese zone system. The Gold potential is here, it may even be under our noses and we do not even know it!
VEIN SYSTEMS OF THE SILVERTON CALDERA: IDARADO, CAMP BIRD AND REVENUE-VIRGINIUS MINES

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The vein systems of the Silverton Caldera have been well documented and described in publications by the U.S.G.S., Colorado Scientific Society, Colorado School of Mines, and others. Mining for gold, silver, lead, copper and zinc began on the veins of the Idarado, Camp Bird and the Revenue-Virginius mines in the 1870's; continued through the Silver Crash in 1893; had intermittent mining during the early 1900's; continued through the depression to World War II; concentrated on the production of base metals through the war-years; and continued with intermittent production through the 1970's and 1980's. The Idarado mine shut down in 1978; the Revenue-Virginus in 1984; and the Camp Bird in the early 1990's.

The Silverton Caldera system, part of the San Juan Volcanic Field of Southwest Colorado, with radial and concentric fractures, has been dated at 27.5 Ma; caldera collapse at 25 Ma; with mineralization of the northwest veins at 17 Ma and 13 Ma; and the gold mineralization of the Camp Bird vein at 10.5 Ma. Although the Camp Bird structure may be interpreted as an older structure that existed along with the other caldera structures in the San Juan district, the unique and anomalous gold mineralization is a younger event that is responsible for the production of 1.48 million ounces of gold from 2.6 million tons of ore. Total production from this district has been 22 million tons of ore, exceeding $300 million in value at the time of production.

Although it has been difficult to interest companies in re-opening these mines or exploring for new deposits in the past 20 to 30 years, within the last two years, due to higher metal prices and the need for economic development in these communities, there are two major projects that have been initiated. One is at the Revenue-Virginus silver mine and the other at the Camp Bird gold mine. Even though there has been a hiccup in the financing of the Camp Bird Project recently, there is still optimism that this project will get back on track. The Revenue-Virginus is continuing with approximately 90 employees, the construction of a new flotation mill, and with the start-up of production scheduled for 2014.
LOCAL AND REGIONAL WATER SUPPLY PLANNING TO EVALUATE AND MANAGE HYDROFRACKING FOR SHALE GAS DEVELOPMENT

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Hydraulic fracturing (fracking) of U.S. shales (e.g., Marcellus and Utica in the regional Appalachian Basin) is underway or under consideration as a means for economically extracting natural gas. Fracking is a controversial procedure, but balancing this is the significant value that domestic shale gas presents to the U.S. in terms of managing energy costs and security. Paramount to the question of whether fracking (and the linked technology of directional drilling) should be allowed to proceed involves the management of water resources for private and public welfare.

A typical fracking procedure at one well pad can consume millions of gallons of water. Some of the water is returned to the surface as “flow back”, and may be recycled at the well pad for additional fracking jobs. Fracking may impact local and regional water supplies, and influence planning efforts. However, without fracking shale gas extraction is likely precluded by economics. Some in the energy industry have expressed concerns that fracking could be headed for a rapid demise if environmental concerns (including water management) are not addressed.

Much of the public discussion regarding fracking focuses on water quality; consideration of water quantity is an equally important component of the discussion. This presentation explores the nexus between fracking and water management, and provides recommendations for local and regional water supply planning. In particular, a critical component of water supply plans includes drought response contingencies. We note that drought conditions in 2012 reduced water use for fracking in Pennsylvania, a state that is leading the eastern U.S. shale-gas revolution.
THE PROPER IMPLEMENTATION OF THE NSSGA MINERAL IDENTIFICATION AND MANAGEMENT GUIDE FOR MINERAL SITE ASSESSMENTS

Daniel Linder, CPG, RJ Lee Group Inc., Monroeville, PA

The NSSGA Mineral Identification and Management Guide dated August 28, 2009 offers a reasonable, complete, and clear methodology to properly address the issue of natural occurrences of asbestos (NOA) in any pit or quarry. This includes tools to determine the presence or absence of asbestiform mineralogy, the mineralogical composition, and spatial distribution of its occurrence. Because of the high degree of regulation associated with these mineral occurrences, the NSSGA guide also demonstrates how a proper mineralogical site assessment should be accomplished for suspect operations. The National Institute for Occupational Safety and Health recognizes that “many questions and areas of confusion and scientific uncertainty remain.” A proper mineral site assessment, accomplished by a professional geologist, can protect a company by deflecting false accusations which may be published and/or significantly reducing the exposure to very expensive testing and likely litigation. With multiple aggregate mining companies addressing the issue of NOA via the NSSGA guide, this demonstrates an earnest concern and interest in worker health, adhering to good business practices, and helping refute junk science with regard to NOA.
THE OFTEN OVERLOOKED USE OF POLARIZED LIGHT MICROSCOPY IN THE MINING INDUSTRY

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The use of the PLM is a widely overlooked ‘art’ form which can be used as a powerful tool in the aggregate industry. A thorough and true understanding of the underlying principles of optical crystallography is required to implement the effective use of the PLM. Knowledge and proficiency in working with grain mounts or the oil immersion technique in particular brings the ability to make quick and accurate mineral identifications possible. These determinations can be made in the office or field on a wide variety of sample types from settled dust to ledge rock or hand samples. Mineral identification can be done at a tremendous cost savings when it is necessary to rapidly distinguish between asbestiform and non-asbestiform mineralogy in particular, thereby possibly reducing the requirement of numerous and more costly analytical methods. This rapid analysis allows multiple mineral site evaluations of aggregate operations to be completed in a timely manner. By use of these ‘traditional’ PLM techniques, aggregate companies can understand the risk or lack thereof with regard to potentially hazardous mineralogy in currently active operations or during evaluation of greenfield sites.
PASSIVE TREATMENT OF CONTAMINANTS USING SUSTAINED-RELEASE OXIDANTS: LABORATORY, MODELING AND FIELD SCALE EFFORTS

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1,4-Dioxane (dioxane) is increasingly recognized as a challenging and emerging contaminant at sites where trichloroethene (TCE) and 1,1,1-trichloroethane (TCA) releases to soil and groundwater have occurred. Dioxane is used as a degreasing agent and solvent stabilizer. Once released into groundwater dioxane migration occurs more rapidly compared to volatile organic contaminants (VOCs) due to its miscibility, low affinity for sorption to soil organic matter, and resistance to biodegradation and abiotic breakdown (Mohr et al. 2010). Due to these factors, dioxane plumes occupy a substantially larger footprint than VOC plumes. For example Walsom and Tunicliffe (2002) report dioxane plumes that are twice the lengths of associated solvent plumes and affect an area up to six times greater. Similarly to VOCs a significant mass of dioxane may reside in fine-grained deposits, slowly diffusing back into the aquifer resulting in the formation of large and dilute plumes (Payne et al. 2008). In 2010, US EPA published a final toxicity review for dioxane recommending a steeper cancer slope factor that resulted in lowering of the California and Massachusetts advisory drinking water thresholds (USEPA 2010).

Dioxane is not easily remediated. Ex situ advanced oxidation processes (AOPs) are the most widely developed approach for dioxane treatment (USEPA 2006). Because of high operation and management (O&M) costs, in situ approaches are required. Traditional ISCO is also not a solution to large dilute plumes because the reactants can be relatively short-lived (Siegrist et al. 2011). Slow-release oxidants have been used successfully to treat chlorinated solvents in reactive barrier and zone configurations with both permanganate and persulfate in laboratory and field efforts (Dugan et al., 2013; Christenson et al., 2012; Kambhu et al., 2012).

A sustainable, simple, and low O&M approach has been developed using innovative oxidation chemistries in concert with innovative slow-release deployment strategies to achieve cost-effective treatment of large and dilute dioxane plumes using sustained-release (SR) oxidants. The SR technology that has recently been developed includes both sustained-release permanganate and sustained-release unactivated persulfate. Paraffin wax is used as the environmentally benign and biodegradable matrix material for encapsulating solid potassium permanganate (KMnO₄) or sodium persulfate (Na₂S₂O₈) particles. The paraffin wax protects the particles from instant dissolution and potentially undesirable nonproductive reactions and is
PASSIVE TREATMENT OF CONTAMINANTS USING SUSTAINED-RELEASE OXIDANTS: LABORATORY, MODELING AND FIELD SCALE EFFORTS
(Continued)

also nontoxic and biodegradable. The oxidant is released from the wax matrix over time through the processes of dissolution and diffusion. SR oxidants contain relatively high mass loadings of either permanganate or unactivated persulfate and can be formed as cylinders for direct push applications or inserted into holders for emplacement in permanent or temporary wells. The material may also be chipped/cubed for hydro-fracturing into low permeability media or fractured bedrock for treating back diffusion of organic contaminants. Experimental results from 1-D column and 2-D tank experiments will be presented as well as the results from pilot-scale field efforts. The experimental results were used to create a Beta version of an SR design tool that provides information on the predicted longevity of the SR technology in a field application. In addition to the laboratory and field data, discussion will include a number of practical applications focusing on the versatility the SR technology for a variety of in situ applications and contaminants of concern.
“CLANCY MINING’S” ARCGIS ONLINE GIS PLATFORM SOLUTION FOR GEOSCIENTIFIC DATA MANAGEMENT, ANALYSIS AND COLLABORATION

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Esri’s ArcGIS Online (AGO) is a cloud-based mapping platform that is quickly becoming a central feature of GIS systems for mining/exploration and geoscientific organizations of all sizes. With AGO, mining industry users get access to dynamic and authoritative content to create, collaborate, catalog, and share maps, data, and applications. Sharing can be with specific groups of users, the entire organization, or even with the public. Through ArcGIS Online, organizations gain private access to a secure Esri cloud, which is scalable and ready to use. ArcGIS Online requires no additional hardware or software and is available through an annual subscription.

This paper will showcase an example of AGO created by Esri’s Energy and Mining Industry Team for the fictitious “Clancy Mining” that will introduce the overall functionality of this platform GIS system implemented in a simple and powerful manner. The Clancy Mining example highlights how a mining company might use framework Esri GIS technology to create a powerful platform for browsing, searching and discovering data and seamlessly launching into a variety of workflows to access, analyze and share data. The system takes advantage of the power of ArcGIS Desktop and ArcGIS Server for authoring and serving a simulated mining company’s data combined with the collaboration tools of ArcGIS Online highlighting the independence of company data and applications using the power of GIS. Several sample mining industry workflows are included in the showcase including Data Discovery and Access, Land Management, Geoscience, Mine Operations and Health-Safety-Emergency Response. In all these examples, mining and exploration data can be easily discovered and quickly added to enable intelligent decision making, discovery and successful mine development and management.
DIGGING SNOWMASTODON: DISCOVERING AN ICE AGE WORLD IN THE COLORADO ROCKIES

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On Oct. 14, 2010 a bulldozer operator discovered a young female mammoth while excavating Zeigler Reservoir on the divide between Snowmass and Brush creeks near Snowmass Village, Colorado. Subsequent investigation by the Denver Museum of Nature & Science (DMNS) led to the discovery of thousands of Late Pleistocene plant and animal fossils. The DMNS, in collaboration with the USGS and multiple research institutions, took advantage of the brief opportunity to study this amazingly well-preserved sequence of high-elevation Ice Age ecosystems. The Snowmass Water and Sanitation District, the owner of the reservoir, gave the DMNS excavation team 70 days in 2010 and 2011 to salvage all the fossils that would have been lost during construction. The effort involved the removal of >8,000 cubic yards of sediment and utilized >250 different people who were mostly volunteers, totally >3,000 days of work, totaling >30,000 hours.

The project resulted in an unparalleled collection of fossil plants and animals from a series of stacked and exquisitely preserved ecosystems that existed between 130,000 and 50,000 years ago. In particular, the excavation revealed approximately 5,426 large mammal bones from extinct Late Pleistocene animals including American Mastodons, Columbian Mammoths, Jefferson’s Ground Sloths and extinct Ice Age bison, horse, deer and camels. Tens of thousands of small bones were screened from the matrix at the site, which led to the discovery of more than 30 species of small animals including otters, muskrats, minks, rabbits, beavers, salamanders, frogs, lizards, snakes, fish and birds. The collection also included fossil logs representing at least three tree genera, hundreds of macro-fossil plants including many exceptionally preserved cones, and thousands of samples of microfossil (pollen) samples. All of the material is currently being conserved and preserved at the DMNS. Presently, 42 scientists from 18 institutions are directly working on this new and truly unique collection of fossil plants and animals to understand the ecosystems of the high Rockies and climate change during the most recent warm period to the present day.
A PALEOENVIRONMENTAL ANALYSIS OF THE MIDDLE DEVONIAN GRAVEL POINT FORMATION, WESTERN MICHIGAN

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A paleoenvironmental analysis of the Gravel Point Formation exposed in western Michigan provides insights into conditions existing in the Michigan Basin during the Middle Devonian Period (Givetian). The Gravel Point Formation is a massive stromatoporoid reef deposit that formed in lagoonal areas within the shallow sea covering Michigan during this time. Samples were collected from shore cliffs and bedding planes at six locations along the Lake Michigan coastline of Little Traverse Bay. The locations were chosen for accessibility and because of increased development of this area, many of these sites will soon be destroyed. This study combines both the samples collected and previous published works by Kesling et al. (1974) and others. The six samples yielded an invertebrate fauna of 17 species distributed among brachiopods, corals, bryozoans, arthropods, cephalopods, stromatoporoids, ostracodes and polychaeta, as well as a possible arthropod bone fragment. Samples were also processed for palynologic remains, and initial results indicate mostly amorphous organic matter. Palynologic processing also revealed the samples to have a petroliferous component. The fossil assemblage, along with sedimentologic evidence indicates the Gravel Point Formation was deposited in a low energy, shallow, normal marine environment, with intermittent storm episodes.
THE LATE EOCENE CASTLE ROCK CONGLOMERATE FLUVIAL SYSTEM AND NEWLY DOCUMENTED TRIBUTARY STREAMS, EAST-CENTRAL COLORADO

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The Castle Rock Conglomerate is a late Eocene fluvial deposit that forms a prominent caprock on buttes and mesas within the Colorado Piedmont. The unit was deposited in a series of valleys that were cut into the older Dawson Formation, Larkspur Conglomerate and Wall Mountain Tuff. Its matrix consists mainly of arkosic sand to pebble-sized fragments of pink feldspar and milky-white quartz with pebble- to boulder-sized clasts of granite, Wall Mountain Tuff, gray-blue quartzite, other quartzite, and, rarely, probable Paleozoic sedimentary rocks. Some clasts reach several feet in length near the base of the unit. Cretaceous through Triassic sedimentary rocks are apparently absent and may indicate timing of exhumation of these rocks along the Front Range. Overall, the unit is cross-stratified with large-scale, well-defined trough cross beds that are good indicators of paleocurrent direction. The Colorado Geological Survey, in conjunction with geologic maps created under the National Cooperative Geologic Mapping Program began a study in 2008 to determine fluvial characteristics of the unit, with the main focus being paleocurrent measurements of channel axes. Approximately 2900 individual troughs plus 100 large-scale tabular cross beds were measured at over 200 locations. At each trough the data collected included: azimuth of trough axis, inclination of foreset beds, length of axis, maximum width of trough, and size and lithology of largest clast. The preliminary findings include: confirmation of a main trunk fluvial channel that trends S-SE from 6 km E-NE of Castle Rock to southeast of Elbert, three tributary streams that are directed from the W-SW and feed into the main trunk, atypical N-NW paleocurrent directions in the westernmost exposures of one of the tributaries, and confluences associated with these newly documented tributaries. Twenty-four surveys of clast lithology, size, and roundness also were performed, and results indicate differences in bed load characteristics between the main trunk channel and the tributary channels.
IS THE CONCEPT OF THE COLORADO MINERAL BELT THE BEST WAY TO UNDERSTAND THE DISTRIBUTION OF EPITHERMAL ORE DEPOSITS IN COLORADO?

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Different models have been presented by Lovering (1930) and Tweto and Sims (1963) to explain the distribution of epithermal ore deposits in Colorado. GIS analyses using the outlines of mining districts and data from the Mineral Resource Data System of the USGS provided tests of the two models. The results reveal that the Colorado Mineral Belt of Tweto and Sims (1963) does not provide the best correlation with Colorado's mining districts and known metallic mineral resources (gold, silver, copper, lead, molybdenum, zinc, tellurium, and bismuth).

Components of Lovering's (1930) model for the Front Range, when applied statewide, provide the most robust correlations— even more so than the correlations with Tweto and Sims' (1963) “maximum extent” Colorado Mineral Belt. The statewide application of Lovering's (1930) model accounts for the “anomalous” mining districts of Rosita-Westcliffe, Cripple Creek-Victor, Rito Seco, and Hahns Peak; all of which are excluded from Tweto and Sims' (1963) “maximum extent” of the Colorado Mineral Belt. The results of this study are also consistent with the detailed work of Caine (2007 & 2008), Klein and others (2008), and Wessel and Ridley (2010) showing that the Proterozoic shear zones are not the primary control for ore deposits in the Front Range.

The results of this study demonstrate that the Proterozoic metamorphic rocks in Colorado provided the first-order, geologic control for the upward migration of Laramide and post-Laramide magmas and ore-forming fluids. Additionally, the analysis confirms Lovering's (1930) conclusion that Proterozoic granitic plutons acted as barriers to upward migration of magmas and ore-forming fluids during the Tertiary. Moreover, our analysis indicates that the Proterozoic granitic barriers probably diverted and concentrated the ascending fluids near the pluton margins because a high percentage of known mining districts and metallic mineral resources in Colorado occur within one mile of these pluton margins.
Heat is the primary form of energy that drives the internal geological processes in planetary bodies. These processes range from large-scale tectonics and volcanism to metamorphism, ore genesis, thermal maturation of hydrocarbons, and the heating of water in thermal springs. For most planetary bodies the heat is a combination of primordial heat (secular cooling) and radiogenic heat. Primordial heat is the thermal energy associated with initial accretion and differentiation, and is primarily associated with kinetic and gravitational energy. This heat is greatest shortly after the body has formed and differentiated. Radiogenic heat from the decay of unstable isotopes of U, Th, and K provides heat later in the life of a planetary body, although secular cooling continues to provide a substantial portion of the Earth's thermal energy budget. The surface temperatures of planetary bodies are controlled by energy gained and lost from the Sun during their rotational (daily) and orbital (annual) cycles. The temperature field inside a planetary body must adjust to the surface temperature boundary conditions: if the surface boundary conditions change, the internal temperature field must adjust to the new boundary conditions. Thus, there is an outer layer in a state of constant readjustment to diurnal and annual temperature changes and to measure the internal heat flow from a planetary body measurements must be made beneath this layer or through an annual cycle. Similarly, the effects of surface temperature variations associated with topography and slope azimuth must be included in corrections, other factors that change surface temperature or refract heat flow, and heat transport by water, magma, or other fluids.

In Colorado, heat-flow determinations are typically made in drill-holes from 100 to several hundred meters in depth. Temperatures are measured in the holes as a function of depth. Thermal conductivities are measured on core samples from the holes and heat flow is calculated as the product of geothermal gradient (rate of increase in temperature with depth) and thermal conductivity. These data are supplemented by heat-flow estimates using geothermal gradients calculated from bottom-hole-temperatures from oil and gas holes and thermal conductivities based on measurements on representative samples. These results show generally higher heat flow in the mountainous regions of Colorado than in the plains. However, superimposed on this general distribution are a number of local geothermal areas (hot springs) associated with hydrothermal systems and areas of higher heat flow commonly over silicic plutons. The correlation among higher heat flow and silicic plutons results from higher concentrations of U, Th, and K in these plutons than in the crust in general.

The only planetary body apart from earth on which heat-flow measurement have been made is the Moon. Determinations at two
sites were made during the Apollo program with the astronauts drilling short holes for the measurements into the lunar regolith. A robotic mission (InSight) to measure heat flow on Mars is planned for 2016. Most of the same physical parameters that must be considered in making heat-flow measurements in Colorado have also been considered in designing the Mars heat-flow experiment. However, the practical limitation of the experiment on Mars are very different from those on Colorado. Taking a drilling rig to Mars is not feasible: the Mars experiment is an instrument designed to drive itself into the martian “soil” with an internal hammering mechanism. It will make stops during penetration to measure thermal conductivity, and trail an instrumented tether to measure the thermal gradient. A penetration of five meters is planned, but adequate data should be collected if penetration is only two meters. The instrument will collect temperatures for one martian year. Corrections will include local topography and shadowing from the spacecraft. We hope to provide a constraint on the bulk U, Th and K composition of Mars.
EDUCATIONAL AND PROFESSIONAL STANDARDS FOR A GLOBAL PROFESSION: INTRODUCING INFORMATION DEVELOPED AS PART OF THE IUGS TASK GROUP ON GLOBAL GEO SCIENCE PROFESSIONALISM WEBSITE

Barbara Murphy, CPG (AIPG), Scottsdale, AZ; Ruth Arlington (European Federation of Geologists), Oliver Bonham (Geoscientists Canada), Rakesh Kumar (Geoscientists Canada), Andrea Waldie

The 4th International Professional Geology Conference (4IPGC) held in Vancouver, British Columbia, Canada in January 2012 was a collaborative effort of several professional geology organizations in planning the successful conference. The two-and-a-half day conference featured speakers from many countries addressing various topics under the theme of Earth Science – Global Practice. It was quite clear that geoscientists worldwide face many of the same concerns and issues regarding professional and educational standards, and communicating to the public the importance of geoscience professionalism. Following the 4IPGC, several members of the planning committee, under the lead of Geoscientists Canada, worked together with the International Union of Geological Sciences (IUGS) in forming the Task Group on Global Geosciences Professionalism (TGGGP). The purpose of the TGGGP is to ensure that geoscientists are fully engaged in the transformation of their global profession by providing information that will result in a greater understanding of geoscience professionalism by all geoscience stakeholders. The TGGGP website is being developed to provide information to benefit society and the global geoscience community by acting as a forum for collaboration on matters of professionalism in geoscience on a local, national, and international level. This collaboration should result in greater protection to the public and the environment through increased communication and understanding of professionalism in the geosciences. A summary of the information on the web site and the activities of the TGGGP will be provided in this presentation.
COLORADO CEMENT INDUSTRY - 2013

Tom Newman, Holcim (US) Inc., Ft Collins, CO

- Overview of Colorado’s cement industry, producers and consumption
- Raw materials and mining methods
- New priorities in mining, social, governmental, and environmental
STATEMAP GEOLOGIC MAPPING IN COLORADO - REAPING MANY BENEFITS

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Colorado Geological Survey (CGS) is one of 48 state geological surveys that has participated in the STATEMAP grant program. The program is part of the National Cooperative Geologic Mapping Program (NCGMP) and is administered by the U.S. Geological Survey (USGS). Sister programs under the NCGMP include FEDMAP (for USGS mapping projects) and EDMAP (for student mapping projects through universities). STATEMAP grant funding requires matching funding from non-federal sources by the recipient state geological survey. The primary aim of the program is to promote general geologic mapping for projects of one-year duration, as per the particular needs of each state.

CGS has mapped 101 7.5-minute quadrangles at 1:24,000 scale since the program’s inception in 1993. Between USGS and CGS, only 25% of Colorado has been mapped to date at that scale. The CGS program is geared toward population corridors where geologic maps are needed to support decisions for land-use issues. Long-range and annual mapping plans and priorities are decided interactively with the Colorado Geologic Mapping Advisory Board, a stakeholder group representing federal, state, local, and tribal governments, academia, and private industry.

CGS runs three to eight mapping projects per year using staff geologists and, sometimes, contract geologists. Mapping has occurred in seven geographical project areas: Front Range, Colorado Rift, San Juan, Gunnison, Western Slope, and Northwestern Colorado. Each project consists of a 7.5-minute quadrangle and requires up to 3 months of field work. Considerations for mapping include the type of geology present, assigning geologists with applicable expertise and availability, hiring of university students as field assistants, and limitations on the field season (as imposed by climate, hunting, and ranching operations). Land access is a key issue, especially because the program focuses on areas of private land.

There are many ways to make a geologic map. And CGS has used them. Typically, the geologist and assistant visit as much of the 58 mi² area as possible to make observations, take measurements, photos, and notes, and map with ink onto stereo aerial photos. We make ever-increasing use of pocket and tablet computers with GIS capabilities. Back in the office, we digitize our own maps and later pass the files to a GIS specialist for clean-up and cartography. After several rounds of editing, the maps are published. All CGS geologic maps can be downloaded for free from our online book store.

CGS 1:24,000-scale geologic maps are relatively detailed and consistent. They are valued for land-use planning, geologic-hazard
STATEMAP GEOLOGIC MAPPING IN COLORADO - REAPING MANY BENEFITS
(Continued)

assessment, and mineral, energy-fuel, and ground-water resource development. In addition to societal benefits, the maps can be used for learning about an area's unique geologic history. Nearly every mapping project yields scientific findings that advance the understanding of that area's geology. Several examples will be highlighted.
LESSONS LEARNED IN SHALE DEVELOPMENT WATER MANAGEMENT AND TREATMENT

Hunter Nolen, with Tom Beck, Bob Kimball, and Jay Accashian, nolench@cdmsmith.com, CDM Smith, San Antonio, TX

Oil and natural gas production from low permeability shale formations has recently become economically viable due to technological advancements in horizontal drilling and hydraulic fracturing. Shale O&G is present in numerous and large “basins” around the world, including across the United States, and has been previously untapped due to the very “tight” low-permeability nature of shale rock. With the combination of horizontal drilling and multi-stage hydraulic fracturing, previously inaccessible oil and natural gas are enabled to flow through newly formed fractures in the shale to production wells. As a result of these new advancements, development of shale formations is one of the most rapidly expanding trends in energy production today. With this rapid expansion come numerous environmental management responsibilities, not the least of which is effective management of water resources and water quality.

Water management in shale development consists of acquisition of water for drilling and fracturing, handling and storage of fresh and produced waters, transport of waters between sources and drilling locations, capture of produced water for handling, storage, treatment, reuse and disposal, and in some cases treatment of produced water for surface discharge. This increased level of required water management has challenged the O&G industry and supporting industries to rapidly expand and improve their water management planning and execution strategies and programs. The purpose of this presentation will be to provide a summary of those challenges and some of the lessons learned in this arena since the early days of large-scale shale development.
HISTORY OF THE NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT (NIROP) NATIONAL PRIORITY LIST SITE, FRIDLEY, MINNESOTA

Harvey D. Pokorny, PG, CPG, NAVFAC MW, Great Lakes, IL

The 83-acre Naval Industrial Reserve Ordnance Plant site (NIROP) lies approximately 700 feet east of the Mississippi River in Fridley, Minnesota. The U.S. Navy and its contractors produced advanced weapons systems at the industrial National Priority List (NPL) site from 1940 to 2012. In 1981, trichloroethene (TCE) was discovered in on-site groundwater wells and in the City of Minneapolis drinking water treatment plant intake pipe, now located within the Mississippi River approximately 4,900 feet downgradient from the NIROP site. In 1983, investigations identified pits and trenches in the “North 40” area of the NIROP site where drummed wastes had been disposed. Contaminated soil and drums have since been excavated from the “North 40” area and properly disposed off-site.

In August 1988, a remedial investigation and feasibility study revealed that impacted groundwater originating from the site was flowing towards the Mississippi River at TCE concentrations of up to 37,000 parts per billion (ppb). In contrast, the Safe Drinking Water Act sets the maximum contaminant limit (MCL) at five ppb TCE for potable water. Concentrations of TCE in area monitoring wells adjacent to the river have since decreased to levels ranging between non-detect to 150 ppb, and TCE has not been detected in the city of Minneapolis water intake pipe since the 1980s.

On September 28, 1990, EPA issued a Record of Decision (ROD) that presented a cleanup remedy to hydraulically contain the groundwater contaminant plume using an extraction well system. The Navy conducts cleanup and groundwater monitoring action at the NIROP site through a partnering arrangement with the U.S. EPA and the Minnesota Pollution Control Agency (MPCA).

Groundwater treatment has been ongoing at NIROP since September 1991 and continues today. Additional wells were installed, replaced, and/or taken out of service over the years, along with treatment system upgrades designed to maximize system performance and gather additional information. More than 4.3 billion gallons of groundwater have been treated since 1991, resulting in a recovery of over 38,000 pounds of TCE.

The system is removing contaminants between 25 and 100 feet in depth, but it will take excessive time for groundwater to reach cleanup goals at the current pace. The Navy is continuously evaluating new cleanup options that may help speed up the process and allow the site to reach cleanup goals in a more timely fashion.
Abstracts

HISTORY OF THE NAVAL INDUSTRIAL
RESERVE ORDNANCE PLANT (NIROP)
NATIONAL PRIORITY LIST SITE,
FRIDLEY, MINNESOTA
(Continued)

Groundwater remediation at the site is complicated by glacial drift sediments intertwined with fluvial terrace channels on the east and stacked channels closer to the river edge. The Navy is planning a source investigation in the summer of 2013 featuring vertical sampling at 30 locations. A preliminary overview of investigation results will be presented.
BANGLADESH RESPONDS TO RISING SEA LEVELS BY RAISING SEA DIKE EMBANKMENTS

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Flood control works control seas and rivers from inundating the land, while drainage control works remove inland waters to seas and rivers. To control the seas and rivers from flooding the land in Bangladesh, there are three types of embankments, all of which are constructed from compacted earthen materials or native soil and slope-covered with native grass. The three embankment types are: 1) Sea Dike; 2) Interior Dike; and 3) Marginal Dike. These are designed and constructed by the Bangladesh Water Development Board (BWDB) to protect the land from seawater intrusion, including from cyclonic storms and tidal bores. Sea Dikes were previously constructed to an elevation of 4.5 meters (m) above mean sea level (AMSL), but more recently are constructed or being upgraded to 5.2 m AMSL to account for the observed net rise in sea level over the past ten years. Sea Dikes have a 7:1 to 5:1 seaward slope and a 2:1 landward slope. Interior Dikes have a 3:1 seawater slope and a 2:1 landward slope. Marginal Dikes have a 2:1 seaward and landward slope. BWDB embankments are usually completed with grasses, but nearly always develop densely forested berms and, in urban and peri-urban area, encroaching human settlements. BWDB also designs and constructs outfalls with flap gates to keep the seas and rivers from intruding the land, and one or two vented sluice gates on the landward side of the structures to control surface water heights and flows to the seas and rivers. Due to lack of sustained funding, BDWB no longer operates or maintains the outfalls and its gates, but has turned this over to local communities with demonstrations and some guidance. The gates then are operated and maintained by local community water management committees, town council engineers, and other local entities. In addition to significant seawater and tidal water challenges to keep outland water from flowing inland, the country has significant drainage challenges to remove inland water outward. The drains are usually earthen as primary, secondary and tertiary. Primary drains discharge to sea. Secondary drains discharge to primary drains. Tertiary drains, which include street drains, discharge to secondary drains. Typically primary and secondary drains have open surfaces, while tertiary drains are often covered to allow for foot and vehicle traffic. Major drainage challenges come from lack of funds and organizations to maintain and clean the drains, often clogged with sediment and solid waste/ trash from human settlements. Flooding and drainage concerns are most severe in secondary towns, or coastal towns, where dry-season drainage is raw sewage with debris, trash and solid waste. Coastal towns in the Ganges-Brahmaputra-Meghna Delta adjoining the Bay of Bengal are usually situated a few kilometers away from the sea shore of the Bay and on the banks of some rivers. The elevation of the towns is on average 2 to 10 m AMSL. The towns are constituted on alluvial deposits, mostly of clayey silt, and may also be overlying land undergoing subsidence.
SECONDARY CONTAINMENT—REGULATIONS AND BEST MANAGEMENT PRACTICES

Beth Powell, New Pig Energy Corporation, Tyrone, PA

With the most recent revision to the Spill Prevention, Control and Countermeasure rule now in effect, this presentation will explain applicability, list plan requirements and answer questions about the SPCC rule. Drilling, workover and production facility requirements and options will be explained. Beyond the Federal Clean Water Act requirements, secondary containment for drilling and hydro fracturing has become a requirement under Pennsylvania Act 13 of 2012 as part of Master Containment Plans. It is also considered a Best Management Practice within the rest of Appalachian shale plays. Practical and newly developed multi-stage containment options will be reviewed. Areas of concern and containment testing options will be discussed, including passive and active secondary containment for temporary and permanent installations.
RARE-EARTH ELEMENTS AND THE BEAR LODGE PROJECT, WYOMING

Donald E. Ranta, Ph.D., CPG, Chairman, Rare Element Resources, Golden, CO

Rare earths are critical to a host of high-tech, clean energy, and national defense technologies including computer hard drives, photovoltaic cells, compact fluorescent lighting, electric and hybrid vehicles, wind turbines, water purification, telecommunications, and magnetic resonance imaging. The fifteen rare-earth elements (REE) have been prominent in the news of the hard minerals industry over the past couple of years as Chinese rare-earth exports have shrunk despite rapidly increasing global demand. China, which mines and produces about 96% of global rare-earth elements, has centralized, consolidated, and/or shut down a substantial portion of its rare-earths production capacity while raising export tariffs on REE-bearing products it ships worldwide. Implementation of internal policies to consolidate and more tightly regulate its rare-earths production sector caused China to announce it may become a net rare-earths importer within four to five years.

Rare Element Resources is developing the Bear Lodge REE project in northeastern Wyoming with exploration and evaluation plans leading toward completion of a Feasibility Study in early 2014. The Bear Lodge deposit has one of the highest grades and one of the best values per ton of all REE deposits outside of China. A preliminary feasibility study has been completed with favorable economic results. The REE mineralization is hosted in carbonatite bodies, and oxidized equivalents, that intrude diatremic breccias and alkalic intrusive rocks of Tertiary age. District zoning of REE mineralization indicates increasing heavy REE in its western portion. Significant gold mineralization is zoned peripheral to and partly overlapping the REE mineralization. Measured and Indicated REE resources in the near-surface oxidized zone are 7.5 million tons averaging 3.79% REO, and Inferred resources of additional oxidized material are 25.7 million tons averaging 2.83% REO. Additional drilling conducted during 2012 is expected to substantially increase the M & I resources.
In 2010, the author was hired by the American Talc Corporation to perform a geological resource assessment of talc deposits at a site within the Trans-Pecos region of West Texas. This site represents a small window of Precambrian meta-sediments and meta-volcanics between the towns of Sierra Blanca and Van Horn. Mapping and resource estimations were last performed on this property in 1983 by the same author when he was 27 years old – exactly half of his age in 2010. Given the nostalgic nature of the project and the historical baseline, special attention was given to the changes in the efficiencies of field methodology and data analysis. Specifically, field mapping that required two years in 1987 was reproduced, at a higher resolution within three weeks in 2010. Resource computations that formerly took two months to complete were accomplished within a few hours. These improvements are due to career-changing technological breakthroughs that have occurred during the last decade. Field devices such as hand-held GPS (Global Positioning System) have essentially eliminated many of the tedious surveying methods employed by geologists. High-resolution satellite imagery readily available through Google Earth on field computers tremendously assist the geologist in locating contacts and faults. Pocket cameras with built-in geo-referencing (embedding the GPS coordinates within the image) have become an indispensable tool. Even the ancient Brunton Pocket Transit has undergone some subtle improvements that double its efficiency when measuring bedding and fracture orientations. All of these wonderful improvements beg the question of “What’s next?” The current explosion in tablet technologies, LiDAR (Light Detection and Ranging), GPS-coupled geophysical equipment, and visual interfacing (e.g. Google Goggles) are already revolutionizing fieldwork. Field “seasons” are now being compressed into weekends. More importantly, the scientific insights provided by these breakthroughs are far more profound. Tom Wolfe’s premise in his book “You Can’t Go Home Again” is wrong. You can go home; it’s just much faster, easier, and more accurate.
A ROTATED BLOCK COMPLEX LOCATED BETWEEN LARGE STRIKE-SLIP FAULTS IN COLORADO’S NORTHERN FRONT RANGE

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In the eastern Livermore Quadrangle, situated in Colorado’s northern Front Range, there are two sub-parallel, large-scale, right-lateral strike-slip faults that are oriented northeast-southwest and located approximately two miles from each other. Campbell Mountain lies in-between the two strike-slip faults. Both the southern and the northern strike-slip faults are actually complex transpressional strike-slip systems. The northern strike-slip fault of the pair, at Horseshoe Monocline, occurs along the northern margin of Campbell Mountain. The southern strike-slip fault of the pair is the eastern extension of the Livermore Fault. The Livermore Fault in this area is manifested as an assemblage of large-scale detachment folds which include the Campbell Valley Anticline and the Livermore Anticline. Both fold structures have been formed in a right-lateral strike-slip, transpressional regime. The Permo-Triassic section in the area has notably thick accumulations of mobile evaporite deposits that have complexly interacted with strata above and below the deposits.

Detailed field investigations completed by others, coupled with ongoing field mapping in the Campbell Mountain area, indicate that Campbell Mountain itself has been rotated in a counter-clockwise motion between the two strike-slip fault systems. The thick accumulations of evaporites within the Permo-Triassic Lykins Formation in the area have facilitated the rotation of the Campbell Mountain block. The areal extent of the rotated block encompasses approximately five square miles.
MINING – ENERGY SECURITY AND INDEPENDENCE FOR THE WORLD

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The mining industry will play a critical role in meeting the world’s future energy needs and in lifting the developing world out of poverty. Currently over 3.5 billion people have no or only partial access to electricity; coal and uranium, which together account for more than half of the U. S. electricity needs, will play a key role in providing affordable and reliable energy throughout the world. Meanwhile, other minerals are essential to emerging renewable energy technologies. Colorado, which ranks 9th in the production of coal, 4th in gold, and 1st in molybdenum is a leader in the production of both traditional energy fuels and in minerals essential to alternative energy. The presentation will analyze trends in mineral development and what the United States must do in order to secure its energy future here and its leadership in mining worldwide.
EXPLORING AREAS OF NATURAL ACID ROCK DRAINAGE IN COLORADO

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Colorado has a world-class mining heritage that is known for historical development of precious and base metal deposits throughout the mountainous portion of the state. Unfortunately, the environmental legacy of some historical mines has led to acid mine drainage that pollutes streams with acidic, metal-laden water.

In Colorado, water quality degradation caused by acid mine drainage from historical mines became a major focus of federal and state environmental regulation, resulting in numerous cleanup initiatives. Identifying and remediating major mining sources of acid- and metal-loading to streams ensued. This focus was appropriate and necessary, but the natural geologic setting of the mines was often not recognized in early cleanup efforts.

In the late 1980s and -90s, geologists involved in programs to identify mining point sources of environmental degradation observed areas of acidic and metal-laden water not associated with mining, but occurring upstream of any significant mining or anthropogenic impacts. Anecdotal and a few documented accounts of these natural occurrences led the Colorado Geological Survey to embark on a statewide inventory of natural acid rock drainage (NARD).

In the study, "Natural Acid Rock Drainage Associated with Hydrothermally Altered Terrane in Colorado," eleven different headwater areas were documented as exhibiting NARD upstream of mining impacts. These areas include the Silverton and Lake City calderas, Platoro-Summitville caldera complex, Kite Lake (San Juan Mountains), East Trout Creek (San Juan Mountains), La Plata Mountains, Rico Mountains, Grizzly Peak Caldera, Ruby Range, Montezuma Stock, Red Amphitheatre (Mosquito Range), and Rabbit Ears Range.

The study collected extensive water quality data at 101 sites; 86 of these were determined to have no anthropogenic influence. In addition, hydrothermal alteration was mapped in several areas through field mapping and remote sensing data compilation. The severity of NARD in an area was directly related to the intensity of alteration and sulfide mineral content. In all of the areas studied, changes in water chemistry, from essentially untainted (near neutral pH/low metal) to NARD (acidic/high metal) water are readily related to changes in alteration type and intensity.

In NARD areas, stream water quality standards were exceeded most often for pH (77%), Mn (67%), Al (76%), Cu (58%), Zn (58%), Fe (44%), and Cd (44%). Less common exceedances included Ni, SO₄, Pb, Tl, As, F, Ag, Cl, Cr.
EXPLORING AREAS OF NATURAL ACID ROCK DRAINAGE IN COLORADO
(Continued)

Many of Colorado's NARD areas are in watersheds where both natural and historical mine-induced acid rock drainage affect water quality. Detailed characterization of the natural and anthropogenic sources is especially important in drainage basins slated for mine-reclamation projects so that realistic remediation goals can be defined.
KEystone Heights, Florida: The Search for New Water

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The City of Keystone Heights, in the northeastern part of Florida, is looking for new water for its near-by lakes. Lake Brooklyn is north of the City and Lake Geneva is to the south. These lakes, and others in the sand hills region, were formed by sinkhole collapse features. The sinkhole lakes characteristically experience the slow but continuous seepage of surface water vertically downward into the Upper Floridan Aquifer (UFA), and are replenished by seasonal rainfall.

The UFA is a regionally large aquifer, of variable confinement. The UFA supports many large and small springs along the Suwannee River and its tributaries. There are two well-defined recharge areas in this large aquifer system. One of them is at the Keystone Heights area. The UFA is the primary source of water for public supply, agriculture, electric power generation, and recreation. The increasing volume of withdrawals from the UFA has affected the potentiometric surface of the aquifer in the Keystone Heights area, causing a continuous decline during the last 30 years. This decline has increased the vertical hydraulic gradient, particularly in areas lacking confinement, resulting in greater seepage losses from the lakes to the underlying UFA. The induced leakage, in combination with a significant reduction in long-term annual precipitation related to climate change, has resulted in a rather dramatic decline in the surface-water levels in lakes in the region, exceeding 20 feet in some lakes.

In 2001 Schreuder, Inc. was selected by the St. Johns River Water Management District (SJRWMD) to identify the possibilities for increasing surface water flows to Lake Brooklyn, Lake Geneva, and other depleted lakes. Following a series of studies and assessments by a variety of government agencies, private consultants, citizens groups, and local officials, a plan was developed to import water from other areas to potentially refill the lakes and promote additional recharge to the UFA.

Although not all of the details of the plan have been officially approved, this presentation will illustrate the proposed framework of the plan, the complex components required to achieve long-term success, and the public involvement which galvanized support at the agency level for an economically sustainable solution. That solution includes the capture of stormwater from a fifty-mile toll road to be built by the Florida Department of Transportation; the capture of high flows and floodwaters in a major drainage basin, and the importation of wastewater effluent previously discharged to the St Johns River. The combined waters will be filtered in a natural wetland treatment system and allowed to infiltrate.
AMMONIUM: EFFECT ON THE HYDRAULIC CONDUCTIVITY AND MEASUREMENT IN THE EXCHANGE COMPLEX OF SODIUM BENTONITE IN GEOSYNTHETIC CLAY LINERS

Melissa Setz, SA, Amara Meier, Sabrina Bradshaw, Craig Benson, University of Wisconsin-Madison; Geological Engineering Program, Madison, WI

Sodium bentonite clay has high swell properties and low hydraulic conductivity. This clay is the primary component of geosynthetic clay liners (GCLs), a hydraulic barrier material commonly used to line municipal solid waste (MSW) landfills. Studies have found that cation exchange, specifically the replacement of sodium cations for other cations in permeant solutions, occurs over time and can cause a decrease in the bentonite swell, increasing hydraulic conductivity, potentially leading to increased leakage from waste containment facilities.

Recent research has identified that ammonium found in MSW leachate can induce cation exchange, causing ammonium to comprise a significant portion of the bentonite exchange complex. Currently the effects of varying amounts of ammonium in the exchange complex of bentonite on the hydraulic conductivity of GCLs are unknown. Studying the effect of ammonium on the hydraulic conductivity of GCL is pertinent due to the elevated presence of nitrogen in MSW landfill leachates, particularly those operating with leachate recirculation or as bioreactors. This study investigated the influence of ammonium on the hydraulic conductivity of GCLs for cases where complete or partial replacement of sodium by ammonium occurred when the GCLs were permeated with ammonium solutions having concentrations representative of those found in MSW leachates.

Hydraulic conductivity tests were conducted with permeant solutions of varying ammonium concentrations. A 1.0 M ammonium acetate permeant solution was use to simulate worst case conditions where complete cation exchange to an ammonium GCL occurs. GCLs were also permeated with 0.05 M and 0.005 M ammonium acetate solutions. These concentrations reflect high and moderate ammonium concentrations found in MSW leachates. Hydraulic conductivity and nitrogen concentration in the effluent were monitored every pore volume of flow until hydraulic and chemical equilibrium were reached. The exchange complex was characterized using a lithium bromide extraction technique adapted from ASTM D7503.

To date, hydraulic equilibrium has been observed in all three permeameters, while chemical equilibrium has only been observed in the 1.0 M ammonium acetate permeameter. The equilibrium hydraulic conductivity for the 1.0 M solution is 5.3x10^{-6} m/s. Initial results for solely hydraulic equilibrium for the 0.005 M and 0.05 M permeant solutions are 1.7x10^{-11} m/s and 2.0x10^{-11} m/s respectively, but will not
AMMONIUM: EFFECT ON THE HYDRAULIC CONDUCTIVITY AND MEASUREMENT IN THE EXCHANGE COMPLEX OF SODIUM BENTONITE IN GEOSYNTHETIC CLAY LINERS
(Continued)

be confirmed until chemical equilibrium is reached. Currently, the more concentrated permeant solution has resulted in an increased hydraulic conductivity. Once chemical equilibrium is reached for all samples, the exchange complex and CEC for the bentonite will be determined to relate the concentration of ammonium in the exchange complex to the hydraulic conductivity of the GCL.
FEDERAL ISSUES AFFECTING THE OIL AND NATURAL GAS INDUSTRY IN THE WEST

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Operating on federal lands has always been a time-consuming, burdensome process compared to non-federal lands. As the political, economic and demographic environment changes in the West, the issues surrounding public lands development have achieved greater prominence in the national debate. Can the Obama Administration claim credit for increased oil and natural gas production, even as it’s down on federal lands? Can the West compete with other regions that aren’t as affected by federal policies? Will natural gas exports help to revive slumping basins hampered by federal regulation? This talk will explore the major federal regulatory, legislative, environmental, and other policy issues facing the exploration and production industry in the West within the context of current events and public debates.
MAPPING GRAVESITES AT A 19TH CENTURY PIONEER CEMETERY USING MAGNETICS, ELECTROMAGNETICS AND GROUND PENETRATING RADAR

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The passing of time degrades cemeteries, gravestones, names, and locations which become forgotten to history. The science of near-surface geophysics can help breathe new life into the search of history. The Daughters of the American Revolution (DAR) are interested in non-invasive ways of re-locating lost graves in old cemeteries. Working with a local DAR chapter, we seek to locate graves of Revolutionary War and War of 1812 veterans. Presently unmarked graves, where headstones have been lost, are known to be present in a particular area of the targeted cemetery based upon plot records and other historical documents. The goal of this study is to determine if such unmarked graves in Southwestern Ohio, from the early 19th century, can be located with geophysical techniques and, if so, which method(s) is(are) most effective.

This study employs three geophysical techniques; magnetics, electromagnetics, and ground penetrating radar. The equipment includes a Geometrics 858 Cesium Magnetometer (gradiometer configuration), GSSI SIR-3000 GPR with a 400 MHz antenna, GSSI EMP 400 Profiler (16 kHz, 9 kHz, & 5 kHz), and a Minelab E-Trac metal detector (1.5-100 kHz, using 28 simultaneous frequencies).

The study site is the Stevenson cemetery near Xenia, Ohio, which dates from the early 19th century. The area selected is largely devoid of headstones but contains visible depressions with dimensions that resemble the grave pattern on hand-drawn plot maps. A common grid was established and used for all three geophysical methods. The preliminary results from the cesium magnetometer data set suggest a grave-like pattern. The EM data and GPR data have been collected and are currently being processed. Additionally, a Minelab E-Trac is being used to map small metallic anomalies in the very shallow sub-surface to complement results from the EM and Magnetics data.

Matching and comparing historical plot maps with the geophysical data, supported by the presence of local headstones, may enable delineation of specific graves of known Revolutionary War and War of 1812 veterans. The local DAR chapter can then appropriately re-mark these graves and bring this piece of history back to life for future generations to experience. The most successful geophysical method(s) identified can then be used to map other sections of this and other cemeteries in the local area.
Black Range Minerals Limited is a USA-focused uranium development company listed on the Australian Securities Exchange. It controls the 90 million pound Hansen/Taylor Ranch Uranium Project located northwest of Canon City, Colorado. Black Range is a 50% owner of the Ablation technology, in a joint venture with Ablation Technologies LLC, and is strategically aligned with Kinley Exploration LLC to refine the Underground Borehole Mining methodology to apply it to mine the Hansen Uranium Deposit.

Ablation is a low-cost method of recovering sandstone-hosted uranium mineralization by applying a physical grain-size separation process. In economic terms the technology reduces ore transportation and milling costs; while in environmental terms it reduces waste at both the mining and milling stages. Underground Borehole Mining significantly reduces surface disturbance and allows for quick access to an ore body at low capital and operating costs.

This talk will examine the Hansen Uranium Deposit and describe both Ablation technology and Underground Borehole Mining.
NEW RESERVES IN AN OLD FIELD, THE NIOBRAARA RESOURCE PLAY IN THE WATTENBERG FIELD, DENVER BASIN, COLORADO

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The Niobrara is one of nine horizons that are productive in the giant Wattenberg Field area (GWA) of Colorado. GWA covers approximately 3200 square miles. The field was discovered in 1970 (J Sandstone) and first significant Niobrara production was established in 1976 from vertical completions. Horizontal Niobrara drilling began in the field in 2009.

Wattenberg straddles the Denver Basin synclinal axis and is regarded as a basin-center petroleum accumulation. The Niobrara is overpressured and drilling depths are 6200 to 7800 ft. The Wattenberg area is a “hot spot” or positive temperature anomaly. Temperature gradients range from 16 – 18°F/1000 ft on the edges of the field to about 28 to 29°F/1000 ft in high Gas-Oil Ratio (GOR) areas.

The Niobrara consists of four limestone (chalk) units and three intervening marl intervals. The lower limestone is named the Fort Hays and the overlying units are grouped together as the Smoky Hill member. The chalk units are referred to in descending order as the A, B, C, and Fort Hays. Erosional unconformities exist at the top and base of the Niobrara. The upper unconformity removes the upper chalk bed in some areas of the Wattenberg Field. The B and C chalks are the main focus of horizontal drilling by operators in the field. The underlying Codell Sandstone/Fort Hays is also targeted with horizontal wells.

Recent horizontal completions have initial production of approximately 100 to 700 barrels of oil per day (BOPD) with a GOR of 500 to 10,000 cu ft per barrel. Estimated ultimate recovery per well is greater than 300,000 barrels of oil equivalent (BOE). The Wattenberg area has a resource estimate from the Niobrara of 3-4 billion barrels equivalent. The combined technologies of horizontal drilling and multistage fracture stimulation have brought significant new life into this 43 year old field.
USED FUELS DISPOSITION IN THE UNITED STATES

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Strategy for the management and long-term storage of used nuclear fuels in the United States has recently been redirected toward additional studies of geologic media other than salt and volcanic tuff. The current recommendation for the US includes an integrated waste management program leading to the development of one or more permanent deep geologic facilities. International consensus indicates preference toward facilities constructed in deep geologic media as the best method for permanent and safe disposition of used nuclear fuels. Fine-grained materials (i.e., shale, clay, marl, argillite) have been specifically targeted for three primary reasons: 1) fine-grained materials are naturally low permeability media, 2) clay mineralogies typically absorb and retain radionuclides, and 3) clay rheology provides self-healing of fractures under heat and pressure regimes typical of depths of underground facilities. European efforts toward construction and testing of such underground storage facilities are arguably ahead of US efforts, having been operational for over 20 years. Currently there are three European underground facilities located in Belgium, France, and Switzerland, all located in fine-grained clay materials. These rocks range in age from Jurassic to Tertiary and are of varying mineralogic and lithologic assemblages. These variations result in wide lateral and vertical variations in engineering and mechanical properties. Thus, it is unreasonable to expect research results of material behaviors from European facilities to be transferable to the US. This has driven recent research in the US toward defining properties of geologic lithologies that could potentially host an underground research laboratory in the future. Salt and tuff have been studied extensively and more recent work has been focused on other fine-grained media. Results of these studies will be utilized to implement the integrated waste management program that is targeted at siting a repository by 2026 and having a fully licensed facility receiving used fuels in 2048.
CONTROLS ON SLOPE EROSION AT BADLANDS NATIONAL PARK

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Precise high-resolution erosion data collected from eighteen slopes at six intensively instrumented sites at Badlands National Park has provided opportunity for detailed analysis of physical controls on slope erosion and landform evolution. Erosion data collected since 2010 included slope wash, erosion pins (0.5 mm resolution), and 3D photogrammetry (sub-mm resolution). All sites were located on fossiliferous Cretaceous bedrock units that were deposited by fluvial processes. Samples were disaggregated and dispersed using a 10% solution of sodium hexametaphosphate and wet sieved using seven screens between No. 230 (63 mm) and No. 850 (10 µm). All material passing the 10 µm screen was analyzed using a laser particle sizer. Lithologically, all bedrock was classified as fine-grained silty-clay and clay where 84 to 99% of the material was <63 µm diameter, and 41 to 91% was <10 µm diameter, and 60% of all material was <10 µm in diameter. The average volumetric aerodynamic diameter of the <10 µm grains was 6.2 µm. These seemingly small variations in characteristic grain populations indicated profound effects on slope processes based on slope angle, length, and height. Mass flux rates of erosion from the bedrock surfaces was greatest on high-angle slopes consisting of coarse material and varied up to 50% across the Park. The slopes composed of the finest-grained material ranked last in net erosion regardless of slope aspect (protection) related to precipitation. Slopes consisting of the same bedrock units that were angled into or protected from precipitation impact varied in net slope reduction by a factor of ~4.5. These data indicate that as erosion proceeds, slope profiles develop as complex functions of bedrock lithology, slope angle, and aspect to precipitation resulting in steep pinnacle and gully topography characteristic of the Badlands.
MAKING EFFECTIVE GEOLOGIC PRESENTATIONS

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If you read only one publication—ever—about the art of giving effective presentations, geologic or otherwise, I recommend *Making Effective Scientific Presentations*, published in 2003 by Gary B. Lewis of the Geological Society of America. Lewis includes only two fundamental rules: be heard, and be interesting. Lewis also notes a general agreement among outstanding public speakers that effective presentations can be evaluated based on four factors. The message accounts for 25%, words and images 25%, rapport 40% and retention 10%. The most important factor is to engage your audience in the presentation. Support the rapport with a strong message, verbal content and images. Make a succinct, enthusiastic conclusion. Chances are the audience will remember you and a key concept.

My career has spanned the transition from print to digital media during the mid-1990s to early 2000s. Presentations that once were based largely on 35 mm film slides now rely mainly on PowerPoint or similar software. Software-based presentations allow the speaker a great deal of flexibility in how to present the information. Nonetheless, the same problems that resulted in awful presentations using 35 mm slides 30 years ago still plague us today. Words and images continue to present the most problems for the speaker. Images should present one concept, in simple fashion, and be visible. No acronyms or abbreviations. No font smaller than 18 points. No more text than would fit on a bumper sticker. No data tables. Simple graphs should be visible from the back of the room. Avoid garish colors. No animation.

Lewis gives a typical speaking rate of about 150 words per minute. This means you have 3,000 words for a 20 minute presentation. Plan on one slide per minute, no more than 20, and write a script. Rehearse the script until you don't need it. This frees you from reading your slides and lets you engage the audience.

Remember the two basic rules—be heard and be interesting. I have used Lewis' booklet over the last few years to good advantage. In this presentation I will show why his advice works.
FERROUS SULFATE EFFECTS ON HIGH pH SOILS

Taylor Sting, SA, PM Environmental/Michigan State University, Stephen Zayko, Jake Patin, Lansing, MI

PM Environmental, Inc. (PM) was requested to conduct a study to address potential characteristically hazardous conditions of high pH soils at a site in Troy, Michigan. The subject property is approximately 3.5 acres of vacant land historically used for agricultural purposes, including lime soil ambient use and storage. The high pH soils (>12) were first identified during completion of a Phase I Environmental Site Assessment (ESA) and confirmed during the completion of a Phase II ESA and Baseline Environmental Assessment (BEA). The desired pH range for the soil on the property was 7.0-9.0.

With approval, PM conducted a field assessment to delineate the extent of high pH soils. Delineation was performed with soil borings to a maximum depth of 10.0 feet below ground surface, and in a five foot step-out pattern, in each of the four compass directions. Approximately 20 cubic yards of high pH soils were identified. A bench scale test was conducted to determine if the addition of ferrous sulfate would reduce the soil pH to neutral conditions (7-9), and the optimal mixing ratio of high pH soil to ferrous sulfate.

The bench scale test consisted of dividing a composite soil into 12 aliquots, measuring the initial weight and pH of the soil samples, and adding a prescribed amount of ferrous sulfate to each sample. The ratios tested were: 1:1, 2:1, 5:1, 10:1, and 20:1, with each test being conducted with a dry and moist mix (20% moisture content). A control sample set (dry and wet) was also tested without the addition of ferrous sulfate. The soil and ferrous sulfate were mixed and allowed to react for a prescribed time period. After the reaction period, the soil pH of each sample mixture was measured and the soil sample mixtures were allowed to equilibrate for seven days. The final pH of the soil sample mixtures were then measured and recorded.

The bench scale study documented that the high pH soil could be neutralized to a pH of 8.0 with a 12:1 ratio soil to ferrous sulfate. Based on that ratio, approximately 4,800 pounds of ferrous sulfate would be required to neutralize the 20 cubic yards of soil.
DIRECT INJECTION OF ZVI AND ORGANIC CARBON SLURRY FOR TREATMENT OF PCE IN CLAY LITHOLOGY

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Groundwater at the former Serry’s dry cleaner site in Corvallis, Oregon was impacted by chlorinated volatile organic compounds (CVOCs). The primary CVOCs found at the site included PCE, TCE, DCE and VC at concentrations up to 22,000, 1,700, 3,100 and 7 ug/L, respectively. Field-scale pilot tests were performed for the Oregon DEQ’s Dry Cleaner Program to evaluate the performance of EHC® in situ chemical reduction (ISCR) technology. The pilot study involved evaluating field performance and physical distribution into low permeability soil using basic Geoprobe® injection tooling.

The lithology at the targeted depth interval at the site is composed of interbedded layers of sandy silt and silty clay. To evaluate the effectiveness of the direct push methods employed, an initial test injection emplaced 204 kg of EHC at a depth of 4.0 to 7.6 m below ground surface (bgs). The EHC slurry was injected into 4 discrete layers, spaced 1.2 m apart, using GeoProbe’s pressure activated injection probe together with a high-pressure pumping system (piston pump rated at 1,500 psi (103 bar)). The presence of EHC fractures in soil cores collected around an injection point (from 0.15 to 1.5 m from the injection point) physically validated a 1.5 m minimal radius of influence for the injection.

The full-scale pilot study was conducted in August 2006 with a total of 4,649 kg of EHC injected into an area measuring approximately 77 m² x 6 m deep (from 3 to 9 m bgs). This resulted in an average application rate of 0.6% EHC to soil mass, which appeared to be the upper limit for soil acceptance in this formation at the targeted flow rate of 19 L/min. Attempts to inject higher application rates resulted in pressure build-up in the subsurface and associated surfacing issues. Injection pressures at the targeted flow rate were generally in the range of 200 to 400 psi (14 to 28 bar) which created EHC fractures throughout the targeted subsurface. Although EHC was distributed in discrete fractures, it is noted that direct contact of the CVOCs with the EHC is not required, as various ISCR mechanisms serve to mineralize the CVOCs with diffusion, dispersion and advection also contributing to distribution.

Two years after the EHC application, total CVOCs decreased > 99.9% at all sampling locations, without an accumulation of conventional catabolites. Ethene levels of up to 760 ug/L (July 2007) represented a two-order magnitude increase compared to background levels, which helped confirm complete degradation. Rebound has been avoided, which can be attributed to the longevity (estimated 3 to 5 years) of the EHC product in the subsurface.
AQUIFER STORAGE – OPPORTUNITIES IN THE LOST CREEK BASIN, COLORADO

Ralf Topper, CPG, Senior Hydrogeologist, Colorado Division of Water Resources, Denver, CO

Hydrologic stresses produced by double-digit population growth, significant increase in urbanization, over-appropriated surface water systems, and periodic drought cycles have caused the depletion and degradation of ground-water resources throughout the arid west. The population of the South Platte River Basin, which includes the Denver Metropolitan area, is expected to double by 2050, resulting in a supply shortfall of approximately 120,000 acre-feet. Additional storage is one of the primary management strategies to address this shortfall. Though still complicated by Colorado’s water law system, the benefit and potential of storing water underground in alluvial aquifer systems is tremendous.

Water users in the Lost Creek basin, a paleo-tributary arm of the South Platte River, are heavily reliant on groundwater from the alluvial aquifer for agricultural, domestic, and commercial uses. The primary goal of this study is to quantify the existing groundwater reservoir and additional available storage capacity in the Lost Creek alluvial aquifer and identify potential sites for aquifer recharge and storage implementation. This objective was achieved through compilation and analysis of existing data, new field work and data collection, and utilization of GIS software for spatial analysis and display.

The Lost Creek alluvial aquifer consists of unconsolidated sand, gravel, silt, and clay deposited by streams and wind that overly Denver Basin bedrock aquifers. The buried bedrock erosional surface is characterized by a major north-south trending channel incised by an ancient river network that filled with alluvium. The greatest accumulation of alluvial material follows the channel axis in the central basin where its thickness can exceed 180 feet. Spring 2010 water levels in the alluvial aquifer range from close to ground surface in the north to over 120 feet below the ground surface in the south-central portions of the basin, and are similar to historic low-level conditions in the early 1970s. The water table contours indicate a water surface sloping to the north, or to the topographically lower part of the basin, at an average gradient of 27 feet per mile.

As much as 120 feet of saturated alluvial aquifer material underlies the northern part of the basin, reducing to between 60 and 80 feet further south. The Lost Creek alluvial aquifer currently holds an estimated 928,000 acre-feet of water in storage, using a uniform specific yield of 17%. Groundwater withdrawal during the period 1993 to 2010, in just a part of the northern and central basin, has exceeded recharge by about 5,700 acre-feet/year resulting in a storage loss of nearly 100,000 acre-feet.

The unsaturated portion of the alluvial aquifer provides the reservoir for additional storage. As of Spring 2010, an estimated 1.2 million acre-feet of new storage capacity is potential. This storage is large enough to provide a critical supply of water to western Colorado to address the chronic water shortage created by hydrologic stresses.
AQUIFER STORAGE – OPPORTUNITIES IN THE LOST CREEK BASIN, COLORADO
(Continued)

acre-feet of unsaturated pore volume exists at depths greater than 10 feet below ground surface. Historical observations and artificial recharge tests indicate effective recharge of the alluvial aquifer is possible in the basin using surface spreading techniques. Areas in the southern and central basin, with the greatest unsaturated alluvial aquifer thickness, represent areas of high potential for implementation of aquifer recharge and storage projects.
GEOLOGY AND MINERALIZATION OF THE EXODUS GOLD PROJECT, EUREKA COUNTY, NEVADA

Joshua Robert Townshend, Newmont Mining Company, Carlin, NV

Exodus underground is a refractory-gold deposit located in the Blue Star sub-district of the Carlin trend which also includes NW Exodus, Lantern, North Lantern, and Green Lantern. Exodus is accessed via three portals from the historical Lantern Pit located approximately 2 miles south of the Genesis Pit and 2.3 miles west of Leeville underground.

Exodus is a Carlin-type series of ore bodies primarily following N20W structural fabric and, to a lesser degree, bedding. Mineralization is hosted within the Devonian Popovich formation and unknown-age intrusives interpreted to be lamprophyres. No known alteration or geochemical signature directly correlates with gold mineralization.

To date, Exodus has produced 161,104 oz. Au and has in reserve 383,844 oz. Au. Greater-Exodus is currently unconstrained to the north and is being explored for similar deposits.
THE MILESTONE SOLUTION POTASH MINE-A WORLD CLASS PROJECT IN THE MAKING SASKATCHEWAN CANADA

Greg Vogelsang, P.Eng., P.Geo., Manager, Environment & Regulatory Affairs, Western Potash Corp., Regina Saskatchewan CANADA, and, Dean Pekeski, P.Geo., Executive Vice President, Western Potash Corp., Vancouver British Columbia CANADA

The western Canadian province of Saskatchewan hosts abundant high-grade deposits of potash within the mid-Devonian Prairie Evaporite Formation.

Potash mining began in Saskatchewan about 50 years ago and has evolved to the development of 10 operating mining and processing facilities. Used as a key ingredient in fertilizer, approximately 50% of Saskatchewan’s production is sold to the United States with the remainder sold to off-shore markets.

Given the anticipated growth in fertilizer demand for increased food requirements, new greenfield potash mining and processing facilities are being proposed in Saskatchewan. Among the new proposed projects is the Western Potash Corp. ‘Milestone Project” located in south-central Saskatchewan. The Milestone project is a world-class potash deposit near major infrastructure and labour supply. The Milestone Project has been advanced to the point of construction-ready and is anticipated to produce 2.8 million tonnes of potash annually utilizing solution mining techniques.

The Milestone Project will be one of the most technically advanced projects in the world and will utilize innovative design features including a recycled water source. Western Potash Corp. will provide an overview of the project including geological resources, engineering studies completed to date and anticipated production plans.
PROCESS-PREDICTIVE EXPLORATION METHODS FOR SHALLOW HYDROCARBON RESERVOIRS IN ANCIENT SEDIMENTARY BASINS, WITH EXAMPLES FROM THE SURAT BASIN, AUSTRALIA AND THE PARADOX BASIN, U.S.A.

Chester A. Wallace, CPG, Windy Point Exploration, LLC, Morrison, CO and David C. Jacobs

Process-predictive methods can improve exploration success in developed and undeveloped sedimentary basins throughout the world. These methods target shallow hydrocarbon reservoirs by integrating geologic, geophysical, and geochemical data to analyze fluid-migration patterns in subsiding sedimentary basins. These patterns focus exploration into areas most likely to host hydrocarbon reservoirs.

All subsiding sedimentary basins are subjected to similar physical and chemical processes that produce similar changes to the lithic fill. The temperature of sediment and interstitial fluid increases. Static pressure increases in proportion to burial depth. Basin tectonics controls dynamic pressure. Basin fluids are expelled from subsiding basins in three main stages: (1) At shallow burial depths pore-water is expelled around detrital particles; (2) At about 3,000 m burial smectite (montmorillonite) is converted to illite, which liberates a large volume of non-saline water; and (3) Low-temperature metamorphic water is released at temperatures and burial depths that convert illite to chlorite. In general, the salinity of basin fluids increases with depth at the same time as H₂S increases and O₂ decreases. Kerogen is converted to liquid petroleum, which along with biogenic and thermogenic gas, are released into migrating fluids.

Accompanying these basin processes are fluid-rock interactions that result in precipitation of a predictable sequence of mineral cements during progressive–burial diagenesis and subsequent alteration diagenesis, thereby marking fluid-migration pathways. Under a regime of increasing temperature and pressure during early subsidence a common paragenetic sequence of burial diagenesis in clastic rocks is Fe³⁺-quartz-clay-carbonate. Late in the subsidence history, alteration diagenesis of conduit strata occurs where reduced, warm, acidic metal-bearing oil-field brine chemically reacts with earlier-formed cements and detrital grains to enlarge pore spaces and pore throats.

Combining alteration characteristics with burial-history diagrams enhances exploration accuracy. In sedimentary basins the timing of water-expulsion and hydrocarbon-generation events is predictable from burial-history diagrams. Chemically reactive basin fluids were expelled from the “hydrocarbon kitchen” into conduit strata where oxidation-reduction (redox) chemical reactions between migrating brine and permeable conduit strata permanently altered minerals.
PROCESS-PREDICTIVE EXPLORATION METHODS FOR SHALLOW HYDROCARBON RESERVOIRS IN ANCIENT SEDIMENTARY BASINS, WITH EXAMPLES FROM THE SURAT BASIN, AUSTRALIA AND THE PARADOX BASIN, U.S.A.

(Continued)

and earlier formed cement. These brine-migration pathways can be mapped in three dimensions. At some places in subsiding basins, migrating fluids under high pressure may break confining seals to forcefully intrude overlying semi-consolidated sediment as breccia in Seal-Bypass Systems. This brecciated sediment or adjacent permeable strata, or both, can become reservoirs for hydrocarbons.

Analysis of diagenesis in rocks of the Surat Basin, Queensland, Australia and the Paradox Basin, Utah, U.S.A. corroborates the effectiveness of these process-predictive methods.
A DAY IN THE LIFE OF A BARREL OF WATER
EVALUATING TOTAL LIFE CYCLE COSTS OF HYDRAULIC FRACTURING FLUIDS

Robin Watts, Oil & Gas Technology Manager, Linde, Smithville, TX

For several years now, regulatory agencies including the U.S. Environmental Protection Agency (EPA) and energy associations like the American Petroleum Institute (API) have provided recommendations, regulations and guidelines to improve water management in oil and gas exploration. Yet, to fully appreciate the life cycle costs of fluids – including water – used for hydraulic fracturing, one needs to examine the total costs of fluid acquisition, management and disposal. Typically, these costs are divided between various groups within an operator’s organization (i.e., completions and production), with budgeting emphasis on acquisition costs during the completions process.

This paper examines the total life cycle costs of hydraulic fracturing fluids, comparing water-based and energized solutions. It evaluates when fracturing fluids energized with carbon dioxide (CO$_2$) can be used to reduce water volume for more economical hydraulic fracturing, though the same evaluations can be made for nitrogen (N$_2$) as well. It also evaluates how the selected fracturing fluid can affect productivity. In certain situations, the increased productivity achieved with energized solutions can more than offset lower per-barrel water costs, driving a lower overall unit cost of production. To approach our analysis, we will look at “A Day in the Life of a Barrel of Water” used for hydraulic fracturing.
This presentation focuses on the early-stage agreements that parties enter into before definitive final agreements. These types of preliminary agreements can take various forms such as verbal commitments, term sheets, letters of intent, proposals, expressions of interest, and memoranda of understanding. They are often used to facilitate exploratory discussions, to develop the terms for a deal or transaction between the parties, to establish the parameters of an agreement prior to the execution of a comprehensive formal contract, and/or strategically to obtain a commitment from the other party.

Real world examples from both the mining and oil and gas sectors will be discussed from “handshake deals” to “bar napkin agreements” to formal written documents. This is a hot topic. For example, a federal court recently required a major natural gas producer to pay $19.7 million to the other party to a letter of intent, despite the producer backing out prior to the execution of closing documents. Often entered into casually, the devil is in the details as these preliminary agreements may create binding obligations between the parties, and set the terms and scope of the final contract. This presentation will provide answers and guidance to the key questions of when and to what degree is a preliminary agreement binding, and what exit or enforcement rights are available if discussions and negotiations break down between the parties.
LEGAL UPDATE ON HYDRAULIC FRACTURING REGULATION

Anne Weber, CPG, Weber Law Firm, Denver, CO

This presentation will summarize the latest developments and current status of the laws and regulations applicable to hydraulic fracturing at the federal, state, and local government levels. Emphasis will be on state regulation as states remain the primary regulators of well drilling and completion activities and the primary similarities and differences among the various state approaches will be covered. Finally, this presentation will identify hydraulic fracturing legal issues that appear to be relatively settled as well as those that continue to be moving targets.
RARE-EARTH ELEMENTS IN URANINITE–BRECCIA PIPE URANIUM DISTRICT
NORTHERN ARIZONA, USA

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The knowledge that the supply of REE will not be able to keep up with new and ever growing demands and that the “potential shortage could impact US renewable energy sources, communications and defense industries” has awakened both politicians and the public as to how critical these metals are, and to how vulnerable the US currently is to REE supply disruption. In 2008, China produced 97% of the worlds REE (primarily from Bayan Obo), India 2.2%, Brazil 0.5%, and Malaysia 0.3%. Up until 2002, the Mountain Pass REE Mine produced about 5% of the world’s REE supply, REE were extracted as a by-product of uranium mining in Canada during 1966-1970 and 1973-1977 at the Elliott Lake and Blind River deposit. At these deposits, the ore mineral, uraninite, contained sufficient REE to make it profitable to extract REE from the raffinate fluids.

A unique, polymetallic-rich, uranium, solution-collapse breccia-pipe district lies beneath the plateaus and in the canyons of northwestern Arizona. It is known for its large reserves of high-grade uranium (average grade of 0.65% U3O8 — Wenrich and Titley, 2009) that were estimated by the US Geological Survey to comprise over 40% of the US domestic uranium resources (Finch et al., 1990). The REE commonly make up over 1% of the breccia pipe ore.

The northern Arizona metallic district can be thought of as a paleo-karst terrain, pock-marked with sink holes, where most “holes” represent a collapse feature that has bottomed out over 3000 ft below the surface in the underlying Mississippian Redwall Limestone. These vertical breccia pipes formed when the Paleozoic layers of sandstone, shale and limestone collapsed downward into underlying caverns. A typical pipe is only approximately 300 ft in diameter and extends upward as high in the section as the Triassic Chinle Formation. Although each breccia pipe is not a huge ore deposit – up to 10 million pounds (m-lb) of uranium per pipe – in total the resources in the district are enormous. Many of the various small, mineralized pipes are clustered together, providing somewhat contiguous mineralization, which reduces the mining costs. The water table is deep below the orebodies, which lie 500-1600 ft below the surface, sufficiently above the water table to minimize any potential contamination of the aquifers.

Rare earth elements are significantly enriched in much of the breccia pipe ores. Whole-rock analyses from across the district show REE enrichment not uncommonly 20 times the average crustal abundance. A study of REE within uraninite was undertaken at the
RARE-EARTH ELEMENTS IN URANINITE–BRECCIA PIPE URANIUM DISTRICT
NORTHERN ARIZONA, USA
(Continued)

facilities of CREGU-GeoRessources, Nancy, France, using Laser Ab-lation ICP-MS in conjunction with electron microprobe analyses of the uraninite (Lach et al., 2013). This research has confirmed that a significant percentage of the bulk rock REE content is tied up in the uraninite crystal structure. Although the breccia pipe light REE content is not as enriched in the uraninites as in the bastnaesite of Mountain Pass, CA, the breccia pipe uraninite is distinctly more enriched in the heavy REE. At Mountain Pass the bastnaesite (REE ore mineral) has to be mined strictly for REE, whereas the ore in the breccia pipes is already processed for the uranium, so the REE collected from the raffinate fluids become an added value to the profit.

Variability in the mineralizing processes and geological setting among uranium deposit types creates distinctive REE signatures in the uranium oxides (Mercadier et al., 2011). All the uranium ox-ides (formed from high salinity basinal brines) from unconformity-related primary ore deposits, in the Eastern Alligator district of Australia and the Athabasca Basin district of Canada are character-ized by a bell-shaped REE pattern centered on dysprosium. The Sage and Pinenut breccia pipes have bell-shaped chondrite-normalized plots that are remarkably similar to those of the Athabasca Basin, McArthur River and Shea Creek uraninites (Bonhoure et al., 2007). Interestingly, the Pinenut breccia pipe, with its bell-shaped REE pat-ttern, has the oldest age, 260 Ma (Ludwig & Simmons, 1992), of those that were part of this study, which suggests that it is primary ore (no age determination was completed on the Sage orebody by Ludwig & Simmons).

The REE element patterns of uraninite from Pigeon, Kanab N, and Hack 2 breccia pipes have chondrite-normalized distributions that show some fractionation and a negative Eu anomaly. They distinctly resemble chondrite-normalized plots of uraninite samples (Mer-cadier et al., 2010) from the Athabasca Basin Eagle Point deposit. The rocks from both the 3 breccia pipe orebodies and Eagle Point show oxidation-reduction fronts within some of the ore suggest-ing remobilization by oxidized meteoric fluids. The uranium oxides from the redox front are characterized by LREE enrichment (Mer-cadier et al., 2011) and have younger ages of 200 Ma, which differ from the primary ores, and clearly demonstrate their distinct condi-tions of formation from the primary ore.

Multiple approaches to uranium resource calculations have been made by separate scientists: (1) Uranium resource estimates based on industry drilling for the 1050 mi² "mineralized corridor" of the breccia pipe district have been made by Spiering and Hillard (2013) to be 270 m-lbs of U₃O₈. (2) In 1987, the USGS Circular 1051 (Finch et al., 1990) calculated the uranium endowment of the entire breccia pipe district. Spiering and Hillard (2013) show that these calculations,
RARE-EARTH ELEMENTS IN URANINITE–BRECCIA PIPE URANIUM DISTRICT
NORTHERN ARIZONA, USA
(Continued)

when applied to the “mineralized corridor”, result in 375 m-lbs of $U_3O_8$. (3) An estimate (Wenrich, this study) using detailed surface mapping of breccia pipes and mineralized rock (Wenrich et al., 1997) on the NE portion of the Hualapai Reservation, has concluded that the “mineralized corridor” contains 260 m-lbs of $U_3O_8$ and the entire withdrawal area 385 m-lbs. The uraninite analyses (this study) in France showed the total REE content of the uraninite to be 0.43%. Hence, from the average of the above three estimates, 302 m-lbs $U_3O_8$, and 1.3 m-lbs of REE could be produced from the breccia pipe district “mineralized corridor.” Furthermore, between 28% and 48% of the REE production would be the more valuable HREE that are sparse to absent in the Bayan Obo and the Mountain Pass Districts. The value added to the uraninite recovery would be around $936 million, based on 2011 REE prices.
Hydrocarbon development in eastern Ohio, in conjunction with economic activity associated with the Devonian Marcellus Shale gas play in western Pennsylvania and northern West Virginia, has had a significant impact on availability of industrial minerals in the region. Advances in horizontal drilling and multistage hydraulic fracturing techniques have facilitated the discovery of significant hydrocarbon resources in the Ordovician Utica-Point Pleasant Shale interval of eastern Ohio. Gas gathering and compression facilities, along with cryogenic fractionation plants to process natural gas liquids were under construction in early 2013. The result is a $7 billion investment in mid-stream infrastructure capable of processing 1.2 billion cubic feet per day of natural gas and 190,000 barrels per day of natural gas liquids from wells in eastern Ohio.

Consequently, the completion of a horizontally-drilled Utica-Point Pleasant well in Ohio may use 5,000 to 10,000 tons of aggregate for drill pad and access road construction; 400 tons of cement to anchor casing; varying amounts of drill mud additives, such as barite; and 4,000 to 6,000 tons of hydraulic fracturing sand. The combination of highways, railroads, and water transportation on the Ohio River has encouraged several companies to establish transloading facilities for aggregates, cement, proppants, and barite. Aggregate producers in Harrison and Belmont Counties have quadrupled production since 2010, primarily from multicommodity operations that have limestone deposits associated with surface coal mines. Existing Ohio industrial-sand producers offer proppants that meet American Petroleum Institute specifications, and exploration is ongoing in eastern Ohio for sandstone deposits that potentially could be used for hydraulic fracturing. Ohio’s industrial-ceramic industry produces petrochemical mass transfer media; the potential exists that high-quality Pennsylvanian clays could be used to manufacture ceramic proppants.
The Yorke Peninsula is on the southeastern margin of the Archaean to Mesoproterozoic Gawler Craton and within the Moonta Sub-domain in the south of the Olympic Domain. The basement geology of the Moonta Sub-domain includes highly prospective pelites, psammites and calcareous sediments of the ca. 1750 Ma Wallaroo Group that were deposited synchronously with bimodal volcanics. The Wallaroo Group was intruded by the Hiltaba Granite Suite (~1600-1575Ma), which is associated with and hosts well known IOCG deposits in the Moonta-Wallaroo region and the world class Olympic Dam deposit.

Extensive carbonate sequences including Tertiary and Quaternary limestone and Holocene calcrete sequences overly the basement rocks on the Yorke Peninsula. The limestones were deposited during periods of sea level transgression and are widely known to be barren of any mineralization. The limestones have been subject to weathering processes such as dissolution by groundwater and chemical exchange within the overlying and underlying regolith. Calcrites are pedogenically derived from a combination of calcium sources from the limestone rising up within the soil profile via capillary action, and/or from re-precipitation of calcium leached from upper soil horizons. The calcrites often contain signatures of copper and gold. Therefore when exploring for mineral deposits via carbonate sampling, it is important to address their origin.

In the field, the barren, weathered limestone and the pedogenic calcrite appear indistinguishable. This research aims to address this problem by investigating and characterizing key chemical indicator(s) that may be used to easily distinguish the two rock types. Strontium isotopes are currently being investigated as they have been used on carbonates to constrain their timing and environment of deposition and are particularly useful in identifying sediments derived from seawater. Here, strontium isotopes are being used to determine whether any shift in isotopic values can be characterized in the transition from the seawater derived (limestone) to the pedogenically derived calcrite. The isotopic values and geochemistry will then be used as a comparison against other samples from the Yorke Peninsula region to identify any other geochemical signatures related to the carbonate lithologies. This research will have implications on increased efficiency of exploration geochemistry using cover sequences and in assessing prospectivity across exploration tenures.
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Granite Dells at Watson Lake-Photo Courtesy of Franz Rosenberger

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