AIPG Rocky Mountains and the Colorado Plateau Conference

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Front and back cover photos are courtesy of the Grand Junction Convention and Visitors Bureau and the Moab Visitors Bureau.

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On behalf of the Colorado Section of the American Institute of Professional Geologists (AIPG), the Grand Junction Geological Society (GJGS), and Mesa State College (MSC), welcome to the 46th AIPG Annual Meeting in Grand Junction, Colorado. As you will have already seen, traveling to Grand Junction, we are surrounded by outstanding examples of very diverse and spectacular geology. To the north and northeast are the Book Cliffs comprised of the shales deposited in the western part of the Cretaceous Western Interior Seaway capped by the regressive sandstones marking the Seaway’s retreat in the late Cretaceous. The formations of the Book Cliffs are dipping into the Piceance Basin, whose center is filled with oil shales of the Eocene Green River Formation and which is the site of active gas exploration in deeper formations. To the east of town is Grand Mesa, capped by Miocene basalts representing about 1 mile of inverted topography above Grand Junction. To the southwest, the spectacular monocline of the Colorado National Monument features the massive cliffs of the Lower Jurassic Wingate and Kayenta Formations. Below the foot of the monocline’s cliffs are the sites from which some of the earliest Jurassic dinosaurs from the Morrison Formation were excavated and shipped to eastern museums. The Morrison Formation of western Colorado and adjacent Utah and New Mexico also hosts major uranium deposits. The Cretaceous shales of western Colorado are (in)famous for their landslides as are the basalts on the sides of Grand Mesa. Southeast of Grand Junction are the San Juan Mountains which contain some of Colorado’s most spectacular scenery and fascinating geology.

The 2009 conference consists of a variety of field trips and a number of short courses. The technical sessions cover a wide range of geoscience topics. You will have a chance to deepen and broaden your geoscience knowledge by participating in these events. Tuesday is split between morning technical sessions and half-day field trips to an active oil rig, western slope water operations, the Colorado National Monument, or a tour to some outstanding wineries in the area. There are also half-day trips to the Rabbit Valley dinosaur sites and tour of local landslide areas on Wednesday afternoon.

This meeting wouldn’t occur without the help of numerous, dedicated people. Ed Baltzer (AIPG), Joe Fandrich (AIPG & GJGS), Bill Hood (AIPG & GJGS), Bill Chenoweth (GJGS), and Verner Johnson (MSC), have provided excellent local support. Ed Baltzer reviewed the abstract submissions, final papers, and arranged the technical program. Bill Siok, along with the AIPG HQ staff, spent long hours arranging contracts and generally taking care of the business side of things. Our field trip leaders, headed by Jim Burnell (AIPG), have assembled great trips supported by road logs and other support material. Bill Chenoweth and Craig Goodknight added the western part of the road log that extends now from Denver to Grand Junction and which Travis Hughes, Gary Mitchell, Laura Wray, and David Abbott prepared for the 2003 AIPG Annual Meeting in Glenwood Springs. Those presenting papers during the technical sessions and short courses provide the important scientific core of our formal program; we couldn’t do it without you. My sincere thanks to all of you who have helped for your contributions, which were and are all important.

David M. Abbott, Jr., CPG-04570
General Chairman, 46th AIPG Annual Meeting
Meeting Sponsors and Exhibitors

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AIPG Arizona Section
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AIPG Rocky Mountains and the Colorado Plateau Conference

Meeting Schedule

Saturday, October 3, 2009

7:00 am - 5:00 pm
    Registration - Lobby
7:00 am - 8:00 am
    AIPG Executive Committee Breakfast - Kokopelli Room
7:00 am - 9:00 am
    Breakfast Buffet (Open to all Registrants) - Kokopelli Room
7:30 am - 5:30 pm
    Field Trip - Underground West Elk Mine Tour (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)
8:00 am - 12:00 noon
    AIPG Executive Committee Meeting (Open to all Registrants) - Bookcliff Room
8:00 am - 5:00 pm
    Field Trip - Douglas Pass: Eocene Plant and Insect Fossil Collecting (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)
8:00 am Depart
    2-Day Field Trip - Mass-Wasting Features Associated with the Lake City Caldera, San Juan Mountains, Colorado (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)
8:00 am - 5:00 pm
    Short Course - Two-Phase Extraction - Innovative Applications with Multiple Remediation Technologies and Recirculation - Aspen Room
12:00 noon - 1:30 pm
    Lunch Buffet (Open to all Registrants) - Kokopelli Room
12:00 noon - 1:00 pm
    AIPG Foundation Luncheon - Telluride Room
1:00 pm - 4:00 pm
    AIPG - Advisory Board Meeting (Open to all Registrants) - Colorado Room
3:00 pm - 4:00 pm
    Break (Open to all Registrants) - Kokopelli Room
4:00 pm - 5:30 pm
    2009-2010 Joint Executive Committee Meeting and Business Meeting (Open to all Registrants) - Colorado Room

Sunday, October 4, 2009

6:15 am - 8:00 am
    Breakfast Buffet (Open to all Registrants) - Columbine/Bookcliff Rooms
7:00 am - 5:00 pm
    Registration - Lobby
**Sunday, October 4, 2009**

7:00 am - 6:00 pm  
Field Trip - Utah’s Arches/Canyonlands & Dead Horse Point (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

7:00 am - 6:00 pm  
Field Trip - Uravan Mineral Belt/Uranium Mine Tour (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

8:00 am - 5:00 pm  
Field Trip - Natural Gas Development-Piceance Basin, Western Colorado (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

8:00 am - 12:00 noon  
Short Course - Techniques for Giving Technical Presentations - Aspen Room

12:00 noon - 1:30 pm  
Lunch Buffet (Open to all Registrants) - Columbine/Bookcliff Rooms

1:00 pm - 5:00 pm  
Short Course - In Situ Bioremediation of Chlorinated Ethenes: DNAPL Source Zones - Monument Room

1:00 pm - 5:00 pm  
Short Course - Natural Resource and Reserve Definitions - Horizon Room

3:00 pm - 4:00 pm  
Break (Open to all Registrants) - Columbine/Bookcliff Rooms

6:00 pm - 8:00 pm  
Welcome Reception and Exhibits (Open to all Registrants) - Kokopelli Room

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**Monday, October 5, 2009**

7:00 am - 6:00 pm  
Registration - Lobby

7:00 am - 8:30 am  
AIPG Past President’s Breakfast (By Invitation Only) - Aspen Room

7:00 am - 9:00 am  
Breakfast Buffet (Open to all Registrants) - Kokopelli Room

8:00 am - 5:00 pm  
Technical Sessions (See Technical Session Schedule on Page 5)

8:00 am - 12:00 noon  
Field Trip - Colorado National Monument Sightseeing (Lunch buffet at hotel upon return, trip includes bottled water and snacks)

8:00 am - 5:00 pm  
Field Trip - Ouray Hot Springs (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

9:00 am - 5:00 pm  
Exhibits Open - Kokopelli Room

12:00 noon - 1:00 pm  
Lunch Buffet with Keynote Speaker (Open to all Registrants) - Senator Penry, Candidate for Governor - Columbine/Bookcliff Rooms

3:00 pm - 4:00 pm  
Break (Open to all Registrants) - Kokopelli Room
Tuesday, October 6, 2009

7:00 am - 6:00 pm  
Registration - Lobby

7:00 am - 9:00 am  
Breakfast Buffet (Open to all Registrants) - Kokopelli Room

8:00 am - 12:00 noon  
Technical Sessions (See Technical Session Schedule on Page 5)

9:00 am - 3:00 pm  
Exhibits Open - Kokopelli Room

10:00 am - 11:00 am  
Break (Open to all Registrants) - Kokopelli Room

12:00 noon - 5:00 pm  
Field Trip - Oil Rig Site Tour (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

12:00 noon - 5:00 pm  
Field Trip - Water System Operations in the Grand Valley (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

12:00 noon - 5:00 pm  
Field Trip - Colorado National Monument (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

12:00 noon - 1:30 pm  
Lunch Buffet (Open to all Registrants) - Kokopelli Room

1:00 pm - 5:00 pm  
Field Trip - Grand Valley Winery Tour (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

6:30 pm - 8:30 pm  
Awards Dinner and Entertainment - Columbine/Bookcliff Rooms

Wednesday, October 7, 2009

7:00 am - 9:00 am  
Breakfast Buffet (Open to all Registrants) - Kokopelli Room

8:00 am - 5:00 pm  
Registration

8:00 am - 12:00 noon  
Technical Sessions (See Technical Session Schedule on Page 5)

8:00 am - 5:00 pm  
Field Trip - Origins of Unaweep Canyon (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

9:00 am - 12:00 noon  
Exhibits Open - Kokopelli Room

10:00 am - 11:00 am  
Break (Open to all Registrants) - Kokopelli Room

12:00 noon - 5:00 pm  
Late Jurassic Dinosaur Localities of Rabbit Valley (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)
**Wednesday, October 7, 2009**

12:00 noon - 5:00 pm  
Field Trip - Mass Movement/Landslides (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

12:00 noon - 1:30 pm  
Lunch Buffet (Open to all Registrants) - Kokopelli Room

6:00 pm - 9:00 pm  
Meet and Reminisce - Bookcliff Room

**Thursday-Friday, October 8-9, 2009**

8:00 am Depart  
2-Day Field Trip - Surface Coal Mining & Reclamation, NW Colorado (Depart and return to the DoubleTree Hotel-includes boxed lunch, bottled water, and snacks)

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**DoubleTree Hotel Meeting Space Map**
<table>
<thead>
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<th>Session</th>
<th>Time</th>
<th>Abstract Title/Author</th>
<th>Room Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening Session</td>
<td>8:00 am</td>
<td><strong>Western Colorado’s Spectacular Geology</strong>&lt;br&gt;Vincent Matthews, PhD, Colorado State Geologist and Director</td>
<td>Monument/ Horizon Rooms</td>
</tr>
<tr>
<td>Technical Session 1</td>
<td>8:30 am</td>
<td><strong>Web-Based GIS Applications for Stakeholder and Project Management Communication</strong>&lt;br&gt;Jim Russell, CPG - Gilpin County</td>
<td>Monument Room</td>
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<tr>
<td></td>
<td>8:55 am</td>
<td><strong>Mobile GIS Solutions for Geoscience Applications - Option with ESRI Technology</strong>&lt;br&gt;Peter Will, CPG - ESRI</td>
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<td></td>
<td>9:20 am</td>
<td><strong>Geographic Information Systems A Powerful Tool in the Area of Military Munitions Response</strong>&lt;br&gt;Paul McCarren, CPG - Shaw E&amp;I</td>
<td></td>
</tr>
<tr>
<td>Technical Session 2</td>
<td>8:30 am</td>
<td><strong>Geologic Investigations of the Manhattan Project on the Colorado Plateau</strong>&lt;br&gt;William Chenoweth - Geologic Consultant</td>
<td>Horizon Room</td>
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<td></td>
<td>8:55 am</td>
<td><strong>Geochemistry of the Rifle Vanadium - Uranium Mine: A Distinct But Confusing Roll Front Deposit</strong>&lt;br&gt;J. Stewart Hollingsworth - Geological Consultant</td>
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<tr>
<td></td>
<td>9:20 am</td>
<td><strong>Radium - Southwestern Colorado’s First Uranium Boom</strong>&lt;br&gt;William Chenoweth - Geologic Consultant</td>
<td></td>
</tr>
<tr>
<td>Poster Session</td>
<td>9:45 am</td>
<td><strong>ArcGIS Maps from KY Geological Survey to Examine Fractal Location Patterns of Oil and Gas Deposits</strong>&lt;br&gt;Keith Andrew - Western Kentucky University</td>
<td>Kokopelli Room</td>
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<td><strong>Method Review: Hydrogeological Site Characterization in Preparation for Uranium In-Situ Recovery Mining</strong>&lt;br&gt;Sophie Hancock, Student MEM - Colorado School of Mines</td>
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<td><strong>Sediments in the Soh Area, South of Kashan, Central Iran and Recognition of Delta</strong>&lt;br&gt;Arash Sohrabi - Payame Noor University</td>
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<tr>
<td>10:10 am</td>
<td></td>
<td><strong>Break - Visit Exhibit Area</strong></td>
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</table>

**Technical Session/Poster Program**<br>**Monday, October 5, 2009**
<table>
<thead>
<tr>
<th>Session</th>
<th>Time</th>
<th>Abstract Title/Author</th>
<th>Room Assignment</th>
</tr>
</thead>
</table>
| Session 3 | 10:35 am | **How Much Coal Does Colorado Have?**  
Chris Carroll - Colorado Geological Survey | Monument Room   |
|         | 11:00 am | **New Chemical Analysis Data from the Sioux Quartzite of Pipestone, Minnesota-**  
**Implications for Study of the Fluvial Origins of the Proterozoic Sioux Quartzite,**  
**Geology of Road Aggregate, and Future Cooperative Studies**  
George Davis, CPG - Missouri Department of Transportation | Monument Room   |
|         | 11:25 am | **Real-Time Geochemical Answers in the Field Using Portable XRF Instruments - Back to the Future**  
L. Graham Closs, CPG - Professor, Colorado School of Mines | Monument Room   |
|         | 11:50 am | **Unconventional Hydrocarbon Resources-A Promising Solution in Helping to Fulfill Global Energy Needs**  
Robert Font, CPG - Geoscience Data Management, Inc. | Monument Room   |
|         | 12:10 pm | **Luncheon with Keynote Speaker**  
Senator Josh Penry, Candidate for Governor | Monument Room   |
| Session 4 | 10:35 am | **Geologists, Energy, Kentucky, and Climate Change Legislation**  
James Cobb, MEM - Kentucky State Geologist and Director | Horizon Room    |
|         | 11:00 am | **Carbon Storage in Lignite Coal**  
Darren Schmidt - Energy & Environmental Research Center | Horizon Room    |
|         | 11:25 am | **The Terrestrial Carbon Sequestration Potential of Rocky Mountain Cordillera Soils Derived from Volcanic Bedrocks**  
Douglas Yager - US Geological Survey | Horizon Room    |
|         | 11:50 am | **How the Earth Sequestrates Oil, Natural Gas and Coal from Carbon Dioxide and Carbon Monoxide Under Reducing Conditions**  
Chris Landau - Science Consultant | Horizon Room    |
|         | 12:10 pm | **Luncheon with Keynote Speaker**  
Senator Josh Penry, Candidate for Governor | Horizon Room    |
| Session 5 | 1:30 pm  | **Environmental Compliance Just Got Easier: A Look at Mobile Data Collection in the Field**  
Scott Randolph - Digital Cartographic Services | Monument Room   |
|         | 1:55 pm  | **Interpretation of Ground Subsidence from Interferometric Data Using Geospatial Techniques**  
Bibhuti Panda - AMEC Earth & Environmental | Monument Room   |
|         | 2:20 pm  | **Preservation of Water Quality Near a Surface Coal Mine, Northwestern Colorado**  
Edward Baltzer, CPG - Walsh Environmental Scientists and Engineers, LLC | Monument Room   |
|         | 2:45 pm  | **Integrating Land Use Regulation, Science, and Community Needs-Mountain Ground Water Overlay District, Jefferson County, Colorado**  
Lawrence Anna, CPG - Jefferson County Planning Commissioner | Kokopelli       |
<p>|         | 3:10 pm  | <strong>Break in Exhibit Area</strong>                                                                   | Kokopelli       |</p>
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<tbody>
<tr>
<td>Technical</td>
<td>1:30</td>
<td>Evaluating the Effects of Open-Pit Iron Ore Mining on South Australia’s Eyre Peninsula Regional Groundwater Resources Shane McDonald, CPG - Malcolm Pirnie, Inc.</td>
<td>Horizon Room</td>
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<tr>
<td>Session 6</td>
<td>1:55</td>
<td>Groundwater Supply Reconnaissance for the Central Plateau Region, Haiti James Adamson, MEM - V3 Companies</td>
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<tr>
<td>Water Resources</td>
<td>2:20</td>
<td>The Role of Remediation Hydraulics Concepts in the Development of a Reliable Conceptual Site Model: A Case Study Jason Lagowski, CPG - ARCADIS</td>
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<tr>
<td>Reclamation</td>
<td>2:45</td>
<td>Remediation of the London Mill Flotation Plant Copper Basin Mining District Ducktown, Tennessee Thomas McComb, MEM - Barge Waggoner Sumner and Cannon, Inc.</td>
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<td>3:10</td>
<td>Break in Exhibit Area</td>
<td>Kokopelli</td>
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<tr>
<td>Technical</td>
<td>3:30</td>
<td>DOE’s Uranium Leasing Program - A Sixty Year Heritage Edward Cotter - S.M. Stoller Corporation</td>
<td>Monument Room</td>
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<tr>
<td>Geology/Permitting</td>
<td>4:45</td>
<td>Sealing a Geologic Repository for Radioactive Waste Lillian Wakeley - U.S. Army Engineer Research and Development Center</td>
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<td>3:30</td>
<td>Taphonomic Characteristics of a Quarry in the Bright Angel Shale (Middle Cambrian), Grand Canyon National Park, Arizona: A Preliminary Look John Foster - Museum of Western Colorado</td>
<td>Horizon Room</td>
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<tr>
<td>Session 9</td>
<td>4:20</td>
<td>Urban Soil Geochemistry of the Denver Area: Mapping Change from 1972 to 2005 L. Graham Closs, CPG - Professor, Colorado School of Mines</td>
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<td>Paleontology/</td>
<td>4:45</td>
<td>Remediation System Design Build Advantages Dan Nolan - Seneca Environmental Services, Inc.</td>
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<td>Planetary</td>
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| **Technical Session 10**  
Water Resources/Water Issues | 8:30 am | **Acid Rain: Where are the Rest of the Data?**  
Robert Corbett, CPG - Professor Emeritus, Illinois State University | Monument Room  |
|         | 8:55 am | **Feasibility of Using Mined Phosphate Lands to Naturally Treat Storm - or Waste Water Prior to Recharge: A Concept that can Expand Regional Ground Water Resources Availability**  
Peter Schreuder, CPG - Schreuder, Inc. |                |
|         | 9:20 am | **Coalbed Methane Produced Water - A Waste or Resource?**  
Ralf Topper, CPG - Colorado Geological Survey |                |
|         | 9:45 am | **A Model of Environmental Sustainability for Managing Resources, Minimizing Wastes and Reducing Groundwater Contamination at a California Community Services District**  
James Jacobs, CPG - Environmental BioSystems, Inc. |                |
|         | 10:10 am | **Break in Exhibit Area** | Kokopelli  |
| **Technical Session 11**  
Water Law/Water Resources/Permitting | 8:30 am | **Domestic Wells in the Española Basin, Santa Fe, NM**  
Jack Frost, MEM - New Mexico Office of the State Engineer | Horizon Room   |
|         | 8:55 am | **Water in the West - Resources vs. Nature Areas: Brace for Impacts!**  
William Hoyt, CPG - Professor, University of Northern Colorado |                |
|         | 9:20 am | **Lessons Learned from Baseline Sampling and Monitoring of Groundwater Resources in Colorado Unconventional Gas Basins**  
Anthony Gorody, CPG - Universal Geoscience Consulting, Inc. |                |
|         | 9:45 am | **Getting Past Go**  
Larry Cerrillo, CPG - Ingenuity Enterprises International, Inc. |                |
|         | 10:10 am | **Break in Exhibit Area** | Kokopelli  |
| **Technical Session 12**  
General Geology | 10:30 am | **Geology of Grand Mesa Basalt Field, Western Colorado**  
Rex Cole - Professor, Mesa State College | Monument Room  |
|         | 10:55 am | **Gold Exploration on the Chihuahuan Frontier: Practical Lessons Learned in the Sierra Madres**  
Matthew Rhoades, CPG - Consulting Geologist |                |
|         | 11:20 am | **A Geological Conservancy**  
Thomas Ewing, MEM - Bexar Geological Surveys |                |
<p>|         | 12:00 pm | <strong>Lunch Buffet or Leave for Field Trips</strong> |                |</p>
<table>
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</table>
| 13      | 8:30 am  | *From Mine to Highway: Commodity Requirements for Hybrid Vehicles*  
James Burnell, MEM - Colorado Geological Survey         | Monument Room    |
| 13      | 8:55 am  | *Oil Shale, Piceance Basin, Colorado-Some Issues Related to Extraction*  
Glen Miller - Geologic Consultant                         |                  |
| 13      | 9:20 am  | *U.S. Energy Policy Coalition*  
George Richardson, CPG - Society of Mining and Metallurgy & Exploration |                  |
| 13      | 9:45 am  | *Environmental Permitting & Compliance in the Oil & Gas Industry in Colorado*  
Doug Dennison - Olsson Associates                        |                  |
|         | 10:10 am | Break in Exhibit Area                                                                                         | Kokopelli        |
| 14      | 8:30 am  | *Geosynthetically Confined Soil Walls Versus Mechanically Stabilized Earth Wall Systems: A Comparison of Reinforced Soil Theories*  
Colby Barrett, Cameron Lobato - Soil Nail Launcher, Inc. | Horizon Room     |
| 14      | 8:55 am  | *The Use of Ballistic Soil Nails for Shallow Landslide Mitigation*  
Colby Barrett, Cameron Lobato - Soil Nail Launcher, Inc. |                  |
| 14      | 9:20 am  | *Roles for Geologists with FEMA Public Assistance in Disaster Recovery and Infrastructure Damage Assessment*  
Thomas Barry - Shaw Environmental, Inc.                  |                  |
| 14      | 9:45 am  | *Dormant Landslides in Mancos Shale at Crested Butte, Colorado; Origin, Hydrology, Material Properties, and Stability*  
James McCalpin, CPG - GEO-HAZ Consulting, Inc.            |                  |
|         | 10:10 am | Break in Exhibit Area                                                                                         | Kokopelli        |
| 15      | 10:30 am | *Geologic Hazards of the Lower Uncompahgre River Valley in Montrose County, Colorado*  
Jonathan L. White - Colorado Geological Survey           | Monument Room    |
| 15      | 10:55 am | *My Favorite Frauds*  
David Abbott, CPG - Consulting Geologist                 |                  |
| 15      | 11:20 am | *Uranium Mining Reserve Estimation: Procedures and Pitfalls*  
George FitzGerald, CPG - Mining Geologist                |                  |
| 15      | 11:45 am | *Estimating Brine and Solid-Phase Mineral Reserves at the Searles Lake Evaporate Deposit, California: Not a Case of “Just Running the Numbers”*  
David Holmes, CPG - Assistant Secretary for Indian Affairs, Division of Energy & Mineral Development |                  |
|         | 12:05 pm | Lunch Buffet or Leave for Field Trips                                                                        |                  |
| 16      | 10:30 am | *Geology & Ore Deposits of the San Juan Mountains*  
Bob Larson, CPG - Geological Consultant                 | Horizon Room     |
| 16      | 10:55 am | *Mining History of the San Juan’s Focusing on Ouray County*  
Don Paulson - Ouray County Historical Society             |                  |
| 16      | 11:20 am | *Integrated Exploration Techniques for Sediment-Hosted Copper, Lower Lisbon Valley, Utah*  
Anthony Adkins, CPG - Consulting Geologist               |                  |
|         | 12:05 pm | Lunch Buffet or Leave for Field Trips                                                                        |                  |
“Vanity, vanity, all is vanity...and there is no new thing under the sun.” While the author of Ecclesiastes never read the King James Version of the Bible, his observation is certainly true about natural resources frauds. In 21 years as a geologist for the Securities and Exchange Commission and subsequently as a consultant, I kept seeing the same types of cases arising again and again. Even the same properties are recycled from one fraud to the next. Fraud, in the words of the SEC’s Rule 10b-5, is, among other things, “to make any untrue statement of a material fact or to omit to state a material fact necessary in order to make the statements made, in the light of the circumstances under which they were made, not misleading.” Or more simply, fraud is theft by lying. An oil and gas case provides an example of the omission of material information. The statement that “the well’s initial production is estimated to be 500 bbl per day” when not immediately accompanied by the statement that production declines with time and an estimate of the decline rate has omitted material information about the well’s production. The use of secret processes to recover precious metals is a common mining scam. The promoter’s must keep these processes secret or they will be stolen by the mining industry. Americans love rooting for the underdog. Using one such “secret process,” the US nickel coin assays Pt: 11.5 oz/ton (opt), Pd: 5.63 opt, and Ir: 5,314 opt. “Dirt pile” cases are common scams in which the investor is offered a specified quantity of “ore” that is guaranteed to contain a minimum amount of valuable minerals. The investor can mine and process his own pile, or this can be done by an “independent” contractor. The purported tax advantage of mineral development is touted as part of the scheme. The Glory Hole or “Patch” property west of Central City, CO is has figured in several cases I’ve encountered over the years. Mormon Mesa, near Overton, NV, the cinders at the San Francisco Peaks, AZ, and the dry lakebeds of Nevada are other repeatedly touted properties. My favorite example of “pulling a rabbit out of a hat” trick was being able to demonstrate that a scam promoter had not improved a road five years previously. Air photos, a field check, and an alder trunk’s growth rings proved that the road had not been improved for many years.

GROUNDWATER SUPPLY RECONNAISSANCE FOR THE CENTRAL PLATEAU REGION, HAITI
Adamson, James K. and Paddock, Jeff, V3 Companies, Ltd, 7325 Janes Avenue, Woodridge, IL 60517, jadamson@v3co.com

A regional groundwater investigation was conducted in May/June 2009 for several areas in the Central Plateau of Haiti where well drilling and water supply development efforts have been unsuccessful. Water supplies in the region are currently provided from springs, rivers and streams and small yielding hand pump wells installed into shallow Miocene aged units. There is no water treatment or delivery infrastructure in the region and the population manually collects their water from the closest water sources. Contaminated water and water scarcity is the cause of a large percentage of deaths in this region of Haiti. The purpose of the investigation was to identify aquifers that are protected from contamination to improve living conditions in the region until the country’s water delivery and infrastructure system is developed.

The investigation characterized, mapped and identified geologic features and specific aquifers throughout the region. Field investigation included research, field geologic mapping and water quality sampling to understand the behavior and structure of the aquifers and to identify the areas where successful water wells could be sited.

Two main types of aquifers were identified during the investigation: variable Miocene aged aquifers and a regional Oligocene confined limestone aquifer. The partially variable Miocene aged aquifers consist of laterally discontinuous conglomerate and sandstone aquifers often containing high concentrations of total dissolved solids. Wells currently located in the central Plateau commonly draw from the Miocene aged aquifers and water quality and yields can vary considerably. The Oligocene/Eocene aquifer is a vast regional confined limestone aquifer that likely contains high quality groundwater reserves. It is virtually untapped and potentially accessible to many communities throughout the region.

The investigation found that the accessibility of both aquifers were dependent on the structure of the Central Plateau, which is dominated by a large regional southeast plunging syncline surrounded to the north and south by two regional anticlines. Locally the aquifers were also dependent on smaller scale folding and the Miocene aged oceanic and deltaic depositional environments. The regional and local structure influences drilling depths by hundreds or thousands of meters throughout the region. Locations where groundwater was most accessible were identified and recommended as drilling locations.

Work is ongoing; the team is organizing a geophysics investigation in addition to several focused projects to further characterize the aquifers and to bring freshwater to several communities in the Central Plateau.

INTEGRATED EXPLORATION TECHNIQUES FOR SEDIMENT-HOSTED COPPER,
LOWER LISBON VALLEY, UTAH
Adkins, Anthony R., Thorson, Jon P., and Geiger, Faye

The Lisbon Valley District, located approximately 40 miles southeast of the town of Moab, Utah, has important occurrences of copper and uranium around the Lisbon Valley anticline. From 1993 to 2006, sequentially related companies installed the Lisbon Valley open pit heap-leach copper mine (LVMC) at a previously mined area near the southeast end of the anticline. During a review of a petroleum test well in Lower Lisbon Valley (LLV), shallow traces of chalcocite were discovered. When LVMC started area exploration, a twin of the test well was drilled resulting in the Flying Diamond discovery.
The Lisbon Valley (LV) district lies near the northern edge of the Colorado Plateau region within the section overlying the Paradox Basin, a Pennsylvanian-age evaporate basin. Copper mineralization is widespread in the Paradox Basin and has been found in many stratigraphic units from Pennsylvanian to Cretaceous in age, normally associated with faults near the margins of salt diapirs. The primary hypogene copper mineral in the LV deposits is chalcocite, with lesser amounts of bornite and chalcopyrite. In LLV minor evidence of copper mineralization occurs along the normal faults that flank the valley, most of the mineralization evaluated by the LVMC occurs blind, under cover of younger strata. In the LV, and LLV areas, the main host for the copper mineralization is the Burro Canyon Formation. There are two phases of alteration in the copper deposits in the LV area: pre-mineralization rock preparation, and alteration associated with the copper-event. The pre-mineralization alteration appears as bleaching alteration of previously red, permeable, red-beds sandstone or siltstone. Copper related alteration is more subtle than the bleaching, the most obvious being ankerite cement in the sandstone near the margins of the copper zone.

Four exploration methods searched for copper mineralization in LLV. These were drilling, the use of geochemical pathfinders, seismic reflection and CO2-O2 soil gas programs. Drilling consisted of core, reverse circulation and single wall rotary “scout” drilling. Core was the standard because high water discharge rates associated with reverse circulation drilling positively skewed the assay results. Based on an ICP analysis of the delineation drill holes from the Centennial Deposit, elements deemed useful for exploration were As, Ce, Mo, Pb, Th, and Zn. Moderately elevated Pb and Zn values from drill holes distal to the main center of LLV mineralization showed a clear spatial relationship to elevated copper values. Stratigraphic separation between the copper and the PB and Zn may indicate the metals were deposited in at least two horizons favorable to mineralization and faults thought to be conduits for mineralizing fluids. The survey found a number of faults and estimated depths to favorable horizons within potential surface mining parameters. The soil gas study indicates that some of the faults identified by the seismic survey may have acted as conduits for copper mineralization. The targets identified by the exploration methods remain undrilled as financial difficulties suffered by LVMC terminated both the mining and exploration efforts in early 2008.

**ARCGIS MAPS FROM KY GEOLOGICAL SURVEY TO EXAMINE FRACTAL LOCATION PATTERNS OF OIL AND GAS DEPOSITS**

Keith Andrew, Department of Physics and Astronomy, Karla Andrew, Center for Water Resource Studies, and Kevin Andrew, Gatton Academy of Math and Science, Western Kentucky University, Bowling Green, KY 42101

Utilizing data available from Kentucky Geonet (KYGeonet.ky.gov) the fossil fuel mining location data created by the Kentucky Geological Survey geo-locating oil and gas wells is mapped using ESRI ArcGIS in Kentucky single plain 1602 ft projection. This data was then exported into a spreadsheet showing latitude and longitude for each point to be used for modeling at different scales. Following the porosity and diffusivity studies of Tarafdar and Roy1 we extract fractal dimensions of each fossil fuel mining locations and search for evidence of scaling laws for each of the deposits. The Levy index, α, and the Fisher critical exponent, τ, are determined to match to a statistical mechanically motivated generalized probability function.

   arXiv.cond-mat/9708100v1

**INTEGRATING LAND USE REGULATION, SCIENCE, AND COMMUNITY NEEDS – MOUNTAIN GROUND WATER OVERLAY DISTRICT, JEFFERSON COUNTY, COLORADO**

Lawrence O. Anna, Jefferson County Planning Commission, Patrick O’Connell, Jefferson County Planning and Zoning Department, and Roy Laws, Jefferson County Health Department

From 1997 to 2001 Jefferson County, Colorado funded a study to address citizens’ concerns of depleted ground water supplies in parts of their mountain communities. As a result of the study, the county appointed a diverse panel of experts and citizens to draft the framework for a regulation that would allow the county to better manage the water supply in conjunction with land use policy. It took several panel sessions before an interim version of the regulation was completed. Outreach workshops for public input were then held, followed by a re-drafting of the proposed regulation. The revised draft was then sent to the Planning Commission for formal public hearings, public comment, and another re-draft of the regulation.

The outcome of this process was a county regulation that further defined property owner responsibilities to demonstrate that the property has an adequate and dependable water supply.

During these proceedings, four key questions surfaced which were addressed either directly or indirectly in the new regulation, although the questions and associated issues were not resolved:

1) Was there a depletion problem as perceived by some citizens?
2) How, and at what scale, should the county manage its mountain ground water supply?
3) How should water rights and augmentation plans be managed?
4) What data was required to demonstrate the availability, quality, and quantity of an adequate water supply?

After a long and arduous process that pitted science against science, science against land use policy, and land use policy against property and water rights, Jefferson County adopted its Mountain Ground Water Overlay District regulation. There was spirited, and often contentious debate on all aspects of this document, but in the end, the process worked and the result is a land use policy that will benefit all county residents.
The Colowyo Coal Mine has operated as a surface coal mine in northwestern Colorado since the 1960s, with several expansions of operations during that time. Multiple seams of coal have been removed from the upper portions of the Cretaceous Williams Fork Formation. Water quality and quantity parameters were obtained by the USGS from 1974-1980 and by the operator from 1974 until the present. Environmental protection regulations required by the Colorado Division of Reclamation, Mining, and Safety have been adhered to by the mine operators. Bedrock groundwater is present in localized, discontinuous pockets within the Williams Fork Formation and over a wide area within the underlying Trout Creek Sandstone. Unconfined groundwater is present in valley fill (alluvium and colluvium) along streams. Surface water is present in several streams and in isolated stock ponds and springs.

To establish background water quality parameters, surface water and groundwater were analyzed over the course of at least one year at over 20 sampling locations for up to 10 ions, total dissolved solids (TDS), and up to 12 metals. Surface water was also analyzed for oil and grease and total suspended solids. Groundwater was also analyzed for ammonia. Field pH, conductivity, and temperature were recorded, as was surface water flow rates and groundwater depths.

To monitor impacts from mining, a reduced analyte list of water quality and quantity parameters have been monitored by the operators at key locations near mine impacts continuously since at least 1989. A review of these revealed no statistically-significant trends in water quality or quantity at any sampling location. Downstream surface water parameters plotted against time had coefficients of determination ($r^2$) less than 0.16; this was similar to the $r^2$ of upstream surface water parameters. Downstream valley-fill aquifer water parameters plotted against time displayed an increasing trend in water elevation, TDS, conductivity, and some ions; this may be due to localized effects raising the groundwater table into vadose soils with an abundance of salts rather than caused by mining impacts. The $r^2$ values for these trends ranged from 0.41 for conductivity to 0.72 for TDS, indicating a weak correlation. Upstream valley-fill groundwater did not have any trends over the study period. These data indicate that the current regulations governing surface mining as applied at the Colowyo Mine protect human health and the environment from potential impacts caused by mining.

**The Colowyo Coal Mine, Northwestern Colorado**

Edward M. Baltzer, CPG

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**Preservation of Water Quality Near a Surface Coal Mine, Northwestern Colorado**

Edward M. Baltzer, CPG

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Launched soil nail technologies also allow for remediation of landslides and erosion using a fraction of the steel, concrete, and other materials used in more traditional repairs, with a much reduced site impact. Where traditional landslide remediation methods require significant excavation and replacement of soils, launched soil nails cause little or no disruption to the surrounding vegetation and soils, which minimizes related erosion, water quality issues, and overall site impact.

This presentation outlines the technical characteristics of launched inclusions (nails, micropiles and drains), the types of slope stability issues and erosion problems they are suited to repair, and their advantages and disadvantages compared to more traditional shallow landslide remediation measures. Basic design methodology using the joint Forest Service (EM-7170-12A) and FHWA (FHWA-FPL-93-003) publication “Application Guide for Launched Soil Nails, Volume 1, Appendix A.” will be presented along with a suite of example landslide repairs using ballistic soil nails.

**ROLES FOR GEOLOGISTS WITH FEMA PUBLIC ASSISTANCE IN DISASTER RECOVERY AND INFRASTRUCTURE DAMAGE ASSESSMENT**

Thomas F. Barry, PG, CHG, CEG, Senior Geologist, tom.barry@shawgrp.com; and Bob Hulet, CPG, PMP, Senior Project Manager, bob.hulet@shawgrp.com, Shaw Environmental, Inc., 4005 Port Chicago Highway, Concord, CA 94520

Following declared disasters, Technical Advisor Contractors (TACs) with various backgrounds are deployed by FEMA to assist in damage assessments of infrastructure. Many TACs have backgrounds in architecture, engineering, construction, and insurance. However, there are important and somewhat underutilized roles for geologists. Engineering geologists with a broad range of skills and experience can serve many roles in disaster recovery efforts. In this presentation I will show examples of facilities damaged by landslides and flooding in California, and facilities in Texas damage by Hurricane Ike. Typical damaged facilities common to all disasters consist of roads, utilities and pipelines, waterworks, parks and recreational facilities, and buildings. Disasters in California caused by heavy rainfall typically include numerous landslides and slope failures where traditional engineering geology skills are required to assess site conditions of damaged infrastructure. On many other disasters, such as Midwest floods and hurricanes, infrastructure damage assessment may appear at first to require only a limited role for engineering geologists. However, there are many important skills common to geologists that can be utilized for disaster recovery efforts. These skills and areas of expertise vary greatly among geologists but include: project management, construction technical management, GIS and mapping, fluvial and coastal processes, environmental site assessment, hazardous waste, and (obviously) geohazards.

**FROM MINE TO HIGHWAY: COMMUNITY REQUIREMENTS FOR HYBRID VEHICLES**

James Burnell, Colorado Geological Survey

The difficulties of the American car industry and the general discussions of decreasing dependence on oil imports has provided publicity to the field of hybrid vehicles. Most of the public does not recognize, however, the level to which these new generation carriages are dependent upon strategic mineral commodities or how dependent the U.S. is on imports for the commodities. Japanese manufacturers are using the nickel metal-hydride battery for their vehicles. The most critical component of these batteries is the rare earth elements (REE), produced only in China at the present time. Other geologic materials include nickel, cobalt and manganese. U.S. manufacturers are basing their cars on the lithium-ion battery, requiring lithium, of course, but also cobalt, manganese and/or phosphorus. Regardless of the battery technology used, the modified motors and generators of hybrid vehicles use significant amounts of REE, boron, cobalt and 50 percent more copper than a standard vehicle. Increased production of hybrid vehicles is dependent on a robust mining industry and the U.S. can begin to position itself to contribute by development of domestic resources.

**HOW MUCH COAL DOES COLORADO HAVE?**

Chris Carroll, Colorado Geological Survey

In 1976 the US Geological Survey (USGS) estimated the original coal resources in Colorado to a depth of 6,000 ft at 434 billion short tons (Speltz, 1976). This resource represents 11% of the nation’s total coal supply, making Colorado the fourth largest coal-bearing state. However, most of that coal is too deep to mine, and may only be useful for coalbed methane production or sequestration purposes. Colorado’s remaining identified coal resources (<2,000 ft deep and >18 inches thick) are nearly 129 billion short tons (Averitt, 1975), 77% of which is low-sulfur bituminous coal.

Since that time an additional 832 million short tons of coal has been mined (through Jan 1, 2009). Assuming a 50% depletion rate, this leaves 127.4 billion short tons as an identified coal resource. In terms of identified bituminous coal resources, Colorado ranks second in the nation behind Illinois, but is first in terms of low-sulfur bituminous coal. Today the USGS coal resource database (USCOAL) indicates that Colorado has 81 billion short tons of coal (total resource). Of this amount, 22.7 billion short tons are in coal beds greater than 42-inches thick and less than 3,000 feet deep, representing the mineable part.

Mineable reserves are much less than the coal resource. The coal resource volume is reduced by surface land-use and technological restrictions to mining to get mineable reserve estimates. These restrictions include roads, towns, critical habitats for endangered species, power plants and pipelines, as well as geologic constraints to mining like faults and steeply dripping beds. The US Department of Energy estimates that there is over 16 billion ton of coal in the demonstrated reserve base for mineable Colorado coal remaining in-place. In recent years the Colorado Geological Survey has produced several coal availability studies to assess the amount of mineable coal remaining in Colorado’s eight coal regions, with a total over 20 billion tons mineable.

We know that over 1.4 billion short tons of coal was mined between 1864 and 2008, and for assessment purposes, the reserve depletion is over 2.32
billion short tons. This leaves how much left for mining? About 17.5 billion short tons. How many more years of coal mining do we have? Our current consumption rate is 35 million tons per year, or about 60 million tons of coal depleted annually. Assuming a 1% growth annually, this leaves about 270 years worth of coal left in Colorado for mining purposes. Of course, it all depends on how we use it in the future.

GETTING PAST GO
Lawrence A. Cerrillo, CPG, Ingenuity Enterprises International, Inc.

Regardless of your endeavor-mining, oil and gas, water, housing, roads, lumbering, raising llamas or raising cane, you most likely cannot get past go until all real and perceived stakeholders are happy. You may have acquired all the requisite permits, licenses and bonds, but the local municipal or county regulator bolstered by NIMBY minions can cause you interminable and costly delays. One of the cards you can play is the ADR or Alternative Dispute Resolution card; preferably viewed as collaborative problem solving. Employing one or more of ADR tools early-on in your proposed project will save considerable time and money as you approach GO. Most applicable of these tools are facilitated dialogue and deliberation and mediation.

Facilitated dialogue and deliberation sessions enable you to identify and deal with NIMBIES and other concerned citizens early in your planning. It is a process that enables all stakeholders to vent and have a part in the project. It enables you, the project proponent, to know what issues may become road blocks that you can prepare for in advance. Most roadblock issues are most always those unanticipated.

Mediation is a process that allows disputing entities a means to resolve their concerns in a safe and controlled environment. Conflict is inevitable, litigation is not. You can avoid the high costs and delays of litigation and resulting costs and delays to your project by engaging in mediated settlements. These can be as binding as a litigated settlement, and are often transforming in regard to the subsequent working relationships. The time and costs of utilizing these tools will be considerably less than the unanticipated costs of delays precipitated by an irate citizen or group of citizens with respect to an activity you thought was of little consequence. As an old commercial went, “pay now or pay later”.

GEOLOGIC INVESTIGATIONS OF THE MANHATTAN PROJECT
ON THE COLORADO PLATEAU
William Chenoweth, Consulting Geologist

In February 1943, the Manhattan Engineer District asked the Union Carbide and Carbon Corporation to form a company to evaluate the uranium resources of the United States and later of the world. The company was named Union Mines Development Company and was based in New York City. It was to operate under the pretense of looking for vanadium, molybdenum and tungsten. To evaluate the Colorado Plateau, where the mineral carnottie, a potassium uranium vanadate was known to occur, a field office was established in Grand Junction, Colorado. All known outcrops of the Salt Wash Member of Jurassic Morrison Formation were prospected as were areas of the Jurassic Entrada Sandstone that contained uraniferous roscolite deposits. The Triassic Chinle Formation was investigated only in the area of Temple Mountain, Utah. All occurrences of carnottie and roscolite that were located were described and mapped, most were sampled. All available vanadium mines were mapped and sampled. Geologic sections were measured to establish the stratigraphy of the Salt Wash Member. Past vanadium production of each mining area was compiled. Union Mines purchased 124 mining claims in the Gateway and Slick Rock areas of Colorado as was a small vanadium mill at Slick Rock and a 960 acre Navajo lease in northeastern Arizona. The uranium ore reserves for the entire Colorado Plateau were calculated in the categories of positive, indicated and inferred. By 1946, 44 reports dealing with the uranium areas on the Colorado Plateau had been prepared plus a summary report. These secret reports could use the word carnottie but not uranium, so codes were used, SOQ= uranium oxide. All facilities and functions of the Manhattan Project were turned over to the newly created U.S. Atomic Energy Commission (AEC) on January 1, 1947. The AEC used the Union Mines data to plan exploration projects. The mining claims became part of the AEC leasing program The vanadium mill was sold and the lease was returned to the Navajo Nation in 1962. The AEC declassified and open filed most of the Union Mines Colorado Plateau data in early 1960s, too late for the public to use during the first uranium boom.

RADIUM-SOUTHWESTERN COLORADO’S FIRST URANIUM BOOM
William Chenoweth, Consulting Geologist

Soon after the Utes were removed from western Colorado in 1881, prospectors were intrigued by the yellow material on the rimrock of Paradox Valley and adjacent areas. Assayers were unable to determine the elements in this substance. In 1889, two French metallurgists at the Cashin copper mine determined the yellow material contained uranium. In that same year, in France, the Curie’s had discovered that all uranium ores contained a new element radium. Back in Colorado, ten tons of high grade ore were sent to France from which a new mineral, carnottie, a potassium uranium vanadate, was discovered and named. Further research found the radium stopped the growth of certain cancers and could be used to make luminous paint. About 1909 a process to recover radium from carnottie was developed in the United States. The next year, hundreds of claims were staked in the Paradox Valley and adjacent areas. Prospectors recognized the most productive horizon was the upper sandstone rim in the lower McElmo (Morrison ) Formation and noted the association with organic material, especially ‘fossil trees’. Plants to extract radium were built in Denver, CO, Canonsburg, PA and in Orange, NJ. One gram of radium could be extracted from 200 -300 tons of ore containing 2.00 percent, or greater, uranium oxide. Mined ore was hand sorted into shipping ore and milling ore. The latter was treated at upgrading plants such as the Joe Junior concentrator. For ten years, 1913-1922, the carnottie deposits of southwestern Colorado and southeastern Utah became the principal world source of radium. Prices ranged from $70,000 to $180,000 per gram. The boom ended in 1923 when lower cost ores from the Belgium Congo took over the market and forced most US mines to close. Between 1910 and 1923, some 202 grams of radium, valued at $20 million had been produced. Small amounts of vanadium and uranium were recovered as byproducts. Much of the uranium was discarded in the tailings at the radium plants, which became Superfund sites. Yesterday’s buried treasures became today’s toxic waste.
REAL-TIME GEOCHEMICAL ANSWERS IN THE FIELD USING PORTABLE XRF INSTRUMENTS - BACK TO THE FUTURE
R.K. Glanzman, Glanzman Geochemical LLC and L.G. Closs, Colorado School of Mines

In the 1950s and early 1960s much of geochemical prospecting was conducted in the field using colorimetric techniques that provided immediate information for mineralization. With the development of more sophisticated laboratory-based analytical instruments, fieldwork shifted to largely sample collection to be analyzed for a broad suite of elements. Recent innovative miniaturization in instrumental developments now make field-based geochemical prospecting again practical.

Evolution of the Field Portable X-ray Fluorescence (FPXRF) instrument, beginning in the 1960s, is reviewed. Today the chemistry of essentially all media for most elements of interest can be determined in the field using FPXRF. This suite includes new exploration rare earth element targets. Samples can be screened and analyzed in the field. Specific samples with key geochemical signatures of the target mineralization can be submitted for conventional detailed laboratory analysis. Specialty laboratory procedures can now be focused on areas with mineral potential rather than a broad suite of elements analyzed on samples covering the entire property. Explorationists can again be fully engaged in onsite real time application of geochemistry, separating mineralized from background areas and defining drilling targets. Enhanced productivity and additional value for allocated funds result from new strategies. The application of FPXRF to mineral development will be illustrated using examples from exploration, production and environmental monitoring. The future of exploration geochemistry, grade control and environmental baseline documentation is now available and it is in our hands!

URBAN SOIL GEOCHEMISTRY OF THE DENVER AREA:
MAPPING CHANGE FROM 1972 TO 2005
David B. Smith1, Dennis R. Helsel1, L. Graham Closs2, James E. Kilburn1, Steven M. Smith1, and John D. Horton1
1U.S. Geological Survey, Denver, CO; 2Colorado School of Mines, Golden, CO

In 2005, the U.S. Geological Survey (USGS) and Colorado School of Mines (CSM) conducted a geochemical survey of roadside soils in the Denver metropolitan area. The top 5 inches of soil was collected at 497 sites uniformly distributed throughout a 450-mi² area from Golden on the west to eastern Aurora on the east and from Thornton on the north to Littleton on the south. Two size fractions, less than 2 mm and less than 250 µm, of each sample were analyzed for the near-total content of 44 elements. The 2005 data set was then compared to similar data generated on 439 soil samples collected in 1972 by Ed Post and Allyn Davis of Skyline Laboratories in Golden, CO. The 1972 samples were also from the top 5 inches of roadside soils. These samples were sieved to less than 250 µm and were originally analyzed for only cadmium, copper, lead, mercury, and zinc. The original data set was never published. The current study involved reanalyzing these samples by the same protocols used on the 2005 samples. The one exception was mercury. This element was not reanalyzed in the 1972 samples because these samples were not stored properly for maintaining a stable mercury concentration.

These two data sets have provided a unique opportunity to map the abundance and spatial distribution of potentially harmful elements in Denver soils at two points in time. Several elements show elevated concentrations in the Denver area in both data sets compared to rural background values. These elements include lead, zinc, arsenic, mercury, cadmium, copper, and antimony. Potential sources for these elements include 1) atmospheric contamination from industrial plants, 2) automobile exhaust, 3) debris from automobile engines, catalytic converters, tires, and brake pads, and 4) mineralization and mining activity in the foothills west of the Denver area.

Quantifying change by comparison of the 2005 and 1972 data sets is not straightforward. Soil exhibits both constitution heterogeneity and distribution heterogeneity and, as a result, all soil geochemical surveys are subject to sampling errors. Despite these inherent errors, some observed changes may be significant. Lead exhibited the greatest decrease in concentration from 1972 to 2005 as a likely result of the phasing out of leaded gasoline beginning in the 1970s.

GEOLOGISTS, ENERGY, KENTUCKY, AND CLIMATE CHANGE LEGISLATION
James C. Cobb, Kentucky Geological Survey, University of Kentucky, Lexington, Kentucky P.G. 1335

Geologists are involved in the national debate over climate change perhaps more than any other legislation in U. S. history. Geologists are working on global climate change, change through geologic time, fossil fuel resources and exploration, and many other aspects of water, carbon sequestration and alternative sources of energy that are involved in this great debate. There may be winners and losers in certain sectors in the end when legislation is enacted, but for versatile geologists, including the 2,000 registered professional geologists in Kentucky, excellent opportunities for good jobs in many areas of energy-related geology will be available.

The Waxman-Markey bill that would institute a cap and trade system for carbon emission credits, limit emissions of CO₂, and promote renewable sources of energy has passed the U.S. House of Representatives and moves to the U. S. Senate. If enacted into law, this legislation could have wide ranging negative consequences on Kentucky’s economy. Kentucky is at ground zero in the raging debate and public policy battles over climate change and the continued use of fossil fuels. Few states stand to lose more than Kentucky if emissions from coal plants become regulated because the Kentucky economy is so strongly linked to the cost of electrical energy. Coal is currently the lowest cost fuel for the production of electrical energy except for hydroelectric power. The cost of electricity in some states is three times higher than Kentucky’s because they lack coal-fired power plants. Kentucky ranks first in aluminum production, first in stainless steel production, and third in automotive-related industries compared to other states because of the low-cost electricity. Kentucky rivers and interstate transportation systems, skilled labor force, central location, and especially the low electrical rates create a favorable environment for energy intensive industries. These industries not only support Kentucky’s economy but serve the entire nation.

In 2005, the U.S. Geological Survey (USGS) and Colorado School of Mines (CSM) conducted a geochemical survey of roadside soils in the Denver metropolitan area. The top 5 inches of soil was collected at 497 sites uniformly distributed throughout a 450-mi² area from Golden on the west to eastern Aurora on the east and from Thornton on the north to Littleton on the south. Two size fractions, less than 2 mm and less than 250 µm, of each sample were analyzed for the near-total content of 44 elements. The 2005 data set was then compared to similar data generated on 439 soil samples collected in 1972 by Ed Post and Allyn Davis of Skyline Laboratories in Golden, CO. The 1972 samples were also from the top 5 inches of roadside soils. These samples were sieved to less than 250 µm and were originally analyzed for only cadmium, copper, lead, mercury, and zinc. The original data set was never published. The current study involved reanalyzing these samples by the same protocols used on the 2005 samples. The one exception was mercury. This element was not reanalyzed in the 1972 samples because these samples were not stored properly for maintaining a stable mercury concentration.

These two data sets have provided a unique opportunity to map the abundance and spatial distribution of potentially harmful elements in Denver soils at two points in time. Several elements show elevated concentrations in the Denver area in both data sets compared to rural background values. These elements include lead, zinc, arsenic, mercury, cadmium, copper, and antimony. Potential sources for these elements include 1) atmospheric contamination from industrial plants, 2) automobile exhaust, 3) debris from automobile engines, catalytic converters, tires, and brake pads, and 4) mineralization and mining activity in the foothills west of the Denver area.

Quantifying change by comparison of the 2005 and 1972 data sets is not straightforward. Soil exhibits both constitution heterogeneity and distribution heterogeneity and, as a result, all soil geochemical surveys are subject to sampling errors. Despite these inherent errors, some observed changes may be significant. Lead exhibited the greatest decrease in concentration from 1972 to 2005 as a likely result of the phasing out of leaded gasoline beginning in the 1970s.
as well. Currently, the state of Kentucky and many other states are doing research on the potential for carbon sequestration in deep saline reservoirs, enhanced oil recovery, and shale gas. Although these are great projects for geologists and could become good employment opportunities for the future, there is no guarantee that these will be successful everywhere they are needed. Preliminary results certainly indicate they will work in some areas. These projects are to find stop gap measures to maintain coal’s viability at least for the short to medium terms into the future. It seems almost certain that there will be changes in the geologic profession to accommodate new geology-related technologies.

**GEOLOGY OF GRAND MESA BASALT FIELD, WESTERN COLORADO**

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Grand Mesa is a prominent east-west oriented landform in western Colorado capped by basalt that ranges in age (argon-argon) from 9.22 to 10.76 MA (average = 10 Ma). Because of extensive erosion and mass wasting, the basalt cap has a present-day surface area of about 53 mi². The remnant has a Y-shaped outline, with Crag Crest on the east forming the stem, and the Palisade and Flowing Park lobes on the west (branches). The total area of the original basalt field may have been as much as 750 mi². The basalt rests on a paleo-topographic Miocene surface that ranges in elevation from 11,227 ft on the east (Crater Peak) to 9,632 ft on the west (Shirt Tail Point); the average east-to-west gradient is about 54 ft/mi. Rocks beneath the basalt include the Uinta, Green River, and Wasatch Formations (Paleocene-Eocene), plus an unnamed Miocene (?) sequence of mudrock, lithic sandstone, and conglomerate, which contains abundant andesite-diorite clasts derived from the West Elk Mountains.

Vent areas for the basalt sequence were probably in the Electric Mountain-Chalk Mountain area, where several large east-west oriented dikes occur. Examination of stretched vesicles (N = 2,404) in the area between Crater Peak and Palisade Point shows that the average flow movement was to the west and southwest (vector mean = 266°). The observation is consistent with the slope of the sub-basalt surface. Thickness of the in-place basalt ranges from 185 and 620 ft in western Grand Mesa and between 50 and 110 ft in eastern Grand Mesa.

Details on basalt stratigraphy come from nine core hole drilled on the Palisade Lobe by the U.S. Bureau of Reclamation in 1985-86. In these cores, thickness ranges from 228 to 613 ft, with general thinning from east to west. Flow thickness ranges from 3.7 to 70.9 ft (average = 23.8 ft), with the maximum number of flows observed being 26 in the thickest part of the sequence. Flow tops usually contain abundant vesicles. Beds of rust-colored siltstone, silty sandstone and silty claystone also commonly occur between the flows, but correlate poorly from core to core. These are probably wind-blown detritus, weathering residuum, and incipient soils. In outcrop, flows have lenticular outline and may be up to 1,000 ft across; most are less than 300 ft across. Each core hole penetrated into sub-basalt variegated siltstone, claystone, sandstone, or lithic conglomerate (rare) that is probably the Miocene (?) unnamed formation.

**ACID RAIN: WHERE ARE THE REST OF THE DATA?**

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The definition of acid rain from a glossary of the E.P.A.

“The result of sulfur dioxide (SO2) and nitrogen oxides (NOx) reacting in the atmosphere with water and returning to earth as rain, fog, or snow.”

This definition has led many to believe that rain with a pH 5.6 or below, and sulfate and/or nitrate is anthropogenic acid rain.

Comparing the characteristics of acid rain and other natural waters is important for an understanding of this topic. First, acid rain is a very dilute solution, and second acid rain contains dissolved constituents (ions of hydrogen, ammonium, and nitrate) in significant relative concentrations such that they exert a major influence on the character of rain water. In surface and ground waters, they (ions of hydrogen, ammonium, and nitrate) are insignificant because of the concentrations of major ions. Similarly, carbonate and bicarbonate ions, constituents of significance in surface and ground waters, are miniscule in acid rain because of the control on carbonate ionic species by pH.

Over 250 sites are sampled in the United States, generally weekly, for rain water. Some analyses are performed in the field, and all are later performed at the Central Analytical laboratory in Urbana, Illinois. To obtain data, go to http://bqs.usgs.gov/AcidRain/ and NADP data. Use the microequivalents per liter scale. Here you can find the rest of the data.

The Piper diagram, around since 1944, has gained widespread usage in geology to characterize the composition and spatial and temporal trends in surface and ground waters. The Piper diagram consists of a three component diagram for cations Mg, Ca, Na+K, a three component diagram for anions SO4, HC03+C03, Cl, and quadrilateral diagram summarizing all these components.

Can it be applied to studies of acid rain and other atmospheric precipitation? In its present form the answer is no for several reasons, all related to the markedly increased influence of hydrogen, ammonium, and nitrate ions in rain water. However the diagram can be converted. By changing the components on the cation diagram to H, monovalent, and divalent ions, and the anion diagram to nitrate, sulfate, and chloride ions, it becomes immensely useful.

Sixteen rain water types become possible by this change. Use the predominant cation name (or “mixed cation” if none is dominant) and the predominant anion name (or “mixed anion”), and you have a type, ex. Hydrogen ion- Sulfate ion.
The results of this investigation were surprising, and offer a unique perspective in the study of the Sioux Quartzite in the future.

Applications of this technique are presented, including the diagram itself, a site in Pennsylvania, another in Wyoming, the color code, and a map of the several year average of rainwater type in the U.S.

DOE’S URANIUM LEASING PROGRAM-A SIXTY-YEAR HERITAGE
Edward T. Cotter, S.M. Stoller Corporation, Steven R. Schliesswohl, DOE Program Manager

The U.S. Department of Energy Office of Legacy Management (DOE) is responsible for administering the DOE Uranium Leasing Program and its 32 lease tracts located in the Urvan Mineral Belt of southwestern Colorado. The Uranium Leasing Program began in 1948 when Congress authorized the U.S. Atomic Energy Commission (AEC), a predecessor agency of DOE, to withdraw lands from the public domain for the sole purpose of exploring for, developing, and mining uranium ore bodies. Through a series of public land orders, AEC took control of approximately 500,000 acres of land in Arizona, Colorado, New Mexico, Utah, and Wyoming. The U.S. Geological Survey assisted AEC in implementing a massive exploration program to identify lands that contained the most favorable geologic formations for uranium. Subsequently, AEC retained only lands (approximately 25,000 acres) that met the most favorable criteria. DOE still administers those lands today.

The domestic uranium industry has survived several boom-and-bust cycles during the last 60 years. In the late 1940s and early 1950s, crowds of would-be prospectors and their Geiger counters converged on the Urvan Mineral Belt hoping to find the next big deposit of uranium. The Uranium Leasing Program was at the heart of that activity. AEC negotiated leases with existing mine operators on adjacent claims. The leases operated from 1948 through 1962. That production period was followed by a decade of only limited activity.

In the 1970s, the prospect of commercial nuclear power again sent the prospecting crowd back into the hills. Uranium prices soared to $44 per pound, and the Uranium Leasing Program flourished once again. This time, the leases were offered through a competitive bid process based on production royalties. Then the accident at the Three Mile Island nuclear power plant almost brought domestic uranium production to a halt. For the next 20 years, the uranium industry saw only modest activity, and it was primarily supported by a few in situ leaching operations. The Uranium Leasing Program continued throughout that time, although in the mid-1990s DOE began the process to substantially reduce the acreage of lands it administered. In 1994, DOE started a reclamation program to address the legacy of its abandoned uranium mine sites. That effort took eight years to complete.

Eventually, those involved in uranium-based energy production, now a worldwide industry, began to realize that the world’s nuclear power plants could not continue to consume twice the amount of uranium per year that was being produced. The resulting speculation caused the price of uranium to spike briefly to $136 per pound before falling back to the $40 per pound range. In 2008, DOE executed new 10-year leases for 31 of the 32 lease tracts. So far, the lease tracts have had only limited activity; however, some speculators believe that the price of uranium will increase to $60 per pound by year’s end. Such an increase would stimulate many mine operators to rejoin the game. That’s the arena that the Uranium Leasing Program is operating in today.

NEW CHEMICAL ANALYSIS DATA FROM THE SIOUX QUARTZITE OF PIPESTONE, MINNESOTA - IMPLICATIONS FOR STUDY OF THE FLUVIAL ORIGINS OF THE PROTEROZOIC SIOUX QUARTZITE, GEOLOGY OF ROAD AGGREGATE, AND FUTURE COOPERATIVE STUDIES
George H. Davis, R.G., CPG, Geologist, Missouri Department of Transportation, Jefferson City, MO

The Sioux Quartzite in the area of Pipestone, Minnesota is inferred to be from the upper third of the formation. It contains thin beds of metasiltstone or metaclaystone, known as pipestone, that have been interpreted as consisting of microscopic crystals of pyrophyllite, diaspore, muscovite, and kaolinite. Most other ‘pipestones’ in the world contain quartz, while the pipestone of this area has little or no quartz. The only known chemical analyses of the stone date from 1836 by a Dr. Jackson of Boston, Massachusetts, and from 1938 by Dr. Ellestad of the University of Minnesota. Their analyses are close, but do not totally agree.

In order to better characterize deleterious materials in the Sioux Quartzite, after deleterious stone was found in aggregate at the A.G. Everest Quarry in Sioux Falls, South Dakota, a sample of metasiltstone from the area of Pipestone National Monument was submitted to the Missouri Department of Transportation (MoDOT)’s Central Laboratory in Jefferson City, Missouri. This was done to understand the range of materials which could be found as deleterious in the Sioux, which ranges from the metasiltstone sampled in Minnesota to the metaclaystone found in South Dakota. A ‘standard’ chemical analysis usually used to characterize aggregates submitted for approval to MoDOT was conducted.

Loss on Ignition (LOI) and Silicon Dioxide were determined in accordance with the reference test method ASTM C114-06, “Standard Method of Test for Chemical Analysis of Hydraulic cement.”Alkalis (Sodium and potassium oxide) were determined by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) on a lithium metaborate fusion of the submitted sample dissolved in dilute (1:24) nitric acid using a Varian VISTA-MPX ICP-OES. Sulfur trioxide and carbon dioxide analysis were performed with a LECO SC-632 at 1450 degrees C using a combustion (tungsten oxide) catalyst. Sodium carbonate fusion was utilized on the remaining residue left in platinum crucible for remaining major and minor oxides (excluding sodium and potassium oxide) using Varian VISTA-MPX ICP-OES. 1 ml of Yttrium in 250 ml volumetric flask was used as an internal standard.

The results of this investigation were surprising, and offer a unique perspective in the study of the Sioux Quartzite in the future.
ENVIRONMENTAL PERMITTING & COMPLIANCE IN THE OIL & GAS INDUSTRY IN COLORADO

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The regulatory environment related to the exploration and production of oil and gas in Colorado has been and continues to evolve rapidly at all levels of government, particularly at the state and local levels. The goal of this presentation is to provide an overview of the significant changes that have occurred in regulations applicable to the oil and gas industry in Colorado and a summary of the various regulations with which oil and gas operators must comply. The potential overlap and conflicts between many of these regulations will also be discussed. In addition, some of the industry’s environmental compliance and mitigation programs, whether mandated by regulations or developed voluntarily, will be described.

A GEOLOGICAL CONSERVANCY

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In our rapidly developing world, preservation of important geological features and areas (“Geosites”) for education and research becomes more and more critical.

I propose that we consider a membership-based nonprofit ‘Geological Conservancy’ on the model of the Archaeological Conservancy and the earlier stages of the Nature Conservancy, to protect, preserve and help interpret key geologic places and areas. Such a group can focus donations of money, land and expertise into efficient activity, and maintain a ‘network of experts’ to assist in site protection, preservation and development for teaching and research purposes (interpretation).

EXOTIC MICROPARTICLES IN SOUTHEASTERN UTAH AND NORTHEASTERN ARIZONA: EVIDENCE SUPPORTING A BOLIDE EVENT AT THE PERMOTRIASSIC BOUNDARY

Joe W. Fandrich, Adjunct Professor of Planetary Geological Research, Mesa State College, WWG Geological Research Facility

Exotic metallic microspherules (MS) were first discovered in the San Rafael Swell of southeastern Utah in 2002. These particles are associated with a chert breccia stratigraphically situated between the Black Dragon Member of the Triassic Moenkopi Formation and the Permian Kaibab Limestone. The breccia has been previously described as a basal pebble conglomerate within the lower Triassic Black Dragon; however, an unconformity is present between the breccia and the Black Dragon placing the breccia between known Triassic and Permian units.

The MS were observed and imaged employing a Leica polarizing light microscope (DMLP) and a scanning electron microscope (SEM). The MS were analyzed for their qualitative composition by energy dispersive spectrometry (EDS). The Utah MS generally range in size from <10μm to ~40μm and are composed primarily of iron (Fe) with varying amounts of chrome (Cr), titanium (Ti), manganese (Mn) and silicon (Si).

One 112μm FeCr MS has been isolated and observed in thin section from P/T rock collected near Cane Valley, in the northeast corner of Arizona. This MS is morphologically and chemically consistent with the microparticles observed in southeastern Utah. The chemical composition of this P/T particle appears similar to metallic FeCr microfragments discovered at the P/T boundary on Graphite Peak, Antarctica in 2005.

As there is no known terrestrial process for the formation of spherical metallic microparticles it is suggested that these particles are the result of a bolide event at the PermoTriassic boundary.

URANIUM MINING RESERVE ESTIMATION: PROCEDURES AND PITFALLS

George Fitzgerald, Mining Geologist, Consultant

Successful uranium mining ventures depend upon five major factors or “keys” to success. The first of these keys include a management desire to accomplish the successful venture regardless of many trials and tribulations along the way. The second is sufficient venture and working capital to continue sufficient exploration, development and operations to obtain a return on the investment. The third is developing and maintaining a realistic ore reserve estimation plan to provide adequate information to develop and operate the mine. The fourth is a sufficient engineering plan to operate the mine. The fifth is obtaining an effective team of management, miners, and operating support staff and working together through startup, development and operating issues to maintain a technically and economically viable venture.

This discussion is focused on the third step and most specifically uranium mining reserve estimation including procedures and pitfalls.

During the early stages of determining how to develop ore reserves, the federal government advised mining industry geologists, engineers and managers that reserves should be determined as Probable and Proven. Probable Reserves were based on surface drilling on spaces that demonstrated continuity in trend direction, ore grade, and thickness. Methods varied but basically it was a “connect the dots” method with calculation of mean values. This resulted in an estimated ore body which would yield a specific volume of ore at a specific grade; e.g., 100,000 tons of 0.015%, (3 pounds per ton) or 300,000 pounds of uranium oxide (U3O8) or yellowcake that could be sold at a price in the neighborhood of $8 per pound. This made the ore body worth $2.4 million. If the cost of mining was in the neighborhood of $2.0 million, the miner could make a 15% rate of return on his investment after taxes. This would be the case for a small near-surface mine pulling out about 100 tons per day over four years. Frequently miners would take this information, start mining and do well. As time went by, and ore bodies were found deeper below the surface, it became important to move to the next phase.
or Proven Reserves. Basically, this method included drilling on closer spacing from the surface. The cost to develop proven reserves could be 50% to 100% greater than the cost for Probable Reserves. The payoff could be great because additional investment costs were required during development of mines that were 1000 feet below ground and included costs for a deep shaft, groundwater pumping stations, subdrifts, development drifts, and deep ventilation holes. Mining reserves took the process another step further with subsurface drilling from subdrifts up through ore zones to detail ore bodies and maximize return on investment.

One of the biggest challenges in uranium mining reserve estimation came about from management trying to determine how much “upfront” investment was required to obtain a mining reserve from a “Probable Reserve” more directly by minimizing additional cost for surface and subsurface drilling. Through years of experience, uranium mining geologists became skilled in recognizing the best procedures and the biggest pitfalls in determining a “reasonably optimistic” mining ore reserve to assist the mine superintendent and production staff in developing and implementing a successful mine plan. Some of the pitfalls included overestimation of mean values using only mathematical procedures without additional geologic expertise and underestimation of external and internal mining dilution due to inexperience in mining procedures and analog interpretation.

**UNCONVENTIONAL HYDROCARBON RESOURCES – A PROMISING SOLUTION IN HELPING TO FULFILL GLOBAL ENERGY NEEDS**

Font, Robert G., Sue L. Bishop, Elaine M. Travers, Cassini Nazir and A. L. Bishop, Geoscience Data Management, Inc., Plano, Texas, USA

Estimated global proven conventional hydrocarbon reserves add up to approximately 1.33 TBO and 6,185 TCFG. Current world petroleum consumption is about 84 MMBOPD plus 276 BCFGPD. As these consumption rates continue to increase, it becomes imperative to define additional energy resources to satisfy worldwide needs.

Even after accounting for extra petroleum reserves obtainable via new discoveries of conventional oil and gas and for added volumes recoverable from existing fields, the expected global consumption rates will force us to tap into new energy resources. Unconventional hydrocarbon deposits hold a great promise concerning our energy future.

Of specific interest to our firm is the potential of “shale gas”, “shale oil”, “coal bed methane” (“CBM”) and “methane hydrates”. In the USA alone, resources of “shale gas” are estimated at a possible 2,884 TCFG with recoverable reserves (under current technologies) of 737 TCFG. World resources of “shale gas” and “shale oil” are estimated at more than 16,100 TCFG and between 2.8 and 3.3 TBO, respectively. “CBM” global resources have been estimated at a possible 2,900 to 9,200+ TCFG with recoverable reserves (under present know-how) of 70-100 TCFG in the USA and 90-100 TCFG in Canada. “Methane hydrates” worldwide resources could reach magnitudes of more than 100,000 to 200,000 TCFG with some estimates reaching the 300,000,000 TCFG figure.

The global potential of these unconventional hydrocarbon resources is currently staggering and may be even greater than anticipated. For example, our own research has documented (to date) nearly 1,000 shale source rocks in over 100 countries with “shale gas” and “shale oil” potential. Similarly, we have highlighted (thus far) more than 800 reservoirs in over 167 countries with “CBM” resource potential. These possible reserves simply cannot be ignored if we are to fulfill our ever-increasing universal energy needs.

A few selected global examples (outside of the USA and Canada) showing areas of “shale gas”, “shale oil” and “CBM” resource potential will be discussed.

**TAPHONOMIC CHARACTERISTICS OF A QUARRY IN THE BRIGHT ANGEL SHALE (MIDDLE CAMBRIAN), GRAND CANYON NATIONAL PARK, ARIZONA: A PRELIMINARY LOOK**

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A site in the Bright Angel Shale on the Tonto Platform of Grand Canyon National Park yielded more than 200 partial and complete trilobite specimens when it was collected by E. McKee in 1930. This site is Middle Cambrian in age (Glossopleura Zone) and occurs in a green-gray shale in the lower third of the formation. The paleofauna includes: brachiopods, hyoliths, and the trilobites *Glossopleura tontoensis*, *Amecephalus piochensis*, and possibly *Glossopleura mckeei*. *G. tontoensis* outnumbers *A. piochensis* in the sample approximately 2:1. Of 141 trilobite specimens assessed for completeness, 92% are isolated pygidia and other sclerites, and 8% are complete or articulated specimens.

Orientation data were taken on 19 slabs of shale from the quarry (in the GRCA museum collections), each containing from 3 to 14 trilobite specimens ranging from isolated pygidia to complete specimens. Although the original up-down orientation of the pieces in outcrop is not known (and thus the actual orientations of the sclerites is unknown) the sclerites appear in individual slabs to have preferred orientations. The ratios range from 3:3 (up vs. down, as preserved within-slab) up to 10:0. Even the slab with the most specimens on it has a ratio of 13:1. Nearly half the slabs have preferred up-down sclerite ratios with binomial probabilities significant at the 95% level (e.g., ratios of 13:1, 10:0, 9:1, 9:0, 8:0), and the chance probability of several of the slab ratios is <0.001.

The average ratio for the 19 slabs is 85.6% one orientation over the other. This is a higher ratio than at other sites also studied preliminarily: another locality in the Bright Angel in Grand Canyon has a per-slab average of 71.5% one orientation over the other (12 slabs with 9-26 cranidia each in ratios
5:4 to 17:1); and one pit in the Lower Cambrian Latham Shale in California has an average per-slab ratio of 58%, although an overall formation sample of several hundred cephala from the Latham is statistically 50:50.

The Bright Angel Shale slabs in the collections contain no ripplemarks or other indicators of original-up; it is therefore impossible to know based on these data whether the average preferred orientation from the slabs reflects the true orientation of the full sample in the outcrop. The data do at least hint at a strong trend in up-down orientation of Glossopleura and Amecephalus sclerites, suggesting that biostratigraphic characteristics of the material were directly influenced by external factors to a greater degree than within some other nearby Cambrian deposits.

DOMESTIC WELLS IN THE ESPAÑOLA BASIN, SANTA FE, NM

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Domestic wells account for roughly 20% of ground water use in the Española geologic basin. New Mexico water law requires the State Engineer to issue a permit for a domestic well, although the City of Santa Fe prohibits new domestic wells within its service area. They are exempt from provisions of New Mexico’s western priority water law. Most occur beyond municipalities, and are commonly used to develop more rural, albeit residential land. Santa Fe County Land Use regulations require metering for new wells. Domestic wells are usually paid for up-front, and may cost, equipped, $30 to 50 per foot ($10,000 to $30,000). Although the hydrogeology ranges from alluvial basin fill to volcanics and fractured granite; with few exceptions, most wells find adequate yields within 200 to 600 feet total depth. The NM OSE WATERS database is the only record of domestic wells in the area, and there are definite problems with locations and data. A sample of the basin from the Galisteo watershed to north of the town of Española contains about 6900 domestic wells, out of 9100 total water rights records. Domestic well water use in the basin is mostly unmetered, but has been estimated from 0.25 to 1.0 afy per year. The impact of these groundwater withdrawals depends on the well density, location, depth to ground water, aquifer properties, pumping rate and duration. Because they pump intermittently at low rates, they are efficient at harvesting the Specific Yield of the aquifer. Most are accompanied by a septic system. In the arid climate of the area, wells located outside of perennial stream valleys are believed to derive most of their water by storage depletion, intercepting regional ground water flow - through and base-flow discharge to the Rio Grande. At this time the impacts of domestic well depletions are estimable by modeling, but compared to flows in the Rio Grande depletions are too small to measure. In addition, fluctuations in groundwater levels due to domestic wells are in general below detection within the current groundwater monitoring network. Domestic wells remain a popular source of supply for new development in the region, while community water systems are constrained by costs and the need to acquire water rights in order to expand service. These wells’ exception to water law pose a conundrum for the State.

LESSONS LEARNED FROM BASELINE SAMPLING AND MONITORING OF GROUNDWATER RESOURCES IN COLORADO UNCONVENTIONAL GAS BASINS

Anthony Gorody, Ph.D., P.G., CPG

Baseline sampling and monitoring of surface and groundwater resources has become a significant risk mitigation option for operators in Colorado’s unconventional gas basins. First instituted by coalbed gas operators in the San Juan basin, the practice has now become an integral part of Colorado Oil and Gas Conservation Commission regulatory permit requirements in the San Juan, Raton, and Wattenberg basins. Several operators in the Piceance basin have been conducting their own groundwater monitoring operations since the turn of the century. Similar work in the Piceance basin has been supplemented by funding from both Garfield County and the COGCC.

Baseline sampling is based on sampling one or more water wells and surface water resources within a pre-defined radius around the planned location of an infill gas well. In that sense, the term “baseline sampling” is somewhat of a misnomer because results usually record existing groundwater conditions after historic drilling operations. Monitoring consists of sampling the same water wells one or more times after a planned well is drilled. Sample analysis includes major ions, selected trace minerals and anions, dissolved methane concentration, dissolved BTEX, BARTTM cultures, Coliform bacteria cultures, and both chromatography and stable isotope analysis of fixed gases and hydrocarbons whenever dissolved methane concentrations exceed 2 mg/L.

Results from hundreds of sampled wells over large areas in Colorado show that most water wells draw water from more than one aquifer regardless of screened interval placement. This is evident from observed seasonal changes in water quality which show signatures of shallow, intermediate, and deep aquifer fluid sources harboring distinct water types. The well bore becomes a mixing zone. Most wells are aggressively infected with iron-related, sulfur-reducing, and slime-forming bacteria. Such results explain most complaints related to apparent progressive losses in water yield and declining water quality. Results also serve to educate water well owners on the importance of proper well maintenance practices. The majority of water wells (>60%) contain measurable amounts of dissolved biogenic methane, with about 5-10% of those containing more than 1 mg/L. A small number of water wells and springs are impacted by oil and gas operations. The weak link in all drilling-related problems is a compromised annulus, not drilling fluids or completions practices. Drilling blowouts, uncedented annuli of both old and new wells in areas with shallow gas, lost cement, and poor cement bonding across highly fractured intervals in both vertical and deviated wells can allow gas and condensate to escape into shallow aquifers. Illegal “midnight dumping” of produced water and other disposal pit fluids is another occasional source of contamination. The availability and consistency of baseline water quality data facilities interpreting forensic geochemical data, makes it possible to routinely and directly identify polluting point sources, and is necessary for evaluating the efficacy of remedial actions.
URANIUM EXPLORATION FOLLOWING THE PETROLEUM SYSTEM APPROACH

John B. Gustavson, Gustavson Uranium Systems

Uranium mineralization of the South Texas type may be pursued by the same systematic approach, which is used for oil & gas exploration. To recap, a petroleum system consists of a source rock, maturation (chemical change of proto-petroleum into oil or gas), migration of the fluids, a trap and a reservoir rock. Many oil & gas discoveries have been made following this model.

The author describes a similar systematic model for uranium exploration, namely 1) a source of primordial uranium, 2) a chemical change, which liberates the uranium, 3) the migration along aquifers, 4) various entrapment possibilities, and 5) the reservoir rock. The geology of the Upper Mississippi Embayment shows all the favorable components, where a major uranium system may exist.

The primordial source was gigantic explosions of silicic volcanic ejecta, which reached ground as rhyolitic ash. The environment was likely a shallow marine embayment, which connected with the Gulf of Mexico in the Paleocene. The geology is readily correlated with the Texas Gulf Coast. Subsequent devitrification (the chemical change) altered the ashes into montmorillonitic clays known as the Porters Creek clay. Where this took place in an oxidizing environment meteoritic waters liberated part of the uranium in form of uranyl ions, which were free to migrate. Some of the uranium migrated south with surface waters into the Gulf and were diluted.

Another part of the liberated uranium migrated with the groundwaters, which currently flow steeply with the local dip toward the axis of the Mississippi Embayment. The flow is generally radially in toward the upper part of the axis from the horseshoe-shaped outcrop of Upper Cretaceous through Paleocene formations. The primary conduits were the McNairy sand (Cretaceous) and the Lower Wilcox formation (Paleocene, Midway group), which sandwich the Porters Creek clay between them.

At some point the uranium-bearing water in the down-dipping aquifers reached anoxic conditions, partially by lithologic influence (pyritic or organic material) or by seepage of hydrogen sulfide or methane along deep-rooted faults from underlying shales. At such traps the uranium would precipitate and form the well-known roll fronts. Other traps may be of stratigraphic nature and more difficult to locate by mapping the ancient depositional systems of the primary aquifers.

The U.S. DOE issued the author’s hypothesis in 1982 as part of the National Uranium Resource Evaluation program. In 2007 upon sale of his consulting company, Mr. Gustavson formed an exploration company and incorporated study results from the intervening 25 years. In parallel, the company acquired land positions.

The company has pursued the exploration model by conducting reconnaissance based on groundwater sampling; mapping of shallow structure based on proprietary bore holes, and gravity and magnetic mapping of the northeastward extension of the New Madrid seismic zone. The resulting down-to-the-basin faults are now drilling targets at 500 to 1200-foot depth. The author concludes that exploration may reveal uranium deposits of substantial magnitude by following the geological principles learned from oil & gas exploration.


METHOD REVIEW: HYDROGEOLOGICAL SITE CHARACTERIZATION IN PREPARATION FOR URANIUM IN-SITU RECOVERY MINING

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Sub-water table uranium roll front deposits developed by In-Situ Recovery (ISR) methods will continue to be important for future global uranium supply. Competent hydrogeological characterization of prospective ISR uranium mines is essential to mitigate the biggest risk: off-site groundwater pollution. To support production of these uranium deposits, a variety of non-traditional tools may be applied to improve estimation of hydrogeologic parameters beyond typical site investigation techniques. Groundwater flow generates an electrical current which can be measured at the surface. Electrical geophysical methods including self-potential, spectral induced polarization and direct-current resistivity are potential site characterization tools. Hydrogeologic parameters which can be measured geophysically include water table position and character, groundwater flow patterns, degree of aquifer saturation, hydraulic head, and transmissivity. Inverse modeling can estimate aquifer transmissivity distribution in heterogeneous aquifers, critical to evaluate ISR production potential. Mapping water saturation as a proxy for pore geometry to calculate in-situ water volume variability is useful to indicate both aquifer heterogeneity, and ISR production/restoration volumes. Applied groundwater geophysics also aids site specific interpretation of field pump test and drawdown data. To varying extents these geophysical techniques are currently being applied to other mineral exploration and water resource problems. Geostatistical methods can be used to produce more representative hydrogeologic parameters. Advantages of applying the geoelectric groundwater exploration methods include improved aquifer understanding for regulation and site development, reduction of the number of pump tests and wells, and resolution of site hydrostratigraphy. Data from such studies enable improvements to site specific ISR subsystems e.g. wellfield design, mine unit recovery and production.
GEOCHEMISTRY OF THE RIFLE VANADIUM-URANIUM MINE: A DISTINCT BUT CONFUSING ROLL FRONT DEPOSIT

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The Rifle Mine, located about 10 miles north-northeast of Rifle, Colorado produced about a million tons of ore grading 1.60% V$_2$O$_5$ and 0.06% U$_3$O$_8$ intermittently between 1924 and to 1978. The deposit is virtually continuous for 1½ miles except for the interval between the Rifle and Garfield mines eroded by East Rifle Creek. The vanadium ores occur in the Jurassic Glen Canyon and Entrada sandstones. The Glen Canyon sandstone is about 40 feet thick at the mine but disappears rapidly to the east. This unit contained the bulk of the ore at the Rifle Mine. Glen Canyon cross stratification consistently dips south-southeast which may be controlling the thick trends and ore rolls trend east-northeast paralleling the strike of the cross stratification. The Entrada Formation disconformably overlays the Glen Canyon. This eolian sand unit contains minor but mineable quantities of ore. The Glen Canyon unconformably overlies redbeds of the Triassic Chinle Formation, while the Morrison Formation with a few small uranium prospects, overlays the Entrada. Consistent elemental zoning is readily detected in rock exposures within the mineralized area as illustrated below. This sequence applies both horizontally and vertically. Large scale “C” roll features dominate in the dip direction with Cr$^{+3}$ above the lower limb and below the upper limb.

This sequence suggests that the oxidizing fluids invaded from the south, thus the reducing fluids were located north of the deposit. The distinctly linear northern boundary observed in plan and section suggests that this boundary represents the level of a natural gas concentration in the relatively porous sandstone. This boundary now dips to the south but about 6° degrees less than the host units thus at the time of ore deposit formation the dip would have been about 6° degrees to the south. The natural gas could have entered the host sandstones from early fractures along the major east-west fault south of the mine. Oxidizing fluids generated by basin dewatering of the Triassic red beds could have provided much of the vanadium to the redox system. In most of the area south of the Rifle deposit the host sandstone is red, except for a limited area along East Rifle Creek and extending a couple of miles to the west, where the Glen Canyon and Entrada sandstones are bleached white with numerous streaks of dead oil. This bleaching apparently was a much later event in which tectonic movement along the Grand Hogback Monocline increased the dip and further movements on the Bowen Ranch fault provided channelways for migration from the petroliferous Weber Sandstone about 1000 ft. below the Rifle Mine.

ESTIMATION OF RESERVES OF THE SEARLES LAKE, CALIFORNIA BRINE AND SOLID-PHASE MINERAL RESOURCES

David A. Holmes, CPG, Assistant Secretary for Indian Affairs, Division of Energy & Mineral Development

The Pleistocene Searles Lake playa evaporate deposit consists of multiple solid-salt layers filled with saturated brines in its crystalline interstices separated by layers of impermeable, unconsolidated mud (clay, silt, organic material, and disseminated insoluble mineral crystals). Many problems face the reserves estimator due to the potentially changing relationship of the brine and solid phases, exacerbated by pumping of brines off to chemical plants where potassium, boron, sodium carbonate, and sodium sulfate values are extracted and the spent liquor is returned to the Lake ore-body from waste streams high in sodium chloride and sodium sulfate values. Complicating this scenario is the fact that of 40% total porosity, only 12% is effective porosity where brines move freely through the solid-phase body and 28% includes brines locked into fluid spaces that have no connection and cannot be recovered without some dissolution of the solid phase around them. Complicating this is the fact that as solid phase minerals dissolve, the relative chemical content of the brines may change as well-along equilibrium patterns established through physical chemistry principles. A third complication is that temperature changes of the brines in situ throughout the year change the chemical equilibrium and the chemical content of the brines. Effective brine production over decades requires careful estimation of brine and solid phase chemical values to optimize plant-feed grades and deposit mine life.

WATER IN THE WEST – RESOURCES VS. NATURE AREAS: BRACE FOR IMPACTS

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Conflicts over beneficial water use in western states, particularly Colorado, have become increasingly intense over the last decade. Since there are many more “beneficial uses” than available water, how do we decide as a society which uses get the water? Alternatively, how do we increase the supply of available water so as not to unduly restrict appropriate uses of water? A partial list of uses (river trails, riparian learning centers, rafting, fishing, bird habitat, natural areas etc.), mineral extraction (such as oil & gas, oil shale, hard-rock minerals, etc.), and others.

In the last decade, consider the following conflicts and controversies that have surfaced:
The shutdown of 440 agricultural irrigation wells in crop-intensive NE Colorado in 2006 shows the competition between junior and senior water right holders along the South Platte Basin;

The Cache La Poudre River in Northeastern Colorado and Southern Wyoming has been designated by federal legislation as a Wild and Scenic River to date all off-axis water storage projects (such as the Two Forks Dam) have been defeated;

Another concern is the use of non-tributary ground water for oil shale in CO, WY, and UT; and

Dividing up Colorado River water (and others) among states continues to be controversial, as shown by Senator McCain’s difficulty in clarifying the Colorado Compact in the 2008 campaign.

How can win-win solutions be achieved? Direct solutions include new storage reservoirs to capture river flows during periods of snowmelt, but the controversy over the Northern Integrated Supply Project (NISP) and other schemes shows the inherent difficulties with new projects. Another solution is the idea to bring water supplies from other river basins or even from other states (such as the Flaming Gorge Proposal currently being reviewed by the U.S. Army Corps of Engineers or the recently-proposed Regional Watershed Supply Project). A third important solution is water conservation, but many estimates show these savings to be only in the 10-15% range. This brings us to the need to educate people, especially the next generation, about the wise and sustainable use of natural resources.

One example of a very positive water education initiative in Northern Colorado has been the establishment of the Poudre Learning Center (PLC), a 65-acre site along the banks of the Cache La Poudre River just west of Greeley, Colorado. Funded by a creative and committed assembly of philanthropic, government, education, water district and community business interests, the PLC focuses primarily on K-12 education and research monitoring. During 2008, approximately 12,000 K-1 students have visited the site, which includes a 20 acre lake (bentonite slurry wall around gravel pit) as well as several field stations where students conduct scientific investigations as part of their school standards. The vision of the PLC is to provide authentic research experiences which train students to inquire and discover knowledge rather than to have any particular political, economic, or scientific interest group indoctrinate students into their “correct” way to approach these controversies. The 5 acre feet of water committed to this use by the Central Colorado Water Conservancy District seems like a very wise investment, and several grants from the state, regional, and federal agencies support the vision.

Overarching the entire debate are concerns over major fluctuations in precipitation experienced during recent and historical droughts; moreover, the scepter of climate change now challenges us and may seriously impact future generations, particularly in the arid west.

A MODEL OF ENVIRONMENTAL SUSTAINABILITY FOR MANAGING RESOURCES, MINIMIZING WASTES AND REDUCING GROUNDWATER CONTAMINATION
AT A CALIFORNIA COMMUNITY SERVICES DISTRICT

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A green business model was developed for the Tamalpais Community Services District (TCSD), located in unincorporated Mill Valley, California. The agency performs solid waste, sewer collection and Park and Recreation services for 2,550 households. With an annual budget of $4.3 million (2008-9), TCSD focuses on managing resources and protecting groundwater and surface water, while also collecting waste. In the process of providing collection services, savings related to energy use and landfill diversion were noted. In 5 years, landfill garbage has been reduced 20% and recycling and green waste (turned into mulch) has increased by 33%. TCSD recycled more than 1,304 tons of paper, cardboard and plastics.

TCSD will collect 100 lbs of used and outdated medicines in 2009. In prior years these pharmaceutical wastes were likely dropped into toilets and released into surface waters after standard wastewater treatment or placed in the refuse containers and deposited in the landfill where these unregulated chemicals could leach into groundwater. Other recycling programs have diverted 3 tons of electronic wastes (TVs, microwaves, computers) per year from landfills. In 2008, battery drop-off collection saved about 1,000 lbs heavy metals, mostly lead and cadmium as well as battery from leaching into the landfill groundwater. Over 12 months, 600 compact fluorescent light bulbs (CFLs) and 480 fluorescent lamps containing 3.0 Kg and 5.8 Kg of mercury, respectively, will be recycled and diverted from the landfill. Between 2005 and 2008, garbage collection was reduced from 2,300 to 1,900 tons, a savings of 800,000 lbs of waste not filling local landfills.

The Mill Valley area served by TCSD lies at sea level on Richardson Bay a part of the greater San Francisco Bay. Due to two tidally influenced creeks, groundwater within about 1 mile of the shoreline is usually encountered within 3 feet of ground surface. Most of the flatland in the valley was originally bay marsh, and significant subsidence occurred over the past 50 years on the residential structures, roads as well as the sewer laterals and main pipelines, causing significant wet weather inflow and infiltration. TCSD has reduced wet weather flows to it’s two nearby wastewater treatment plants by 10% by reducing infiltration and inflow and by repairing numerous broken sewer laterals and mains. One set of sewer repairs has reduced wet weather flow to one wastewater plant by 40%. With less pumping of storm water and shallow groundwater, energy consumption was reduced by 20% in 2008 from 2006. The focus on environmental sustainability has lead to a waste collections program which saves money, environmental resources and generates broad community support.
The concepts of remediation hydraulics and geologic/hydrogeologic expertise are utilized in the development of a reliable site conceptual model, illustrated in a recent case study for a site in Michigan. Remediation hydraulics can be defined as the application of hydrostratigraphic techniques that aid the geoscientist in evaluating the role of the depositional environment in determining groundwater flow and contaminant distribution in the subsurface. The aquifer beneath an industrial property in Benton Harbor, Michigan is affected with chlorinated volatile organic compounds (CVOCs) at concentrations exceeding regulatory criteria. The original conceptual site model indicated the lithology consisted of an upper and lower sandy aquifer separated by a laterally continuous intermediate clay unit. Previous site conceptual models assumed that only the upper aquifer was affected by CVOCs. As an interim remedial solution, a groundwater pump-and-treat system was installed in 2004. The extraction well network was located in the downgradient portion of the plume. Several rounds of in-situ chemical oxidation were applied in the identified source zone in the upper aquifer. A review of the system performance data indicated that the highest concentrations of CVOCs were consistently found in the extraction wells, which showed little variation over a five-year period. ARCADIS applied remediation hydraulics concepts that challenged the existing conceptual site model as inadequate to explain site-specific observations, and that further data collection and hypothesis testing was necessary. In order to better define the depositional environment beneath the site and understand groundwater flow and contaminant distribution, ARCADIS conducted high-resolution sampling using vertical aquifer profiling (VAP) techniques. This investigation identified high concentrations of CVOCs within the lower aquifer directly below and adjacent to previous impacts identified in the shallow aquifer system. The cross-section resulting from the VAP soil borings identified a complex sequence of sediments reflecting depositional environments consistent with proximity to the St. Joseph River and historical glacial lake levels in nearby Lake Michigan. Concentrations discovered within the lower aquifer exceeded those previously identified within the upper aquifer by up to two orders of magnitude. The dissolved-phase CVOC impacts are distributed within both higher permeability channel deposits and lower permeability silty sands, while soil samples collected from the intermediate clay layer indicate that diffusion has resulted in high concentrations of CVOCs within these relatively impermeable deposits.

The complex nature of the stratigraphy will create challenges in achieving successful remediation of the site and ultimately final regulatory closure. Source impact reduction within higher permeability deposits may be readily achievable with targeted pump-and-treat systems and/or augmented with in-situ remedial treatments; however, back diffusion from the fine grained, lower permeability deposits will create a long-term ongoing source of dissolved contaminants to groundwater. The significance of this ongoing source of dissolved contamination will be considered when projecting future remedial performance and to develop an effective overall site closure strategy.

Inorganic chemical pathways exist for producing coal, natural gas and oil from dolomite, limestone, calcium carbonate rich sandstones and mudstones, carbon dioxide and carbon monoxide. It is proposed that the carbon atom in calcium carbonate is changed to methane and other hydrocarbon gases and liquids by heat, pressure and by reducing hydrogen sulphide and water. The hydrocarbons are formed by inorganic syntheses. Coal oil and gas are being replenished today. Active fault zones and regions of tectonic activity increase all natural hydrocarbon production. Dolomite and limestone are being converted to natural gas oil and coal today at 1-2 miles in depth. Hydrogen sulphide is a major contributing reducing chemical to calcareous formations, carbon dioxide and carbon monoxide.

Natural gas is found within, below and above limestone or calcium rich sandstone layers. These layers are the source of methane. They are not the traps for natural gas. In a reducing environment, limestone is changed to methane. The main syntheses are:

Limestone & hydrogen sulphide & iron form hydrated lime, methane, water and pyrite

In the presence of water and hydrogen sulphide, a reducing and hydrating environment, limestone is changed to, methane and gypsum, if temperatures and pressures are raised.

Coal and methane form from carbon dioxide or carbon monoxide bubbling out of volcanic vents in the presence of hydrogen sulphide (black smokers). The presence of water and hydrogen will form other reactions. Well-known reactions being done industrially today are:

Carbon monoxide and water form carbon dioxide and hydrogen. (The Water Gas Shift Reaction)
Carbon dioxide and hydrogen form methane and water. (Sabatier Reaction with corundum)
Hydrogen and carbon monoxide will form methane and water. With an excess of hydrogen, ethane, propane, butane, pentane and other longer chain alkanes are produced (Fischer-Tropsch).

Hydrogen sulphide will react with iron to form pyrite. It will also react with carbon to form pyrite bands in coal and emit methane gas. The carbon is further reduced to methane gas. Water will combine with sulphur trioxide gas to form sulphuric acid. Sulphuric acid and limestone combine to form gypsum and give off water and carbon dioxide. Sulphur trioxide converts limestone to gypsum or anhydrite and carbon dioxide.
Coal is therefore created by the reduction of carbon monoxide by hydrogen sulphide gas with the release of sulphur dioxide and water. Graphite or solid carbon can also be created by the pyrolysis of methane in the absence of air. Coal can also be produced in the absence of oxygen by the reduction of carbon dioxide to carbon monoxide and then to carbon by heat and pressure.

The accepted origin for coal and gas is through forests and plankton being buried under heat and pressure. Tree fern fossils or pterodactyl fossils in coal do not mean that these fossils created the coal. The fossils were preserved in non-oxidizing, reducing conditions. Coal is therefore a chemical sedimentary deposit as is chert and dolomite. The accepted origin for oil is through burial of plankton. I propose the Fischer-Tropsch and Wurtz synthesis for gas and oil’s syntheses. Where methane bubbles through salt water brines, methyl chloride is formed. Two methyl chloride molecules then bind by the action of a sodium ion from salt to form ethane. Longer chain hydrocarbon creation is a simple addition of alkyl chlorides to form alkanes.

Conclusions New oil and gas fields can be found in active, hydrogen sulphide rich fault zones in carbonate geology, around salt domes and rich saline brines, and near to reserves of gypsum or anhydrite. Oil, gas and coal dating will help us find active renewable reserves compared to ancient non-renewable oil, gas and coal reserves.

GEOLOGY & ORE DEPOSITS OF THE SAN JUAN MOUNTAINS
Bob Larson, Geological Consultant

Cenozoic volcanism within calderas and associated structures provided a stratigraphic sequence that has eroded into magnificent scenery and landscape that is recognized as the “Switzerland of America”. Precambrian-Mesozoic strata flanks most of the area defined as the San Juan Volcanic Field and encompasses a large portion of southwestern Colorado. Within the San Juan’s are numerous calderas and volcanic centers that were the source for ash flows, lava flows and water-lain tuff-breccias. These same volcanic centers are also the source areas for hydrothermal solutions that carried mineralization into many of the fracture systems and favorable host formations.

Two major periods of mineralization exist within the San Juan’s, late Cretaceous-Early Tertiary and Mid-Tertiary (Miocene). The “Blowout”, north of Ouray, is a classic example of the first period of mineralization and is characterized by alteration and mineralization within intrusives and sediments that are underlying unaltered volcanic formations. Disseminated mineralization exists within the intrusives, skarn-type mineralization is found surrounding the intrusive center and vein-type and replacement mineralization is found away from the center. The second period of mineralization is found within the typical volcanic sequence and is a part of the veins, breccia pipes and replacement ore associated with the Mid-Tertiary volcanic activity and calderas. As these calderas were being developed and formed 40-25 million years ago, mineralized centers became source areas of the zones that contain gold, silver, lead, copper, zinc and other minerals. The Red Mountain area between Ouray and Silverton is one such “center” located near the northwest boundary of the Silverton Caldera. Veins and breccia pipes along the boundary of the caldera contain deposits of these minerals as do the radiating vein systems that extend outward from the Red Mountain area.

The Idarado, Camp Bird, and Revenue-Virginius mines are located along northwesterly vein systems, radiating outward from the Silverton Caldera, and within an area defined as the Red Mountain—Mt. Sneffels sag. The Yankee Girl, Guston, Robinson, Genesee-Vanderbilt, National Belle and Longfellow mines are part of the Breccia Pipe systems that are within the boundary faults of the caldera and adjoin the Red Mountains. The mineralization within each of these systems follows classic zoning patterns that can be related to major mining districts throughout the world. The Eureka Graben, that connects the Silverton and Lake City calderas, is the location of the Sunnyside, Gold King, and Treasure Mountain mines. Each of these are steeply dipping, vein-type mines that have produced significant ore throughout the mining history of the San Juan Mountains.

MOBILE GIS SOLUTIONS FOR GEOSCIENCE APPLICATIONS - OPTIONS WITH ESRI TECHNOLOGY
Willy Lynch, ESRI

GIS is a standard office tool for geoscience activities such as map making, data management and analysis. Integration of GIS technology into fieldwork activities for field data collection has become a requirement for many organizations and a variety of options are available from server based mobile applications to high powered digital field computers to simple paper map technology. This presentation will include a brief introduction to uses of GIS for Geoscience and continue with more detailed discussions of various options using ESRI technology for field (i.e.- mobile) applications. The correct technology for any organization will depend on budget, staff and workflow requirements and constraints.

Technologies and workflows to be described include: 1) ArcGIS Server (Enterprise-Advanced) deploying maps and mobile applications, 2) ArcGIS Desktop technology on high powered ruggedized tablet PC’s; 3) Stand alone ArcGIS ArcPad technology on ruggedized tablet PC’s or Windows mobile devices; 4) Integrated ArcGIS Desktop in the office with ArcPad on Windows Mobile devices in the field; 5) ArcGIS Desktop in the office using ADAPX pen and paper maps and forms in the field; and 6) Traditional paper maps in the field.

ArcGIS Server Mobile is a task-based mobile GIS application for viewing, collecting, searching and synchronizing GIS data directly with ArcGIS Server. It provides central control, configuration and deployment of mobile data, maps and projects. ArcGIS Desktop provides advanced data management and editing and check-out and check-in management of ArcPad data and maps. ArcPad is a feature rich mobile GIS application and includes advanced tools for finding, creating and updating GIS information. ArcGIS Desktop with the ADAPX pen allows GIS teams to collect and share data from the field quickly and naturally, using software that integrates paper-based map markups into ArcGIS.

Some brief examples of mobile GIS for geologic mapping, mineral exploration, mine permitting and compliance and environmental studies will be shown.
GIS technology and use is constantly evolving. The most current information about existing mobile GIS applications can be found at the ESRI website http://www.esri.com, more information about training for mobile GIS can be found at http://training.esri.com and current geoscience industry examples and case studies can be found at http://www.esri.com/industries.html.

**DORMANT LANDSLIDES IN MANCOS SHALE AT CRESTED BUTTE, GUNNISON COUNTY, COLORADO; ORIGIN, HYDROLOGY, MATERIAL PROPERTIES, AND STABILITY**

James McCalpin, GEO-HAZ Consulting, Inc.

The Mancos Shale underlies the surface in much of western Colorado, forming badlands landscapes in areas of low precipitation. However, the Mancos also underlies higher elevations (up to 13,000 ft) and the increased precipitation (snow) there causes extensive landsliding. In Gunnison County the heavy laccoliths of Mt. Crested Butte, Snodgrass Mountain, and Gothic Peak lie on a bed of Mancos Shale, the perimeter of which has widely failed in slump-earthflows. Although this landslide terrain makes for interesting skiing, the potential for slide reactivation becomes an issue in Environmental Impact Statements.

The southeast slope of Snodgrass Mountain has been proposed for an expansion of the Crested Butte ski area, with trails to be cut and artificial snow to be added. As part of the pre-EIS studies, we prepared a landslide inventory map of the southeast slope that documents 57 landslides of various sizes (1-20 acres), various ages (recent to pre-latest-glacial), and various movement types; they underlie about half of the slope. Landsliding begins directly at the laccolith/Mancos contact and is controlled by a ca. 60 m-thick transition zone of thin (10-15 m) sills of fractured, granitic porphyry intercalated with the uppermost Mancos. These fractured sills, as well as the fractured zone at the base of the laccolith, deliver large quantities of groundwater into the weak, impermeable Mancos Shale in the transition zone. Landsliding is much less common below the transition zone. Landslide deposits are composed of isolated, gravel-to-boulder-size blocks of porphyry, floating in a matrix of chaotically deformed Mancos Shale.

In order to assess slope stability pre- and post-development, we installed two stream gaging stations, 16 piezometers (some nested) and 7 inclinometers in Spring-Summer 2007. We dug two large trackhoe trenches across suspected toescarp thrusts of the East Slide, the largest slide polygon. The existing network of 9 landslide monitoring stakes installed in 1995 (and measured yearly since then) was increased to 19. Direct-shear and triaxial tests indicate that in-place Mancos Shale has relatively high peak strengths (peak $\phi=30°-40°$, $c=200-400$ psf) but much lower residual strengths in previously-failed material ($\phi=10°-11°$, $c=0-120$ psf).

Landslides of the SE flank show considerable current stability (Factor of Safety, FS>1.3) where slope angles are low to moderate, regardless of the morphologic age of the slide (e.g., landslide polygons 9, 11, 12). Development actions are not predicted to decrease the FS below 1.3, according to estimates of hydrologic change due to trail clearing and snowmaking. In contrast, landslides on the steeper slope bands (>17° slopes), have minimum predicted FS of 1.08 to 1.11. Where development actions are concentrated, they are predicted to decrease the stability by about half (e.g., in polygon 21, FS 1.11 to 1.05; in polygon 1, FS 1.11 to 1.07; in polygon 14, FS 1.08 to 1.04). In peripheral areas such as the East Slide (a no disturbance zone), the impacts are slight (FS 1.11 to 1.10).

Even though slope failure is not predicted to result from the proposed actions, the minimum post-development FS is close enough to 1.0 on the steep slope bands that aggressive mitigation was recommended there (surface water management to decrease runoff and infiltration above the steep slope bands, and horizontal drains to lower the pore pressures on the steep slope bands). However, the US Forest Service requested that about half of the landslide complex be made a “no disturbance” area within the ski area, due to the low factors of safety, and the uncertainties in predicting post-development FS values.

**GEOGRAPHIC INFORMATION SYSTEMS**

**A POWERFUL TOOL IN THE AREA OF MILITARY MUNITIONS RESPONSE**

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A Geographic Information System (GIS) is an integrated approach for data collection, data management, results analysis, and visual presentations. GIS is an effective way to visualize and display data. GIS software is a powerful tool that allows the user to manage and analyze large spatial datasets, while also being a strong cartographic resource. Efficient use relies on effective project planning to ensure that field activities, data collection, and data management can be used for data analysis and visual presentation. GIS platforms can be used to manage historical and current data. GIS platforms are user-friendly and can be applied to projects ranging from small acreage site inspections to projects which encompass thousands of square miles.

In 1986 the US Congress authorized the Defense Environmental Restoration Program (DERP) to address the evaluation and cleanup of contamination at Department of Defense (DoD) installations and formerly used defense sites (FUDS). In 2002, Congress modified DERP and created the Military Munitions Response Program (MMRP) to address unexploded ordnance, discarded military munitions, and munitions constituents contaminations at DoD installations and FUDS. The MMRP is concerned with the identification, investigation, and remedial actions (or a combination of removal and remedial actions), to address munitions and explosives of concern (MEC) or munitions constituents (MC). The identification and safe removal/remediation of MEC/MC is the ultimate goal of the MMRP.

The MMRP was designed to address DoD installations and FUDS that exist in many locations throughout the United States. These properties are both publicly and privately held and can be located in remote areas or in large population areas. They range in size from 5 acre pistol ranges to aerial bombing ranges which can encompass several hundred square miles. GIS can effectively be applied to these small- and large-scale projects alike. The MMRP implements GIS on all related projects, including Site Inspections (SI) at FUDS as well as range clearances on active military training ranges.
The MMRP project sites encompass varied geomorphology and geology due to the size ranges. GIS is used to manage both historical and current data. Project can implement both historical and currently available data to characterize site conditions before ever going out in the field. This data is then passed on to field teams to help with ‘on the ground’ site inspections. The information provided by GIS helps concentrate field efforts in “most-likely” locations.

GIS is a tool that has been effectively used at hundreds of MMRP sites. It provides a path for discipline interaction as well as creating a comprehensive view of each site. The implementation of GIS incorporates allows the project to manage data, integrate disciplines, for visual data. It has worked successfully on the MMRP-related projects and continues to be a vital resource for these projects.

REMETICATION OF THE LONDON MILL FLOTATION PLANT
COPPER BASIN MINING DISTRICT, DUCKTOWN, TENNESSEE
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The Copper Basin Mining District is located in the southeast corner of Tennessee, near the borders with Georgia and North Carolina. The Copper Basin is the site of a massive sulfide deposit that was discovered in the 1840s. By the 1900s mining and mineral processing activities had left the basin denuded of vegetation and the streams filled with sediment. The historical mineral beneficiation included flotation of sulfide ores at the London Mill Flotation Plant from the 1920s to the 1980s. Glenn Springs Holdings has successfully remediated the London Mill area. The objective of the remedial actions was to eliminate human health hazards from the site and to significantly reduce metals and acid loading to the adjacent streams.

The remedial activities included three phases:

- Inventory of waste materials
- Disposal and capping of waste materials
- Segregation of contaminated surface and ground water from clean water

The initial phase was waste inventory and sampling activities to determine the types and volumes of waste materials. The waste materials were characterized as potential human health hazards (asbestos and PCBs), Bevill exempt potentially acid-producing materials (mill tailings and mined rock), or non-Bevill exempt materials. The second phase of the remediation was the disposal and capping of waste materials. The asbestos and PCB contaminated materials were transported offsite to an approved disposal facility. The Bevill exempt potentially acid-producing material remained onsite. Tailings were transported to a flooded mine collapse structure for subaqueous disposal, while mined rock was placed under a soil cap. The non-Bevill exempt material was placed within the foundation of the flotation mill and covered with a multilayered, engineered cap. The final phase of the remediation was the segregation of the contaminated surface and ground water from clean water. This included the construction of diversion swales for clean stormwater runoff, construction of an infiltration system to collect contaminated water from a large former tailings pond, capping tailings areas, and construction of a pump station and pipeline to transport contaminated water from the London Mill area to the North Potato Creek Water Treatment Plant.

EVALUATING THE EFFECTS OF OPEN-PIT IRON ORE MINING ON SOUTH AUSTRALIA’S EYRE PENINSULA REGIONAL GROUNDWATER RESOURCES
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When the South Australian miner, Centrex Metals Limited developed their Mining Lease Proposal for the Wilgerup Iron Ore Project, the regional permitting agency, the Department of Primary Industries and Resources South Australia (PIRSA) required that Centrex demonstrate the mine pit would not adversely affect other water resources in the region, particularly fresh to brackish groundwater resources. Freshwater lenses exist in the Musgrave Prescribed Wells Area about 30 to 50 kilometers to the west of the proposed iron ore mine. PIRSA wanted assurances that evaporation from the mine over the next 500 years will not result in drawdown affecting the freshwater lenses. Malcolm Pirnie and Sinclair Knight Merz were retained by Centrex to conduct a study to evaluate the potential effects of the mine pit on regional water resources.

A quantitative conceptual model was developed to evaluate the proposed mine’s hydraulic relationship to the freshwater lenses. The mine will extract ore from steeply-dipping Precambrian aged basement rock adjacent to a failed rift valley, the Polda Trough. The Polda Trough contains relatively flat-lying sediments from the Permian, Jurassic, and Tertiary with the Polda Freshwater Lens existing in Quaternary sediments that partially overlie the trough. The concern was that drawdown caused by evaporation in the mine pit might propagate preferentially in the Polda Trough to the freshwater lens. The conceptual model, which was based on regional hydrogeologic investigations, the state’s water well database, regional climatic data, and water resource studies, showed that preferential drawdown in the Polda Trough was unlikely and that the mine pit would not affect the freshwater lenses. PIRSA agreed with the conclusions of the study which enabled their assessment of the Mining Lease application to progress.
Oil shale in the Piceance Basin is a world-class fossil hydrocarbon resource of critical value to our nation’s future. At current U.S. oil consumption, recovery of the entire 1.5 trillion barrel resource would be about a 200 year supply for the U.S. Adequate water exists in local surface streams and in-basin ground water produced during mine dewatering to supply a large extraction industry.

Past test operations and current R&D plans for extraction reportedly would recover only about one half or less of the hydrocarbon resource. Also, there are no announced plans to extract several potentially valuable mineral elements in the shale. Several of these mineral resources in raw oil shale could potentially equal the “raw rock” value of the hydrocarbons contained in the shale. A vigorous and carefully planned research effort is needed to ensure maximum recovery of all hydrocarbon and mineral resources, to minimize adverse environmental effects, and to leave the post-extraction Basin in a useful and productive condition for vegetation, wildlife, recreation and water resources.

**REMEDIATION SYSTEM DESIGN BUILD ADVANTAGES**

Dan Nolan, Seneca Environmental Services, Inc.

This presentation covers a wide array of advantages achieved in design build of environmental remediation systems including improved system designs, building methods, quality, testing, equipment options, noise abatement, energy efficiency and industrial controls illustrated by three example projects.

**INTERPRETATION OF GROUND SUBSIDENCE FROM INTERFEROMETRIC DATA USING GEOSPATIAL TECHNIQUES**

Bibhuti Panda, Ph.D., P.E., Brian Sovik

Remote sensing and geographic information systems (GIS) are a powerful combination. They form a very unique perspective into the behavior of ground subsidence resulting from the decline of groundwater in alluvial aquifers. The potential to understand the geological and hydrological factors that influence subsidence behavior has recently been enhanced by the application of interferometric synthetic aperture radar (InSAR) data. InSAR utilizes satellite-based data acquired at two different times along orbits of a similar trajectory to detect changes in the ground surface elevation. This presentation demonstrates the successful use of InSAR to map the distribution and rate of ground subsidence occurring over the past decade, with vertical precision in the range of 0.5 to 1 centimeter. We will also share how InSAR has been used as a valuable tool to detect zones at risk of earth fissuring, in that regions of sharp differential ground subsidence.

The presentation will also show how the interpretation of InSAR data leveraged GIS through advanced spatial analysis. For example, a three dimensional (3D) surface subsidence map and series of vertical subsidence profiles will be shared.

Finally, the presentation will show how the ground subsidence and earth fissuring were modeled using InSAR data by employing a two-dimensional coupled seepage and stress-strain finite element analysis. The model was able to simulate the subsidence and earth fissure activity, and predict future subsidence and locations with the potential for earth fissure formation.

**MINING HISTORY OF THE SAN JUANS FOCUSING ON OURAY COUNTY**

Don Paulson, Curator, Ouray County Historical Society

Boom and Bust followed by Boom and Bust fairly well describes the history of mining in the San Juan Mountains of western Colorado. The various San Juan mining towns have a similar history and therefore in this talk I will review the mining history of Ouray County from 1875 through the late 1970s.

Ouray was founded in 1875 and for the first two decades of Ouray’s existence silver mining dominated the industry. The first activity was located up canyon creek and then beginning in 1879 the mines on Red Mountain dominated the scene. The Yankee Girl, Robinson, Guston, Genesse-Vanderbilt, National Belle and Silver Bell each made millions for their owners. The boom ended with the 1893 silver panic and most Ouray silver mines were closed by the late 1890s.

The discovery of gold in the Camp Bird Mine in 1896 along with other big producing mines such as the American Nettie on Gold Hill revived Ouray’s mining industry and the boom was on again for another two decades. Numerous smaller mines flourished as well during the early years of the 20th century.

By the mid 1920s Ouray mining fortunes were again on the decline. Ouray survived the depression years mainly due to the efforts of Gustav Farnz and his Banner American Mining Company. At the height of the depression Franz employed as many as 50 Ouray miners. William McCullough also helped by keeping open half a dozen local mines.

Another boom occurred after WWII with large-scale mining of base metals at the Idarado and Genesse Vanderbilt Mines on Red Mountain as well as the
Camp Bird and Revenue Mines west of Ouray. Ouray’s mining fortunes again began to decline in the early 1970s and one by one the big mines closed down. The Revenue was the final large scale operating mine closing in 1984.

Today with the price of gold at all time highs several mines have reopened in Ouray County. The Ruby Trust Mine, first opened in 1890, is operating today and several more may open in the near future.

ENVIRONMENTAL COMPLIANCE JUST GOT EASIER: A LOOK AT MOBILE DATA COLLECTION IN THE FIELD
Scott Randolph, Digital Cartographic Services, Inc., Lisa Tunnell, Digital Cartographic Services, Inc.

Global Warming, Environmental Stability, Environmental Sustainability: these are just a few concerns facing the global economy today. It is becoming increasingly important for companies to address these concerns and prove environmental compliance and contribution to their shareholders, political agencies, and communities in which they are involved. With that responsibility comes the need for a viable method to collect, store, analyze, and present environmental data. Mobile GIS technology is an answer to that need. Recent advancements in handheld computing, GPS Technology, and wireless communications have made mobile GIS a vital tool for organizations striving to keep data current and allow field workers maximum flexibility. Through the use of PDAs, mobile phones, and notebook computers in the field, organizations can add real-time (and near real-time) spatial and tabular information to their enterprise databases thus speeding up analysis and decision making. In addition, digital data collection provides a host of benefits for the integrity and security of data, providing a centrally-located secure infrastructure for the storage of data. With current GIS innovation, data can be collected in the field and seen within minutes from any location in the world, allowing fast, effective, and efficient use of the data collected. In this presentation, we will discuss the different mobile GIS technologies in use today (as applied to environmental compliance at selected mine sites) and methods to manage, report, and analyze this information in a timely and user-friendly format.

GOLD EXPLORATION ON THE CHIHUAHUAN FRONTIER: PRACTICAL LESSONS LEARNED IN THE SIERRA MADRES
Matthew J. Rhoades, CPG

In a remote area with no road access, an exploration program can only succeed if innovative thinking and quickly-learned lessons rule the day. This presentation, intended for students, relates the tactical and practical lessons learned in airlifting people and supplies while launching an exploration core drilling program. Without the benefit of copious graphics, a program such as this can be difficult to appreciate from our daily perspective. In this presentation, the geology of the rugged Sierra Madre Occidentals and the exploration targets are discussed, along with the very pragmatic aspects of exploration geology in challenging terrain. This presentation includes many photos and graphics intended to clearly illustrate what can be accomplished in the field, under difficult circumstances, when a focused team pulls together toward a common goal.

U.S. ENERGY POLICY COALITION
George L. Richardson, Consulting Geo-Scientist

This is the story behind an initiative to influence federal energy policy, industry, and the public, through dialogue and education. This grass roots effort was born out of a belief that individual professionals, engineers, and scientists without bias, can, and indeed should, have an impact on U.S. Energy Policy.

The goal of the movement is to create an opportunity for a greener, balanced, shock resistant energy future. The political reality is that we face a new administrative philosophy favoring greater transparency, less lobbying, and more scientific analysis. The federal agenda is to encourage cleaner fuel by reducing CO₂ and begin to transition to a broader renewable energy base.

The U.S. Energy Policy Coalition’s Mission is:

“To assist the Federal Government in the analysis, evaluation, and formation of a long term, greener, shock resistant, U.S. Energy Policy. To educate and inform policymakers on energy choices available in forming an economic bridge to the future.”

Our approach will be to utilize existing industry, environmental, and academic research from the public domain to develop multi-dimensional analysis and dialogue of different energy choices against a set of criteria.

We have structured the movement to have a core group of generalists (6) … scientists, engineers, and policy specialists, who will address the macro issues of energy choices and their benefits and opportunities through what we term as Energy Option Analysis. The secondary tier of the initiative will consist of professional society committees and subcommittees that will handle detailed analysis of complex issues, and give the Core Group feedback to be presented to Policy Makers.

SME is our primary sponsor, but we are gathering sponsor societies as we speak. Our ultimate desire is to develop and present informed and unbiased views on behalf of our sponsoring technical societies. We are not lobbyists, nor do we represent specific commercial interests. Rather, we are experienced professionals/scientists, leaders, and caring citizens.
WEB-BASED GIS APPLICATIONS FOR STAKEHOLDER AND PROJECT MANAGEMENT COMMUNICATIONS
James Russell, CPG, PMP

Good communications with team members, managers, and stakeholders are critical to successfully run projects. Internet-based methods to distribute information such as progress reports and other important data are now a reality. Local governments commonly use new technologies to distribute data on land ownership, tax records, and other community planning documents requested or needed by the taxpayer. This technology can be easily extended to large commercial projects to distribute important project management data to upper management, contractors, and other stakeholders.

GIS applications as a management tool can integrate disparate datasets into a dash-board environment through the use of secure data servers. In this way, important timely information can be shared with managers in distant geographic locations and improve communications between team members. Communicating sensitive data within a small group of individuals where project management decision-making is dynamic yet geographically remote enhances the chances of success. Methods of project data distribution can include custom applications that integrate server-based data through a secure connection, or a secure web-based GIS server application that is accessible only by project management.

Data sharing scenarios also include 1) information distribution to project team members where data is still sensitive or 2) communicating public, non-sensitive data, geographic or otherwise, to a broader audience such as local landowners or public governmental officials. Internet server-based GIS technologies fit well with the distribution of project information given that many stakeholders are now connected to the Internet. Project personnel can update data quickly. The ability to distribute project updates quickly also improves feedback from stakeholders, avoiding potential problems later in the project. Methods used to distribute project data include web-based GIS server applications available to anyone with access to the URL.

CARBON STORAGE IN LIGNITE COAL
Darren D. Schmidt, Senior Research Manager, Energy & Environmental Research Center

The United States possesses abundant un-minable lignite resources, which can provide viable options for greenhouse gas geological carbon storage. However, feasibility of carbon dioxide (CO2) storage in lignite coal has yet to be proven. The Plains CO2 Reduction (PCOR) Partnership has developed a lignite field validation test in Burke County, North Dakota, to investigate the feasibility of carbon dioxide storage in un-minable lignite seams. The PCOR Partnership is one of five partnerships investigating carbon storage funded by the Department of Energy and commercial sponsors.

Recently, several field tests for CO2 sequestration in coals have been conducted worldwide. However, many aspects of the sequestration process still need to be better understood including fluid transport in coals of different ranks, mechanism and efficiency of the replacement of natural gas by carbon dioxide, stability of the system during and after the injection, and the importance of cofiring seals for this type of storage. This study provides data and analysis concerning lignite permeability, natural gas content, adsorption and desorption of natural gas and carbon dioxide, and the stability of the system during and after injection. A comprehensive sampling program was implemented to ensure that meaningful results will be obtained. The program will included site design and development to allow for efficient monitoring, in-situ measurements, and laboratory tests.

FEASIBILITY OF USING MINED PHOSPHATE LANDS TO NATURALLY TREAT STORM - OR WASTE WATER PRIOR TO RECHARGE: A CONCEPT THAT CAN expand REGIONAL GROUND WATER RESOURCES AVAILABILITY
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The economic development of Florida depends on the availability of reasonably priced water of suitable quality to meet the water demands of the state. In 1995, FIPR approved a study to assess the use of mined phosphate lands to store excess surface and wastewaters for later use to help meet these future demands. The scope of the study changed to use mined lands for natural treatment of surface and wastewaters to meet drinking water standards for storage in the Floridan Aquifer and later retrieval, now known as the Aquifer Recharge and Recovery Program (ARRP).

A treatment wetland and tailing sand filter basin was constructed and operated for three years, and the results are reported in: “Pilot Project to test Natural Water Treatment Capacity of Wetland and Tailing Sand Filtration on Mined Phosphate Lands” (FIPR #03-136-209). The results of the project were quite promising. Of all the drinking water standards, the project documented only six chemical compounds that exceeded the non-primary recommended concentrations.

One of the preliminary indications of this project was that water from the natural treatment system was anoxic and in a reducing state, therefore, the hypothesis that the injection of this naturally treated water would not dissolve the pyrite minerals in the limestone matrix and would not cause the liberation of arsenic from the pyrite. This was tested in a follow-up study co-funded by FIPR and SWFWMD with contributions by Progress Energy Florida.
The noted bed with 2,500 km² area uplifted by mountains that have heights above 3,000 m above sea level.

After late Cimmerian Orogeny, the early Cretaceous sea advanced over the small continent of central Iran, the transgression in the Soh area began from late Barremian and continued to the early Albian.

Thick sediments were eroded from these uplifts with several facies deposited such as; Conglomerates, sandstone and sandy limestone in upper Barremian and early Aptian, Orbitolina grey limestone with marl intercalations containing Orbitolina in late Aptian, shales with intercalations of limestone containing ammonites in late Aptian and limestone, and green marl in early Albian.

Kohrod Mountains are located between two lacustrine basins of Yazd-Ardestan in the north-east of Soh and Zayanderod Gavkhoni basin in the southwest of Soh area. The Soh area has many drainages that carry sediment from the mountains to the basins, forming long alluvial fans in the basins.

The roundness of fragments indicate the long distance these sediments were carried, and the thick conglomerate in the area shows the period of erosion. There is an abrupt change in the type of sedimentation with state age dolomites and middle Triassic limestone to thick sandy sediments and argillic upper Triassic (1,400 meters in the Nayband formation) containing ammonites and liassic (1,000 meters in the Shemshak formation) containing coal revealing that the Cimmerian Orogeny caused this facies change.

The Jurassic sandstone has ripple-marks in the Soh area (Kalhorad Anticline) indicating that these areas were probably sea or lake border at that time. Jurassic sediment also has micro conglomerates with entirely rounded silis’s corn, indicating a possible fluvial environment.

Jurassic sediments have coal deposited in a deep environment overlain by shale and also in a shallow environment where it is associated with sandstone and in paleo-lagoons. Marl and shale generally grade upward into sandstone. These sandstones have variable thickness, in such a way that a thick bed of sandstone pinches out laterally into shale.

In some layers there is coal and plant parts on sandstone that indicate shallow depth and marshy environment at the time of formation and also in some layers are benthic trace fossils such as horizontal excavations.

This information indicates that these Jurassic deposits in the Soh area were deposited in deltaic environment.

**COALBED METHANE PRODUCED WATER – A WASTE OR RESOURCE?**  
**Ralf Topper**, Senior Hydrogeologist, Colorado Geological Survey

Development of unconventional oil & gas reserves such as production of coalbed methane (CBM) has increased dramatically since the mid 1990s. CBM is a form of natural gas that is generated and trapped within coal seams being held there by hydraulic pressure. CBM now accounts for 10% of total natural gas produced in the U.S., most of which (79%) comes from the Rocky Mountain Region. Colorado contains significant CBM reserves in many structural basins including the world-class San Juan Basin (43% of US proven CBM reserves). The shallow exploration targets for CBM require dewatering to extract the gas resource which may impact potable ground water supplies and produce injury to senior water rights holders via stream depletion.

The rapid growth of CBM development has posed difficult challenges for the associated communities. One of those conflicts is in the extraction and disposal of produced water. CBM wells are typically shallow, and are often completed into the same formations that supply ground water to wells. Before CBM can be produced, the hydraulic pressure of the reservoir must be reduced by partial dewatering of the aquifer. Annual water production in the three main CBM producing basins in Colorado, the San Juan, Piceance, and Raton is in excess of 200 million barrels (26,000 acre-feet). The Colorado Oil & Gas Commission has the authority to regulate oil and gas wells within the state, and treats produced water as a waste under Rule 907. Costs of produced water disposal vary widely from $0.12/bbl in New Mexico where evaporation/infiltiration pits are common to $5.00/bbl in some Wyoming basins requiring deep well injection.

Produced water quality will determine its suitability for beneficial use and feasibility for treatment. Water treatment costs at existing facilities range from $0.25-$2.00/bbl. As is typically in the semi-arid west, Colorado is a water short state. While market demands vary regionally, lease rates ($1,700/ ac-ft) for available water along the Front Range are equivalent to the low end treatment costs. A producer’s waste may become a water manager’s resource with economic benefits to both parties.

Recent stream depletion studies commissioned by the Colorado Geological Survey indicate that in portions of producing basins the aquifers and coal seams are tributary to the surface water system. Depletions of stream flows, i.e. impacts to water rights holders, range from less than 1 ac-ft/year in the Piceance Basin to over 2,500 ac-ft/year in the Raton Basin. In the recent decision by the Colorado Supreme Court (Vance vs. Simpson/Wolfe) the court decided that ground water withdrawn in the process of extracting CBM is a beneficial use and subject to administration (permitting) by the State Engineer. CBM wells are subject to permitting, adjudication, and administration pursuant to Colorado’s water laws, under the jurisdiction of the Division of Water Resources, including the requirement of augmentation for out-of-priority depletions. Current House Bill 09-1303 addresses the administration of CBM wells.
Uranium exploration on US Forest Service land south of the Grand Canyon has been delayed more than two years due to environmental group objections, and because of delays in the statutory environmental analysis process created by Kaibab National Forest budget shortages and understaffing. The environmental group objections are based on their well-publicized fears that uranium mining activities in the Grand Canyon region would lead to mining-related contamination of the Colorado River. In late 2008, the Kaibab Joint Venture between DIR Exploration, Inc., and Takara Resources, Inc., decided to carry out a NEPA Environmental Assessment in order to expedite the processing of its drilling plans. With the help of three consultant firms, the Kaibab JV completed its 185-page Draft EA in 3 ½ months and submitted the document to the Kaibab National Forest in mid-February 2009. A copy of the Draft EA can be downloaded from http://public.dirxploration.fastmail.us/.

Risk-analysis described in the EA, based on US Geological water quality data and hydrological studies, easily shows that the Colorado River water quality would be under no threat from continued uranium exploration and mining in northern Arizona. This result is consistent with the preliminary findings of the Water Sustainability Program at the University of Arizona reported this past February 23rd by the Environmental Working Group. The EWG article summarizing these findings is archived at http://www.dirxploration.com/EWG2232009.pdf.

Using breccia pipe exploration and ore body discovery data obtained from the BLM, the US Forest Service, breccia pipe mining companies, and historical uranium spot prices, the Kaibab JV EA also determined that from 6 to 20 new high-grade breccia pipe uranium mines can be expected to be developed in Coconino County south of the Grand Canyon over the next 20 years. Employing a mean or expected value of 11 new mine developments in this area, the EA showed that 1,100 additional jobs for a total of 11,000 job-years would be created in Coconino County by the establishment of the uranium mining industry south of the Grand Canyon. Estimated total annual personal income added to the Coconino County economy would be about $67,400,000 per year with only temporary and minor impacts on the natural environment of the county. In a useful comparison, this amount of added annual income and job growth would be almost 6X’s the amount of annual personal income and 3X’s the full-time equivalent jobs currently supported each year by the commercial rafting industry of the Grand Canyon.

Interestingly, re-entry of the uranium mining industry to Coconino County appears to be very timely: Newly-published economic research indicates that states that add new types of businesses to their economies during a recession experience significantly shorter periods of recession than states that do not economically diversify (http://www.jrap-journal.org/pastvolumes/2000/v38/F3831.pdf).

**SEALING A GEOLOGIC REPOSITORY FOR RADIOACTIVE WASTE**

Lillian D. Wakeley, U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi 39180

The Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM, is the only licensed facility for permanent disposal of radioactive wastes in the U.S. Its closure system was designed to include multiple materials and mechanisms for isolating the wastes from the biosphere, more than 2,100 ft underground in a geologic formation of salt. During the 1990s, the U.S. Army Engineer Research and Development Center developed a specialty salt-saturated concrete, chemically and physically tailored to perform as a component of the WIPP seal system. In May 2009, after 10 years of waste-disposal operations, the WIPP filed an application to renew its Hazardous Waste Facility Permit. The permit application documents successful disposal of tens of thousands of m3 of transuranic wastes and successful installation of first-level seal entities. The specialty concrete and other geologic components of the original design remain as major contributors to the permanence and predictable performance of the seal system. Continued use of this concrete demonstrates the efficacy of tailoring a cement-based composite with unusual ingredients to serve a non-traditional long-term function in a challenging environment. The first 10 years of disposal operations have filled approximately 1/3 of the total capacity of the repository. The experiences of operating the WIPP should guide future plans for additional geologic repositories for permanent disposal of radioactive wastes.

**GEOLOGIC HAZARDS OF THE LOWER UNCOMPAHGRE RIVER VALLEY IN MONTROSE COUNTY, COLORADO**

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The lower Uncompahgre River valley flows south to north in central Montrose County to its confluence with the Gunnison River in nearby Delta County. The valley contains the town of Montrose (the county seat) as well as the major population and agriculture areas where the river valley is extensively irrigated. Most of Montrose County’s population growth and land-use development pressure occur within the valley. For those reasons and a general lack of quality geologic maps at useful scales, the Colorado Geological Survey completed a geologic and geologic hazard mapping program for this area.

The Uncompahgre River flows through a broad river valley that lies upon the thick Cretaceous Mancos Shale. River incision and erosional lowering of the valley over the last 10 million years has preferentially removed the Mancos Shale, leaving a 12-mile wide valley. Geomorphologically, the valley separates the structural flanks of the Uncompahgre Uplift to the west and the Gunnison Uplift to the east. The valley floor is mantled with several glacio-fluvial terrace remnants (colloquially called mesa) at differing elevations. These mesas record Quaternary glacial epochs of the San Juan Mountains to the south. The Uncompahgre Plateau to the west is also incised with many subparallel side canyons that outlet onto the valley floor.
The Mancos Shale is a marine shale that is prone to developing a number of geologic conditions that can be hazards to human development and land use. The shale is generally weak, easily eroded, and saline. Within the weathered zone, the shale is also highly fractured and abundant gypsum fracture filling exists. Landslides regularly occur where slopes are steep. Expansive bentonite and smectite clay minerals are common in the shale, which can lead to swelling soils and bedrock. Collapsible soils can also form in weathered claystone and sediments (soils) derived from it. Salinity and total dissolved solids in percolating water are also factors in corrosion of buried steel and concrete, as well as overall degradation of water quality. Flash flooding and debris flows are also potential hazards from the shale badlands and the mouths of tributary side canyons. These hazards have been mapped individually as GIS layers that were delivered to the county. The geologic hazards report and GIS map files will also be available to the public.

THE TERRESTRIAL CARBON SEQUESTRATION POTENTIAL OF ROCKY MOUNTAIN CORDILLERA SOILS DERIVED FROM VOLCANIC BEDROCKS

Yager, D. B., Burchell, Alison, Johnson, R.H., Aiken, G.R., and Butler, Kenna

The possible economic and environmental ramifications of climate change have stimulated atmospheric carbon mitigation discussions and studies to understand and quantify potential carbon sinks. However, current carbon management strategies for reducing atmospheric emissions might underestimate a critical component. Soils could represent between 15 and 30 percent of the terrestrial carbon sink needed to prevent atmospheric doubling of CO₂ and may be a component in mitigating climate change through natural terrestrial sequestration (NTS). NTS includes the cumulative, biologic and geologic processes that either remove CO₂ from the atmosphere, or prevent net CO₂ emissions through photosynthesis and microbial fixation, soil formation due to mineral weathering, and adsorption reactions involving aluminoferramagnesian minerals, volcanic glass, clays, and allophane. Additionally, NTS supports ecosystem services by improving soil productivity, moisture retention, water purification and reduced erosion. To better understand NTS, we analyzed soil cores from Colorado, Rocky Mountain Cordillera sites. North-facing, high-plains to alpine sites in non-wetland environments were selected to represent temperate soils that may be less susceptible to carbon pool declines due to global warming than soils in warmer regions. Undisturbed, A-horizon soils have 2 to 6 times greater total organic soil carbon (TOSC) than global TOSC averages (4 to 5 wt. percent). Forest soils derived from weathering of intermediate to mafic volcanic bedrock have the highest TOSC (34.15 wt. percent; 4 to 6 kg m⁻²), C:N (43) and arylsulfatase, an indicator of fungal biomass (ave. 278, high 461 μg p-nitrophenol/g/h). Intermediate TOSC was identified in soils derived from Cretaceous shale (7.2 wt. percent; 2.5 to 4.5 kg m⁻²) and Precambrian, felsic gneiss (6.2 wt. percent, 0.7 to 2.6 kg m⁻²). Unreclaimed mine-sites have low TOSC (0.01 to 0.78 wt. percent; 0.07 kg m⁻²), C:N (2.4 to 6.5), and arylsulfatase (0 to 41). However, reclaimed and undisturbed mined-lands A horizon soils derived from propylitized andesite have high TOSC (13.5 to 25.6 wt. percent; 1.4 to 8.2 kg m⁻²), C:N (27), arylsulfatase (338). In our previous studies, propylitic bedsrocks were also found to have a high acid neutralizing capacity (ANC) stemming from the mineral assemblage calcite-chlorite-epidote. Radiocarbon dates on charcoal collected from paleo-burn horizons (found in high C, N soils) indicate an old carbon pool (500-5,440 ± 40 yrs B.P) suggesting that black carbon, when preserved in soil aggregates can provide a relatively stable carbon sink. High-flow, dissolved organic carbon (DOC) concentrations are low (ave. 1.9 mg/L) in both surface water and ground-water samples collected in subalpine catchments underlain by intermediate to mafic igneous bedsrocks. The low DOC concentrations are consistent with these soils retaining carbon against hydrologic loss. This is likely related to high specific surface area and high adsorption-capacity Ca-Mg-Fe clays. Observations at naturally-reclaimed mining areas indicate the use of high ANC rock plus other soil amendments (biochar, soil nutrients, bioactive teas, native vegetation seeding) may aid more traditional reclamation measures that use limestone and compost hauled from long distances by reducing both the cost and carbon footprint of reclamation projects.
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