American Institute of
Professional Geologists
55th National Conference

Program

Purple Mountain Majesties

September 8-11, 2018
Colorado Springs, Colorado

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Congratulations!!!
AIPG 2018 National Awardees

Ben H. Parker Memorial Medal
Barbara H. Murphy, CPG-6203
Glendale, Arizona

Martin Van Couvering Memorial Award
Dennis Pennington, CPG-4401
Ambler, Pennsylvania

John T. Galey, Sr. Memorial Public Service Award
Thomas A. Herbert, CPG-2551
Tallahassee, Florida

Award of Honorary Membership
Ronald J. Wallace, CPG-8153
Roswell, Georgia

Welcome!

The Colorado Section welcomes you to Colorado Springs for the 55th Annual AIPG National Conference. The theme of this year's conference, *Purple Mountain Majesties*, comes from Katherine Lee Bates' 1893 poem, Pikes Peak, written after a trip to the summit and which was later renamed America the Beautiful. Pikes Peak and the Garden of the Gods are the geologic highlights of the Colorado Springs area. Unlike the Denver area, a lower Paleozoic section exists at Colorado Springs. We've planned a diverse program that should appeal to geoscience professionals and students. A short course on expert witness testimony, a session on how the AGI/AIPG GOLI (Geoscience Online Learning Program) works and how you can contribute, a short course on Rockworks, an AWG workshop on Bystander Intervention Training, and the AIPG Student Career workshop supplement a diverse technical program.

I want to thank Cathy Duran and Wendy Davidson of AIPG National and the following Colorado Section members for their contributions to the meeting. Doug Peters and Ron Pritchett organized the technical program; Lynne Carpenter organized the field trips following suggestions from a variety of sources; Tom Van Arsdale and Sue Abbott organized the guest trips, which would have included a trip up the Pikes Peak Cog Railway, had it been running; Mark Mathisen solicited the sponsors; and Dawn Schippe helped edit and format the abstracts and field guides. Thanks are due to the various field trip leaders who have either updated prior trips or created new ones covering parts of Colorado's geology that differ from those of previous Colorado AIPG annual meetings. I also want to thank those who will be presenting papers and posters at the meeting. Your contributions are vital to the success of our meetings.

Sincerely,
David M. Abbott, Jr, CPG-4570
General Chairman, 2018 Annual Meeting

Congratulations Awardees!!!

Presidential Certificates of Merit

Larry Austin, CPG-05181, MI
For his peerless work as Chair of the National Screening Committee

Helen Hickman, CPG-07535, FL
For unwavering service to the Florida Section and determined efforts to preserve the working rights of Geologists in the State

Christine Lilek, CPG-10195, WI
For superb efforts on behalf of the Wisconsin Section and service to the Profession

Anne Murray, CPG-11645, FL
For untiring commitment to the Florida section and determined efforts to preserve the working rights of Geologists in the State

Shanna Schmitt, CPG-11781, MN
For tireless efforts on behalf of the Minnesota Section and service to the Profession

John Stewart, CPG-11115, NC
For exemplary leadership on the National Executive Committee and in the Carolinas Section
Awarded Posthumously

Michael Urban, MEM-1910, MN
For providing excellent content on the Educator's Page in TPG

Section Leadership Awardees

Troy Bernier, FL — SA-3872
Robert Blauvelt, NJ — CPG-06508
Ramona Cornea, IL — CPG-08983
Michael Hultgren, MN — CPG-09292
Dennis McGrath, NY — CPG-08578
Shanna Schmitt, MN — CPG-11781
Brent Smith, OH — CPG-11130
Tom Van Arsdale, CO — CPG-11073

Student Chapter of the Year Award

Columbus State University
Columbus, Georgia

Saturday, 9/8

7:00 am - 8:30 am
Continental Breakfast
Salons F-G
(open to all registrants)

7:30 am - 5:00 pm
Registration
Ballroom Pre-Assembly

8:00 am - 12:00 noon
AIPG Executive Committee Meeting
Salon D
(open to all registrants)

8:00 am - 12:00 noon
AWG Workshop - Bystander Intervention Training to Reduce Hostile Work Climates
Salons A-B
(free to all/non-registrants welcome)

8:00 am - 5:00 pm
Field Trip - Cripple Creek and Victor Open-Pit Gold Mine Tour

9:00 am - 4:00 pm
Rockware Software Workshop
Salon C
(free to all/non-registrants welcome)

12:00 noon - 1:00 pm
AIPG Student/Professional Luncheon
Salons F-G
(open to all registrants)

* All field trips will depart and return to the Colorado Springs Marriott Hotel outside the front lobby doors.

1:00 pm - 4:30 pm
AIPG Advisory Board Meeting &
AIPG 2018-2019 Joint Executive Committee Meeting & Business Meeting
Salon D
(open to all registrants)

1:00 am - 5:00 pm
Student Career Workshop
Salons A-B
(free to all/non-registrants welcome)

4:30 pm - 5:30 pm
AIPG Foundation Meeting
PineCliff (2nd floor)
(open to all registrants)

5:00 pm - 6:30 pm
Student Speed Networking with Professionals
Salons F-G
(*open to all registrants-includes cash bar)*

Silent Auction

Be sure to stop by and bid on your favorite items!!!

Sunday, 9/9/18 5:30 pm - 8:30 pm

Salons D-E

**All proceeds go to the Foundation of the AIPG.*

Bidding will end at 8:30 and all items can be picked up.

Sunday, 9/9

7:00 am - 6:00 pm
Field Trip - South Park Colorado-An Exploration of the Complex Geologic Framework

7:30 am - 5:00 pm
Registration
Ballroom Pre-Assembly

8:00 am - 4:00 pm
Field Trip - Wall Mountain Tuff-The Puzzling Presence of the Colorado Rockies

8:00 am - 5:00 pm
Field Trip - Portland Quarry & Cement Plant; Florence Oil Field

10:00 am - 4:00 pm
Exhibitor and Poster Set-up
Salons D-E (Exhibit Hall)

1:30 pm - 5:00 pm
Guest Trip - Garden of the Gods Geology

5:30 pm - 8:30 pm
Silent Auction (sneak peak 5:30 pm-6:30 pm)
Salons D-E (Exhibit Hall)
(open to all registrants)

6:30 pm - 8:00 pm
Reception - Exhibit Hall Open
Salons D-E (Exhibit Hall)
(complimentary for all registrants-includes cash bar)

* All field trips will depart and return to the Colorado Springs Marriott Hotel outside the front lobby doors.

Monday, 9/10

7:30 am - 8:15 am
Section Delegate Meeting
Salons D-E (Exhibit Hall)
(open to all registrants/sections)
**Breakfast is on your own.*

7:30 am - 5:00 pm
Registration
Ballroom Pre-Assembly

8:00 am - 5:00 pm
Field Trip - Arkansas Valley Geothermal

8:30 am - 10:00 am
Plenary Session
Salons D-E (Exhibit Hall)

9:30 am - 3:00 pm
Guest Trip - Western Museum of Mining & Industry and the US Air Force Academy Tours

10:00 am - 5:00 pm
Exhibits Open
Salons D-E (Exhibit Hall)

10:00 am - 10:30 am
Poster Sessions / Networking Break
Salons D-E (Exhibit Hall)
see Technical Session Schedule page 12
(complimentary for all registrants)

10:30 pm - 12:00 noon
Student Poster Contest Judging
Salons D-E (Exhibit Hall)
(students, please be at your poster for judging)

Front Cover Photos Courtesy of VisitCOS.com

Monday, 9/10

10:30 am - 5:00 pm
Technical Sessions
see Technical Session Schedule page 12

12:00 noon - 1:30 pm
Luncheon with Keynote Speaker
James Reed
RockWare Incorporated, Golden, CO
Salons D-E (Exhibit Hall)
(complimentary for all registrants)

3:00 pm - 3:30 pm
Networking Break
Salons D-E (Exhibit Hall)
(complimentary for all registrants)

6:30 pm - 8:30 pm
AIPG Awards and Dinner
Aspen Leaf Room
(all attendees welcome with additional fee-includes cash bar)

Seven Falls - Photo Courtesy of VisitCOS.com

Tuesday, 9/11

7:30 am - 3:30 pm
Registration
Ballroom Pre-Assembly

8:00 am - 5:00 pm
Field Trip - Colorado Springs Hazards/ Landslides in the Cheyenne Mountain Area

8:30 am - 5:00 pm
Technical Sessions
see Technical Session Schedule page 18

10:00 am - 3:30 pm
Exhibit Hall Open
Salons D-E (Exhibit Hall)

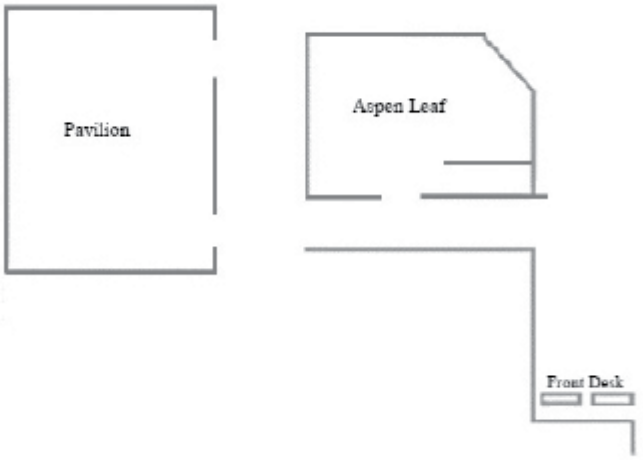
10:00 am - 10:30 am
Networking Break
Salons D-E (Exhibit Hall)
(complimentary for all registrants)

12:00 noon - 1:30 pm
Luncheon with Keynote Speaker
Dr. Uwe Kackstaetter
Associate Professor of Geology, Metropolitan State University of Denver, Denver, CO
Salons D-E (Exhibit Hall)
(complimentary for all registrants)

1:00 pm - 5:00 pm
Guest Trip - Florissant Fossil Beds National Monument Trip

3:00 pm - 3:30 pm
Networking Break
Salons D-E (Exhibit Hall)
(complimentary for all registrants)

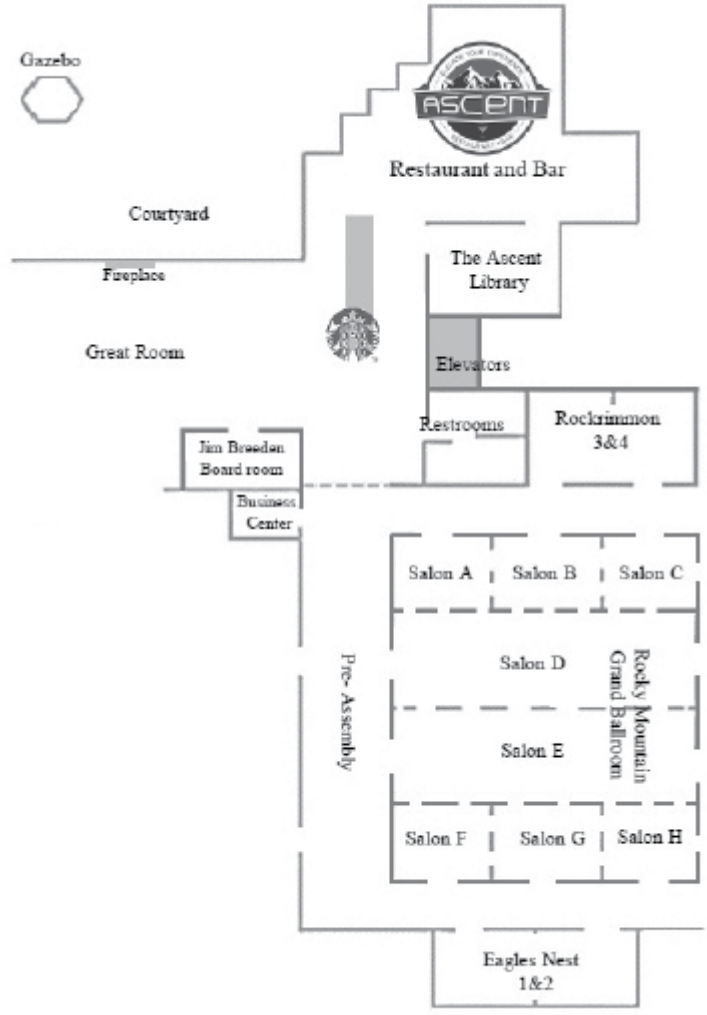
Hotel Site Map



Colorado Springs Marriott
5580 Tech Center Drive
Colorado Springs, CO 80919
(719) 260-1800

* All field trips will depart and return to the Colorado Springs Marriott outside the front lobby doors.

Hotel Site Map



Technical Sessions

Monday, September 10, 2018 8:30 am-10:00 am

Salons D-E

— Plenary Session —

Welcome
David Abbott, CPG - 2018 General Chairman
Douglas Bartlett, CPG - 2018 AIPG National President

INTRODUCTION TO A NEW TECTONIC PARADIGM
Matthew Rhoades, CPG, Consulting Geologist, Golden, CO; **David Abbott,** CPG, Consulting Geologist, Denver, CO

THE GEOLOGIC PROFESSION AT A CROSSROADS
Douglas Bartlett, CPG, 2018 AIPG National President, Scottsdale, AZ; **Keri Nutter,** CPG, 2018 National President-Elect, Anchorage, AK

Monday, September 10, 2018 10:00 am-10:30 am

Poster Session Presentations - Salons D-E

— Poster Session —

COST-EFFECTIVE ENHANCED HEAVY OIL RECOVERY BY DIFFERENT AQUEOUS IONIC SOLUTIONS: ALTERNATIVE STUDY OF HIGH ENERGY COST METHODS
Hasan Al-Saedi, SA, Missouri University of Science and Technology, Rolla, MO

SAND AND SAGE - A MATCH MADE IN WYOMING
Jeneane Barber, SA, Metropolitan State University of Denver, Centennial, CO

TRACE ELEMENT ANALYSIS OF QUARTZITE CLASTS FROM SESPE FORMATION AND SOURCE ROCKS FROM SOUTHEAST CALIFORNIA AND CENTRAL ARIZONA
Austin Fellmy, SA, Wayne State University, Detroit, MI

SEDIMENTOLOGY AND FACIES ANALYSIS OF JERIBE RESERVOIR (EARLY-MIDDLE MIOCENE) IN TAWKE OILFIELD, ZAKHO, KURDISTAN REGION, NORTHERN IRAQ
Diar Ibrahim, Salahaddin University, Kurdistan Iraq

Luncheon Keynote Speaker

James Reed
RockWare Incorporated,
Golden, CO

Using Geological Exploration Methods to Locate Clandestine Grave Sites for Homicide Investigations

Salons D-E 12:00 noon-1:30 pm

Monday, September 10, 2018 **10:00 am-10:30 am**

Poster Session Presentations - Salons D-E

THE CHARACTERIZATION, COMPOSITION, AND WEATHERING OF THE KASOTA STONE OF THE CATHEDRAL OF SAINT COLUMBA
Brigitte Petras, Youngstown State University, Youngstown, OH

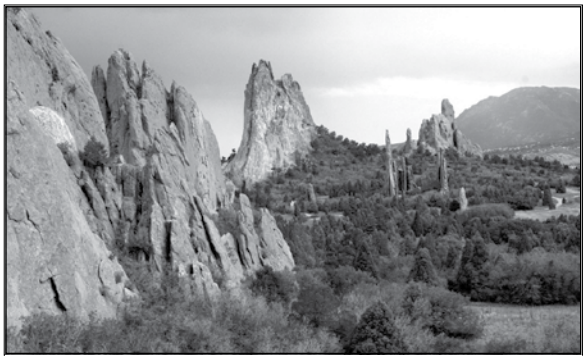
GENESIS OF GOLD BEARING QUARTZ IN THE USAK, ESMETAS, TURKEY
Gulay Sezerer Kuru, CPG, GSK Consultancy & Lab, Ankara Turkey

MICROTEXTURAL CHARACTERISTICS OF COLLOFORM-BANDED EPITHERMAL VEINS FROM THE BUCKSKIN NATIONAL GOLD-SILVER DEPOSIT, NORTHERN NEVADA
Tadsuda Taksavasu, SA, Colorado School of Mines, Golden, CO

Poster presenters will need to be available at their posters Monday during the morning break, 10:00 am - 10:30 am.

Student Poster Contestants will need to be available at their posters Monday during the morning break, and also following the break from 10:30 am - 12:00 noon to answer questions from the judges.

Student Poster Contest results will be announced Monday during lunch in Salons D-E



Garden of the Gods - Photo Courtesy of VisitCOS.com

Technical Sessions

Monday, September 10, 2018 10:30 am-12:00 pm

Session 1A - Eagles Nest 1&2

— Mining and Minerals I —

• Moderator - **Doug Peters,** CPG, CO

10:30 am – 11:00 am
A NOVEL APPROACH TO THE MINERAL EXPLORATION IN POPULATED AREAS - INNOVATIVE, NON-INVASIVE AND FULLY ACCEPTABLE EXPLORATION TECHNOLOGIES (PROJECT INFACT)
Marko Komac, EFG

11:00 am – 11:30 am
EXPLORATION AND CHARACTERIZATION OF THE GIBELLINI VANADIUM DEPOSIT, EUREKA COUNTY, NEVADA
Matthew Rhoades, CPG, Consulting Geologist, Golden, CO

11:30 am – 12:00 noon
WATER AND SOIL QUALITY AT TWO EASTERN KENTUCKY COAL FIRES
Trent Garrison, YP, Northern Kentucky University, Lexington, KY

Session 1B - Salons FGH

— Environmental Site Characterization —

• Moderator - **Ron Pritchett,** CPG, CO

10:30 am – 11:00 am
OPTIMIZATION OF LNAPL RECOVERY FROM A SEMI-CONFINED AQUIFER: THE IMPORTANCE OF AN ACCURATE SITE CONCEPTUAL MODEL AND UNDERSTANDING LNAPL RECOVERABILITY TECHNIQUES
Don Mullis, CPG, Tetra Tech, Annapolis, MD

11:00 am – 11:30 am
UPDATE ON CURRENT HIGH-RESOLUTION SITE CHARACTERIZATION (HRSC) TECHNOLOGY, 3D DATA MODELING, AND APPLICATIONS FOR REMEDIAL DESIGN (PART 1)
John Fontana, MEM, Vista GeoScience, Golden, CO

11:30 am – 12:00 noon
IMPROVED RESULT FOR IN-SITU REMEDIATION PROJECTS BY UTILIZING HIGH-RESOLUTION DATA, INJECTION, AND HYDRAULIC PLACEMENT TREATMENT METHODS – IT'S A CONTACT SPORT (PART 2)
John Fontana, MEM, Vista GeoScience, Golden, CO

Monday, September 10, 2018 1:30 pm-3:00 pm

Session 2A - Eagles Nest 1&2

— Oil & Gas Technology and Production —

• Moderator - **Ron Pritchett,** CPG, CO

1:30 pm – 2:00 pm
PETROLEUM POTENTIAL AND LEASE PROPOSAL FOR THE ROCKY MOUNTAIN ARSENAL LAND, COLORADO
Ronald Pritchett, CPG, Retired, Lone Tree, CO

2:00 pm – 2:30 pm
COUPLING LOW SALINITY WATER FLOODING AND CO_2 FLOODING FOR SANDSTONE RESERVOIRS; LOW SALINITY-ALTERNATING-CO_2 FLOODING (LSAGF): A GLOBAL ENERGY DEMAND AND SUPPLY-HYDROCARBONS TO THE UPCOMING DECADES
Hasan Al-Saedi, SA, Missouri University of Science and Technology, Rolla, MO

2:30 pm – 3:00 pm
PAPOOSE CANYON: A CASE STUDY OF REENTRY ECONOMICS FOR MATURE AND ABANDONED FIELDS
Jessica Davey, SA, MHA Petroleum Consultants, Denver, CO

Session 2B - Salons FGH

— Environmental Policy & Remedies —

• Moderator - **Matt Rhoades,** CPG, CO

1:30 pm – 2:00 pm
WHAT SOCIOECONOMIC FACTORS INFLUENCE STATE ENVIRONMENTAL AGENCY SPENDING?
Robert Blauvelt, CPG, GEI Consultants, Bloomfield, NJ

2:00 pm – 2:30 pm
KEYS TO OPTIMIZING CHEMICAL BASED REMEDIATION
Ken Summerour, MEM, Eden Remediation Services, Monroe, GA

2:30 pm – 3:00 pm
KARSTIC TERRAIN HYDROGEOLOGIC CONSIDERATIONS FOR PROTECTIVE REMEDY SELECTION AND IMPLEMENTATION
David Heidlauf, CPG, Ramboll, Geneva, IL

Monday, September 10, 2018 3:30 pm-5:00 pm

Session 3A - Eagles Nest 1&2

— GOLI Workshop —

GOLI! ONLINE CONTINUING EDUCATION FOR THE MODERN WORKFORCE

3:30 pm – 5:00 pm

-**Heather Houlton,** American Geosciences Institute, Workforce Development, Education & Outreach Specialist, Alexandria, VA

AIPG and AGI partnered to build a platform called the Geoscience Online Learning Initiative that hosts online courses covering a variety of geoscience topics. Courses are developed as one of two formats: either live webinar events or on-demand courses. Many of our live webinar events get converted into on-demand courses. Heather Houlton, AGI's Workforce Development Specialist will demonstrate how to become involved with GOLI. She will provide guidance to our attendees about process and mechanics of presenting a live webinar and then converting it to an online program. She will also review the process by which AIPG members can contribute to GOLI without being a speaker on a live webinar event. This session will be of interest to those who value continuing education and professional development. To view the available courses, please visit: https://goli.americangeosciences.org/courses/. We look forward to seeing you!

Pikes Peak - Photo Courtesy of VisitCOS.com

Monday, September 10, 2018 3:30 pm-5:00 pm

Session 3B - Salons FGH

— Mining and Minerals II —

• Moderator - **Doug Peters,** CPG, CO

3:30 pm – 4:00 pm
ALASKA'S PLACE IN THE GLOBAL MINING INDUSTRY
Curt Freeman, CPG, Avalon Development Corp., Fairbanks, AK

4:00 pm – 4:30 pm
MEMOIRS OF A URANIUM MINE GEOLOGIST
Steven Huddleson, CPG, PG, CPG, Retired, Albuquerque, NM

4:30 pm – 5:00 pm
TBA

Session 3C - Salons ABC

— Water Projects and Supplies —

• Moderator - **Matt Rhoades,** CPG, CO

3:30 pm – 4:00 pm
OVERVIEW AND COMPARISON OF LARGE-SCALE WATER PROJECTS IN THE AMERICAN WEST
Matthew Rhoades, CPG, Golden, CO

4:00 pm – 4:30 pm
AQUIFER STORAGE AND RECOVERY — HOW IS IT REGULATED IN COLORADO?
Matthew Sares, MEM, Colorado Division of Water Resources, Denver, CO

4:30 pm – 5:00 pm
DOWNSCALING USGS GROUNDWATER MODELING RESULTS TO EVALUATE RENEWABLE WATER SUPPLY OPTIONS (CASE STUDY - ELBERT COUNTY, CO.)
Dennis McGrane, PE, CPG, McGrane Water Engineering, LLC, Lyons, CO

Technical Sessions

Tuesday, September 11, 2018 8:30 am-10:00 am

Session 4A - Eagles Nest 1&2

— Environmental Sampling & Monitoring —

• Moderator - **Matt Rhoades,** CPG, CO

8:30 am – 9:00 am
USING MULTIPLE TECHNIQUES TO MONITOR EFFECTIVENESS OF IN-SITU INJECTIONS
Tom Harp, CPG, Remediation Risk Reduction, LLC, Golden, CO

9:00 am – 9:30 am
OBTAINING HIGH-RESOLUTION DATA TO DEMONSTRATE BOS 100® PERFORMANCE IN A LARGE TCE PLUME WITH EXTENSIVE DNAPL PRESENT
Tom Harp, CPG, Remediation Risk Reduction, LLC, Golden, CO

9:30 am – 10:00 am
PERFLUOROALKYL SUBSTANCE SAMPLING AND ANALYSIS: 2018 STATE OF THE PRACTICE
Andy Horn, Westwater Hydrology, Wheat Ridge, CO

Session 4B - Salons FGH

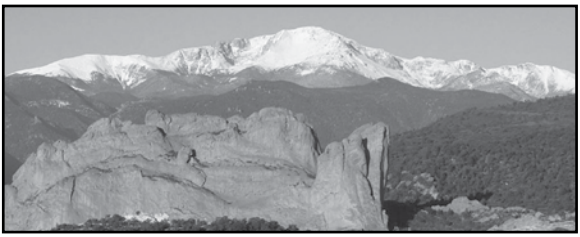
— Oil & Gas II —

• Moderator - **Ron Pritchett,** CPG, CO

8:30 am – 9:00 am
GETTING PAST GO AND OTHER PROFIT ROBBERS
Larry Cerrillo, CPG, Collaborative Problem Solving Hydrogeology, Mediation, Facilitation, Evergreen, CO

9:00 am – 9:30 am
NORWAY'S GEOLOGY AND ITS IMPACT ON HYDROCARBON RESOURCES AND MASS WASTING PROBLEMS
Robert Font, CPG, Parker, TX

9:30 am – 10:00 am
TRUE ORIGIN OF HYDROCARBONS IN PETROLEUM
Suresh Bansal, J S Ispat Udyog, Sunshine Hotel Road, Mandi Gobindgarh, India



Pikes Peak - Photo Courtesy of VisitCOS.com

Tuesday, September 11, 2018 10:30 am-12:00 pm

Session 5A - Eagles Nest 1&2

— Mining and Minerals III —

• Moderator - **Doug Peters,** CPG, CO

10:30 am – 11:00 am
THE STRANGE WORLD OF BALL CLAYS - A RARE, UNUSUAL INDUSTRIAL MINERAL RESOURCE WITH LIMITED OCCURRENCES
Uwe Kackstaetter, MEM, Metro State University of Denver, Earth & Atmospheric Sciences, Denver, CO

11:00 am – 11:30 am
PERMIAN BASIN SAND DUNE EXPLORATION & MINING: "WHAT'S ALL THE FRAC ABOUT?"
Michelle Lee, Westward, Boerne, TX

11:30 am – 12:00 noon
BACK TO THE MINES: ELECTRICAL RESISTIVITY OVER ABANDONED COAL MINES IN SOUTHEAST KANSAS
Neil Croxton, CPG, Kansas DOT, Salina, KS

Session 5B - Salons FGH

— Environment & Engineering —

• Moderator - **Larry Cerrillo,** CPG, CO

10:30 am – 11:00 am
RECOLLECTING THE JUNE 9, 1972 CATASTROPHIC FLOOD IN RAPID CITY SOUTH DAKOTA
William Siok, CPG, Tucson, AZ

11:00 am – 11:30 am
MINE TAILINGS DRAINAGE - A BOTTOMS UP APPROACH USING HDD DRILLING AND INSTALLATION METHODS
David Bardsley, Directed Technologies Drilling, Bellefonte, PA

11:30 am – 12:00 noon
SOIL MECHANICS: FORENSIC GEOLOGICAL AND ENGINEERING ASPECTS OF PROBLEMATIC SOIL CONDITIONS
Terrance Zich, CPG, Envista Forensics, DeLand, FL

Luncheon Keynote Speaker

Dr. Uwe Kackstaetter
Associate Professor of Geology
Metropolitan State University of Denver
Denver, CO

Salons D-E 12:00 noon-1:30 pm

Tuesday, September 11, 2018 1:30 pm-3:00 pm

Session 6A - Eagles Nest 1&2

— Expert Witness Short Course —

1:30 pm – 3:00 pm

-**David Abbott,** CPG, Consulting Geologist, Denver, CO
-**Thomas M. Johnson,** PG, CHG, CPG, Thomas Johnson Associates, Sausalito, CA
-**Sara Pearson,** CPG, Michigan DEQ - RRD, Portland, MI

This course will be presented by Thomas Johnson, Sara Pearson, and David Abbott, all of whom have experience as expert witnesses in a variety of civil and criminal proceedings. Topics to be covered include working with your attorney; depositions and investigative testimony; the battle in the courtroom—legal terms, depositions, and testimony; maintaining your integrity as an expert witness; and lessons learned—trick questions and real experiences in the hot seat. Not everyone has the temperament to be an expert witness, and sometimes you may not have a choice. Learning from those who have experience can help prepare you. This course can also provide you with a sense if expert witness work is something you would like to pursue in your career. Being an expert witness is very hard work, but it can be rewarding and pay well.

Session 6B - Salons FGH

— Groundwater Issues —

• Moderator - **Matt Rhoades,** CPG, CO

1:30 pm – 2:00 pm

COLORADO SIGNS ON TO THE NATIONAL GROUNDWATER MONITORING NETWORK
Kevin Donegan, CPG, Colorado Division of Water Resources, Denver, CO

2:00 pm – 2:30 pm

RAPID SITE CLOSURE OF A LARGE GAS PLANT USING IN-SITU BIOREMEDIATION TECHNOLOGY IN LOW-PERMEABILITY SOIL AND FRACTURED BEDROCK
Tom Harp, CPG, Remediation Risk Reduction, LLC, Golden, CO

2:30 pm – 3:00 pm

HORIZONTAL DIRECTIONAL DRILLING FOR WATER SUPPLY APPLICATIONS
David Bardsley, Directed Technologies Drilling, Bellefonte, PA

Tuesday, September 11, 2018 3:30 pm-5:00 pm

Session 7A - Eagles Nest 1&2

— Expert Witness Short Course (continued) —

3:30 pm – 5:00 pm
- **David Abbott,** CPG, Consulting Geologist, Denver, CO
- **Thomas M. Johnson,** PG, CHG, CPG, Thomas Johnson Associates, Sausalito, CA
- **Sara Pearson,** CPG, Michigan DEQ - RRD, Portland, MI

Session 7B - Salons FGH

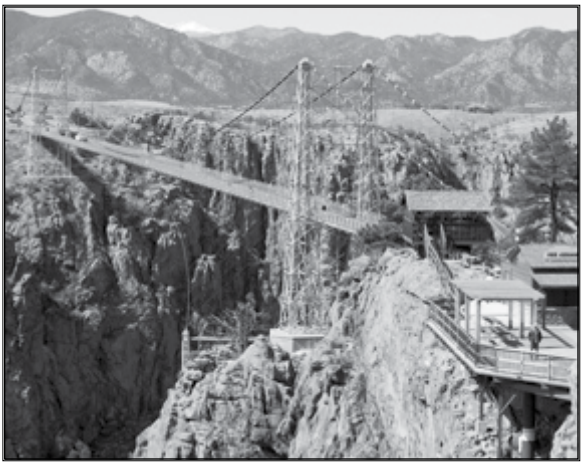
— Environmental Case Studies —

• Moderator - **Doug Peters,** CPG, CO

3:30 pm – 4:00 pm
JULY 4TH FIREWORKS AS AN UNCONVENTIONAL SOURCE OF GROUNDWATER CONTAMINATION
Alyssa Olson, Golder Associates, Lansing, MI

4:00 pm – 4:30 pm
ADDRESSING THE ENVIRONMENTAL LEGACY OF ASBESTOS MANUFACTURING IN AMBLER, PENNSYLVANIA
Joseph Kraycik, MEM, Environmental Standards, Inc., Valley Forge, PA

4:30 pm – 5:00 pm
ASSESSMENT OF THE VAPOR INTRUSION RISK FROM DRY CLEANERS - CASE STUDIES AND LESSONS LEARNED
Adam Flege, MEM, Civil & Environmental Consultants, Inc., Cincinnati, OH



Royal Gorge - Photo Courtesy of VisitCOS.com

Conference Abstracts

(Alphabetical According to Lead Presenter)

2018

Purple Mountain Majesties

Conference Presented by
American Institute of
Professional Geologists (AIPG)
and
AIPG Colorado Section

COST-EFFECTIVE ENHANCED HEAVY OIL RECOVERY BY DIFFERENT AQUEOUS IONIC SOLUTIONS: ALTERNATIVE STUDY OF HIGH ENERGY COST METHODS

Hasan Al-Saedi, SA, Missouri University of Science and Technology, Rolla, MO, hnav36@mst.edu; **Ralph Flori,** Missouri University of Science and Technology, Rolla, MO

In this study, we propose to quantify a control of water chemistry on water-rock interactions and wettability alteration during low salinity water-flooding of sandstone cores containing heavy oil. We intended to identify the dominant process of wettability alteration through considering all possible water-rock interaction mechanisms simultaneously instead of using high energy (high cost). Water chemistry partially determines the dominant wettability alteration. This includes salinity, type of ions, and possibly pH.

A series of sandstone cores were sampled close together from the same zone with the same petrophysical properties. The same core preparations were conducted on all cores. The cores were pre-aged in heavy oil for three weeks at 90°C. We examined two kinds of water for water flooding, high salinity water and low salinity water (d_{100HS}). The water flooding was conducted at different temperatures (room temperature -120°C). High salinity water was injected into the cores until residual oil saturation was reached. After that, d100HS was injected until no more oil was produced and injection pressure stabilized. On the other hand, the effect of the potential determining ion towards sandstone 'calcium ion' was presented in this work as an alternative for using EOR methods requiring high costs such as steam, hot water, or surfactants...etc. The Divalent cation Ca^{2+} was examined to be a wettability modifier in sandstone. Manipulation in water using Ca^{2+} could provide an additional heavy oil recovery.

The ultimate oil recovery for high viscosity core from high salinity water flooding was 48% OOIP at room temperature. Upon switching to LS water the ultimate oil recovery jumped by 6% OOIP at room temperature. The oil recovery from the same LS water was 4% of OOIP at 70°C, while it was about 4 and 3% OOIP at 90 and 120°C, respectively. Reducing Ca^{2+} in the FW improved the recovery to 8% of OOIP. Different LS water was prepared with different Ca^{2+} concentrations, the results showed that using 6 times diluted Ca^{2+} in the LS water could improve the heavy oil recovery to 13% of OOIP without heating the injected brine. The pH jump in the other LS water effluent was not as pronounced as that in the 6 times Ca^{2+} diluted, meaning that the 6 times Ca^{2+} diluted resulted in more ion exchange.

The results showed that using 6 times diluted Ca^{2+} in the LS water could improve the heavy oil recovery to 13% of OOIP without heating the injected brine. That provides a low-cost EOR alternative instead of applying heat which represents more expenses. Desorption of Ca^{2+} associated with pH jump, thereby, increases microscopic sweep efficiency, and it seems to have a large impact on LS water EOR heavy oil.

COUPLING LOW SALINITY WATER FLOODING AND CO_2 FLOODING FOR SANDSTONE RESERVOIRS; LOW SALINITY-ALTERNATING-CO_2 FLOODING (LSAGF): A GLOBAL ENERGY DEMAND AND SUPPLY-HYDROCARBONS TO THE UPCOMING DECADES

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The ever-growing global energy demand and natural decline in oil production from mature oil fields over the last several decades have been the main incentives to search for methods to increase recovery efficiency. Eastern Kansas oil fields contain heavy oil that is produced via rod sucker pumps. The daily production from Bartlesville Sandstone reservoir is around 500 bbl/day with high water cut. Such reservoirs have a low temperature and the oil viscosity of several hundreds of centipoise. The mobility ratio is quite different between the water and the heavy oil, and if a conventional water flooding would be conducted, the oil recovery could be low. Low salinity water flooding and CO_2 flooding are a two novel combination technique. We did couple both techniques due to the important role of each method in increasing oil recovery. Low salinity was examined by many laboratory and field works and it showed an interesting result in increasing oil recovery. CO_2 was tested on increasing oil recovery. The oil recovery increased by altering the wettability towards more water-wet and interfacial tension reduction. Although the CO_2 showed an improvement in oil recovery, the density difference between CO_2 and oil raised a gravity override, channeling, and early breakthrough problems. For that reason, we develop the low salinity alternating CO_2 flood in order to gather the benefits of low salinity itself and to improve sweep efficiency by CO_2 and prevented CO_2 problems mentioned earlier as well as capturing the CO_2 from the atmosphere. This method can be considered as a low-cost method since it needs only water and CO_2.

Numerous Bartlesville Sandstone reservoir cores were saturat-

ed with a synthetic formation water, the water was displaced with crude oil (same reservoir oil) to S_{wi}, and then allowed to age for three weeks at 90°C. These cores were then flooded with two pore volume (PV) high salinity (HS) and then followed by one PV low salinity (LS) water at room temperature. The HS water was identical to the formation water, while the LS water was diluted 100x (symbolized d_{100HS}) from the HS water. HS water was injected into the cores until (Sor) was reached. The new combined technology was conducted by five scenarios on five cores: (1) One PV CO_2 followed by two PV LS water, (2) 0.5 PV CO_2 + 1 PV LS water + 0.5 PV CO_2 + 1 PV LS water, (3) 0.25 PV CO_2 + 0.5 LS water + 0.25 CO_2 + 0.5 LS water, (4) Same as scenario #1 but with half value back pressure, and (5) Huffed 0.9 PV CO_2 and puffed it after two hours, then 0.5 LS water was injected + 0.5 CO_2 +0.5 LS water.

The laboratory experiments of all scenarios showed an incremental oil recovery, but the optimum scenario was the scenario (5) with incremental oil recovery 14.5% of OOIP beyond the 55% of OOIP from injecting FW. The two hours huffing make it easy for the following flooding LSASF. Scenario (3) was the second optimum with incremental oil recovery 11% of OOIP because of the short cycle injected LS water and CO_2.

In this paper, simulation work was conducted in order to visualize the new coupling method. This combination technology can solve the CO_2 flooding problems and support the CO_2 by LS water which itself has the ability to increase oil recovery by altering the wettability towards more water-wet.

TRUE ORIGIN OF HYDROCARBONS IN PETROLEUM

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Expulsion of commercial oils and gas from organic-rich sedimentary source is scientific and true, but bio mass is not a dominant source of these hydrocarbons as previously assumed and fossil fuel theory is not scientifically correct . There is a need to understand how mantle origin organic compounds (abiotic) have been migrated in sedimentary environments to form productive sedimentary source rocks and these abiotic compounds have obtained some biotic characteristics in the burial history with bio debris to confuse us. Sedimentary rocks that have been formed without any involvement of these organic compounds are not productive and lead us to dry holes only. New balanced hypotheses between the both biogenic v/s abiogenic and respecting the strong evidences of both can suggest some more signatures to find new oil and gas deposits and may reduce the number of dry wells dramatically.

SAND AND SAGE - A MATCH MADE IN WYOMING

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The Killpecker Sand Dunes, one of the largest active dune fields on the planet, present a unique dark "toothpick" shape in contrast to the surrounding landscape when viewed aerially on Google Earth. Research was performed to investigate the source of this darker color, with an initial hypothesis of underlying lamproite dikes known to exist in the area. By traveling to the area to compare what was seen on the ground with GPS location data and collecting ant hill samples to search for indicator minerals, it was determined that a relatively subtle change in vegetation, rather than rock type, is the cause for the "toothpick" feature. Sagebrush dots the whole of the Great Divide Basin, in which the dunes reside. However, where the substrate consists of deeper sand, the sagebrush grows somewhat taller and thicker, with individual plants closer together. This provides an effect akin to pointillism, seen in art. Future research will determine the controls on the sagebrush growth, combining knowledge from several different fields - biology, meteorology, chemistry, and climatology, perfectly demonstrating the interdisciplinary nature of geoscience.

MINE TAILINGS DRAINAGE - A BOTTOMS UP APPROACH USING HDD DRILLING AND INSTALLATION METHODS

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Mine tailing impoundments present a significant hazard to surface and subsurface water quality. Tailings ponds often hold a combination of solids and liquids in sludge or slurry form. These tailing sludges are typically high in heavy metals and/or have pH values at the extremes.

Currently, efforts are being taken to remediate historic mine tailing sites. At some sites the first step in remediation is to dewater the impoundment. Recently the Maine Department of Environmental Protection looked to horizontal wells to dewater a tailings pond. A horizontal well provides a dewatering option that could be placed under, not through the boulder/rubble tailings dam.

The Maine mine tailing site provided several challenges. One, the remote location and rugged terrain limited equipment access. Two, the impoundment's embankments were constructed of mine waste including boulder and cobble materials. Three, little field data was available as to composition and water content of the sludge at the bottom of the pond.

To treat the tailings drainage, a gravity-fed bio-reactor was to be constructed down gradient of the impoundment. The future site of the bio-reactor and the improved roads leading to it provided a logical location for drilling activities. By setting up in this location and drilling under the clay and rock embankments the first two challenges could be overcome.

The third challenge required a unique solution. By drilling under the embankment and then up through the floor of the pond a potentially uncontrollable drain may develop. Depending on the water content or slurry composition this could lead to a catastrophic toxic release. During the design phase of this project, this became poignantly clear with the Gold King Mine release into the Animas River, Colorado.

To avoid a similar release, several controls were implemented at the Maine site. Notably, casing was driven under the embankment with the drilling going through the length of casing. The casing provided support to the overlying embankment and also focused any potential discharge through this one control point.

A gravity-fed dewatering drain was successfully installed via horizontal directional drilling. When taking this approach thorough planning and preparations are necessary to avoid an uncontrollable release of tailings materials. Takeaway lesson from this project is that with proper planning, mine tailings ponds can effectively be drained using horizontal wells.

HORIZONTAL DIRECTIONAL DRILLING FOR WATER SUPPLY APPLICATIONS

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Horizontal directional drilling (HDD) methods have been utilized for environmental and engineering applications starting in the late 1980's. Since then, HDD wells have been installed for a wide variety of environmental and geotechnical applications. One industry that has not significantly applied HDD drilling and well installation methodology is the water supply industry. Over the last twenty years only a handful of high capacity water wells have been installed using HDD, compared with hundreds of environmental and geotechnical wells. Most

of these water supply installations have been in relatively shallow aquifers with direct connections to surface water bodies. It has long been recognized that horizontal wells allow significantly more screen to be placed into the production zone of a thin aquifer than vertical wells. Decades of experience are now being applied to develop water supply wells for industrial use. The talk will describe the aquifer characterization using geophysics, site selection in a relatively thin aquifer, and groundwater modeling completed prior to construction. We will also provide details of the well completion process, including drilling and locating assemblies, well materials, reaming processes, well installation and development operations.

WHAT SOCIOECONOMIC FACTORS INFLUENCE STATE ENVIRONMENTAL AGENCY SPENDING?

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This analysis explores how state environmental agency expenditures have changed between 2000 and 2014 and if there is a pattern or set of factors that are associated with or may be influencing these changes. Findings are supplemented by interviews with selected state environmental agency representatives. After an initial bivariate correlation, seven independent variable data sets were selected for more in-depth analysis on their potential influence on environmental agency funding levels: population, per capita income, total state expenditures, gross state product, educational attainment, number of environmental agency (full-time equivalent or FTE) employees, and government ideology. State environmental agency expenditures between 2009 and 2014, adjusted to 2014 dollars, were chosen as the dependent variable for regression analysis.

On a national level, the independent variable data sets most commonly correlated with state environmental expenditures are gross state product, government ideology, per capita environmental agency FTEs, and educational attainment. Possible explanations for these associations are provided. Correlations among these independent variables and individual state environmental spending levels also are described.

Supplementing the statistical analysis, a representative from each state environmental agency was asked to describe the factors that they perceive exert a direct, real-time influence on budgets and staffing levels. Nine state agencies agreed to participate in the survey. Respondents confirm that program responsibilities related to climate change, expanded development of natural resources, or federal mandates have increased substantially. Agency budgets and staffing levels continue to decline and a common sentiment is that state environmental

agencies are victims of their own success with funding level increases occurring only because of a local environmental need or catastrophe. In addition, even though local environmental quality has improved significantly, most of those interviewed cite a lack of trust as to environmental agency motives by their constituents.

The relationships defined by these correlations are not purely technical or administrative, rather they may echo state constituencies political or social priorities. A deeper understanding of the forces influencing state environmental spending would provide policy makers with an increased insight into the values of their electorates.

GETTING PAST GO AND OTHER PROFIT ROBBERS

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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 and your staff 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 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 collaborative processes and mediation. For those familiar with "partnering," collaborative processes may be viewed as similar.

BACK TO THE MINES: ELECTRICAL RESISTIVITY OVER ABANDONED COAL MINES IN SOUTHEAST KANSAS

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In the southeast corner of Kansas, Highway K-7 crosses an area that is undermined by abandoned coal works. Beginning in the late 1800s, coal was mined for railroad locomotives using the room-and-pillar method. After the railroad companies abandoned the mines, local men would re-enter them to take coal for heating their houses. The pillars are now gone, and some of the roofs began to collapse and continue to do so.

Highway K-7 between the towns of Scammon and Columbus crosses a particularly worrisome 2-mile stretch of shallowly-undermined land. In the early 1990s, the Kansas Department of Transportation backfilled this portion of the narrow highway with grout to prevent cave-ins of the roadway. Recently, a widening project required further remediation of the subsurface voids.

Grouting for the new project began in September of last year. As part of KDOT Geology's efforts to understand the effectiveness of the procedure, electrical resistivity surveys were performed across one mile of the project. A survey was completed before grouting began, then the same line was repeated after grouting was finished.

Resistivity data was excellent across both surveys. In places, the results showed mining or bedding trends. Some resistivity highs and lows marked areas of interest, such as a buried, forgotten crossroad pipe and a groundwater passage that was constructed as part of the project. An unexpected finding, however, was that the resistivity profile changed very little across much of the survey.

PAPOOSE CANYON: A CASE STUDY OF REENTRY ECONOMICS FOR MATURE AND ABANDONED FIELDS

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Since 1970, oil and natural gas have been commercially produced from the Desert Creek, Ismay, and Honaker Trail formations of Papoose Canyon Field, located in Dolores County, Colorado. Many of the wells drilled during the early life of the field were shut-in when oil commodity prices declined to historic lows during the 1980s with hopes of reactivating them as prices recovered. During that time, though, many of the operators in the region either went bankrupt or merged with larger operators, and many of the shut-in wells were never reactivated. A second round of wells, drilled during the 1990s, had commercial production of both oil and natural gas but were prematurely shut-in during the subsequent downturns in prices at the turn of the century.

A 2005 U.S. Bureau of Land Management study concluded that the Papoose Canyon field was nearly depleted. However, new technologies, such as directional and horizontal drilling paired with hydraulic fracturing, have led to the rejuvenation of numerous mature oil and gas fields. These new technologies are especially suited to stacked plays such as Papoose

Canyon. In light of this trend of renewed production in older fields, this study will investigate the economic variables associated with commercially viable reentry and production of the existing and infill wells in the field, and to determine the necessary oil and natural gas prices required for selected economic hurdles. A decision tree model will be presented to aid in adapting this case study as a basis for reentering similar mature and abandoned fields.

COLORADO SIGNS ON TO THE NATIONAL GROUNDWATER MONITORING NETWORK

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The National Groundwater Monitoring Network (NGWMN) is a nation-wide collection of groundwater monitoring wells provided by Federal, State, and Local Agencies. The network was established in 2009 through sponsorship from the Advisory Committee on Water Information's Subcommittee on Groundwater. By combining groundwater information from data providers across the country, the network aims to display water level and water quality data in a consistent manner through a mapping interface. These data will assist in planning, management and development of groundwater resources in Principal and Major Aquifers of the United States.

The Colorado Division of Water Resources (CODWR) joined the NGWMN as a new data provider in 2018. Four USGS Principal Aquifers are located in Colorado: the High Plains, Denver Basin, Rio Grande and Colorado Plateaus. The first project period focused on providing water level data for the Colorado Plateaus and High Plains. Relying on the NGWMN framework criteria, CODWR selected and classified wells into subnetworks and monitoring categories, collected required information related to each well for an online well registry, connected water level and well construction databases to the NGWMN through web services, and prepared a report summarizing the selection and classification processes and minimum quality assurance requirements.

Each aquifer presents unique challenges related to available well information and geologic context. The low-density network in the Colorado Plateaus Aquifer presents challenges in confirming aquifer confinement and well construction information, while the High Plains aquifer has a large number of wells, but selecting and vetting is difficult because the network has a long, poorly documented history and multiple administrative and geospatial databases.

The experience of joining the NGWMN has allowed CODWR the opportunity to fill data gaps in its water level and well construction databases while reexamining the frequency and quality of measurements within the groundwater monitoring networks. The relationships established with the USGS, other Colorado State Agencies, and surrounding states will contribute to the quality and availability of critical groundwater information in Colorado and the United States.

TRACE ELEMENT ANALYSIS OF QUARTZITE CLASTS FROM SESPE FORMATION AND SOURCE ROCKS FROM SOUTHEAST CALIFORNIA AND CENTRAL ARIZONA

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The Sespe Formation is an Eocene to Miocene sedimentary unit outcropping in the northwest regions of the Transverse Range north of the Los Angeles Basin. In the late 1990s, the general consensus about the Sespe Formation was that it is a fluvial sequence created in a deltaic system by two paleorivers. Jeffrey L. Howard in 2000 made petrographic comparisons between quartzite conglomerate clasts from the Sespe with various quartzite source rocks in central Arizona and southeast California and concluded that one river flowed north and south near present-day Death Valley and it was the ancient Colorado river, and the other river flowed off the Mazatzal Peaks in central Arizona and was the Gila River. For this research, the quartzite clasts and source rocks analyzed petrographically by Howard were reanalyzed and compared through trace element composition and statistical calculations to determine if the Sespe clasts match the source rocks. X-Ray Fluorescence was used to get the ppm values of all the elements present in each rock. Using MATLAB, the ppm values were used to make line plots comparing the values of individual elements between the two rock groups, a correlation coefficient chart was made comparing the correlation between the two rock groups, and principle component analysis was done to plot the loads of individual rock samples to see how they relate with each other. The data from the correlation coefficient chart and PCA plots confirmed that the quartzite clasts in the Sespe have very similar trace element compositions with the quartzite source rocks which further supports the hypothesis that two paleorivers flowed through central Arizona and near present-day Death Valley and into present-day Los Angeles Basin area.

ASSESSMENT OF THE VAPOR INTRUSION RISK FROM DRY CLEANERS - CASE STUDIES AND LESSONS LEARNED

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Dry cleaners have historically used tetrachloroethene (PCE), a chlorinated volatile organic compound (VOC), as the primary dry cleaning solvent. These dry cleaners are often found to have subsurface environmental media, soil and groundwater, impacted with PCE and associated degradation products, including trichloroethene (TCE), dichloroethene (DCE), and vinyl chloride (VC). Volatilization of these VOCs from impacted environmental media contributes to an increased risk for vapor intrusion into the overlying dry cleaner space as well as surrounding tenant spaces and buildings. Environmental assessment of properties that have historically or are currently occupied by dry cleaner tenants and evaluation of the associated risk of vapor intrusion into indoor spaces has become a common due diligence practice in commercial real estate transactions. The geology underlying these properties often determines how building foundations and utility conduits are designed and constructed and can contribute to the ease with which VOC vapors migrate into overlying and surrounding buildings. Several case studies will be presented, each including a discussion of the environmental assessment of each property, evaluation of the vapor intrusion risk, influence of the subsurface geology on vapor intrusion, and resulting risk mitigation strategies.

NORWAY'S GEOLOGY AND ITS IMPACT ON HYDROCARBON RESOURCES AND MASS WASTING PROBLEMS

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The geological history of Norway is very complex and accounts for the country's spectacular beauty, impressive hydrocarbon resource potential, and significant mass wasting concerns. Some of the crucial events affecting Norway's geological development include the Caledonian and Hercynian orogenies, the development of the Oslo Rift, the rifting of the North Sea Graben Province, the Alpine Orogeny and subsequent rifting and the effects of the Pleistocene glacial periods.

Currently, Norway has more than eighty petroleum-producing fields in the North Sea, Norwegian Sea and Barents Sea regions. Outstandingly-rich source rocks contain types II and III kerogen with notable TOC and R_o values. Reservoirs include both submarine-fan clastics and carbonate lithologies. Traps

involve both structural (fault-rotation) and stratigraphic components. Overlying impermeable strata provide the seals. In addition to its proven reserves, Norway has immense potential concerning undiscovered conventional as well as unconventional reserves. Shale gas and oil, coal bed methane and methane hydrates are among the possible resources from which the country may be able to profit.

Mass wasting in Norway involves nearly the entire spectrum of possible types of landslides. In particular, Norway is well known for its infamous quick clays with sensitivity values that may range from 500 to 1000! These quick clays have led to loss of life and considerable property damage, with the "Rissa Landslide" near Trondheim constituting a classic case history. In addition, the colossal "Storegga Landslides" and related tsunami are examples of the dangers involving the destabilization of methane hydrates that may trigger dramatic slope failures.

UPDATE ON CURRENT HIGH-RESOLUTION SITE CHARACTERIZATION (HRSC) TECHNOLOGY, 3D DATA MODELING, AND APPLICATIONS FOR REMEDIAL DESIGN (PART 1)

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Over the past 20 years, site characterization has benefited from the development, and advancement, of direct-push enabled subsurface investigation tools such as the electrical conductivity (EC) probe, hydraulic profile tool (HPT), and membrane interface probe (MIP). These tools have been around for several years, and have advanced recently to include the low-level MIP tool (LL-MIP) for better detection of low concentrations VOCs, combined tools (MiHPT), and the newest tool, the Optical Image Profiler (OIP-UV) tool for identifying NAPL fluorescence. A single combined tool can now log three or more chemical sensors, soil conductivity, hydraulic pressure and flow, hydraulic conductivity, in a single bore hole push. These tools have become significantly more robust over recent years, enabling greater productivity. Data is collected at a vertical density of 20 data points/foot of bore hole, so the vertical resolution is indeed high. Highly detailed data logs give us insight and resolution that cannot that cannot be seen in the physical examination of a core, or from the typical two laboratory samples from the same core. Today's inexpensive computer power allows us to input and process hundreds of thousands of data points into a complex three-dimensional (3D) model, giving us the ability to finally peer underground,

and see "what is going on." The presentation will review the current state of the technology, including new tools, recent advancements, and briefly how to obtain and review quality control data from a service provider. The newest tool is a combination of the Optical Image Profiler UV-Fluorescence (OIP-UV) tool with the Hydraulic Profile Tool (HPT), also called OiHpt, for mapping petroleum non-aqueous phase liquids (NAPLS) and hydraulic pathways. Examples of data interpretation and important consideration when creating 3D models of this data are presented. Various uses and remedial applications will be discussed including both initial and supplemental site characterization, and remedial design projects.

IMPROVED RESULT FOR IN-SITU REMEDIATION PROJECTS BY UTILIZING HIGH-RESOLUTION DATA, INJECTION, AND HYDRAULIC PLACEMENT TREATMENT METHODS - IT'S A CONTACT SPORT (PART 2)

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The recent improvements in the collection of high-resolution subsurface data has improved our ability to surgically apply in-situ injection technologies and utilize in-situ treatment products with better results. Previously, many in-situ remediation designs were based on limited and inadequate data, often relying on old initial site characterization data. Both qualitative and quantitative data are needed in three dimensions to effectively apply treatments, saving time and money. Qualitative high-resolution site characterization (HRSC) tools such as Membrane Interface Probes (MIP), Optical Image Profiler (OIP-UV Fluorescence), Hydraulic Profiling Tool (HPT), and Electrical Conductivity (EC) are combined with quantitative high resolution vertical sampling of saturated soil cores to gather the data required for a Remedial Design Characterization (RDC). Once this data is acquired and modeled, a high-resolution treatment can be designed. The biggest failure of in-situ treatments has been the improper dosing and/or placement of the treatment product. It's a contact sport – If the treatment does not contact the contaminant, the treatment will fall short of remediation goals. Utilizing properly designed injection equipment and methods combined with calculated product dosing and placement, one treatment can clean up a site. Even plumes with Lighter Non-Aqueous Phase Liquids (LNAPL) have been successfully treated using these methods. Methods and equipment required to apply many different types of liquid and slurried solid treatment products, both chemical and biological, and how to apply them in various types of heterogeneous soil types and bedrock forma-

tions, are presented. Techniques for dealing with several types of lithologic challenges will be presented. Techniques for determining ROI, distribution, and designing horizontal and vertical injection spacing will be discussed along with methods for performance monitoring.

ALASKA'S PLACE IN THE GLOBAL MINING INDUSTRY

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The lode (hardrock) mining industry has been an integral part of Alaska's economy for almost 150 years. The globalization of lode mining has allowed professional geologists to roam the globe, Alaska included, in search of a wide range of metals and minerals, many of which are considered strategic and/or critical to the U.S. economy. Although not the only risk-factor considered by the global exploration industry, natural geologic endowment ranks near the top when mineral exploration firms are deciding where to invest. Alaska enjoys a deserved reputation as a jurisdiction where major mineral deposits can still be located at or near the Earth's surface. With the global mining industry coming out of a +4-year down-turn, this presentation presents a number of measurable, quantifiable parameters that demonstrate how Alaska stacks up against other jurisdictions with favorable mineral endowments.

Four topics that are integral to Alaska's competitive position in the lode mining industry will be examined, including:

1. Global Mineral Demand: a brief review of near past, present and forecast future global supply and demand characteristics for several metals will provide a larger canvas from which to consider Alaska's place in an increasingly competitive and metal-intensive world.

2. Geological Framework: Alaska's unique tectonic history has resulted in the amalgamation of a diverse assemblage of geological terranes containing a remarkably broad spectrum of metals and minerals. A brief presentation will be made outlining the salient geologic features that make Alaska a mineral storehouse and examples will be presented showing how data mining can lead to new discoveries in Alaska.

3. Mining Risks: A thorough risk assessment is one of the first things mineral companies do before acquiring a new project in a new jurisdiction. And risk assessments are not static, requiring early and often review to remain relevant in a rapidly changing world. In the global village where Alaska must compete, the risks inherent in Alaskan mineral development include both positive attributes and negative challenges. A

summary of some obvious and not so obvious risks will be considered with a view toward ranking Alaska versus other mineral-rich jurisdictions.

4. Perception Versus Reality: With the explosion of the digital information over the last 20 years, perceptions regarding a political jurisdiction can condemn or bless a given jurisdiction overnight, justly or unjustly. Unfortunately, initial perceptions often can be incorrect, however changing public perception is often more difficult than logic would dictate. Mineral exploration personnel often are the first representatives of the mineral industry to interface with stakeholders in Alaska's far-flung mineral districts. These "First Ambassadors" can dramatically and sometimes permanently affect an entity's ability to obtain its Social License to Operate.

WATER AND SOIL QUALITY AT TWO EASTERN KENTUCKY COAL FIRES

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In this study, volatile organics and other relevant constituents in soil and water were analyzed at two fires in eastern Kentucky (the Truman Shepherd fire in Knott County and the Lotts Creek fire in Perry County). The samples were analyzed for a number of relevant constituents, notably benzene, toluene, ethyl benzene, and xylenes (BTEX); and polycyclic aromatic hydrocarbons (PAHs). No water contamination was noted at either site and relatively low levels of soil contamination [defined as exceeding EPA soil screening levels (SSLs)] were observed at Truman Shepherd, but numerous Lotts Creek soil samples exhibited PAH concentrations above EPA SSLs. Specifically, benzo (a) anthracene, considered a highly carcinogenic PAH, was found at over 7000 times higher than the EPA SSL for soil (32 mg/kg). BTEX concentrations were low even where PAH and other constituents were high. This is likely due to the low atomic masses and high volatilities of BTEX compounds. The PAHs with the highest concentrations at Lotts Creek were in the mid- to high atomic mass range. The discrepancy in soil contamination between the two sites is consistent with differences in total organic carbon concentrations, which may reflect differences in soil cover.

USING MULTIPLE TECHNIQUES TO MONITOR EFFECTIVENESS OF IN-SITU INJECTIONS

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Background/Objectives
Challenges of injecting abiotic/biotic, reagents/amendments into the subsurface to remediate soil and/or groundwater can include unexpected treatment results and deleterious/catastrophic affects to solute transport. "Everything's good" right up until the moment when it's not. Practitioners find themselves asking questions like: "Did matrix variation deflect distribution of injectate? Are injections propagating out to the design radius, or falling short? Did temporary hydraulic mounding expand the plume or push fugitive emissions into unintended locales? Fortunately, answers can often be found using commonsensical convention; however, some answers are more elusive and require innovative cleverness. Success is riding on it; so, multiple techniques have been developed and implemented to achieve project objectives. Then there are occasions when "all remains good" throughout a project, and the task-at-hand is merely to document just how effective an injection program truly was.

Approach/Activities
Sampling to observe solute-concentration reductions and monitoring hydraulic-head changes in pertinent wells during injections are simple and recommended techniques to evaluate injection effectiveness. If object wells are not responding as hoped, however, more "detective work" is necessary such as collecting samples from intervening locations using discrete sampling methods, e.g., hydro-punch or "implants," or conducting forensic drilling to observe if injectate is present in the matrix adjacent to a subject well. If injection radii cannot be determined by these conventional techniques, then more innovative efforts can be employed such as measuring surface uplift caused when injectate displaces the native matrix. This differential movement, ranging from abrupt to subtle, provides a map of "where injectate is and where it isn't." The key to success is gathering such intel when outcomes deviate from the plan, such that adjustments in the injection process can be made, accordingly.

If "hydraulic push" is a concern, then a relatively-straightforward technique is to compare the total-fluid injection volume with the estimated native matrix pore-water volume. If displacement potential needs to be more-accurately quantified, then a hydrology assessment can be conducted whereby temporary piezometers equipped with transducers are installed at different radial distances from a pilot-test injection point such that hydraulic-head changes can be calculated to evalu-

ate temporary mounding and/or pressure pulsing. Again, if risk potentials are exacerbated due to injections, mitigating adjustments can be made to avert unintended consequences.

On the other hand, if all appears to go well on an injection project, confirmatory sampling can be conducted to estimate mass reductions in soil and non-aqueous phase liquid and dissolved-phase plumes. This technique is used to compare "after" results with initial (pre-treatment) concentrations to evaluate injection effectiveness.

Results/Lessons Learned
Conducting successful, in-situ injections, is as much an art as it is a science. It's not easy predicting or accounting for subtle nuances inherent to a target matrix. Even if considered homogeneous, matrix architecture can result in failed injection efforts. Gathering "effectiveness" data during or immediately following an injection program allows the practitioner to identify critical problems or expected outcomes. Being "nimble" in the field can make the difference between failed and successful remediation treatment.

OBTAINING HIGH-RESOLUTION DATA TO DEMONSTRATE BOS 100® PERFORMANCE IN A LARGE TCE PLUME WITH EXTENSIVE DNAPL PRESENT

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Background/Objectives
Burgeoning technologies such as Membrane Interface Probes can be effective qualitative screening tools, but are ineffective for accurate design or performance monitoring, especially at sites where dense-non-aqueous-phase-liquid (DNAPL) is present. High-resolution, quantitative data are needed to accurately characterize and map solute distribution in soil and groundwater. Data gathering does not stop at the design or implementation phases in that it is also needed following a treatment episode to evaluate performance, i.e., "how did we do?" and/or "do we need to do it again?" In other words, successful remediation programs need to be flexible and supported by robust performance monitoring that allows using "where you have been" to adjust for "where you need to go."

A high-resolution, quantitative-data approach was implemented at a large, urban industrial facility where trichloroethene (TCE) was used extensively as a cleaning solvent. The site was underlain by river deposits and sedimentary bedrock. The selected remedy was in-situ treatment using BOS 100®, an immiscible, activated carbon solid injectate. Impacted alluvium consisted of well-graded, fine-to coarse-grained sand.

The source area was underlain by an aquitard of clayey silt where DNAPL pooled at the interface. Impacts did not extend into the underlying claystone bedrock. Solute transport was dictated by physical properties of the DNAPL, (e.g., density) and by aquifer characteristics such as heterogeneity, anisotropy, variance in matrix density, grain size in the alluvial sands, and gradient. Subtle facies changes resulted in solute concentrations that varied by orders-of-magnitude in distances of only several millimeters. This inherent complexity was the impetus for using quantitative, high-resolution data to demonstrate remedy performance.

Approach/Activities
Once an accurate conceptual site model was constructed and treatment was underway, the high-resolution program was tailored to demonstrate mass reduction as a result of BOS 100® performance. In total, 1,291 continuous soil samples were analyzed from 186 borings, and 5,515 groundwater samples were analyzed from 1,349 monitoring wells.

The greatest value of the high-resolution, performance-monitoring approach was in areas where DNAPL or high concentration soil or dissolved-phase impacts were observed. The sequence was to: 1) use (continuous) soil and groundwater data to design a discrete and accurate remedial design; 2) inject BOS 100®; 3) complete confirmatory/performance borings to observe remedy distribution and to evaluate if "the target was hit" (or to make adjustments to subsequent injections, accordingly); 4) analyze corresponding groundwater samples; and 5) calculate mass reduction. The sequence was repeated until cleanup goals were met in a subject area.

Results/Lessons Learned
The project was a success because of the effectiveness of the BOS 100® and the quantity and quality of data gathered to demonstrate treatment performance. The DNAPL portion of the plume was reduced from percent-level concentrations (up to 254,770,000 micrograms per kilogram TCE in soil and 1,280,000 micrograms per liter TCE in groundwater) to closure levels. The dissolved-phase plume was also mitigated, and site-closure monitoring began in 2014. A No Action Determination for the site was granted in 2016.

RAPID SITE CLOSURE OF A LARGE GAS PLANT USING IN-SITU BIOREMEDIATION TECHNOLOGY IN LOW-PERMEABILITY SOIL AND FRACTURED BEDROCK

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Background/Objectives
Natural-gas condensate and other natural-gas liquids released to the subsurface from a large gas-processing plant generated a petroleum-hydrocarbon plume approximately 30 acres in area. The affected matrix was complex and included low permeability, residual clays overlying shallow, fractured limestone bedrock. Solute concentrations indicative of light-non-aqueous-phase-liquid (LNAPL) were observed at depths as shallow as 4 feet below ground surface. Undulating surface topography with paleo-channels (incised, erosional features) and a relatively steep groundwater gradient caused a dissolved-phase plume of benzene, toluene, ethylbenzene, and xylenes (BTEX) to extend more than 1/4-mile downhill from the source.

Approach/Activities
The initial Remedial Action Plan prepared by a predecessor and submitted to the Railroad Commission of Texas (RRC) was to install soil-vapor extraction and groundwater recovery and treatment systems to achieve site cleanup. Instead, an *in-situ* BOS 200^{O} injection program was implemented to expedite remediation for a pending property sale. BOS 200® is a granular, activated carbon injectate inoculated with cultured microbes (consortia of facultative microorganisms), electron acceptors (nitrate and sulfate), and nutrients (phosphorus and nitrogen) designed to quickly biodegrade BTEX compounds.

Subtle facies changes in overlying, low-permeability soil and thin bedding planes and complex fractures in highly weathered bedrock resulted in solute concentrations that varied by orders-of-magnitude in distances of only several millimeters. The first step was to conduct a high-resolution, quantitative-data assessment to characterize plume strength and geometry. The outcome was an accurate conceptual site model used to 1) apply (continuous) soil and groundwater data to design a discrete remedial design; 2) inject BOS 200®; 3) complete confirmatory/performance borings to observe remedy distribution and evaluate if "the target was hit" (or adjust subsequent injections, accordingly); 4) analyze corresponding groundwater samples, and 5) calculate mass reduction. This sequence was repeated until cleanup goals were met in a subject area.

The site was subdivided into six regions, based on constituent concentrations. Treatment was implemented in three phases

over a 15-month period. Approximately 4,800 injections were completed at 1,230 locations throughout the 30-acre plume. The remedy consisted of 185,875 pounds of carbon slurry, 5,650 pounds of supplemental sulfate (gypsum), and 352 gallons of microbes.

Results/Lessons Learned
The project was a success because of the effectiveness of the BOS 200® and the quantity and quality of data gathered to demonstrate treatment performance. The primary petroleum constituent, benzene, was reduced from concentrations of over 70,000 micrograms per liter (µg/L), i.e., LNAPL, to less than 1 µg/L. Following 24 months of post-treatment groundwater monitoring, a No Further Action determination was issued for the site by the RRC.

KARSTIC TERRAIN HYDROGEOLOGIC CONSIDERATIONS FOR PROTECTIVE REMEDY SELECTION AND IMPLEMENTATION

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The Pohatcong Valley Groundwater Contamination Superfund site is situated in a fault dominated, fractured, karstic carbonate aquifer in a narrow, linear valley (approximately 1 mile wide) with crystalline bedrock walls. TCE groundwater impacts were discovered in the late 1970's and subsequent investigations documented the presence of an approximately 10-mile-long "TCE plume" within the valley. USEPA and the USGS conducted extensive investigations within the valley in the 1990's and 2000's and ultimately adopted a conservative, traditional, multi-remedy approach of vadose zone source area treatment, source area groundwater extraction and treatment, provision of alternative water supply, and long-term groundwater Monitored Natural Attenuation (MNA). Remedy implementation has proceeded in a staggered sequence with MNA groundwater monitoring being initiated in August 2013, installation and operation of the source control groundwater extraction and treatment system (GWETS) in March 2016, design of the alternative water supply in June 2017, and initiation of the vadose source area treatment design in July 2017.

At the direction of USEPA, the MNA groundwater monitoring network is currently being expanded from 26 wells to 46 wells to expand density, the lateral extent, and vertical extent of the monitoring network. Groundwater data generated since 2008 indicate marked decrease in the concentration and extent of

the "TCE plume" which has been further enhanced with the GWETS start-up in 2016.

Once the source of the TCE was effectively cut-off from the aquifer, the aquifer's very high hydraulic conductivity, which lead to the creation of 10-mile long plume, is now aiding in the rapid reduction in the extent of the site's "TCE plume." The attenuation appears to be due to advection, dilution, and dispersion. Monitoring for natural attenuation parameters has indicated that there is minimal evidence of biodegradation. The rapid attenuation of the downgradient portion of the aquifer is not surprising when considering past USGS studies that concluded that the median age of the site's groundwater is very young, ranging from only 6 to 12 years. The length of the "TCE plume" which exceeds the New Jersey regulatory threshold of 1 ug/l is now less than 5 miles and is continuing to shrink. The necessity of a yet to be installed, expensive alternative water supply remedy in a former downgradient portion of the "TCE plume" with no detectable concentrations of TCE above its regulatory threshold is questionable given the profound and rapid recent improvements to the groundwater quality within the Pohatcong Valley.

JULY 4TH FIREWORKS AS AN UNCONVENTIONAL SOURCE OF GROUNDWATER CONTAMINATION

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The city of Evart, Michigan (pop. 1,903) first detected perchlorate in one of its two municipal wellfields in 2015. The source of perchlorate was determined to be the annual Fourth of July fireworks displays at the County Fairgrounds, located directly adjacent to and hydraulically upgradient from the wellfield. The annual 30-minute shows were found to have deposited approximately 5 to 10 kg of unreacted perchlorate downwind of the launch site each year, in an area directly above the unconfined sand and gravel glacial outwash aquifer used for municipal supply. Being highly soluble in water, most perchlorate was efficiently transported to the aquifer during the first significant summer storm after each holiday event. Soil and groundwater investigations mapped the rapidly-developed and fast-moving groundwater plume as it was drawn toward the nearest municipal well in about 11 months. To minimize public exposure to perchlorate, the City actively managed the wellfield and constructed an additional supply well. However, residual perchlorate in the unsaturated soils persists as a long-term contaminant source. Perchlorate is not yet regulated by the Environmental Protection Agency or the State of Michigan under the Safe Drinking Water Act and is

therefore not typically analyzed during routine water quality monitoring. Future regulation of perchlorate as a drinking water contaminant is likely to result in its unexpected detection in other small towns.

PERFLUOROALKYL SUBSTANCE SAMPLING AND ANALYSIS: 2018 STATE OF THE PRACTICE

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Perfluoroalkyl Substances (PFAS) are synthetic chemicals used in a variety of products including fire-fighting foams, food packaging, and non-stick coatings. These compounds may be present in standard environmental sampling materials such as Teflon™ tubing and pump parts or everyday items. The U.S. EPA Health Advisory Levels are 70 ng/L, and some states have set much lower limits for allowable drinking water concentrations. Sub-part-per-trillion analysis is commonly required, and the ubiquity of these compounds require special precautions to ensure and demonstrate samples are not biased during collection, transport, and analysis. Current state of the practice sampling and analysis considerations will be described in this presentation.

MEMOIRS OF A URANIUM MINE GEOLOGIST

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There is something unique about going down into the mine, a combination of smell, sound, and the deep blackness outside of the limited pool of light from a headlamp. I was amazed how dark it was outside my cap lamp beam and how quickly it became normal when I stepped off the cage onto the station. These are my recollections, a non-technical glimpse into the world of a uranium mine geologist.

In the mid-1970's, uranium mining was in its final and greatest boom. At Kerr-McGee mines we were running three shifts per day, six and seven days a week. Every drill rig was busy, and new shafts were being sunk at a number of locations in the area. The mining town of Grants, New Mexico boasted 22 saloons, a Pizza Hut, and a housing shortage. Miners, laborers, engineers, geologists, and technicians of every discipline were heading for Ambrosia Lake. The Kerr-McGee mill dominated the valley with red mesas, headframes and tailings piles everywhere you looked. I was assigned to the Section 30W mine

as a Grade Control Geologist, and at the kickoff of my career, I was only slightly more respected in the scheme of the mine society than the common laborer. But it was my first job as a professional geologist, and I was there to ensure that the miners were mining ore, not waste rock. A contract miner earned his money by production; feet of development or haulage drift driven, number of timber sets or rock bolts installed, cars hauled, or tons of ore mined. The uranium ore we chased was primarily coffinite and uraninite which formed a black coating on the sand grains of the Westwater Canyon Member of the Morrison Sandstone, or occasionally concentrated in organics such as trees and dinosaur bones. At 30W this sandstone was friable and soft, and we had some of the worst ground conditions in the basin. Two of my friends and coworkers were killed through rock-fall accidents at 30W during my decade underground, and injuries to every part of the body were common. My job was to keep the development miners on the ore body which involved directing the miner on how to follow the ore. The ore body was generally tabular but frequently would change vertical level without any apparent reason, or simply pinch out to nothing. I used a meter equipped with a ten-foot cable and a two-foot-long stinger that held the Geiger tube. The meter head was the size of a coffee can and weighed about five pounds. With it all together and the cable coiled it was carried on the shoulder on a short rope sling, the two-foot stinger hanging down in front. It was a device guaranteed to catch on anything, or it would sometimes just throw itself off of your shoulder out of spite. While climbing a ladder into a stope, it would coil itself around your arm like an anaconda. If I ever had to jump out of an airplane, I would carry that rig instead of a parachute because it was impossible to travel more than ten feet without it hanging up on something.

Hundreds of young geologists started their careers in the uranium mines working for a dozen companies in New Mexico alone. The ups and downs of the industry forced most, as I eventually did, to branch out into other forms of practice. But the most important lessons I learned were not in geology, but in human nature, management style and life choices, and they served me well over the next forty years. The powder smoke is as fresh in my mind today, as it was 42 years ago when I began my adventure.

SEDIMENTOLOGY AND FACIES ANALYSIS OF JERIBE RESERVOIR (EARLY-MIDDLE MIOCENE) IN TAWKE OILFIELD, ZAKHO, KURDISTAN REGION, NORTHERN IRAQ

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A detailed study on microfacies analysis and depositional en-

vironment of notorious Early-Middle Miocene, Jeribe Formation, in Tawke Oilfield reveals three main microfacies groups that are subdivided into 5 sub-microfacies within the entire section. These microfacies were recognized using core sections, in two newly drilled exploratory wells, TW-1 and TW-2 in Tawke prospect area. In addition, petrography of the Jeribe Formation using core analysis is coupled with facies analysis descriptions to re-examine the depositional environment, based up on 45 thin sections. Core evidences show main microfacies assemblages are mainly composed of: lime mudstone (Micrite) and lime wackestone microfacies, which are, in turn, subdivided into: a) foraminiferal lime wackestone and b) bioclastic lime wackestone submicrofacies. The lime packstone microfacies is divided into two submicrofacies: a) foraminiferal lime packstone and b) bioclastic lime packstone submicrofacies. Various diagenetic processes influenced limestones, dolomite and dolomitic limestones that were partially recognized within the successions of the Jeribe Formation, which are, in ascending order of significance: dolomitization, micritization, cementation, compaction, neomorphism, anhydritization, dissolution, fracturing, and silicification, suggesting that the formation has undergone extensive diagenetic processes to generate secondary porosity. Some of these diagenetic processes, affected positively, and others were affected negatively on enhancing and destroying the petrophysical properties of the Jeribe Reservoir. These processes were more effective in late rather than early diagenetic stages. The facies and petrographic analyses of the Jeribe Formation are more likely suggesting evidence indicating the formation was deposited in a restricted, lagoon of depositional environment. Therefore, this research sheds light on a new perspective based on delicate sedimentary and facies analysis for future oil exploration and development in Tawke Oilfield.

THE STRANGE WORLD OF BALL CLAYS- A RARE, UNUSUAL INDUSTRIAL MINERAL RESOURCE WITH LIMITED OCCURRENCES

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Ball clays or plastic clays are one of the rarest industrial bulk minerals in the world, found only in a few localized geographic areas (IMA Europe, 2011). The main mineral constituents of ball clays are kaolinite or china clay (~20 - 80%), quartz (~6 - 65%), other clay group minerals (10 - 25%), as well as small amounts of accessory minerals and carbonaceous (organic) materials (IMA North America, n.d.). In addition, ball clays have ultrafine particulate sizes with the majority mea-

suring less than 1 micron or 0.001mm (IMA North America, n.d.). Unlike other claystone deposits which are extensive and form primarily in clastic (particulate) sedimentary depositional environments such as mudflats, lakes or ocean floors, the extremely rare ball clays are secondary in nature, generated by exceptional natural mechanical mixing of source material through low energy river action (IMA Europe, 2011).

Their said specific mineralogy and ultrafine composition gives ball clays very unique and sought after ceramic properties. The fired end product of high-grade ball clay is white in color and of superb fine quality, unrivaled by other porcelain products. China clay (kaolinite), which is many times more common than ball clay, cannot be used alone or the resulting ceramic will be an inferior weak and brittle product (IMA North America, n.d.). Thus, all fine china and common ceramics, such as sinks, toilet bowls and floor tiles depend on the extremely rare clean ball clays (IMA Europe, n.d.) as a necessary additive to produce an end product of excellent quality.

Europe contributes 66% to the total global production of ball clays, with Ukraine and Germany being the worldwide leaders, ball clay occurrences are more concentrated in Europe than in any other part of the world. This presentation focuses on my recent visit to ball clay deposits in Germany and the Czech Republic and will discuss their unique chemical and mineralogical properties and geology, the history of the ball clay industry, current industry outlook and applications and recent undergraduate research projects at MSU Denver associated with this unique resource.

A NOVEL APPROACH TO THE MINERAL EXPLORATION IN POPULATED AREAS – INNOVATIVE, NON-INVASIVE AND FULLY ACCEPTABLE EXPLORATION TECHNOLOGIES (PROJECT INFACT)

Marko Komac, Ana Braña Bergshjorth, Ludger Benighaus, Isabel Fernandez, Isla Fernandez, Richard Gloaguen, Moritz Kirsch, Helene Köpf, Stephane Ruiz Coupeau, Jon Russill

Exploration is the crucial first stage in the raw materials chain and has the goal of discovering economically viable deposits of raw materials. Periods of significant discovery directly follow innovations that either change the geological targets of exploration (fundamental theories), the physical places that are reached (regions and depths), or the manner in which they are explored (techniques and methods). Despite its rich history of mining and residual mineral wealth, current conditions within the EU present a number of social, political, legislative,

cost and physical barriers to raw material exploration: barriers to be overcome by innovation, dialogue and reform.

The goal of the Innovative, Non-invasive and Fully Acceptable Exploration Technologies (INFACT) project is to drive innovation in cost-effective and sustainable exploration techniques that are relevant to the particular conditions and strategic raw material targets of Europe. Its aim is to facilitate access to prospective locations that have remained under-explored due to technical, physical, social or cost restrictions.

Recognizing that the future of sustainable exploration requires a reduction in environmental and social disturbance, the INFACT project focuses on innovative exploration techniques that are 'non-invasive' (airborne geophysics and remote sensing). The project includes investigation of the social aspects of raw materials exploration by integrating technological innovation and stakeholder engagement (encompassing local communities, wider society and industry) in order to encourage best-practice exploration conduct, measure public perceptions and improve relevance to industry and society alike. INFACT is comprised of the following main components:

•Development and test of innovative, environmentally and socially 'acceptable' exploration technologies and processes - in an industrially-relevant environment,

•Foundation of three reference sites in Europe for demonstration, benchmarking and certification of new technologies and analysis of public awareness and opinion in the south, middle and north of Europe, and

•Stakeholder engagement and education: exploration practitioners, policy-makers and wider society.

ADDRESSING THE ENVIRONMENTAL LEGACY OF ASBESTOS MANUFACTURING IN AMBLER, PENNSYLVANIA

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Gerald Kirkpatrick, CPG, Environmental Standards, Inc., Valley Forge, PA

The Borough of Ambler is a small, long-urbanized community with a population of approximately 6,500, located in Montgomery County, Pennsylvania (County) along the Wissahickon Creek. Ambler is part of Philadelphia's "inner-ring" suburbs, and the community boasts parks, an historic main street, and ethnically-diverse residential neighborhoods. Affordable housing and access to public transportation are two of Ambler's most important and under-utilized attributes.

Ambler was the home of Keasbey and Mattison (K&M) from 1881 until the 1960s. K&M was the largest producer of asbestos products in the world at the start of World War I and, fatefully, the Borough was proudly referred to as the "Asbestos Manufacturing Capital of the World". Unfortunately, Ambler's historical legacy also included the creation of large tracts of environmentally-impacted properties. Ambler's Borough-wide environmental conditions have long been barriers to private investment and redevelopment.

In recent years, the Redevelopment Authority of the County of Montgomery (MCRDA) has administered numerous grants which focused on providing a much-needed source of funding for the assessment and cleanup of sites in Ambler where an otherwise insurmountable funding gap existed. Grant funding has been provided through multiple sources including the U.S. Environmental Protection Agency (US EPA), the Commonwealth of Pennsylvania, and Montgomery County. These partnerships continue to stimulate development of a safer, healthier, economically stronger, and more attractive community. Despite these successes, however, challenges and barriers to redevelopment continue to be encountered in Ambler.

This presentation will provide a summary of the history of asbestos manufacturing in Ambler which led to the environmental legacy issues. Several case studies will be presented that illustrate the remediation and subsequent redevelopment successes that have been achieved at sites in Ambler using federal, state, and local grant programs as well as private investment capital. In addition, a discussion of the challenges that continue to face Ambler and upcoming redevelopment projects will be presented.

PERMIAN BASIN SAND DUNE EXPLORATION & MINING: "WHAT'S ALL THE FRAC ABOUT?"

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In 2017 & early 2018, Westward Geological Services (Westward) crews spent fourteen months in West Texas assessing the regional dune sands for suitability as use as proppant, or frac sand. Westward designed and supervised an exploration program that was comprised of over 900 borings across 173,000+ acres in Winkler, Ward, Gaines, Andrews, Dawson, Lynn, Midland & Howard Counties. As of last count, that equivocates to over 70,000 ft core drilled of which over 61,000 ft of sample was bagged in five-foot intervals and transported to laboratories in Illinois and Texas for frac sand testing. Total depths drilled ranged from 10 ft to 171 ft which were drilled in

80 ft tall dunes as well as on level ground. Although the overall thickness of the deposit varied widely across the region, physical characteristics of the sand did not. Westward was also responsible for the ecological and environmental permitting of several frac sand plants in the region. This presentation will focus on the methodology used and results obtained from this exploration effort.

DOWNSCALING USGS GROUNDWATER MODELING RESULTS TO EVALUATE RENEWABLE WATER SUPPLY OPTIONS (CASE STUDY - ELBERT COUNTY, CO.)

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Denver Basin groundwater is the principal source of water for rural domestic water users and numerous municipal water providers in the south Denver metropolitan area, primarily in Arapahoe, Douglas, El Paso and Elbert counties. A recent 2017 study conducted by Forsgren Associates Inc. (FA) and McGrane Water Engineering, LLC. (MWE) for Elbert County, CO, concluded that groundwater can meet the County's future needs for decades. This allows time to transition to alternative renewables in a thoughtful, cost-effective manner. These conclusions were based on downscaling groundwater modeling forecasts made by the U.S. Geological Survey for the Denver Basin (Paschke, 2011) to the county level. The USGS model is the best available tool for evaluating groundwater conditions in the Denver Basin, and has been underutilized as a planning tool.

MWE extracted Elbert County modeled pumping and compared it to historical use and future predictions made by FA. We focused on three study areas that have different aquifer properties, drawdown conditions, and aquifer use predictions. Predicted water levels were validated by observed water level trends.

The engineering cost comparison evaluated "status quo" groundwater pumping vs. scenarios where 10 or 25 percent of the demand in higher growth areas would be met by importing renewable water to the county. To evaluate costs, we implemented a "prototypical well" approach (URS, 2013) which uses average aquifer well depths, water demand and aquifer parameters in a cost model developed for each study area. The net present value of future costs for the three scenarios will be presented. We believe this simplified approach

is reasonable for Elbert County.

Transitioning municipal users to renewable supplies is one of the primary objectives of the Colorado Water Plan (CWCB, 2015, p.6-21). The results of this study show that continued use and careful management of Denver Basin groundwater as a primary supply can allow for reasonable, cost-effective diversification of a water portfolio with renewable water over time. Whether this diversification will occur without governmental influence in the form of policy (zoning) or funding is subject to continued debate. We believe this methodology can be scaled to apply to any pumping entity within the Denver Basin, or used in other locations which have been modeled and documented by qualified professionals.

OPTIMIZATION OF LNAPL RECOVERY FROM A SEMI-CONFINED AQUIFER: THE IMPORTANCE OF AN ACCURATE SITE CONCEPTUAL MODEL AND UNDERSTANDING LNAPL RECOVERABILITY TECHNIQUES

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Optimization of Non-Aqueous Phase Liquid (LNAPL) recovery from a semi-confined aquifer presents technical challenges due to specific stratigraphic, lithologic, and hydrogeologic factors as well as LNAPL pore-fluid saturations, LNAPL buoyancy, and recoverability of petroleum hydrocarbons. The development of an accurate Conceptual Site Model is critical to understanding the placement of recovery well locations, the effectiveness of short and long term LNAPL recoverability, and remedial system optimization. This paper presents a case study of site delineation and long term recovery of LNAPL trapped below a semi-confining unit within a Cretaceous fresh water delta in the Mid-Atlantic Area (USA). A systematic approach was developed to define stratigraphic and hydrogeologic relationships, conduct initial recoverability testing, evaluate LNAPL recoverability, and optimize LNAPL recovery by managing "recovery zone" thickness and avoiding "watering-out" a well due to over pumping.

THE CHARACTERIZATION, COMPOSITION, AND WEATHERING OF THE KASOTA STONE OF THE CATHEDRAL OF SAINT COLUMBA

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The composition and characterization of building stones can give insight into the nature of the stone's cavity structures that allow for weathering and erosion. Mankato/Kasota Stone, a calcitic dolomite, has been used as a building stone and is still quarried today. Previous characterization and composition of the building stone has been conducted by Twin City Testing, Bowles (1918), and Sledge et al. (2017), but this study is the first analysis on the Kasota stone at the St. Columba Cathedral in Youngstown, Ohio. The stone's rich cultural and geologic history is explained, and its properties are investigated. The overall clastic nature of the rock and distinct color is characterized. The composition is analyzed by X-ray diffraction (XRD), the elements are analyzed using X-ray fluorescence (XRF), and the crystal habit is examined by using the scanning electron microscope (SEM) and energy-dispersive x-ray spectroscopy (EDS) scans and mapping. The crystal growth of calcite is indicative of the environment in which the dolomite was formed. (Folk 1973). The SEM images reveal the formation of the dolomite was under a low ratio of Mg, and there is authigenic formation of potassium feldspars in the cavities. The overall elemental ratios of the stone are mapped using the SEM EDS. Another mineral was found using the SEM imaging and EDS scan that was not indicated by the XRD, yet the EDS results are inconclusive. The results of all three analyses are compared with the aforementioned analyses, and there are several similarities and differences. Last, current weathering and remediation efforts are included, and future research directions are listed.

PETROLEUM POTENTIAL AND LEASE PROPOSAL FOR THE ROCKY MOUNTAIN ARSENAL LAND, COLORADO

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Arsenal land area is 25.5 contiguous square miles (16,320 acres), located at the margin of the giant Wattenberg oil and gas field in Colorado. Due to war-time manufacturing for national defense and a significant contribution to the United States victory in WWII, the Arsenal land has been classified as a Superfund site. No human habitation is allowed on the Ar-

senal land. Current uses of the land are restricted to a wildlife preserve, public hiking and fishing, visitor center and administration buildings. Volumetric estimates of recoverable oil and gas from the Cretaceous Niobrara petroleum system, underlying Arsenal land at a depth of 7,500 - 8,000 feet, are on the order of: 170 million BOE (barrels of oil equivalent with gas) recoverable with modern drilling and production techniques, including a two-mile subsurface "reach" with drilling and production equipment. Horizontal drilling and hydraulic fracturing is a use of Arsenal land which can be compatible with current uses. Drilling and production facilities would not require surface occupancy of mineral estates outside the Arsenal. The Bureau of Land Management within the Department of the Interior controls mineral rights of Arsenal land - this proposal calls for competitive leases, in a manner consistent with BLM procedures. Dept. of Interior Order 3354 of 7/6/2017 was signed to "*...ensure that quarterly lease sales are consistently held and to identify other ways the Department of the Interior (Department) may promote the exploration and development of both Federal onshore oil and gas resources and Federal solid mineral resources.*" State land and additional Federal land is included in this Arsenal area concept; currently these lands are "stranded" from the benefits of petroleum production, due to lack of access. Opening Arsenal land to operations will enable access to stranded land. Successful operations will be defined by gainful revenue, shared royalties with agencies and numerous mineral owners, added economic activity for surrounding communities, and enhancement of wildlife habitat. Public and worker safety would be paramount in operations; monitoring and mitigation of induced seismic activity would be fundamental to prudent operations. With successful oil and gas operations across Arsenal land, the public will benefit by production and sale of a significant hydrocarbon reserve, continuing the national defense legacy of the Rocky Mountain Arsenal.

INTRAPLATE TECTONICS — A GEOPOETIC INTRODUCTION TO A NEW TECTONIC PARADIGM

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About fifty years ago, the earth sciences were undergoing a revolution, a paradigm shift, as the plate tectonic model changed from a hypothesis to a theory. In 1962, H.H. Hess published his "essay in geopoetry," "History of the Ocean Basins." By the late 1960s, increasingly numerous and diverse lines of evidence were converting Hess' geopoetry into an increasingly well-supported tectonic description of what occurred at the boundaries of tectonic plates. Moreover, plate tectonics explained a wide variety of geoscience problems

from the distribution of Gondwanan plant and animal lineages in South America, Antarctica, Africa, and India to the origin and distribution of a wide variety of ore deposits from the volcanogenic massive sulfides of Cyprus and Kidd Creek to the porphyry copper deposits of the Andes. We remember these heady times.

Plate tectonic theory is great for plate boundaries. But what about Colorado? Why are Colorado and northern New Mexico so high? The boundary of the North American plate is about 1,000 miles west. The Basin and Range province have been undergoing extensional tectonics for the past 29–30 my. The 36.7 Ma year-old Wall Mountain Tuff erupted across the beveled Rocky Mountain Surface from the vicinity of Mount Princeton to Castlewood State Park northeast of Colorado Springs. To our immediate west Pikes Peak stands at 14,115 feet above sea level and is a notable disruption in the Rocky Mountain Surface that the Wall Mountain Tuff traversed. What about the Rio Grande Rift? Where are the other two arms of this rift system? Why is the biggest historical earthquake in the United States at New Madrid, MO? Articles are beginning to appear that report on more complex motions within the mantle and on other topics addressing issues of intraplate tectonics. We suggest that we are in the early stages of another tectonic revolution, one that will explain what goes on in the middle of tectonic plates.

EXPLORATION AND CHARACTERIZATION OF THE GIBELLINI VANADIUM DEPOSIT, EUREKA COUNTY, NEVADA

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The Gibellini Vanadium deposit is located near the southern end of the Fish Creek Range in southern Eureka County. It is located approximately 25 miles south of the town of Eureka and just three miles north of the Nye county line. It is in the northern half of the Cockalorum Hills quadrangle. The vanadium deposit occurs within the Devonian Woodruff Formation; a deep marine siltstone that also contains chert and carbonaceous intervals. The Woodruff Formation at this locality is an allocthonous body situated on top of the underlying clay-rich Webb Formation. The Gibellini deposit itself is densely fractured throughout and occurs as a stacked sequence of imbricate thrusts that verge eastward. The vanadium occurs as vanadium pentoxide (V2O5) in liesegang banding which occurs throughout the deposit and originated three-dimensionally from joint, fracture and bedding surfaces throughout the deposit. Kinematic indicators documented in the field would seem to indicate that the injection of vanadium-rich fluids was contemporaneous with the eastward-directed thrusting of the Woodruff Formation.

OVERVIEW AND COMPARISON OF LARGE-SCALE WATER PROJECTS IN THE AMERICAN WEST

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There are many high-profile water infrastructure projects that have been proposed to deliver water to different communities throughout the West. These proposed projects are controversial and not all of them are sustainable. This presentation will provide an overview of a select few that have been gaining more attention as they slowly move forward through the regulatory review and financing processes. Two of the projects to be presented here are in California; the proposed Delta Bypass Tunnels for the Sacramento and San Joaquin Rivers, and the Cadiz water supply project proposed for the southern deserts of San Bernardino County. Another proposed water delivery project to be presented is the Las Vegas Moapa project, which will deliver water to the Las Vegas metropolitan area from the Moapa area located more than a hundred miles north, near the Utah state line. This presentation will also include another proposed water supply project which is in southern Utah and includes a controversial diversion from the Virgin River to growing populations along the I-15 corridor. Lastly, two controversial water supply projects from New Mexico will be presented. The first involves the pipeline delivery of water from Catron County to the growing population of Rio Rancho, an Albuquerque suburb. The second involves a diversion of water from Ute Reservoir, located on the Canadian River in eastern New Mexico. From a lift station and pipeline, it is proposed that water will be delivered to the town of Clovis, located close to the Texas state line. Clovis has been adversely and steadily impacted by the water-level declines in the Ogallala Aquifer (aka the High Plains Aquifer) and the need for new municipal supplies is paramount.

AQUIFER STORAGE AND RECOVERY — HOW IS IT REGULATED IN COLORADO?

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Water users in Colorado have recharged groundwater aquifers with surface-water sources for decades. Most of the recharge is implemented in shallow alluvial aquifers to mitigate stream depletion due to well pumping and prevent potential injury to senior water rights holders. In this process, during times of "free river" surface water is captured and diverted

into recharge structures on the alluvial aquifer at some distance from a stream. Water then migrates to the stream in a timeframe to mitigate depletions caused by well pumping. This process implements short-term, seasonal to multi-year alluvial aquifer storage and eventual discharge to the adjacent stream. The lower South Platte River Basin and the San Luis Valley are the primary areas where this type of recharge is prevalent. These stream augmentation plans operate under statutes 37-92-302, -308, and -501.5. C.R.S., are approved through Colorado Water Court, and are administered by the State Engineer.

Longer-term aquifer storage and recovery (ASR) has also taken place for decades within the Denver Basin aquifer system, for which legislation and rules governing ASR were promulgated and took effect in 1995. Recently, there is renewed interest in implementing ASR projects in aquifers outside the Denver Basin. These include the designated groundwater basins and other nontributary aquifers near the Front Range urban corridor. In response, the Colorado legislature passed House Bill 17-1076 amending 37-90-137(9)(d), C.R.S., which directs the Colorado Division of Water Resources to promulgate rules governing the permitting and use (recovery) of recharged water for nontributary aquifers outside the Denver Basin. This was done by amending and expanding the existing Denver Basin Extraction Rules (2 CCR 402-11) to include nontributary aquifers throughout the state. In addition, new Designated Basin Rules (2 CCR 410-1) are being promulgated to appropriately govern ASR in the seven designated groundwater basins located in eastern Colorado. The results of these efforts will expand the allowable areas and aquifers for implementation of long-term ASR projects and clarify the regulatory environment in Colorado.

GENESIS OF GOLD BEARING QUARTZ IN THE USAK, ESMETAS, TURKEY

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The study area is located between Güney and Balabancı villages of Eşme district of Usak province named as the Menderes Massif are consists of rocks formed under different metamorphic facies conditions in Western Anatolia region of Turkey.

Gold mineralization is observed in the quartz veins with larger crystalline and epithermal structures that cut through the metamorphic rocks are usually found in brecciated zones (hydrothermal breccia, tectonic breccia). The gold mineralization, in the form of scattered, stockwork, filled with and fracture-faults in the quartz veins and silicified metamorphic rocks.

Gold-bearing quartz veins and quartz zones in the metamorphic host rock which are parallel to the foliation planes of the metamorphic rocks, contains of some fluid inclusion assemblages, (FIAs) with high temperature, carbon dioxide and high salinity liquid inclusions indicating metamorphic water. Some gold mineralization is visible in the epithermal-hydrothermal quartz and the gold mineralization are composite of mercury, platinum group minerals and silver composite.

The gold mineralization in this study, is formed under the metamorphism conditions that formed during the Alpine oregenesis and hydrothermal-epithermal conditions after the alpine orogeny. The gold mineralization values are 3 ppm on average in quartz veins and silicified metamorphic.

RECOLLECTING THE JUNE 9, 1972 CATASTROPHIC FLOOD IN RAPID CITY, SOUTH DAKOTA

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The author, then a 26-year-old SDSM&T graduate student from New England, recalls the evening preceding the flood and shares some personal pre-flood and post-flood observations. The evening of June 9, 1972, was sultry, the local weather reports were predicting heavy rain, an SDSM&T meteorologist (the author cannot recall his name) was warning of potentially catastrophic rainfall. Consequently, the author decided to cancel a planned weekend camping trip into one of the nearby box canyons, which had a typically alluring Black Hills creek flowing through it.

The author lived in a travel trailer at a park located near Rapid Creek. In 1972 there were three television stations broadcasting in the Rapid City area. These ended daily broadcasts no later than 10 pm. Mayor Don Barnett did go on the air the evening of June 9, but after many had gone to bed. Some simply did not hear his urgent message.

There was an onset of incessant, drumming rain between 5 and 6 pm. At some point in the early hours of the morning, the rain fell so heavily that (although not likely) there was a momentary concern that the intensity of the impacting water would cause the collapse of the travel trailer in which he and his wife were living. Fitful sleep for the entire night was followed by a deathly stillness at 5 am, June 10th. The atmosphere was eerily quiet and dense with fog, none of the usual birdsong was evident, and conspicuous by its absence was the sound of traffic.

The author went out to drive around Rapid City to survey the certain flooding. He climbed into his VW bug, heard a Civil

Defense announcement repeating on the car radio, and went out to see the rapid response of government and private agencies and volunteers mobilizing to address devastation, death, looting, and loss.

KEYS TO OPTIMIZING CHEMICAL BASED REMEDIATION

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In recent years, soil and groundwater remediation efforts have been greatly enhanced through the application of in-situ/ex-situ chemical-based treatment methods involving oxidation-reduction reactions (ISCO and ISCR) often combined with bioremedial approaches. During chemical oxidation (ISCO) electrons are removed from the contaminant species usually with the insertion of oxygen in molecular bonds. ISCO is effective on a variety of carbon-based compounds including fuel based hydrocarbons, chlorinated hydrocarbons, pesticides, herbicides, PCBs, and even non-aqueous phase liquids (NAPLs). Chemical reduction (ISCR) involves the addition of electrons to a contaminant species resulting in its transformation to less harmful chemical substances or by-products. ISCR is commonly used in the treatment of chlorinated hydrocarbons, metals, explosives, as well as highly oxidized chemical species that may be difficult to treat with ISCO. Both treatment processes may be combined or followed by enhanced bioremediation relying on longer-term aerobic or anaerobic microbial populations. Chemical oxidation/reduction/enhanced bioremediation can be applied via injection, in-situ/ex-situ soil blending, or as permeable reactive barriers (PRBs). Successful treatments start with a good conceptual treatment model, realistic estimate of contaminant mass, selection of suitable chemistry and process, and implementation of a performance monitoring plan. This talk explores the proper selection and application of these technologies with example case studies provided.

MICROTEXTURAL CHARACTERISTICS OF COLLOFORM-BANDED EPITHERMAL VEINS FROM THE BUCKSKIN NATIONAL GOLD-SILVER DEPOSIT, NORTHERN NEVADA

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This study is focused on colloform-banded textures of the high-grade gold-silver epithermal veins collected from the dumps of the Buckskin National deposit in northern Nevada. On the hand specimens, they exhibit multiple colors including white, gray, black, and/or yellow, asymmetric, botryoidal, and mammillary-like structures ranging from 1 to 5 mm in thickness. Moss-like grains, which appear in two-dimensional spheroidal shapes within colloform bands, perfectly represent individual circular-rounded shapes ranging from 0.1 to 0.2 mm in diameter. Microscopically, some colloform layers contain small-grained precious metal minerals associated with silica minerals. Cloudy zones are found within most of colloform bands. The moss-like grains typically show radiating and concentric structures. Using a high-magnification microscope, the cloudy zones found in colloform bands clearly indicate cavities among tiny silica spheres that show various shapes depended on types of aggregates such as crescent-like, needle-like, and rectangular. The radiating and concentric structures of moss-like grains are similarly formed by silica spheres that aggregate as chain-like structures and form in two different ways. Silica spheres are commonly 1-5 μm in diameter, which are similar to sizes of amorphous-silica spheres that formed silica sinters in the geothermal plant. Under the cross-polarized light, these colloform bands mostly consist of various-sized microcrystalline quartz and fibrous chalcedony due to (re)crystallization of amorphous silica to quartz. The observation and results of this study suggest that the colloform-banded veins from the Buckskin National mine are evidently formed by silica sphere aggregates that were likely precipitated as silica colloids to form amorphous silica. Colloform quartz and fibrous chalcedony are the best results of (re) crystallization that still contain evidences of amorphous-silica precursors.

SOIL MECHANICS: FORENSIC GEOLOGICAL AND ENGINEERING ASPECTS OF PROBLEMATIC SOIL CONDITIONS

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Problematic soil conditions include soils that cause additional problems from the geological and geotechnical engineering perspective in relation to its effects on the stability of structures. The definition of soil mechanics is the study of the physical properties of soil, especially those properties that affect the behavior of soils on their ability to bear weight, including such things as mineralogy, water content, density, strength, depositional environments, etc. Well-defined forensic problematic soils studies include teams of geologists and engineers.

Awareness of problematic soils during the design process should result in an engineering design that conditions the site prior to the development of the structure. However, when structures are constructed on problematic soils and/or constructed with problematic soils without proper advanced design and treatment, a team of forensic geologists and engineers are required to adequately evaluate the forensic cause of distress that may develop in the structure. There are many reasons other than problematic soils that can cause distress to structures, and these other features must be included in the final forensic evaluation of the cause of the distress and how they relate to any underlying problematic soils.

A partial list of the most common types of problematic soils that cause distress in structures include: Soil conditions caused by Sinkholes (Limestone/dolomite, Salts, Man-made e.g. mines); Shrink-Swell Clays; Collapsible soils; Peat/Organics; Very loose sands/Very soft clays; Buried debris within soils; and other Miscellaneous soils.

The Doctrine of Uniformitarianism by James Hutton has been paraphrased as *The Present is the key to the Past*. This is an important key in understanding the areas where different types of some problematic soils may be encountered, relating the uniqueness of Geology to Geography for problematic soils development.

Geologic Maps are one of the key readily available sources of research information that provide geographic information related to the distribution of potential problematic soils areas. Many states provide state-specific maps with geologic/geographic distribution of problematic soils information that has been, or can be used, to assist in better targeting specific

types of forensic problematic soils. The United States Department of Agriculture's Natural Resource Conservation Service provides some general shallow soils information, however, no site-specific soils testing is included. These tools can be useful as research information in an evaluation, but cannot be relied upon to confirm or deny the presence of site-specific problematic soils. Therefore, field sampling and/or laboratory testing can be used to verify that the structure distress are related to problematic soils.

If problematic soils are indicated as the source of distress to the structures, remediation and stabilization methods are available. The methods of remediation used to stabilize a structure vary greatly depending on factors such as the types and depth of the problematic soils and other factors causing the distress, the type and size of the structure, the building materials used to construct the structure, types of foundations and other design and logistical parameters.

Thank You for Attending!!

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