

# **35th Oil Shale Symposium 2015**

Salt Lake City, Utah, USA  
5-8 October 2015

ISBN: 978-1-5108-3065-3

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2015) by Colorado School of Mines  
All rights reserved.

Printed by Curran Associates, Inc. (2016)

For permission requests, please contact Colorado School of Mines  
at the address below.

Colorado School of Mines  
1500 Illinois St.  
Golden, CO 80401  
USA

Phone: 303-273-3000 or 800-446-9488

[www.mines.edu](http://www.mines.edu)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## **SESSION 1: OPENING PLENARY**

|                                                                               |           |
|-------------------------------------------------------------------------------|-----------|
| <b>WELCOME TO THE 35TH OIL SHALE SYMPOSIUM.....</b>                           | <b>1</b>  |
| <i>Jeremy Boak, James H. Gary</i>                                             |           |
| <b>UTAH SCHOOL AND INSTITUTIONAL TRUST LANDS ADMINISTRATION (SITLA) .....</b> | <b>7</b>  |
| <i>John Andrews</i>                                                           |           |
| <b>OIL SHALE: TREASURE TROVE OR PANDORA’S BOX?.....</b>                       | <b>11</b> |
| <i>Ron Stites, Lee Yuan Ming, Matthew James</i>                               |           |
| <b>LT. GOVERNOR’S WELCOME TO UTAH .....</b>                                   | <b>19</b> |
| <i>Spencer Cox</i>                                                            |           |

## **SESSION 2: IN SITU PROCESSING**

|                                                                                                                                                                                                             |           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>ECONOMIC ANALYSIS OF IN SITU OIL SHALE DEVELOPMENT IN THE UINTA BASIN .....</b>                                                                                                                          | <b>20</b> |
| <i>J. Wilkey, M. Hradisky, J. Spinti, P. J. Smith, T. Ring, K. Kelly</i>                                                                                                                                    |           |
| <b>QUALIFICATION OF HIGH-POWER-DENSITY MINERAL-INSULATED ELECTRIC HEATER CABLES .....</b>                                                                                                                   | <b>30</b> |
| <i>A. Burnham, C. Sandberg, K. Thomas, V. Reiling, J. Faull, L. Bourgeois, J. Huffman, L. Switzer</i>                                                                                                       |           |
| <b>SURFACE QUALIFICATION SYSTEM FOR DOWNHOLE HEATERS .....</b>                                                                                                                                              | <b>38</b> |
| <i>J. Faull, R Lafollette, A. Papineau, V. Reiling, L. Switzer, V. Saubestre</i>                                                                                                                            |           |
| <b>GEO THERMIC FUEL CELLS FOR IN-SITU OIL SHALE PROCESSING .....</b>                                                                                                                                        | <b>48</b> |
| <i>Neal P. Sullivan, Buddy Haun, Mark Daubenspeck, Gladys Anyenya, Robert J. Braun, Joseph V. Bonadies, Bernhard Fischer, Adam Wright, Gerald Jones, Robert Li, Mark Wall, Alan Forbes, Marshall Savage</i> |           |

## **SESSION 3: MODELING**

|                                                                                                                  |           |
|------------------------------------------------------------------------------------------------------------------|-----------|
| <b>A THERMOPLASTICITY MODEL FOR OIL SHALE.....</b>                                                               | <b>55</b> |
| <i>Shabnam Semnani, Joshua White, David Camp, Alan Burnham</i>                                                   |           |
| <b>EFFECTS OF POROUS MEDIA CHARACTERISTICS ON HEAT TRANSFER MECHANISMS IN POROUS OIL SHALE BEDS .....</b>        | <b>67</b> |
| <i>Tom Plikas, Umesh Shah, Wayde Johnson, Jianping Zhang</i>                                                     |           |
| <b>RELATIONSHIP BETWEEN PARTICLE SIZE DISTRIBUTION (PSD) AND VOID FRACTION IN RUBBLIZED OIL SHALE BEDS .....</b> | <b>76</b> |
| <i>James W. Bunger, James W. Patten</i>                                                                          |           |

## **SESSION 4: SURFACE PROCESSING**

|                                                                                                                                                           |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>THE CHESS PROCESS: ENVIRONMENT FRIENDLY, LOW-COST SHALE OIL RECOVERY .....</b>                                                                         | <b>86</b>  |
| <i>Thomas H. Fletcher, Carlos Adams</i>                                                                                                                   |            |
| <b>DESIGN, CONSTRUCTION, PROCESS AND PRODUCTION EFFICIENCY IMPLICATIONS OF SHALE BED VOID FRACTION FOR THE RED LEAF RESOURCES ECOSHALE® PROCESS .....</b> | <b>98</b>  |
| <i>James W. Patten, James Bunger, Samuel Lethier, Hamid Ghorbani, Majid Maleki</i>                                                                        |            |
| <b>UMATAC INDUSTRIAL PROCESSES FUSHUN ATP PROJECT UPDATE &amp; VALUE ADDED PROCESSING .....</b>                                                           | <b>108</b> |
| <i>N/A</i>                                                                                                                                                |            |
| <b>OPTIMIZING REACTOR PARAMETERS IN AN EX-SITU OIL SHALE REACTOR .....</b>                                                                                | <b>116</b> |
| <i>Anand Alembath, Hassan Golpour, Joseph D. Smith</i>                                                                                                    |            |

## **SESSION 5: CHEMISTRY & GEOCHEMISTRY**

|                                                                 |            |
|-----------------------------------------------------------------|------------|
| <b>OCCURRENCE OF RARE EARTHS IN GREEN RIVER OIL SHALE .....</b> | <b>123</b> |
| <i>Alan K. Burnham, Jeremy Boak</i>                             |            |

|                                                                                                                                   |            |
|-----------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>COMPARISON OF MINERAL OCCURRENCES IN THE PICEANCE AND UINTA BASINS OF THE EOCENE GREEN RIVER FORMATION .....</b>               | <b>130</b> |
| <i>Justin E. Birdwell, Ronald C. Johnson, Tracey J. Mercier, Michael E. Brownfield</i>                                            |            |
| <b>MULTISCALE CHARACTERIZATION OF GEOLOGIC PROPERTIES OF GREEN RIVER OIL SHALE .....</b>                                          | <b>147</b> |
| <i>Y. Mehmani, A. K. Burnham, M. D. Vanden Berg, H. Tchelepi</i>                                                                  |            |
| <b>USING <sup>13</sup>C NMR CHEMICAL STRUCTURE DATA TO MODEL OIL SHALE PYROLYSIS FOR GREEN RIVER AND ESTONIAN OIL SHALE .....</b> | <b>160</b> |
| <i>Thomas H. Fletcher, Ronald J. Pugmire</i>                                                                                      |            |

## **SESSION 6: INTERNATIONAL UPDATES 1**

|                                                                                        |            |
|----------------------------------------------------------------------------------------|------------|
| <b>IRATI ENERGY DEVELOPMENT OF THE OIL SHALE RESOURCES NEAR CURITIBA, BRAZIL .....</b> | <b>179</b> |
| <i>Karen Payrazyan</i>                                                                 |            |
| <b>JORDAN 2015 UPDATE - SHELL INTERNATIONAL EXPLORATION &amp; PRODUCTION INC. ....</b> | <b>180</b> |
| <i>Mariela Araujo, Jack Emmen, Tom Fowler, Thomas Meijssen</i>                         |            |
| <b>JORDAN'S OIL SHALE DEVELOPMENT PROJECTS: CURRENT STATUS &amp; WAY FORWARD .....</b> | <b>189</b> |
| <i>Hazem Al-Ramini</i>                                                                 |            |
| <b>LICENSING ECOSHALE® TECHNOLOGY .....</b>                                            | <b>190</b> |
| <i>Alex Bocock</i>                                                                     |            |
| <b>BURIED HEATING PIPE DESIGN FOR ECOSHALE PROCESS .....</b>                           | <b>195</b> |
| <i>H. Ghorbani, M. Al-Dojayli, M. Maleki, K. Johns, J. Patten</i>                      |            |

## **SESSION 7: GEOLOGY & STRATIGRAPHY**

|                                                                                                                                      |            |
|--------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>HYDROLOGIC CHARACTERIZATION OF THE SOUTHEASTERN EXTENT OF THE BIRDS-NEST AQUIFER, UINTAH COUNTY, UTAH .....</b>                   | <b>205</b> |
| <i>Ryan Clerico</i>                                                                                                                  |            |
| <b>EVOLUTION OF THE LOWER TERTIARY ELKO LAKE BASIN, A POTENTIAL HYDROCARBON SOURCE ROCK IN NORTHEAST NEVADA .....</b>                | <b>219</b> |
| <i>Ronald C. Johnson, Justin E. Birdwell</i>                                                                                         |            |
| <b>SEDIMENTOLOGY AND STRATIGRAPHY OF THE DOUGLAS CREEK MEMBER IN THE GREEN RIVER FORMATION, MAIN CANYON, UINTA BASIN, UTAH .....</b> | <b>245</b> |
| <i>Ryan D. Gall, Lauren Birgenheier</i>                                                                                              |            |

## **SESSION 8: RESOURCE & ENVIRONMENT EVALUATION**

|                                                                                                                                        |            |
|----------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>ANALYSIS OF RETORTED WATER PRODUCED FROM PARTIAL COMBUSTION OF SULTANI OIL SHALE .....</b>                                          | <b>260</b> |
| <i>Omar Al-Ayed, Surah Al-Harashsheh, M. Amer, M. Moutq</i>                                                                            |            |
| <b>MULE DEER AND ELK HABITAT IMPROVEMENT RESEARCH PROGRAM AT RED LEAF RESOURCES SEEP RIDGE SITE .....</b>                              | <b>269</b> |
| <i>Miles Hanberg, James Patten</i>                                                                                                     |            |
| <b>SOME POTENTIAL LONG-TERM EFFECTS OF OIL AND GAS DEVELOPMENT ON WATER AND OIL SHALE .....</b>                                        | <b>292</b> |
| <i>Glen Miller</i>                                                                                                                     |            |
| <b>A NEW PROJECT IN TURKEY: HASANLAR (BOLU, WESTERN ANATOLIA) BITUMINOUS SHALE DEPOSIT AND ITS SYNTHETIC CRUDE OIL POTENTIAL .....</b> | <b>293</b> |
| <i>Ilker Senguler, Abdurrahman Murat, Ferudun Alp Ugur, Murat Yukunc</i>                                                               |            |

## **SESSION 9: PYROLYSIS**

|                                                                                                         |            |
|---------------------------------------------------------------------------------------------------------|------------|
| <b>A SIMPLE KINETIC MODEL OF OIL GENERATION, VAPORIZATION, AND DEGRADATION .....</b>                    | <b>294</b> |
| <i>Alan K. Burnham</i>                                                                                  |            |
| <b>VISUALIZATION OF POROSITY EVOLUTION OF OIL-SHALE PYROLYSIS USING X-RAY COMPUTED TOMOGRAPHY .....</b> | <b>302</b> |
| <i>Guenther Glatz, Louis Castanier, Anthony R. Kovalick</i>                                             |            |

|                                                                                                                                                                                |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>DIRECT CONVECTIVE HEATING WITH RECYCLED PYROLYSIS GASSES IN THE ECOSHALE PROCESS AND POTENTIAL IMPLICATIONS FOR DESIGN, CONSTRUCTION, AND PRODUCTION EFFICIENCIES .....</b> | <b>303</b> |
| <i>Eric Chabal, James Patten</i>                                                                                                                                               |            |
| <b>EXPERIMENTAL APPARATUS FOR INVESTIGATION OF DIRECT CONVECTIVE HEATING WITH RECYCLED PYROLYSIS GASSES.....</b>                                                               | <b>304</b> |
| <i>Jerry Wisner, James Patten, James W. Bunger</i>                                                                                                                             |            |

## **SESSION 10: PANEL DISCUSSIONS**

|                                                                                                             |            |
|-------------------------------------------------------------------------------------------------------------|------------|
| <b>REGULATORY FRAMEWORK FOR OIL SHALE DEVELOPMENT - CHALLENGES AND OPPORTUNITIES .....</b>                  | <b>314</b> |
| <i>Selma Sierra, Kent Hoffman, Denise Dragoo, John Baza</i>                                                 |            |
| <b>OIL SHALE PERMITTING AND DEVELOPMENT ON STATE AND PRIVATE LANDS IN UTAH.....</b>                         | <b>317</b> |
| <i>Denise Dragoo</i>                                                                                        |            |
| <b>OIL SHALE PERMITTING - OIL SHALE SYMPOSIUM.....</b>                                                      | <b>324</b> |
| <i>John Baza</i>                                                                                            |            |
| <b>OIL SHALE LEASING AND DEVELOPMENT ON PUBLIC LANDS ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT.....</b> | <b>329</b> |
| <i>Kent Hoffman</i>                                                                                         |            |
| <b>35<sup>th</sup> OIL SHALE SYMPOSIUM .....</b>                                                            | <b>333</b> |
| <i>N/A</i>                                                                                                  |            |
| <b>COLORADO SCHOOL OF MINES 35<sup>th</sup> OIL SHALE SYMPOSIUM.....</b>                                    | <b>346</b> |
| <i>Tom Faddies</i>                                                                                          |            |
| <b>35<sup>th</sup> OIL SHALE SYMPOSIUM: GLADSTONE NEW FUELS PROJECT UPDATE OF STATUS AND PROGRESS .....</b> | <b>348</b> |
| <i>John Parsons</i>                                                                                         |            |

## **SESSION 11: INTERNATIONAL UPDATES 2**

|                                                                                                          |            |
|----------------------------------------------------------------------------------------------------------|------------|
| <b>START-UP AND OPERATING EXPERIENCE OF THE 3 PETROTER OIL SHALE PROCESSING PLANTS IN 2010-2015.....</b> | <b>357</b> |
| <i>Jaanus Purga</i>                                                                                      |            |
| <b>NEW DEVELOPMENTS IN CHINESE OIL SHALE ACTIVITIES .....</b>                                            | <b>358</b> |
| <i>Yue Ma, Shuyuan Li</i>                                                                                |            |
| <b>STATUS UPDATE OF ENEFIT280 PLANT OPERATION.....</b>                                                   | <b>373</b> |
| <i>Indrek Aarna</i>                                                                                      |            |

## **SESSION 12: CLOSING PLENARY AND U.S. UPDATES**

|                                                                                                                             |            |
|-----------------------------------------------------------------------------------------------------------------------------|------------|
| <b>ENEFIT AMERICAN OIL: A PROVEN, EFFICIENT AND ENVIRONMENTALLY SOUND MEANS TO HELP UTAH BECOME ENERGY INDEPENDENT.....</b> | <b>381</b> |
| <i>N/A</i>                                                                                                                  |            |
| <b>RED LEAF: OIL SHALE SIMPOSIUM.....</b>                                                                                   | <b>389</b> |
| <i>Alex Bocock, Adolph Lechtenberger</i>                                                                                    |            |
| <b>THE OIL SHALE INDUSTRY'S FORTUNES IN AN ERA OF DRAMATIC AND PUZZLING! – CHANGE .....</b>                                 | <b>396</b> |
| <i>Patty Limerick</i>                                                                                                       |            |
| <b>STATUS OF THE OIL SHALE INDUSTRY IN 2015 AND CLOSING REMARKS .....</b>                                                   | <b>397</b> |
| <i>Jeremy Boak</i>                                                                                                          |            |

## **SESSION 13: POSTERS**

|                                                                                                                         |            |
|-------------------------------------------------------------------------------------------------------------------------|------------|
| <b>AN OVERVIEW OF THE COLD EXTRACTION METHOD APPLIED TO JORDAN OIL SHALE .....</b>                                      | <b>398</b> |
| <i>Musa Resheidat</i>                                                                                                   |            |
| <b>EFFECT OF OIL SHALE ALKYL RESORCINOLS ON PHYSICO-CHEMICAL AND THERMAL PROPERTIES OF POLYCONDENSATION RESINS.....</b> | <b>399</b> |
| <i>Ana Jurkeviciute, Larisa Grigorieva, Ksenia Moskvina</i>                                                             |            |

|                                                                                                                                                                                                                                                                |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>DETAILED CHARACTERIZATION OF LAMINATED OIL SHALE AND SOURCE ROCKS<br/>USING LASER-INDUCED BREAKDOWN SPECTROSCOPY AND INFRARED MICROSCOPY .....</b>                                                                                                          | <b>400</b> |
| <i>Kathryn Washburn, Justin Birdwell</i>                                                                                                                                                                                                                       |            |
| <b>EXPERIMENTAL AND NUMERICAL INVESTIGATION OF DYES ADSORPTION ON SHALE<br/>OIL ASH .....</b>                                                                                                                                                                  | <b>401</b> |
| <i>Mohammad Al-Shannag, Khalid Bani-Melhem, Zakaria Al-Qodah</i>                                                                                                                                                                                               |            |
| <b>RESEARCH AND APPLICATION OF TECHNOLOGY TO IMPROVE THE PERMEABILITY OF<br/>MAOMING OIL SHALE IN CHINA.....</b>                                                                                                                                               | <b>402</b> |
| <i>Qiulian Long, Yuanping Gao, Jianzheng Su, Bue Wang, Jiayuan He</i>                                                                                                                                                                                          |            |
| <b>STUDY ON NUMERICAL SIMULATION OF IN-SITU PROCESSING OF MAOMING<br/>OIL SHALE .....</b>                                                                                                                                                                      | <b>415</b> |
| <i>Jianzheng Su, Youping Wang, Yiwei Wang, Xianglong Meng, Bue Wang</i>                                                                                                                                                                                        |            |
| <b>FINITE ELEMENT ANALYSIS OF CRYOGENIC LIQUID TEMPERATURE AND FLOW RATE<br/>ON THE UNDERGROUND TEMPERATURE FIELD .....</b>                                                                                                                                    | <b>426</b> |
| <i>Huanan Liu, Dajun Zhao, Wei Guo, Chen Chen, Qiang Li, Mingyi Guo</i>                                                                                                                                                                                        |            |
| <b>STUDY OF PYROLYSIS TECHNOLOGY OF NONG'AN OIL SHALE IN-SITU PROCESS AND<br/>THE NUMERICAL SIMULATION.....</b>                                                                                                                                                | <b>427</b> |
| <i>Pengfei Jiang, Youhong Sun, Wei Guo, Qiang Li, Sunhua Deng</i>                                                                                                                                                                                              |            |
| <b>CHARACTERIZATION OF OIL SHALE FRACTURE BEFORE AND AFTER PYROLYSIS<br/>USING X-RAY MICRO CT .....</b>                                                                                                                                                        | <b>428</b> |
| <i>Huaqing Xue, Bo Xiong, Shangwen Zhou, Gang Yan, Wei Guo</i>                                                                                                                                                                                                 |            |
| <b>CHARACTERIZATION OF TYPE I SOURCE ROCK BY PORE-SCALE SIMULATIONS.....</b>                                                                                                                                                                                   | <b>429</b> |
| <i>Cyprien Soullaine, Alexandre Lapene, Yifan Wang, Nicola Castelletto, Hamdi Tchelepi</i>                                                                                                                                                                     |            |
| <b>GEOPHYSICAL ALTERATIONS AND GROUNDWATER FLOW IMPLICATIONS OF IN SITU<br/>AND EX SITU CONVERSION OF OIL SHALE IN THE PICEANCE BASIN, COLORADO, WITH<br/>APPLICATIONS FOR OTHER OIL SHALE BASINS VIA GROUNDWATER AND 3D<br/>GEOLOGIC COMPUTER MODELS.....</b> | <b>430</b> |
| <i>Paul G Quinn, Jillian L Goldfarb, Ami Vyas</i>                                                                                                                                                                                                              |            |
| <b>ASPECTS OF GROUNDWATER FLOW AND 3D GEOLOGIC MODELS IN THE TARFAYA<br/>BASIN, MORROCO .....</b>                                                                                                                                                              | <b>431</b> |
| <i>Paul G Quinn, Zouhair Taleb</i>                                                                                                                                                                                                                             |            |
| <b>ASPECTS OF GROUNDWATER FLOW AND 3D GEOLOGIC MODELS IN THE OIL SHALE<br/>BASINS, JORDAN .....</b>                                                                                                                                                            | <b>432</b> |
| <i>Paul G. Quinn, Omar Al-Ayed</i>                                                                                                                                                                                                                             |            |
| <b>THE CHANGE OF THE PERMEABILITY OF OIL SHALE DURING THE EXTRACTION BY<br/>SUB-CRITICAL WATER.....</b>                                                                                                                                                        | <b>433</b> |
| <i>Li He, Sunhua Deng, Youhong Sun, Wei Guo</i>                                                                                                                                                                                                                |            |
| <b>EFFECT OF ORIGINAL MINERALS ON THE PYROLYSIS OF OIL SHALE KEROGEN .....</b>                                                                                                                                                                                 | <b>434</b> |
| <i>Jian Shi</i>                                                                                                                                                                                                                                                |            |
| <b>RECOVERY OF OIL AND GAS FROM OIL SHALE THROUGH IN SITU PYROLYSIS USING<br/>RADIO FREQUENCY HEATING .....</b>                                                                                                                                                | <b>435</b> |
| <i>Preston Grounds, Jack Young, Robert Gardner</i>                                                                                                                                                                                                             |            |
| <b>PORE-SCALE X-RAY MICRO-CT IMAGING AND ANALYSIS OF OIL SHALES .....</b>                                                                                                                                                                                      | <b>436</b> |
| <i>Tarik Saif, Kamaljit Singh, Branko Bijeljic, Martin Blunt</i>                                                                                                                                                                                               |            |
| <b>Author Index</b>                                                                                                                                                                                                                                            |            |