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EDITOR'S PAGE

HIGHLIGHTS OF THE 28th OIL SHALE SYMPOSIUM

Introduction

The 28th Oil Shale Symposium was held on the campus of the Colorado School of Mines (CSM) in Golden Colorado, October 13–15, 2008. Three hundred forty delegates from sixteen countries and twenty-five states within the United States attended two opening plenary sessions, sixteen technical sessions, and one poster session covering all aspects of oil shale development. In addition, forty delegates toured the Piceance Basin and visited Shell and ExxonMobil oil shale sites on a field trip to western Colorado October 16–17, 2008.

Plenary Session – U. S. and Global Programs

The opening plenary sessions on Monday focused mainly on issues surrounding development of oil shale in the United States. Myles W. Scoggins, President of the Colorado School of Mines welcomed delegates and introduced the keynote speaker as well as a representative of the state of Colorado, and of the U. S. Department of the Interior. He also announced the creation of a new research center for oil shale, the Center for Oil Shale Technology and Research (COSTAR), headquartered at CSM and sponsored by Total, Shell, and ExxonMobil.

The keynote address, by Governor Jon Huntsman of Utah, was exceptionally well received by nearly everyone present. Highlighting the 77 billion barrels of recoverable shale oil in Utah, Huntsman called on the U. S. Interior Department to move forward with issuing commercial leasing regulations before a new presidential administration takes over in January. "We have an energy demand that we are unable to meet at this point in time. We need to be working on all fuel energy in order to try to make up that deficit," he said. "My bottom line to you is, we in our state are open for business" for oil shale development, Huntsman told the audience.

The contrast was strong with the succeeding speaker, Harris Sherman, the Executive Director of Colorado's Department of Natural Resources, who reiterated Colorado Governor Bill Ritter's publicly expressed concern that the Bush administration has moved too quickly toward commercial oil shale

development, drafting rules for leasing before companies have determined the technology they will use to produce oil from oil shale. Sherman said the rapid move undercuts the ability of state and local government to determine the potential impacts on water availability and quality, on air quality, and on wildlife, tourism, and recreation in Northwest Colorado. The infrastructure demands for oil shale production would be added on top of requirements of the current gas development boom. Department of Interior Deputy Assistant for Land and Minerals, Foster Wade, described the process underway to develop and implement rules for leasing oil shale land. He pointed out that two more levels of environmental review will still be needed before commercial leasing could occur. He suggested that industry needed a clear view of the leasing regulations to proceed with very capital intensive production.

Terry O'Connor, vice president of external and regulatory affairs for Shell, said there is no risk to the government in establishing regulations, "because they don't authorize anything. All they do is set out rules of the road." Shell has three federal research, demonstration and development leases in Rio Blanco County, Colorado. He pointed out that once an oil shale lease is granted, a company must still clear 47 county, state and Federal permitting agencies' review to operate the lease, and that water rights reside with the states, not with the Federal government. Pierre Allix summarized the global program of Total in unconventional oil resources, including oil shale. Total is actively pursuing a variety of heavy oil properties around the world, and is engaged in research and development with partner Petrobras (and the national governments) to evaluate the potential of surface processing of oil shale in the Timahdit and Tarfaya areas in Morocco and the Wadi Maghar area of Jordan. In addition, it has signed an agreement with Independent Energy Partners to test their Geothermal Fuel Cells® system for *in-situ* production of shale oil.

Tony Dammer of Ecoshale and Mike Hagood of the Idaho National Laboratory reviewed a proposal for a Western Energy Corridor Initiative, which seeks to apply objective science and engineering analysis to answer key questions about unconventional fuels' development in the Western Energy Corridor. The Corridor, encompassing states and provinces of the Rocky Mountains and western Great Plains, contains large conventional and unconventional fossil energy resources, including oil shale, complemented by significant renewable resources and energy infrastructure. Development of these resources will require integrated stewardship of diverse energy resources, infrastructure, and environmental assets. The U. S. DOE and national laboratories are building a bi-national regional network to support the initiative. Laura Nelson of Ecoshale provided an overview of the status of oil shale development in Utah. She highlighted the diversity of oil shale land ownership in Utah, reviewed the Utah Mining Association's Oil Shale Tar Sands Committee, and discussed the Committee's policy paper, including its recommendations for Federal and State actions and industry commitments to enable development of these resources.

Technical Program Highlights

The technical program of Tuesday and Wednesday covered research and development activities relating to both surface processing of mined oil shale and *in-situ* processing of oil shale. These included a variety of presentations by the major international oil companies engaged in oil shale development as well as smaller focused primarily on oil shale production.

In-Situ Processing

In the first of two sessions focused on *in-situ* process development, Bill Meurer of ExxonMobil described experiments to optimize the product mix from conversion, evaluating the effect of hydrostatic pressure and effective stress. The experiments indicate that increased effective stress resulted in decreases in heavy n-alkanes and isoprenoids, and increases in aromatic and saturated ring concentrations. Increased hydrostatic pressure suppressed the effective stress effects, but did not otherwise change the product composition.

Gary Beer of Shell showed that oil quality increased with slower heating rates, and that increased pressure increased the API Gravity and hydrogen content of the product due to a reduction in molecular size. Lab experimental results were consistent with the results of Shell's field tests. The apparent differences between the two sets of results are likely due to significantly different experimental conditions. Bill Symington of ExxonMobil reported on screening tools based on linear heat conduction and basin modeling source rock calculations to provide estimates of process effectiveness and resource suitability. For *in-situ* process development work, these tools can estimate conversion efficiency, evaluate the impact of parameters like heating geometry, size, spacing, total heat input, and heating duration, and define the sensitivity of the Electrofrac™ process to problems like imperfect heating geometry or performance. They can also support estimates of the suitability of resources for *in-situ* processing, and examine the effects of rock property variations.

Henrik Wallman of American Shale Oil presented modeling results for their proposed system that showed that the heating rate for shale is determined by the permeability of the shale and the pressure difference between the produced oil pool and the surrounding retort zone. Heating rates need to be adjusted to ensure that the horizontal target interval is heated, and that excessive heat does not back up into the vertical well segment. Hai Huang of Idaho National Laboratory presented results of preliminary attempts to modeling heating induced fracturing processes in oil shale. Using a combination of Discrete Element Models for the rock and continuum fluid flow models, the authors were able to reasonably model some lab-scale experiments, but identified a variety of future enhancements needed.

Milind Deo of the University of Utah presented results of their characterization and modeling of Utah oil shale. They calculated an overall energy balance for oil shale production of about three units of energy out for each

unit in, about two thirds of that from the gas produced. They conclude that understanding the kinetics of the conversion process was in fact crucial to the reservoir model, but that it was possible to implement a multi-step kinetic model for the reservoir. Underlying kinetic data for the model, derived from Thermogravimetric Analysis, was discussed in a related paper by Pankaj Tiwari. Vijay Nair of Shell discussed refining of the product of their *In-situ* Conversion Process. The significant issues he identified included the content of nitrogen, olefins, particulates, metals, asphaltenes. All of these issues can be reasonably addressed, using conventional refinery technology, to produce marketable gasoline, jet fuel, ultra-low sulfur diesel, hydrogen, and a variety of chemical feedstock products.

Alan Burnham presented an overview of the American Shale Oil (AMSO) system for shale oil production on their RD&D lease, which will at first be restricted to the illite-rich lower zones of the Green River Formation to reduce ground water concerns. The system uses paired horizontal wells (to minimize the surface footprint) for heating oil shale and producing the products. AMSO favors downhole burners as a means of heating the formation. Production from the shale depends upon the heater creating a controlled thermal fragmentation wave that enables release of the pyrolysis products.

Jack Bridges gave an overview of past tests of radio-frequency heating of both oil shale and tar sands and discussed the potential of such techniques to be powered by wind turbines. Dwight Kinzer of Quasar Energy LLC reviewed the very extensive list of patents relating to RF technology for hydrocarbon production and discussed his own patented process.

Surface Processing

Several sessions highlighted technology and modeling capabilities and results for surface processing of oil shale. A vital theme of many of these presentations was the fact that surface retorting involved proven technology that is currently operational and readily available. In a session on company programs, Steven Odut of UMATAC Industrial Processes summarized recent development of the Alberta Taciuk Process retorts, highlighting steady increase in scale of retorts and in their thermal efficiency as a result of enhanced capture of heat from shale and product vapors. Gary Aho of Sage Geotech presented an update on the Oil Shale Exploration Company program at the White River Mine on the one RD&D Lease in Utah, and on OSEC's 46,000 acre land base. He highlighted the recent agreement with Petrobras and Mitsui to bring Petrosix™ technology to the project, and described the multi-phase development plan for OSEC.

Petrobras was highly visible throughout the meeting, presenting its operational and environmental profile in Brazil, but also teaming with Mohammed Bencherifa of ONHYM in Morocco to discuss plans with Total to evaluate oil shale production, and with OSEC and Mitsui in Utah. Petrobras was one of the most vocal in pointing out that surface processing is proven technology.

Harri Mikk of Eesti Energia summarized the potential value of Estonian TSK solid heat carrier technology, and made several points about the oil shale industry in general. He asserted that each oil shale deposit is unique, and that the proper technology must be selected and tailored to that deposit. As a consequence, in situ and surface processing technology are not necessarily in competition with each other. Eesti Energia is currently working to 1) increase product sales and volume to 30,000 barrels per day, 2) increase product value (in part through hydrotreatment upgrading), 3) reduce environmental impacts through lower CO_2 and other emissions, higher efficiency, and improved ash handling and 4) expand operations internationally. The successful hydrotreatment upgrading program for Estonia was presented in another session by Alan Goelzer of Jacobs Engineering.

Material and Resource Characterization

Two geology and stratigraphy sessions focused on U. S. and international oil shale respectively. In the first session, Jennifer Walker of Encana and the University of Wisconsin presented stable isotope data correlated to stratigraphic details of Green River Formation sections in Wyoming that highlight the significant influence of changes in the drainage network supplying Lake Gosiute. Changes in the drainage system drove changes among underfilled, balanced-filled, and overfilled lake systems that are reflected in the mineralogy and stratigraphy of the lake systems in both Wyoming and Colorado. Ron Johnson of the U. S. Geological Survey presented results of studies on the Axial Arch that separated Lake Gosiute in Wyoming from Lake Uinta in Utah and Colorado. He documented a northerly volcaniclastic sand source that initially crossed the arch midway through the oil shale depositional interval, reflecting the development of a new drainage pathway across the arch. Rick Sarg of Colorado School of Mines discussed the sequence stratigraphy of the Piceance Basin and its relationship to the lake evolution framework being developed in conjunction with the University of Wisconsin and Binghamton University as part of COSTAR. The integration of the different perspectives is already providing valuable hypotheses for testing, especially with regard to the sequence stratigraphy of the two major lake systems. Mark Picha of Shell summarized his company's work on the stratigraphy of the rich and lean zones of the Green River Formation and how stratigraphic considerations guided Shell's choice of its RD&D lease areas.

In a session on oil shale properties, Michael Herron of Schlumberger presented initial steps in defining appropriate well log parameters for Green River Formation oil shale. Oil shale is mineralogically very complex because the mineral suite includes clastic, carbonate, and evaporitic minerals, some nearly unique to the saline lake environment, as well as the kerogen. Using Dual Range Fourier Transform Infrared Spectroscopy, Schlumberger has developed an approach to determining locally applicable log parameters. Glenn Mason documented bacterial microfossils from oil shale in a poster.

In the international section, Meng Qingtao of Jilin University in China presented a summary of oil shale types in China, discussing tectonic and geologic environments of deposition and the effect of those environments on oil shale composition. The recently completed evaluation of oil shale resources should lead to. Hani Al-Nawafleh presented results of studies of the El-Lajjun oil shale of Jordan, documenting the marine nature of the oil shale, although the organic matter does indicate contributions of terrestrial material in more marginal parts of the basin. The richest oil shale was deposited during highstands when suboxic to anoxic conditions were most widespread, and organic productivity appears to have been high.

Environmental and Socioeconomic Issues

Bill McKinzie of Shell described its successful freeze wall test, which demonstrated that freeze wall holes could be drilled with sufficient accuracy to enable consistent freezing, that groundwater from the surrounding area could not penetrate the freeze wall containment, and that the higher pressure of the exterior zone provided a barrier to release of contaminants. Heating of a zone within the freeze well generated hydrocarbons without damaging the freeze wall. Water was then injected to produce steam, which stripped out the hydrocarbons, and cooled and resaturated the rock. The hydrocarbons were stripped to levels that allowed the freeze wall to be released, although monitoring continues.

Uuve Kirso of the National Institute of Chemical Physics and Biophysics in Tallinn, Estonia, discussed issues surrounding the very large residue of shale ash and spent shale from power plants and retorts, respectively, in Estonia. She highlighted the significant potential of these residues to contaminate surface and ground water with, for example, polycyclic aromatic hydrocarbons. Secondary utilization of coal fly ash is significantly higher in many countries than is oil shale ash/spent shale in Estonia, so the opportunity exists to develop alternative uses. A related paper by Gan Shucai of Jilin University discussed comprehensive use of oil shale ash in China.

Judith Thomas of the U. S. Geological Survey presented initial stages of a web-based hydrologic database for the Piceance Basin aimed at providing regional baseline data on hydrologic conditions in the area. James Covell of the National Energy Technology Laboratory provided a qualitative environmental assessment matrix for a variety of potential oil shale processes that evaluated potential impacts on water and air quality, areal footprint and resource requirements.

A session was devoted to the carbon footprint of oil shale operations. Alan Burnham of AMSO discussed the potential for disposition of captured CO_2 in spent in situ oil shale retort zones in which removal of products should leave twice the required porosity (even after compaction), and residual heat may accelerate formation of carbonate minerals. Kevin Beacom of SI International reported on an assessment of possible deep saline aquifer disposition options in the area of the Green River Formation, indicating good

potential for disposition of CO_2 captured from oil shale operations. Balesh Kumar of India's National Geophysical Research Institute summarized carbon sequestration options and issues for India's future hydrocarbon uses, including the oil shale of Assam. Douglas Smoot of CRE Energy presented a description of a near zero CO_2 emissions surface retorting system for oil shale processing that involves coal gasification to fire the retort, and capture of CO_2 from the gasification and retort processes. Ralph Coates of CRE Energy presented preliminary results of models of their rotary kiln, in a session on surface processing. Peter Kobos of Sandia National Laboratories presented a poster proposing an approach to integrated assessment of water, CO_2 and energy balances for oil shale production.

A number of presentations and posters reflected the higher profile and energy level of oil shale activities worldwide. A poster by Meelika Nõmme representing the Estonian Journal Oil Shale summarized the journal's program. The upcoming Estonian Oil Shale Symposium that is being co-sponsored by the Colorado School of Mines was highlighted in a booth and in the program, reflecting the effort to integrate international activities in oil shale. At the conclusion of the Symposium, Jeremy Boak, Chair of the Symposium and Director of COSTAR summarized the research program of COSTAR.

Field Trip

The post-Symposium Field Trip visited five sites in the Piceance Basin of Colorado. A broad overview of the Green River Formation at Rifle, and geologic sections at Hay Gulch and Douglas Pass offered a general view of the geologic and stratigraphic elements of the lacustrine sedimentary environments. Stops at the Shell Visitor Center and Freeze Wall Test site gave a review of Shell's operations in the area. A visit to the ExxonMobil's Colony site gave an additional geologic view of the Green River Formation, and a review of the historic operations in the area. The field trip ended with a panel discussion at the Battlement Mesa Activity Center by local and state officials on the potential impact of an oil shale industry on the area. The ensuing discussion was very lively.

Conclusion

The preceding highlights constitute a subjective and somewhat idiosyncratic summary of selected presentations that unfortunately cannot cover every presentation of interest. The caliber of talks and posters improved significantly this year. We look forward to the upcoming Estonian Oil Shale Symposium in June 2009, and to the 29th Oil Shale Symposium in October 2009.

Jeremy BOAK
Chair of 28th Oil Shale Symposium