APPRAISING AND DEVELOPING COALBED RESERVOIRS
June 20, 2008; Morgantown, WV

BOTTOM LINE

The instructor, Creties Jenkins, offered the following summary of an effective plan for developing a gas from coal beds project. First, conduct a rigorous evaluation of critical reservoir parameters. This includes static data from cores, logs, coal mines and other coal bed gas leases, as well as dynamic data such as well tests, pressures and rates. All data should be reconciled and used to develop robust interpretations. Second, develop an effective appraisal and pilot strategy. A key component of this plan is to determine the minimum number of appraisal wells necessary to adequately assess the project, and then the optimal pilot pattern size and geometry. Third, make accurate estimates of gas in place, reserves, production rates and economics. Simulations should be performed to understand mechanisms and estimate well flow rates. An uncertainty analysis will help capture the range of potential outcomes. Upstream and downstream components (drilling through marketing) should be integrated in the final evaluation strategy.

PROBLEMS ADDRESSED

Appraising and developing unconventional reservoirs such as coal beds and shales is more difficult than working in conventional plays, requiring new approaches and methods, and an understanding of how gas is generated and stored, how logs should be analyzed and wells should be tested, how to model the reservoir, and how to evaluate reservoir performance. This two-day course was organized to provide practical insights and tools that the geologist and engineer can use to identify and appraise coal bed and shale gas reservoirs. For reporting purposes, a separate report will be written for each day.

TECHNOLOGY OVERVIEW

Presentations on coal bed gas were organized very logically, beginning with the origin of coal itself, and how different gases are generated in the coal and trapped in the matrix and cleat system. The middle part of the workshop included discussions on how to study coal cores and thin sections and methods to collect data in the laboratory. The final part of the workshop began with a discussion of gas undersaturation and its impact on gas production, reserves and payout time, and ended with presentations on evaluating prospects through log analysis, well testing, reservoir performance, modeling and simulation.

Throughout the day, the instructor kept the class constantly involved by asking numerous questions, departing from his power point slides to conduct demonstrations and draw diagrams on a white board or pad, passing around rock and core samples, and holding up large cross sections, measured sections and core descriptions, many of which were from his own research. He often pulled “volunteers” from the audience to assist him in these

efforts and offered "prizes" to reward them. At the end of the day, attendees were divided into small working groups, each of which evaluated a case history and reported back to the entire group.

Cores should not be sent directly to the lab. Instead, the instructor emphasized the importance of detailed core description and what can be learned from a core prior to sending it for testing. Once coal samples reach the lab, four analyses should be performed: proximate analysis, the determination of saturation state, vitrinite reflectance, and maceral analysis. The "enemies" of reliable data were identified, and a warning was issued that there are a lot of "bad data" out there.

Undersaturation of gas due to high water content in the coal is a serious problem in coal bed reservoirs, not the least of which is the necessity of producing large volumes of water, which delays the desorption of gas from coal and increases pay out time. Attendees were cautioned that we have no control over this parameter, so they need to be prepared to spend plenty of time – and perhaps money.

Open hole logs recommended by the instructor include: natural gamma ray, SP, caliper, bulk density, neutron, induction, microlog, borehole deviation and temperature. Other logs, including spectral GR, dipmeter, image logs, nuclear magnetic resonance, sonic, and Pe (litho-density) are considered to be optional.

An understanding of the hydrogeology of the basin is very important, because hydrogeology influences gas saturation, affects dewatering of coals, and can provide information about connectivity. Coals that crop out on the updip edge of a basin can be recharged, introducing fresh water and often bacteria to the shallow coal reservoirs, leading to the generation of biogenic gas. As water moves downdip and mixes with connate water, ion concentrations change, so ion concentration maps can indicate permeability pathways.

Well testing is performed to determine reservoir and completion properties, including permeability, directional permeability, reservoir pressure, boundary conditions, coal continuity, wellbore damage/stimulation, and fracture properties. Coal bed permeability can change greatly even over a small area of the reservoir, and permeability can change significantly in the same place over the life of the field as gas saturation increases and water saturation and pressure decrease. Permeability and how it changes with time can be tracked using pressure transient analysis of wells with single or dual phase flow.

Using an isotherm is essential to estimate ultimate recovery, and the most efficient abandonment pressure. A small drop in pressure near the end of reservoir life can result in a large percentage of the original gas in place being produced prior to abandonment.

Numerical simulation has many uses in appraising coal reservoirs, but the best use is as a tool for integrating widely different data types, such as reservoir, completion and well performance data. With careful application, it can also be used to resolve data discrepancies, and evaluate development options.

In recent years, drilling horizontal wells in coals has become increasingly more popular. Lateral lengths of 5000-6000 ft are common, but wellbore stability is a concern. Horizontals work well in low-permeability coals that are water free and stiff enough to resist collapse. Multilateral and pinnate wells are the next generation of horizontal wells, and have worked well in the Appalachian basin. Large areas can be drilled from a single pad, and recovery estimates are significant.

Finally, attendees were advised to drill appraisal wells and field pilots. Appraisal wells should be placed in the best locations, and should be cored and logged, and all possible data should be collected and analyzed. An effective project plan should include a rigorous evaluation of critical reservoir parameters, and effective appraisal and pilot strategy, and an accurate estimate of gas in place, reserves and economics.

CONNECTIONS

The above observations were based on a workshop sponsored by PTTC's Appalachian Region in Morgantown, WV on June 20, 2008.

Speaker:

Creties Jenkins, a Vice President of DeGolyer and MacNaughton in Dallas, Texas, whose primary emphasis is on training, research and technical service work involving quantitative description of clastic reservoirs, including coals and shales. Phone 214-519-4806; e-mail cjenkins@demac.com

SUMMARY OF EVALUATION FORMS

*"**Appraising and Developing Coalbed and Shale Gas Reservoirs**"*
June 20-21, 2008

1. How did you hear about the workshop?

__ Direct mailing	__ Periodical	__ Phone
17 E-mail	__ Internet/www	**2** Other

2. What additional topics would you like to see in future Focused Technology Workshops? **See other page**

3. Are you a(n):
   - **16** Operator (field supervisor, geologist, engineer)
   - __ Service Company employee
   - **2** Consultant
   - __ Educational Institution employee
   - **1** State/Federal Government employee

4. Please circle the response that best indicates your agreement, with 5 being the strongest:

	5	4	3	2	1
A) The program met my expectations	**12**	**6**	**0**	**0**	**0**
B) The speakers/facilities were acceptable	**12**	**6**	**0**	**0**	**0**
C) The program was well organized	**16**	**2**	**0**	**0**	**0**

5. The workshop fee was:__ too low _**17**_ OK __ too high

6. Additional comments: (Please use back of page if needed).
See other page

7. Please indicate which tech transfer method is most helpful to you. Rank from 1 to 5, with 5 being the most helpful:

	5	4	3	2	1
Workshop	**9**	**4**	**0**	**0**	**0**
Individual assistance	**4**	**3**	**4**	**0**	**0**
Reports/Case studies	**5**	**3**	**3**	**1**	**1**
Internet	**1**	**0**	**5**	**4**	**2**
Newsletters	**1**	**1**	**1**	**3**	**5**

8. Have you attended other PTTC events? __**11**_ Yes (how many? **0-20)** _**7**_ No

Have you used any new technologies based on knowledge gained through PTTC events? _**4**_ Yes _**8**_ No If yes, please describe (in general) the application/results. (PTTC will only use your response with your permission.)
See other page

9. Would you be willing to share with others any technology innovations or best practices?
_**4**_ Yes _**6**_ No If yes, briefly list topics/information you are willing to share. **See other page**

1. What additional topics would you like to see in future Focused Technology Workshops?
Tight gas reservoirs assessment
Simulation of shale-guidelines, rules of thumb, common mistakes

More drilling and completion
Petrophysics
Additional shale and reservoir talks

6. Additional Comments
Speaker was very good and knowledgeable
Found the case studies very helpful
Room was too cold on Saturday
Very beneficial
Needed more time, workshop deserved another day
Coordinator needs a pay increase

8. Have you used any new technologies based on knowledge gained through PTTC events?

9. Topics/info willing to share.
Fracture results- CBM
More field studies

ATTENDANCE

The following individuals attended the workshop on "Appraising and Developing Coalbed and Shale Gas Reservoirs" either one or both days.

Last Name	First Name	Address	City	State	Postal Code
Bajek	David T.	1550 Coraopolis Heights Road, 2nd Floor	Moon Township	PA	15108
Barnes	Becky				
Blood	Randy	P.O.Box 6070	Charleston	WV	25362
Botterman	Robert	1301 Grandview Ave.	Pittsburgh	PA	15211
Cunningham	Chad	501 56th Street	Charleston	WV	25304
Fowler	Dave				
Greenawalt	Jeff	1164 School Street	Pittsburgh	PA	15220
Griffith	Craig	626 Cochrans Mill Road	Pittsburgh	PA	15236
He	Zhong	1310 Commerce Drive, Park Ridge 1	Pittsburgh	PA	15275
Heim	Bob	Brookside Office Parl Two, Ste 204 61 McMurray Road	Pittsburgh	PA	15241
Jackson	Josh				
Kennedy	Elizabth	1301 Grandview Ave	Pittsburgh	PA	15211
Kravits	Matthew	5134 Oak Road	Jefferson Hills	PA	15025
Leberfinger	Jeffrey	1129 West Governor Road	Hershey	PA	17033
Menotti	Tess				
Pancake	Jim				

Puskar	Martin				
Schmid	Katie				
Shumway	Martin	660 High Street Suite 201	Worthington	OH	43085
Sillers	Amy	1301 Grandview Ave.	Pittsburgh	PA	15211
Sinemus	Lydia	P.O. Box 2136	Abingdon	VA	24212
Smith	Diane	380 Southpointe Blvd	Canonsburg	PA	15317
Steptoe	Anne	P.O. Box 6070	Charleston	WV	25362
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Wozniak	Jeff				
Wrightstone	Greg	560 Epsilon Dr.	Pittsburgh	PA	15238-2837
Zinn	Chris				