Methane to Markets (M2M) Conference

Advancing Project Development in India through Public Private Partnership

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Reliance CBM Exploration in India

By

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OUTLINE

- RIL’s CBM blocks
- CBM exploration experience
  - CBM prospect evaluation approach
  - Highlights & major achievements
  - Corehole program
  - Saturation conditions in coal beds
  - Permeability of coal reservoirs
  - CBM well drilling & completion
  - Emerging technologies
- CBM gas usage options
RIL’s CBM BLOCKS

<table>
<thead>
<tr>
<th>Block Name</th>
<th>(Area Sq. Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajasthan West</td>
<td>1045</td>
</tr>
<tr>
<td>Rajasthan East</td>
<td>1020</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2065</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Block Name</th>
<th>(Area Sq. Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sohagpur West</td>
<td>500</td>
</tr>
<tr>
<td>Sohagpur East</td>
<td>495</td>
</tr>
<tr>
<td>Sonhat</td>
<td>825</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1820</strong></td>
</tr>
</tbody>
</table>
**CBM EXPLORATION EXPERIENCE**

**CBM PROSPECT EVALUATION APPROACH**

- **Pre-drilling Assessment**
  Geological evaluation, based on available information
  Remote sensing studies
  Lineaments, natural fracturing studies

- **Core Program**
  Core & Log
  Gas Content, Adsorption Isotherm
  Injection/ Falloff Permeability Test

- **Production Test (5-Spot Pilot)**
  Production Test
  Completion Effectiveness
  Relative Permeability

- **Reservoir Simulation**
  Spacing & Pattern
  Field / Area Production Potential
  Field / Area Development Program

- **Commercial Pilot**
  Step out wells
  Larger Spacing
  Completion optimization

**Exploration Objectives**

- Fixing CBM Gas-in-place and identification of CBM fairway by corehole drilling
- Fixing well producibility numbers from 5-spot cluster wells further refined by commercial pilots
Minor fault in Raniganj coal and shale interbands, north of Kanchanpur

Steeply dipping micaceous sandstone abutting against massive sandstone along E-W fault, Kaser nala
E-W major joint cut across by N-S joint, Kaser nala section
CBM EXPLORATION EXPERIENCE

HIGHLIGHTS

- CBM Discovery : 3.65 TCF, validated by the Directorate General of Hydrocarbons (DGH)
- Technology used for drilling : Air Drilling (First ever used in India for CBM Drilling)
- Gas Production Potential : 3 - 5 MMCMD in a Frontier Area
- Water Production Potential : 50,000 – 70,000 BPD of good quality water
- Investment Potential
  - CBM Production : Over Rs.3000 crores
- Employment Generation
  - Direct employment : In thousands
  - Indirect employment : In thousands
- Infrastructure Development : Roads, Ancillary Industries, Support Industries
- CSR Scope : Health, Education, Environmental conservation, Agricultural Support
- USTDA Funding - Considering positive viability, funding of 0.5 million USD approved for project Techno-economic feasibility study. Contract signed with TDA in May this year
The CBM key reservoir parameters acquired:

- Compleatable Coal thickness and coal seam continuity
- Gas content and gas saturation
- Permeability and its variability

Corehole drilling:

- Faster completion of corehole in 15 days average as against about 60 days by others.
- Faster drilling of dolerite rocks (80-170 m) in 2-3 days as against 1 month by others
- 100% core recovery
- Many open hole Injection / fall off tests have been carried out first time in the country for determination of permeability of the coal seams
COREHOLE PROGRAM

- Critical parameters essential to determine gas in place resource and fairway areas of high gas production
  - Coal thickness
  - Gas content
  - Permeability: a key CBM production parameter, may vary drastically over short distances

*There is a paucity of data on gas content and permeability for Indian coal basins*

- Exploration Campaign in any frontier basin should aim at getting fix on these 3 parameters
CBM EXPLORATION EXPERIENCE

SATURATION CONDITIONS IN COAL BEDS

- Oversaturated
- Saturated
- Undersaturated

Critical desorption pressure

Gas content (scf/ton) vs. Pressure (psi)
11

**CBM EXPLORATION EXPERIENCE**

**PERMEABILITY OF COAL RESERVOIRS**

- Permeability, the key parameter of coal for commercial CBM production can be low and vary drastically over short distances. Therefore, almost all CBM wells are routinely stimulated.

- Coals at deeper depths with high stress conditions, usually have insufficient permeability to allow flow of CBM gas into the well.

- Generally speaking, such adverse conditions are less evident in US, Australian and Indian coals. That is why USA & Australia have many CBM producing fields, whereas drilling in Europe has drawn a blank so far.

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**Permeability vs. Depth Curve for Different Stress Regimes in the Bowen Basin, Australia**

(Modified after Peter Decker et al., 1991)

Permeability (md) vs. Depth (ft)

- RELAXED STRESS
- NORMAL STRESS
- HIGH STRESS
Gas productivity from low stress naturally fractured coal seams is high.
CBM WELL DRILLING

• In general, coals are susceptible to damage from drilling, cementation and frac fluids
  ➢ Air / Air mist drilling
  ➢ Light weight cement slurries and compatible fluids
  ➢ Careful selection of frac fluids

DRILLING

Underbalanced or Air Drilling helps reduce Formation Damage in CBM Wells and results in faster rates of drilling
CBM EXPLORATION EXPERIENCE

CBM Flow Computers – Sohagpur west 5 spot
West 5 – Spot CBM Gas / Water Separation
CBM EXPLORATION EXPERIENCE

CBM Gas Flare – Sohagpur west 5 spot

Photo – 04.05.05
Water Quality

TDS Limits For Water Usage

<table>
<thead>
<tr>
<th>TDS Content</th>
<th>Tolerance [mg/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500</td>
<td>Drinking Water</td>
</tr>
<tr>
<td>&lt;2,500</td>
<td>Cattle</td>
</tr>
<tr>
<td>&lt;3,000</td>
<td>Crop irrigation</td>
</tr>
<tr>
<td>&lt;5,000</td>
<td>Sheep</td>
</tr>
</tbody>
</table>

Initial water analysis for Sohagpur water shows that TDS is less than 1000 mg/l

P.S. : Rajasthan Barmer district drinking water bore wells : 5000 + mg/l
CBM WELL COMPLETION

High-Perm Completions in other CBM Basins

<table>
<thead>
<tr>
<th>Field</th>
<th>San Juan (USA)</th>
<th>Arkoma (USA)</th>
<th>Fairview (Australia)</th>
<th>Moranbah (Australia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perm range (md)</td>
<td>5-100</td>
<td>10-30</td>
<td>10-1000</td>
<td>1-300</td>
</tr>
<tr>
<td>Completion</td>
<td>Cavity for high k; HF for low k; Recent horizontals</td>
<td>Single horizontals</td>
<td>More cavity Some HF</td>
<td>SIS</td>
</tr>
</tbody>
</table>
CBM EXPLORATION EXPERIENCE

AVERAGE WELL PERFORMANCE-CAVITY VS CASED HOLE IN SAN JUAN BASIN

Number of Wells:

<table>
<thead>
<tr>
<th>Year</th>
<th>Open -Hole</th>
<th>Cased-Hole</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>598</td>
<td>230</td>
</tr>
<tr>
<td>1</td>
<td>477</td>
<td>207</td>
</tr>
<tr>
<td>2</td>
<td>366</td>
<td>169</td>
</tr>
<tr>
<td>3</td>
<td>263</td>
<td>140</td>
</tr>
<tr>
<td>4</td>
<td>185</td>
<td>114</td>
</tr>
<tr>
<td>5</td>
<td>117</td>
<td>74</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>57</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>9</td>
<td>17</td>
<td>8</td>
</tr>
</tbody>
</table>

Average Daily Gas Production Per Well, Mcf/d

- Cavity Completion
- Cased-Hole-Frac

Year
EMERGING TECHNOLOGIES – CAVITY COMPLETION

Ideal Targets

• High rank, Low to medium volatile bituminous Coals
• Fragile coals
• Moderate to good permeability, 10+ mD
• Over pressured coal reservoirs
• Costs about 1.5 times more than normal vertical wells but produce 4 to 6 times more

• Many Parts of Sohagpur CBM blocks having the above characteristics are good for Cavity Completion
EMERGING TECHNOLOGIES IN CBM - IN SEAM DRILLING

Plan for Sohagpur West Block, Seam-III

Drilling in seam – directional well from a distance of 1200 m.

Estimated production potential – 1.5 to 2.0 MMSCFD per well
EMERGING TECHNOLOGIES IN CBM - IN SEAM DRILLING

Surface to in-seam horizontal directional drilling in chevron pattern

CH₄, Australia drilled over 100 sets of chevron wells producing 1-2 million cubic feet per day of CBM Gas
### Advanced technology implementation – Potential Impact

<table>
<thead>
<tr>
<th>Technology</th>
<th>Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal and in-seam drilling</td>
<td>Increase ultimate recovery by up to 50%</td>
</tr>
<tr>
<td>Multilateral drilling</td>
<td>Increase ultimate recovery by up to 50%</td>
</tr>
<tr>
<td>Air drilling</td>
<td>Cut drilling time and cost by up to 50%</td>
</tr>
<tr>
<td>Optimizing stimulation</td>
<td>Increase ultimate recovery by 20-50%</td>
</tr>
<tr>
<td>Better well spacing</td>
<td>Could double NPV</td>
</tr>
<tr>
<td>Continuously variable pump controller</td>
<td>Save workovers, boost ultimate recovery By 5-10%</td>
</tr>
<tr>
<td>Foam cement</td>
<td>Increase ultimate recovery by 5-10%</td>
</tr>
<tr>
<td>Coiled Tubing Frac</td>
<td>Increase ultimate recovery by 15-30%</td>
</tr>
<tr>
<td>Down hole gas compression</td>
<td>Increase ultimate recovery by 20-40%</td>
</tr>
<tr>
<td>Smaller rigs</td>
<td>Save $15,000 per location</td>
</tr>
<tr>
<td>Closed loop air drilling</td>
<td>Save $20,000-30,000/well</td>
</tr>
<tr>
<td>Casing drilling</td>
<td>Save $10,000/well</td>
</tr>
<tr>
<td>Jet slotting</td>
<td>Save $10,000/well, increase ultimate recovery by 20-50%</td>
</tr>
</tbody>
</table>

- Green: Implemented in Phase-I
- Yellow: Being implemented in Phase-II
Possible CBM Based Industries

- Fertilizers, chemicals & petrochemicals
- Town Gas & Industrial fuel supply
- Power generation
- Cement
- Paper and paper products
- Sponge iron & steel
- Ceramics
- Glass
- Textiles

**Steel, Glass, Ceramics and Paper manufacturing companies are showing keen interest to put up their plants in the region**
## CBM GAS USAGE OPTIONS

### Gas demand in the region

<table>
<thead>
<tr>
<th>Location</th>
<th>Industry</th>
<th>Distance from CBM blocks in Km</th>
<th>Gas Demand Potential in MMSCMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shahdol</td>
<td>Chemicals, Paper, Power, Fuel, City gas</td>
<td>25</td>
<td>0.35</td>
</tr>
<tr>
<td>Katni</td>
<td>Cement, Fuel, City gas</td>
<td>135</td>
<td>2.92</td>
</tr>
<tr>
<td>Maihar</td>
<td>Cement, Fuel, City gas</td>
<td>153</td>
<td>0.40</td>
</tr>
<tr>
<td>Rewa</td>
<td>Cement, Fuel, City gas</td>
<td>200</td>
<td>1.12</td>
</tr>
<tr>
<td>Satna</td>
<td>Cement, Fuel, City gas</td>
<td>200</td>
<td>0.65</td>
</tr>
<tr>
<td>Allahabad</td>
<td>Fertilizer complex</td>
<td>350</td>
<td>4.50</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>Chemicals, Paper, Power, Fuel, City gas</strong></td>
<td></td>
<td><strong>9.99</strong></td>
</tr>
</tbody>
</table>

With availability of CBM gas, accelerated industrial development is a good prospect in and around Shahdol apart from above demand.
Thank You