UNTAPPING TIGHT GAS RESERVOIRS

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Definition of “Tight Gas Reservoir”

- Reservoirs with effective permeabilities of less than 1 mD exclusive of fracture permeability

- Operational definition for TGR may include ‘the reservoirs which exhibit sub-economic reservoir qualities during normal production practices

- TGRs are usually sandstones, siltstones and carbonates
Advances in drilling and completion methods allow operators to drill wells with least formation damage for exploiting tight zones more successfully.

1. **Directional and horizontal drilling**
   This has become a relatively common approach in exploiting tight gas reservoirs. Horizontal wells can open up long sections of marginal-quality reservoir, access stratigraphic sweet spots more readily, intersect large numbers of natural fractures with near vertical orientations, and drain larger areas.

2. **Under-balanced drilling – UBD**
   This is another drilling strategy that has become relatively a common place, and is often used in tandem with directional and horizontal drilling. Low-density drilling fluids, employing hydrocarbons, foams, emulsions, and air, are designed to prevent extensive filtrate invasion in reservoirs, thus avoiding or reducing formation damage.

3. **Advanced Fracture Stimulation** –
   Sophisticated fracturing techniques are the key to making many tight gas targets flow at economic rates.
Location Map

Study Area
Possible Candidates for TGRs

- Lower Goru Tight Sands
- Sembar Sands and Siltstones
- Sui Upper Limestone
- Habib Rahi Limestone
- Pirkoh Limestone
Lower Goru Tight Sands

- Sub lithic to lithic sandstone, fine to medium grained at places grading to siltstone
- The finer grain size and high content of Iron chlorite has narrowed down the pore throat
- Porosity 0.08 – 13.9 %
- Permeability ~ 1 md
Lower Goru Tight Sands
Porosity vs Permeability Plot
Lower Goru Tight Sands  
Comparative Testing Results

**PRE-FRAC (28/64")**

<table>
<thead>
<tr>
<th>WHFP (Psi)</th>
<th>Qg (MMSCFD)</th>
<th>Qw (bbls/MMSCF)</th>
<th>WHT (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700</td>
<td>03</td>
<td>16</td>
<td>119.5</td>
</tr>
</tbody>
</table>

**POST-FRAC (48/64")**

<table>
<thead>
<tr>
<th>WHFP (Psi)</th>
<th>Qg (MMSCFD)</th>
<th>Qw (bbls/MMSCF)</th>
<th>WHT (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100</td>
<td>06</td>
<td></td>
<td>119.5</td>
</tr>
</tbody>
</table>

The well is currently stabilized at 4.35 MMscfd and 16 bbl/MMscf of water, on 28/64” choke with 1190.4 psi WHP, at 119.5°F WHT.
Sembar Sands

- Comprises of shale, sands beds and siltstone
- Sands fine to medium grained, moderately sorted and cemented with argillaceous matrix
- Permeability ~ 1 md
- Enough data in not available for proper evaluation
- Potential TGR candidate
Sui Upper Limestone

- Normally behaves as conventional reservoir
- Can be treated as TGR locally
- Highly variable carbonate facies across the area comprising argillaceous mudstone to wackstone deposited on carbonate bank complex with in a mud dominated shelf setting
- Inter-particle porosity is of limited development due to relatively low energy paleo environment
- Interbedded shale reduces vertical communication
- Porosity 1% - 19 % (avg 8.33%)
- Permeability 0.001 md – 6.07 md (avg 1.78 md)

Pelodal Packstone
relatively tight fabric has resulted from calcite cementation

Foraminferal Skeltal Wackstone
Wackstone is tightly cemented by NF calcite
## Vertical Well

<table>
<thead>
<tr>
<th>Choke</th>
<th>28/64&quot;</th>
<th>32/64&quot;</th>
<th>36/64&quot;</th>
<th>48/64&quot;</th>
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<tbody>
<tr>
<td>$Q_{\text{gas}}$ (mmcf d)</td>
<td>5.14</td>
<td>5.74</td>
<td>6.04</td>
<td>6.57</td>
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<tr>
<td>$Q_{\text{cond}}$ (bpd)</td>
<td>2.00</td>
<td>4.00</td>
<td>1.50</td>
<td>6.00</td>
</tr>
<tr>
<td>$Q_{\text{water}}$ (bpd)</td>
<td>4.00</td>
<td>3.00</td>
<td>5.00</td>
<td>3.00</td>
</tr>
<tr>
<td>WHFP (Psi)</td>
<td>1020</td>
<td>900</td>
<td>750</td>
<td>490</td>
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</table>

**Well** with 87° inclination and 250m Horizontal Section

## Well with 87° inclination and 250m Horizontal Section

<table>
<thead>
<tr>
<th>Choke</th>
<th>56/64&quot;</th>
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<th>64/64&quot;</th>
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<tbody>
<tr>
<td>$Q_{\text{gas}}$ (mmcf d)</td>
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<td>$Q_{\text{cond}}$ (bpd)</td>
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<tr>
<td>$Q_{\text{water}}$ (bpd)</td>
<td>4.50</td>
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<td>5.00</td>
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<td>WHFP (Psi)</td>
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<td>1410</td>
<td>1020</td>
<td>1260</td>
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</tbody>
</table>
Habib Rahi Limestone

- Normally behaves as conventional reservoir
- Can be treated as TGR locally
- Fine grained nummulitide wack-packstone
- Comprises of different carbonate facies deposited in deep water setting, passing up into shoals and in places lagoons
- Lateral variation in facies is more common grading from good reservoir quality to poor
- At places the porosity is obscured due to calcite cement and micritic clay matrix
- Porosity
  - 0.67% - 32.08% (avg 18.43%)
- Permeability
  - <0.01 md – 5.17 md (avg 0.66 md)
Habib Rahi Limestone
Comparative Testing Results

**Vertical Well**

<table>
<thead>
<tr>
<th>Choke</th>
<th>24/64&quot;</th>
<th>32/64&quot;</th>
<th>36/64&quot;</th>
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<tr>
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</tr>
<tr>
<td>Q cond (bpd)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q water (bpd)</td>
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<td></td>
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<tr>
<td>WHFP (Psi)</td>
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<td>794</td>
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<td></td>
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</table>

**Well with 89° inclination and 296m Horizontal Section**

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<th>48/64&quot;</th>
<th>64/64&quot;</th>
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</thead>
<tbody>
<tr>
<td>Q</td>
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<td>9.5</td>
<td>14.50</td>
<td>18.0</td>
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<tr>
<td>gas(mmcf d)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q cond (bpd)</td>
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<tr>
<td>Q water (bpd)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>WHFP (Psi)</td>
<td></td>
<td>794</td>
<td>940</td>
<td>790</td>
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Pirkoh Limestone

- Normally behaves as conventional reservoir in some gas fields
- Can be treated as TGR locally
- Highly variable carbonate facies across the area comprising argillaceous mudstone to packstone deposited in shallow marine mud dominated shelf setting
- Porosity 10% - 25%
- Permeability <1.0 md (based on MDT Results)
- Good dry gas shows were reported during drilling
- Post drilling testing deferred
- Being evaluated for ACID FRAC and HORIZONTAL DRILLING
Conclusions

- Present economic scenario warrants revisiting previously declared non-commercial reservoirs and use of innovative technology.
- Proper understanding of sequence stratigraphy for the distribution of tight reservoir facies in sedimentary basins is required for further exploitation.
- GOP and E & P Companies should take the initiative to invest more on developing infrastructure to deal with TGR and pertinent Research and Development.
- Periodic upgradation of TGR estimates.
- GOP to offer more incentives on TGR development and exploitation considering it an important source of renewable energy on sustainable level.
- Local Academia to be involved to play its role.
Thanks