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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

Modern Drilling and Completion Technology

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.

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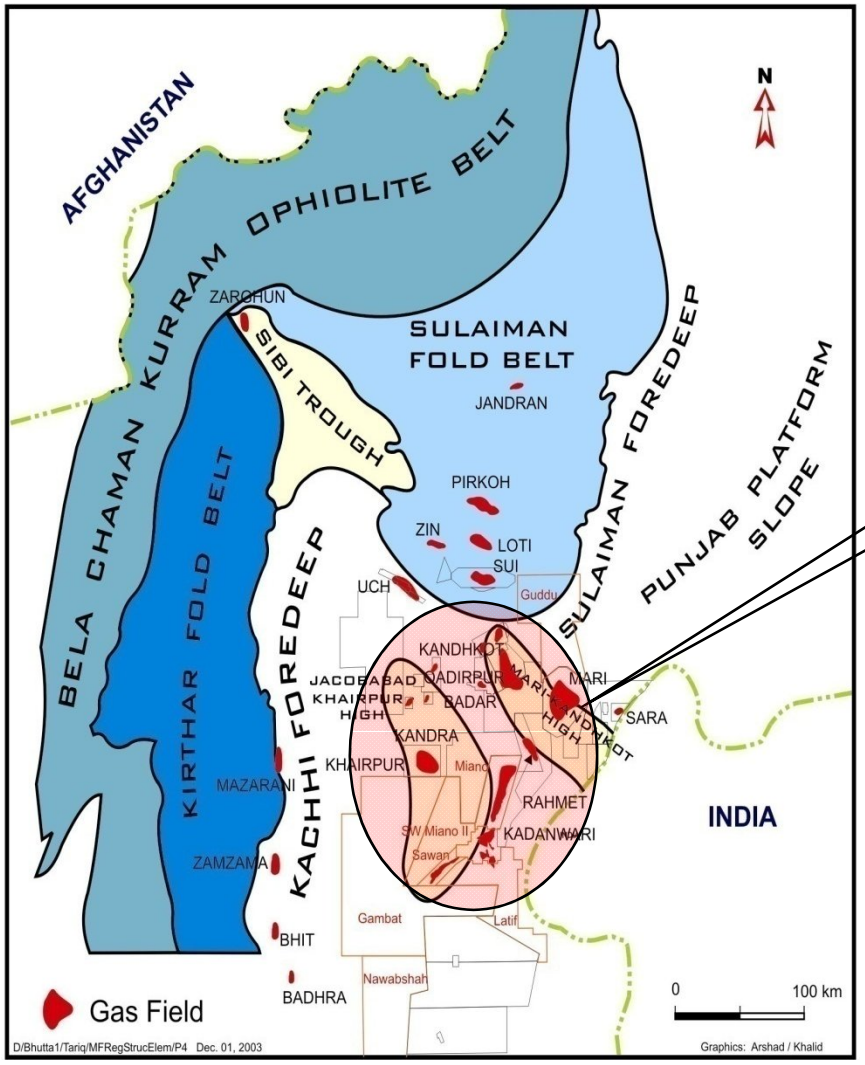
2. **Under-balanced drilling – UBD**
   This is another drilling strategy that has become relatively a common place, and is often used in tandem with directional and horizontal drilling. Low-density drilling fluids, employing hydrocarbons, foams, emulsions, and air, are designed to prevent extensive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

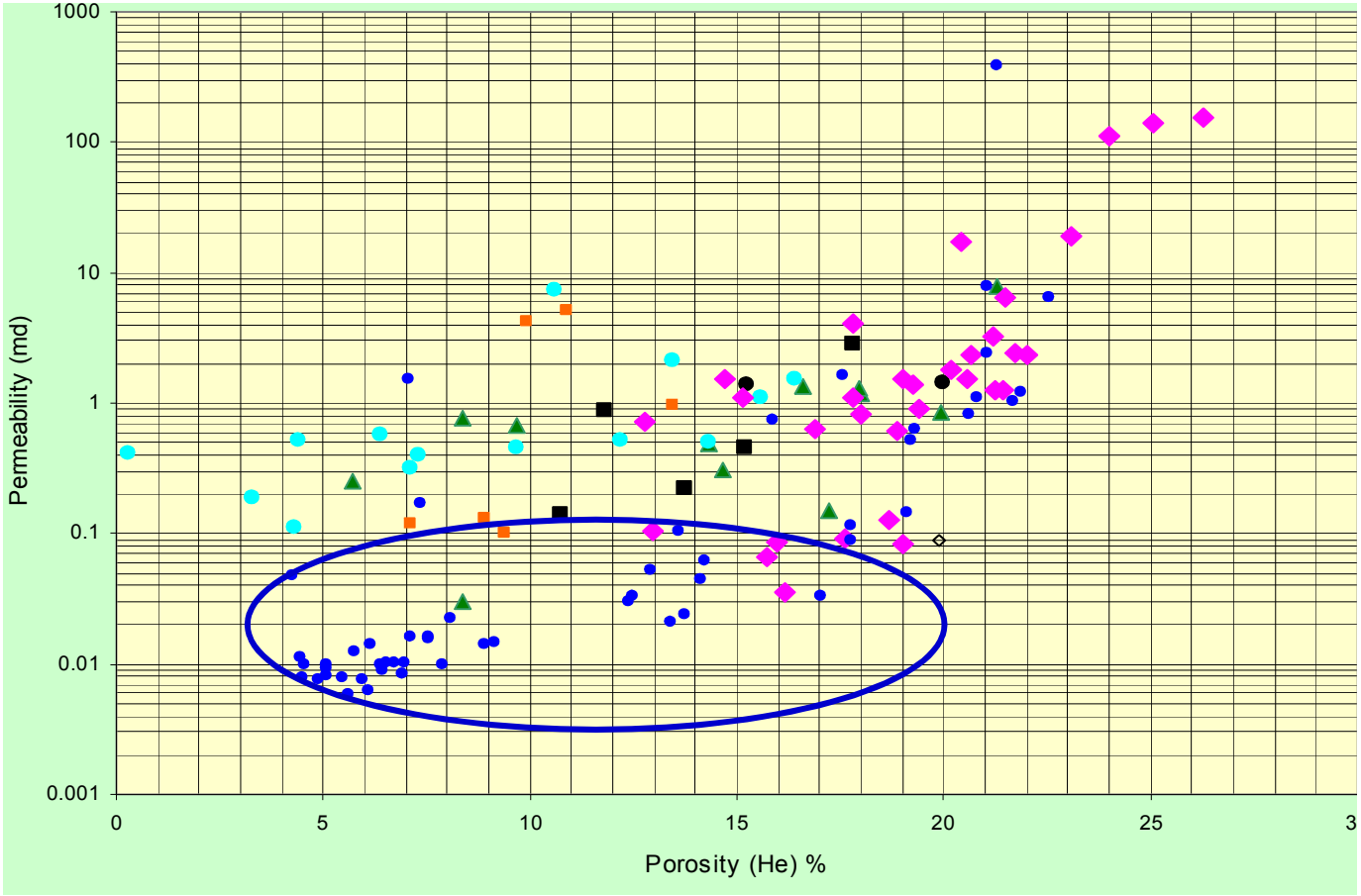
- Lower Goru Tight Sands
- Sembar Sands and Siltstones
- Sui Upper Limestone
- Habib Rahi Limestone
- Pirkoh Limestone

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”)

WHFP	Qg	Qw	WHT
(Psi)	(MMSCFD)	bbls/MMSCF	(°F)
1700	03	16	119.5

POST-FRAC (48/64”)

WHFP	Qg	Qw	WHT
(Psi)	(MMSCFD)	bbls/MMSCF	(°F)
2100	06		119.5

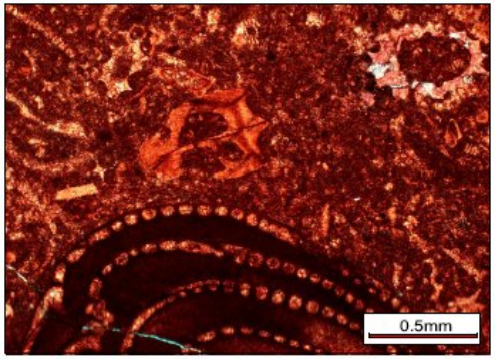
The well is currently stabilized at 4.35 MMscfd and 16 bbl/MMscf of water, on 28/64” choke with 1190.4 psi WHP, at 119.5°F WHT

Sembar Sands

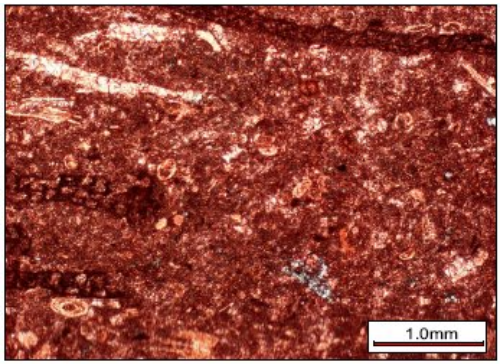
- Comprises of shale, sands beds and siltstone
- Sands fine to medium grained, moderately sorted and cemented with argillaceous matrix
- Permeability ~ 1 md
- Enough data in not available for proper evaluation
- Potential TGR candidate

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

Sui Upper Limestone
Comparative Testing Results

Vertical Well

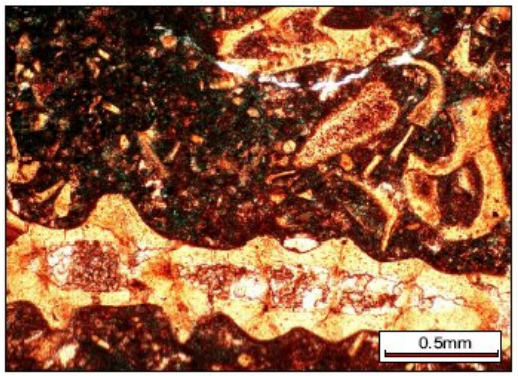
Choke	28/64"	32/64"	36/64"	48/64"
Q gas(mmcfd)	5.14	5.74	6.04	6.57
Q cond (bpd)	2.00	4.00	1.50	6.00
Q water(bpd)	4.00	3.00	5.00	3.00
WHFP (Psi)	1020	900	750	490

Well with 87° inclination and 250m Horizontal Section

Choke	56/64"	32/64"	64/64"	48/64"
Q gas(mmcfd)	18.30	6.8	21.59	14.5
Q cond (bpd)	8.00	4	8.00	7.50
Q water(bpd)	4.50	2	5.00	4.00

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 – 5.17md (avg 0.66 md)



Wackstone - Packstone
A low energy facies characterised by thin walled assilinids with fine debris in micritic matrix

Habib Rahi Limestone
Comparative Testing Results

Vertical Well

Choke	24/64"	32/64"	36/64"	48/64"
Q gas(mmcfd)	-	3.45	-	-
Q cond (bpd)	-	-	-	-
Q water(bpd)	-	200	-	-
WHFP (Psi)	-	794	-	-

Well with 89° inclination and 296m Horizontal Section

Choke	24/64"	32/64"	48/64"	64/64"
Q gas(mmcfd)	-	9.5	14.50	18.0
Q cond (bpd)	-	Nil	Nil	1.0
Q water(bpd)	-	-	-	-
WHFP (Psi)				

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