Scientific Research Outcome Report

Permeability Characterization and Modelling of Tight Gas Sandstone Reservoirs

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2. **Branch / Department:** School of Petroleum Technology, PDPU

3. **Researcher's Name along with designation:**
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4. **Research Title:** Permeability Characterization and Modelling of Tight Gas Sandstone Reservoirs

5. **Major Goal of this Scientific Research Project**

   Tight reservoir means that reservoir of low porosity and low permeability. In the 1970s, the United States government defined a "tight gas reservoir" as one in which the expected value of permeability to gas flow would be less than 0.1 md. These wells typically will not flow prior to being stimulated. Stimulation requires thorough understanding of the petro-physical properties and modeling of the reservoirs. Estimating pore pressure, permeability in multilayer low permeability gas reservoir can be time consuming and, in a few cases, cost prohibitive. Even very few conventional well tests are completed in multilayered low permeability gas reservoirs and an optimized completion requires knowledge of permeability and pore pressure.

6. **Major Activities**
   - GSPC KG Rock sample analysis successfully done
   - KG Core flow and electrical conductivity measurements dome
   - GSPC KG Pore scale models reconstruction and network model analysis done
   - Scaling analysis and data correlation done
   - Field data comparison done
   - Inputs to Field development plans of Krishna-Godavari Deendayal fault Block (KG-OSN-2001/3)

The results are compared with available porosity and permeability correlations in the literature. Most of the correlations in the literature were developed for conventional sandstone reservoirs. It is therefore expected that the results from the tight gas sandstone may not be properly predicted by those correlations. We investigated the issue of permeability prediction based on the micro-scale images of the rock samples.

7. Specific Objectives & Research Hypothesis

A total of 14 samples of KG-16 were analyzed in routine air conditions to measure their base permeability and porosity values. Based on an evaluation of the microstructure of these core samples, a representative set of samples (samples – 2, 6 and 12) were selected for additional and systematic HPHT measurements. These measurements are the first set of HPHT measurement ever done for KG core samples.

Table: Routine air core sample measurements (Sample-2)

Sample	Depth (m)	Porosity (%)	Permeability (mD)
1	4985.60	0.247	<0.0001
2	4986.81	1.256	<0.0001
3	4987.75	0.396	<0.0001
4	4988.33	3.086	<0.0001
5	4989.80	7.720	<0.0001
6	4990.65	11.942	6.68
7	4991.23	8.182	<0.0001
8	4993.38	3.570	<0.0001
9	4994.52	11.405	<0.0001
10	4998.74	8.028	<0.0001
11	4998.96	6.262	<0.0001
12	4999.67	6.989	<0.0001
13	4999.92	7.382	<0.0001
14	5004.90	3.095	<0.0001

HP-HT measurements for sample-2

Pore Pressure (psi)	Confining Pressure (psi)	Temp. (C)	Attenuation	Phase Shift	Period	Permeability (mD)
1450	4351	24.8	0.0307076364	0.3142372273	480	5.8276E-08
1450	4351	24.8	0.0673406071	0.26802775	960	6.1834E-08
1450	4351	58	0.0033648	0.4084054286	240	9.5425E.08

1450	4351	58	0.0288892917	0.3146287083	480	2.9442E.08
1450	4351	90	0.0182285714	0.3666128095	240	2.7124E.08
1450	4351	90	0.0402685714	0.2905114583	480	2.7082E.08
1450	4351	105	0.0449675652	0.2542902308	480	2.5087E.08
1450	4351	139	0.0486612778	0.2719544444	480	2.0844E.08
1450	4351	139	0.0877624444	0.2680397778	960	1.9225E.08
1450	4351	205	0.05776225	0.305456	480	1.734E.08

HP-HT measurements for sample-2

Pore Pressure (psi)	**Confining Pressure (Psi)**	**Temperature (C)**	**Permeability (mD)**
1450	1885	21.3	1.89E+02
1450	2175	21.3	1.88E+02
1450	2175	47.6	1.78E+02
1450	2900	48.5	3.71E+01
1450	2900	76.5	3.75E+00
1450	3625	77.4	3.28E+00
1450	3625	113	1.45E+00
1450	4061	77	3.52E+00
1450	4351	113	8.29E-01
1450	4351	135	3.67E-03
1450	4351	144	1.01E-02

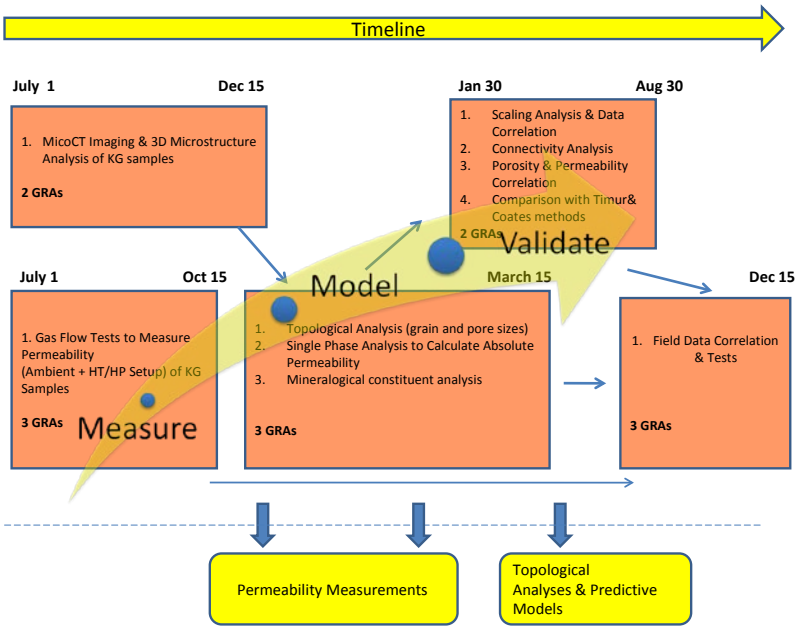
HP-HT measurements for sample-2

Pore Pressure (psi)	**Confining Pressure (psi)**	**Temperature (C)**	**Attenuation**	**Phase Shift**	**Period**	**Permeability (mD)**
1450	4351	25.5	0.07476905	0.2973566	60	1.16E-6
1450	4351	25.5	0.1650703529	0.2524155882	120	1.27E-6
1450	4351	73	0.1693201429	0.2515728462	60	1.14E-6

To predict the permeability of HP_HT reservoirs in Krishna Godavari basin and use the results for Field Development plans.

8. Material and Methods along with necessary diagrams

Core analysis, Log analysis, integration of core and log data. The workflow is depicted below.



Work flow for field development planning

9. List of equipment, technical facilities/resources used from PDPU for the above mentioned research activity

Rock Cutter, Rock Polisher, Hand Specimen Studies

10. Significant Results/key outcomes/achievements along with necessary pictures / diagrams / images

- To get a comprehensive understanding the rock samples from the tight gas sandstone field of GSPC
- To establish the transport properties of the tight gas sandstone
- To develop pore scale models reconstruction and network model analysis
- To establish data correlation with scaling analysis of the above studies
- Field data comparison

11. Impact of the research outcomes or findings that address the intellectual merit and broader impacts of the research work

This project helped in developing a Field Development Planning tool for High Pressure-High Temperature reservoir conditions which helps in correlating porosity with permeability.

12. How the results have been shared/ disseminated:

A detailed report was submitted to GSPC, which can be accessed and used by industry personnel as well as research community for analytical studies.

13. Give also name of other PDPU individuals involved in the research

N.A.

14. Which organizations have been involved as partners?

- GERMI
- Georgia Tech

15. Have other collaborators been involved?

- Dr. Vijay Medisetti- GATECH-USA
- Mr. Arshadeep Baghha- GATECH-USA

16. Mention if any infrastructure got added out of research outcome to PDPU institutional resources.

- Polarized microscope was procured for the project which is being used by the students and researchers in SPT

17. Includes up to six images (images are optional)