IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

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| **Project Title:** | **Pathways for clean energy development through using neutron scattering and gas sorption studies in gas shales** |
| **Project Number** | **IMURA0884** |
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## Research Clusters:

**Highlight which of the Academy's CLUSTERS this project will address?**
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

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|---|---|
| 1 | *Material Science/Engineering (including Nano, Metallurgy)* |
| 2 | *Energy, Green Chem, Chemistry, Catalysis, Reaction Eng* |
| 3 | *Math, CFD, Modelling, Manufacturing* |
| 4 | *CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control* |
| 5 | ***Earth Sciences and Civil Engineering (Geo, Water, Climate)*** |
| 6 | *Bio, Stem Cells, Bio Chem, Pharma, Food* |
| 7 | *Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng* |
| 8 | *HSS, Design, Management* |

## Research Themes:

**Highlight which of the Academy's Theme(s) this project will address?**
*(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

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|---|---|
| ***1*** | *Advanced computational engineering, simulation and manufacture* |
| 2 | *Infrastructure Engineering* |
| 3 | ***Clean Energy*** |
| 4 | *Water* |
| 5 | *Nanotechnology* |
| 6 | *Biotechnology and Stem Cell Research* |
| 7 | *Humanities and social sciences* |
| 8 | Design |

## The research problem

Shales once assumed to be of limited use are now viewed as mainstream energy resources. While the world is making a shift from high- to low-carbon intensive fuels, India is moving ahead in developing alternative fuel resources to bridge the gap between the available supply and projected demand. Methane in gas shale formations is stored in adsorbed state and a developing a good understanding about the pore attributes, fluid flow mechanism as well as gas-solid interaction are essential for recovery gases.

Dimensions of the pores (porosity), their connectivity (permeability), Eh-pH conditions, oxidizing/reducing environment (adjacent to the pores) play crucial roles in element/ion/gas molecule migrations through the porous matters. In fact, all these factors influence 'Fick's diffusion models' significantly, in a complex manner, according to their relative dominance. As porosity in gas shale formations are dominated by micropores, understanding the micropore attributes are crucial in understanding the gas storage behaviour, which, combined with the gas flow model to visualize the reservoir behaviour during shale gas recovery. The variation of pore attributes and composition of the rock with increasing depth poses challenge in long term recovery and reservoir stability estimation.

The present project will involve shales collected from Gondwanas and those geologically equivalent. This approach is taken to ensure minimum 'post depositional' deformation / alteration effects. Further emphasis will be shales associated with reducing environment, e.g. shales containing pyrite, high Fe2+/Fe3+ ratio, associated with coal / coal bed methane / oil & gas etc, as this discourages cation migrations.

## Project aims

For a given sedimentary basin with wide range of shale rocks, following aims will be addressed

1. To establish mineralogy of the shale rock, including identification of organic material components using CHNSO and rock-eval analysis. Quantification of shale pores shall be done using image analysis, images obtained from FEG-SEM.

2. Quantitative analyses of porosity and permeability of the rocks using SAXS/SANS, and verifying the data with low pressure gas adsorption data.

3. Develop effective numerical models to visualize gas flow in shale based on the understanding developed in the experimental study.

## Expected outcomes

Shale characterization using X-ray diffraction will provide the chemical composition of the selected shale. Further characterization using high-resolution FEG-SEM will provide pore size and shape information in addition to the extent of connectivity between the kerogen and clay components of the shales as well as diagenetic signatures of shales. Further, pore size distribution and surface area analyses will be determined from low pressure gas adsorption using $N_2$ and $CO_2$ as probe gases. Fractal dimensions, micropore visualization, pore type (organic or inorganic) depending on the scattering length and pore availability to liquids can be calculated using data generated from SANS/USANS and SAXS. The characterization, geochemical and geomechanical properties of the shale, low pressure gas adsorption results and most importantly, the SANS/USANS and SAXS result will be used as inputs to the development of single-pore and 3D pore network models to investigate gas adsorption and transport through the porous structure of these natural subsurface systems. Results of this work will provide improved understanding of gas-in-place estimates in these systems, methods for enhancing gas recovery, in addition to the potential of depleted shale reservoirs to serve as geological reservoirs for $CO_2$ storage.

**How will the project address the Goals of the above Themes?**

This project addresses the themes like clean energy, and advanced computational engineering, simulation and manufacture.

## Capabilities and Degrees Required

Capability in laboratory experiments and numerical modelling with a background in geology, chemistry, chemical engineering may be desired.

## Potential Collaborators

BARC, Navi Mumbai

Please provide a few key words relating to this project to make it easier for the students to apply.

Gas shales, numerical modelling, geomechanics, small angle neutron scattering, low pressure gas adsorption, permeability