Project Code (MoC S&T) CE-35

Reservoir characterization and numerical modeling of coal reservoir for enhanced Coal bed methane recovery and prospects for carbon sequestration (CE-35)

Project Completion Report

Submitted to

Central Mine Planning and Design Institute Limited (CMPDIL),

Gondwana Place, Kanke Road, Ranchi,

PIN: 834031, Jharkhand, India

Submitted by

Dr. Vikram Vishal

Principal Investigator

Professor, Department of Earth Sciences

Centre for Climate Studies

Indian Institute of Technology Bombay, Mumbai

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Project Completion Report

1. Title of the project: Reservoir characterization and numerical modeling of coal reservoir for enhanced Coal bed methane recovery and prospects for carbon sequestration.

2. Project Code: (CE-35).

3. Date of commencement: January 02, 2023.

4. Approved date of completion: January 02, 2025.

5. Actual date of completion: January 01, 2025.

6. Objectives as stated in the Proposal

1. A comprehensive petrophysical and geomechanical characterization of coal.

2. Determination of adsorption characteristics of targeted coal seams, including the samples from old workings – using both low-pressure and high-pressure adsorption methods.

3. Multi-phase CO_2 flow and deformation attributes of coal at simulated sub-surface conditions.

4. Development of a complete numerical modeling platform using COMET3 for reservoir scale simulation of the performance of the ECBMR project.

5. Indigenous capacity building for continued R&D and exploitation of CBM from other prospective basins.

.Recommendation and Conclusions

A comprehensive experimental and numerical analysis was conducted to understand the CO_2 storage potential in coal seams encompassing four coal mines in Jharkhand, West Bengal, Chhattisgarh, and Madhya Pradesh. Based on available data on the seam thickness and petrophysical and geomechanical analysis, we performed a preliminary simulation to understand the CO_2 storage capacity in each of these regions after 10 years of injection. The conclusions of the study are as follows:

1. Other than the organic matter, the coal and shale samples contain quartz and clay minerals (such as kaolinite and illite) as major components, while feldspar, siderite, apatite, pyrite, calcite, sericite, ankerite, and dolomite is present in minor amounts. The observations indicate that the Tamra block has the highest clay mineral content (kaolinite) and a considerable quartz content. Meanwhile, the South Damuda block from Jharia shows a significant presence of quartz, kaolinite, and illite. Additionally, the Chulaha Bhulia block sample shows a significant amount of quartz and kaolinite. However, the Moonidih block in the Jharia coalfield reveals a higher amorphous content and the lowest amount of clay minerals and quartz. These findings provide valuable insights into the mineral composition and structural properties of the samples, which directly influence gas adsorption and gas flow dynamics.
2. In this study, the Rock-Eval pyrolysis method was used to evaluate the hydrocarbon potential, thermal maturity, and gas-generating potential of coal and shale samples. It provides quantitative and qualitative information about the organic matter present in these samples. These parameters directly influence the efficiency and effectiveness of ECBM recovery. The observations reveal that the Moonidih block has a higher Total Organic Carbon (TOC) content, ranging from 68.07 to 68.40. In contrast, the South Damuda block in the Jharia coalfield shows TOC values varying from 50.23 to 67.64. Additionally, the Tamra block in the Raniganj coalfield exhibits a TOC range of 15.74 to 70.06, which includes coal, coaly shale, and shale samples. Furthermore, the Salanpur and Chulaha Bhulia blocks in the Sohagpur coalfield show significant TOC values, varying from 52.02 to 72.56 and 47.46 to 67.92, respectively. Notably, higher TOC values indicate a greater potential for CH_4 (methane) generation and CO_2 storage.
3. The LPGA data reveals a good correlation between micropore attributes and TOC values, as well as a significant relationship between clay mineral content and mesopore

attributes. However, some samples from the South Damuda block in the Jharia coalfield and the Chulaha Bhulia block in the Sohagpur coalfield deviate from this trend due to the presence of siderite, pyrite, and calcite in the samples. The presence of these minerals does affect the pore attributes of coal and shale. These findings provide key insights into the pore structure attributes and gas adsorption capacity, which directly influence gas storage, production, and fluid flow through subsurface formations.

4. The high-resolution imaging methods determine insights into pore morphology and structure. Fluid-invasive methods such as LPGA provide quantitative data on pore attributes, while the imaging method shows qualitative information about pore structures. Further, the HPGA analysis provided the Langmuir isotherms and the associated parameters. The SEM image shows intraparticle pores, interparticle pores, organic pores, and microcracks in coal and shale samples. In addition to this, organic pores in shale are crucial for storing methane, with gas adsorption primarily affected by the presence of organic matter.
5. Based on the numerical simulation, coal volume, and seams' thickness, the South Damuda and Tamra block of Jharia and Raniganj Coalfields, respectively are the best choice for CO_2 injection. The selected Raniganj and Jharia coal blocks can accommodate between 115.70 and 393.27 million m^3 of CO_2 after 10 years of injection, post 10 years of production (without injection), respectively, based on our 1 well injection configuration, assuming a depleted reservoir condition. In contrast, Sohagpur and Sonhat selected coal blocks can store between 30.44 and 61.75 million m^3 of CO_2 after 10 years of injection, post 10 years of production (without injection), respectively. However, it is important to note that numerous assumptions were made in this analysis regarding parameters that significantly influence injection rates and plume sizes, such as coal permeability, Langmuir curves, and swelling and shrinkage effects. Once real data on permeability and Langmuir parameters become available, more accurate estimations of injection volumes, production volumes, and CO_2 plume sizes can be generated.
6. With promising scoping-level results, the specific seam-by-seam estimation is encouraged to be evaluated through dedicated drilling, characterization, and simulation for decision-making, leading to a pilot CCS project in India.