# Exploring $CO_2$ storage potential in Lithuanian deep saline aquifers using digital rock volumes: a machine learning guided approach

**Shruti Malik[1], Pijus Makauskas[2], Ravi Sharma[3], Mayur Pal[4]**
[1, 2, 4]Kaunas University of Technology, Department of Mathematical Modelling, Kaunas, Lithuania
[3]Department of Earth Sciences, Indian Institute of Technology, IIT Roorkee, India
[4]Corresponding author
**E-mail:** [1]*shruti.malik@ktu.lt*, [2]*pijus.makauskas@ktu.lt*, [3]*ravi.sharma@es.iitr.ac.in*, [4]*mayur.pal@ktu.lt*

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**Abstract.** The increasing significance of carbon capture, utilization and storage (CCUS) as a climate mitigation strategy has underscored the importance of accurately evaluating subsurface reservoirs for $CO_2$ sequestration [1]. In this context, digital rock volumes, obtained through advanced imaging techniques such as micro-Xray computed tomography (MXCT), offer intricate insights into the porous and permeable structures of geological formations [2]. This study presents a comprehensive methodology for assessing $CO_2$ storage viability within Lithuanian deep saline aquifers, namely Syderiai and Vaskai, by utilizing petrophysical properties estimated from digital rock volumes [3, 4]. These petrophysical properties were derived from core samples collected from these formations. Utilizing machine learning algorithms, porosity was estimated while the Lattice Boltzmann method (LBM) was applied to determine permeability [5]. The methodology employed for estimating these petrophysical parameters was initially validated using samples from formations analogous to Lithuanian formations. Subsequently, it was applied to rock samples specifically obtained from Lithuanian formations. The estimated petrophysical properties were compared with peer-reviewed data from published literature. When fluids such as $CO_2$ or $H_2$ are injected into sub-surface reservoirs, they can alter pore and grain characteristics. Therefore, it is crucial to extract representative element volumes (REVs) from segmented volumes to study the impact of fluids on porosity and their distribution [6]. These mini models, representing small portions of the larger formation, assist in predicting fluid flow within the formation, which is vital for assessing the efficiency and safety of carbon capture and storage (CCS) operations. Subsequently, numerical modelling was conducted using the petrophysical parameters as inputs to assess the storage capacity of the Lithuanian formations using tNavigator software [7]. This research contributes to an enhanced understanding of pore space distribution and its role in various aspects of long-term $CO_2$ storage. It also demonstrates the potential of integrating advanced imaging techniques, machine learning, and numerical modeling for accurate assessment and effective management of subsurface $CO_2$ storage. This study shall aid in enhanced understanding of pore space distribution and their contribution towards various aspects of long-term storage. The results can be extended to study the geochemical reactions and geo-mechanical behaviour of the rocks. Such studies shall further facilitate identification of reservoir(s) wherein sequestration potential can be reliably explored.

**Keywords:** carbon capture, utilization and storage (CCUS), saline aquifers, storage potential, digital rock volumes, machine learning, lattice Boltzmann method, numerical modeling.

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