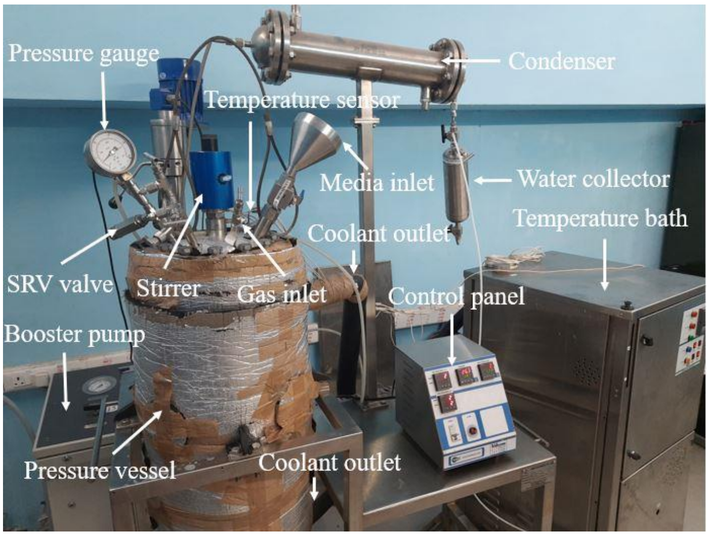
Gas Hydrate Lab Activities

Gas Hydrate Lab is actively involved in thermofluidic simulations and experiments for broad research areas of energy, environment and water resources. A summary of the activities is presented below:

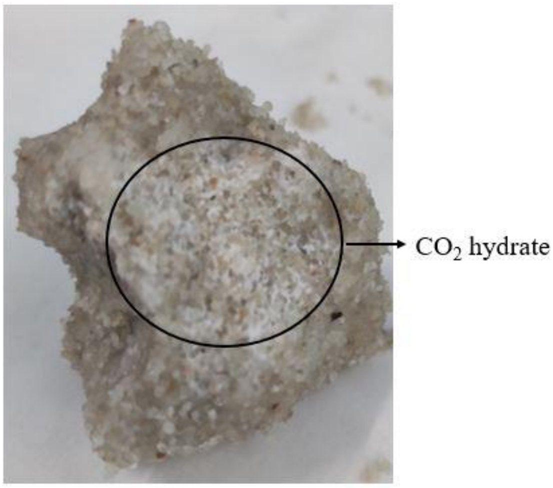
Research Area: Storage and Transportation

Project Title: Enhancement of CO_2 Storage in hydrate form using additive

Abstract: The increase in concentration of CO_2 in atmosphere is responsible for global warming. Fossil fuel-based power plants are mainly responsible for the emission of CO_2 gas, which produce one-third of CO_2 emission worldwide. Therefore, there is an urgent need of technology that can be used to capture and sequestrate CO_2 gas. The focus of the current project is related to CO_2 capture and storage in the form of hydrate. Gas hydrates are crystalline solids in which gas molecules are trapped inside hydrogen-bonded water molecule at high pressure and low temperature. The slow hydrate formation rate and low gas storage capacity limits the industrial use of this technology. Therefore, there is a need to enhance the hydrate formation rate and increase in gas storage capacity to make this technology commercially viable. Our laboratory is working towards development of novel Cu-Al Layered Double Hydroxide nanoparticle based promoter and its successful application.

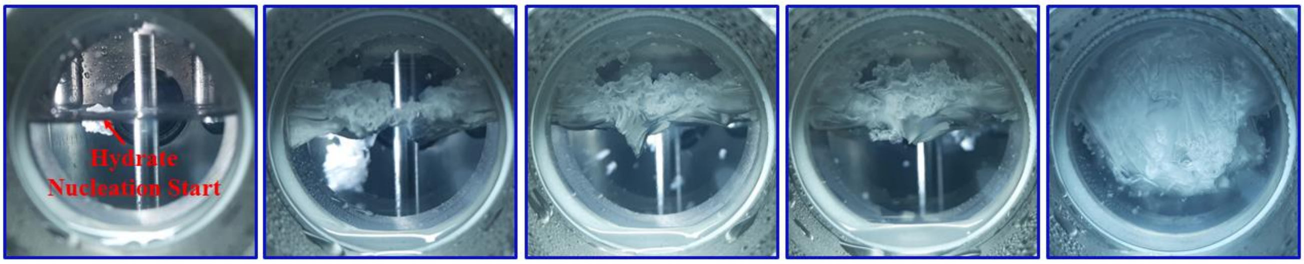


Pressure vessel with accessories



CO_2 hydrate formed in porous media

Team Members: Ayaj, Samarshi, Randeep



(A) At nucleation (N) (B) T= 15 min from N (C) T= 60 min from N (D) T= 120 min from N (E) T= 360 min from N

Visual observation of CO_2 hydrate growth in the presence of nanoparticles

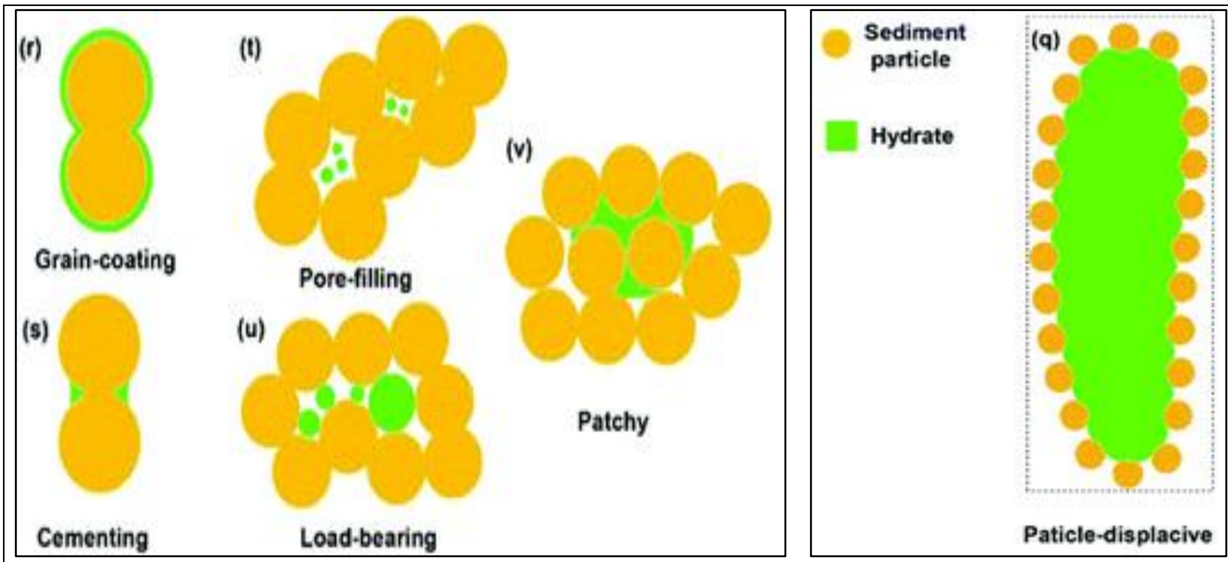
Research Area: Environment

Project Title: CO_2 Sequestration in Marine Hydrate Reservoir

Abstract:

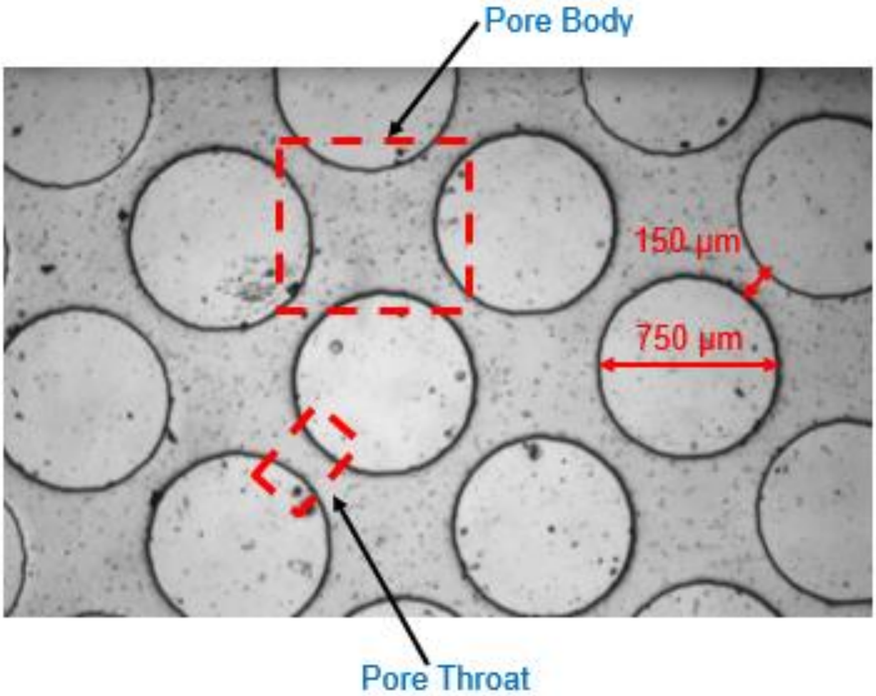
The effect of hydrates on seismic wave velocities is not only dependent on hydrate saturation but also on the microstructural distribution of hydrate grains within host sediments, which may include morphologies such as contact cementing, grain-coating, pore-filling, matrix-supporting, matrix-inclusion and fracture-filling. Thus, Investigation of hydrate morphology is crucial for modeling the elastic behaviors of GHB sediments and for better understanding the gas hydrate deposit environments as well as for revealing the hydrate occurrence mechanism.

Our group is studying the influence of grain size, pore space, degree of driving force (ΔT), and composition of the hydrate forming components etc. on hydrate growth morphology using glass micromodel. Not only grain distribution but also the grain surface wettability and surface roughness influence the hydrate morphology in Pore scale. To capture that effect, Numerical scheme based on the Volume-of-Fluid method is being implemented using the Open FOAM open source CFD package along with the phase change models.



Pore-scale growth habit of hydrate.

1)



2D glass micro model

Team Members: Saurabh

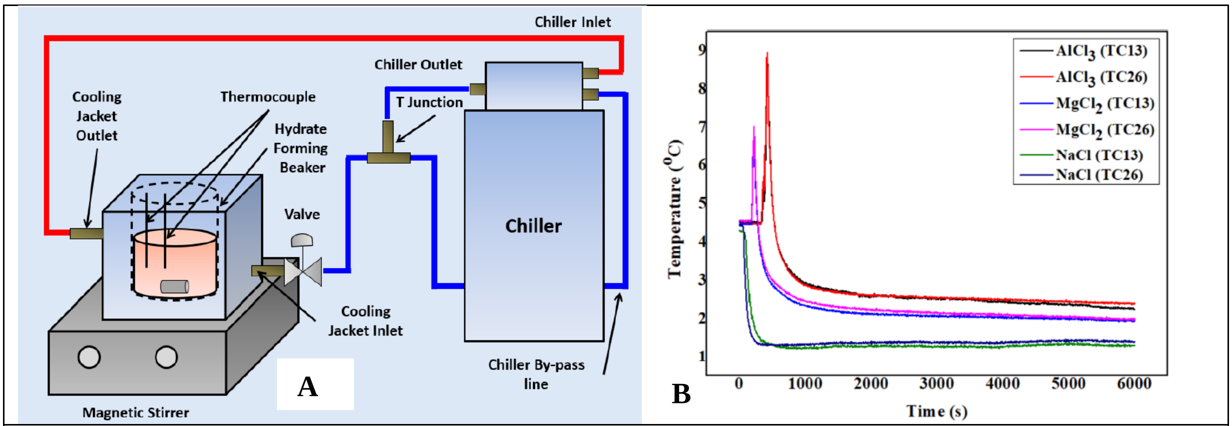
Research Area: Energy Resource Exploration

Project Title: Use of additives and packing materials to improve gas storage and recovery

Abstract: The addition of additives such as surfactants, nanofluids, salts, and alcohol can significantly alter the performance of hydrate forming reactor. The appropriate selection of additives can both enhance and inhibit hydrate formation process. Hydrate promoters are useful in storage and transport application whereas inhibitors are necessary for prevention for hydrate plugs in natural gas pipelines. The objectives of present study is to investigate suitable additives. The usage of appropriate porous media and material packing are also being explored for increasing the performance of reactor. Figure 1(A) shows the facility developed for a testing performance of salt based inhibitor at atmospheric pressure. A glass vessel is equipped with stirring arrangement and temperature control jacket. The distinguishing feature of the study is to utilize the solvation energy of the salt to Dissociate hydrate. Aluminum chloride is found is found to be most effective in increasing the temperature of the solution because of its higher solvation energy.

Team Members: Randeep Ravesh, Pankaj Kumar, Deepak

Project Title: Simulation of Methane Recovery and structural stability of Hydrate Reservoir



(A) Schematic diagram of the experimental set up for study of salt based inhibitor, and (B) Effect of solvation energy on temperature rise in THF solution

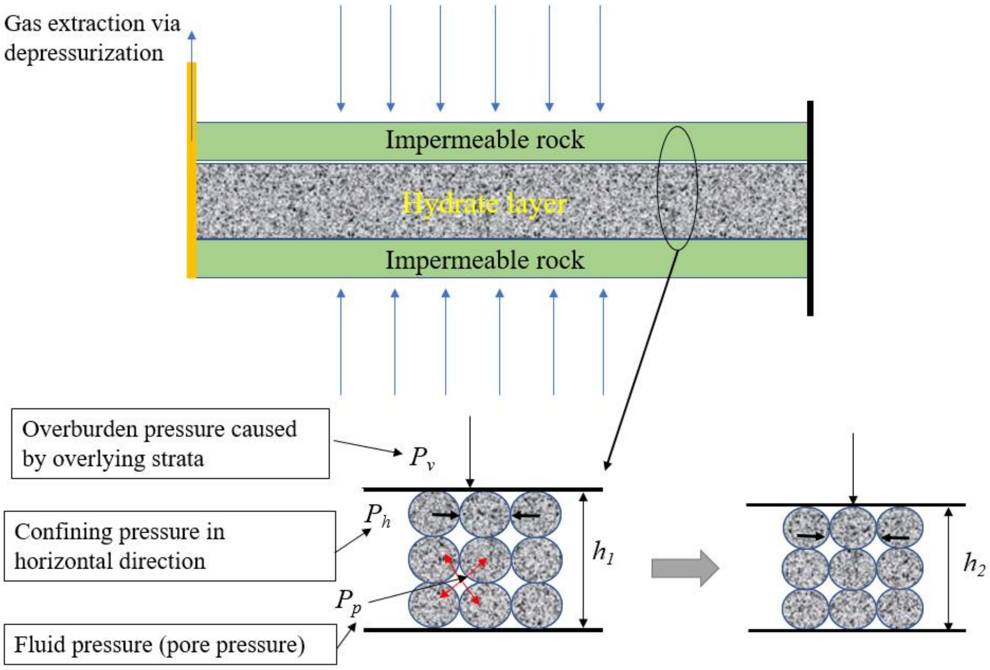
Abstract: The project aims at obtaining computational estimates of methane production from hydrate reservoirs. The procedure of extracting methane includes dissociation of hydrate by stand alone or combination of standard methods such as depressurization, thermal stimulation and chemical injection. The simulation of these methods involves solving the governing equations of multi-phase, multi-component flow and heat transfer in porous media. The hydrate dissociation has a direct effect on the sediment strength and its consolidation due to pore pressure reduction. It disturbs the stress equilibrium of the reservoir bed and thus may trigger geomechanical hazards in terms of unexpected subsidence. The modelling of the dissociation and stability aspects of the hydrate reservoirs is a coupled flow and geo-mechanical problem. The accurate quantification of gas production and induced subsidence is only possible by performing multi-phase multi-component flow simulations with an assessment of geomechanical response. Such simulations also generate database to develop surrogate models, which can be helpful for on board prediction of reservoir characteristics and health monitoring.

Team Members: Raghvendra, Rahul, Faizal

Project Title: Microwave thermal stimulation-based dissociation of hydrate at reservoir scale

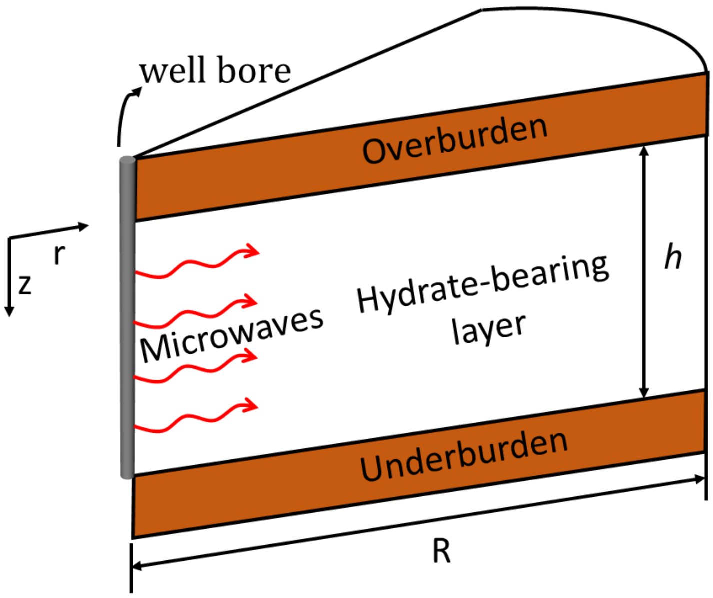
Abstract: There is growing need of alternate methods to provide thermal stimulation during the hydrate dissociation process. The thermal stimulation is required to supply the necessary heat to the hydrate reservoirs and heat the hydrate above the equilibrium temperature. The heating triggers the hydrate dissociation, and releases the methane gas. Microwave radiation may provide a fast and rapid heating alternative for hydrate dissociation. It has deeper penetration into the reservoir and through optimal control of the process, the possible heat losses can be minimized. The project studies the significance of microwave heating in combination with depressurization and discusses it as a possible method of production. It also

proposes several possible variants of applying microwave thermal stimulation with



Schematic of depressurization-based production and direction of various pressures acting on the reservoir. The production induced reduction in pore pressure results in increase of vertical stresses and reservoir compaction.

depressurization and compares them with pure depressurization.



Microwave heating at the well bore of the hydrate reservoir for dissociation.

Team Members: Rahul, Akash