

Rate of Cooling Mechanism of Gas Hydrates in Clay Environments Using Non-Stirred and Stirred Reactor

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Radhika Ikkurti¹

¹. Basic Sciences, G. Narayanamma Institute of Technology & Science, Hyderabad, IND

Corresponding author: Radhika Ikkurti, daakshayini.radhika@gmail.com

Abstract

We experimented with gas hydrate in various clay media. We discovered that in a clay environment, the rates of methane conversion were evidently smaller for higher R_w ratios than those in other media that are used experimentally. We express that the differences are due to the distinct water compositions at various pressures in different media in induction time and rate of cooling. In sediments like clay, because of its small particle size, the proportion of water that is bound is much higher than in sand, and the bound water is more difficult to hydrate. During thawing cycles, our experiments show that the rate of formation after the sub-cooling temperature has a rapid growth during the saturation level.

Categories: Advanced Materials, Fossil Fuel Energy, Hydrocarbon and Natural Gas Engineering

Keywords: gas hydrate, clay, dissociation, formation, rate of formation

Introduction

It is commonly known that hydrate formation mostly takes place at the interface between water and gas. In the case of water comfortable sediments that are compatible with water, hydrate formation is kinetically accelerated over time as a result of an increase in methane consumption for various sediments with varying water ratios. Diffusion controls subsequent conversion. When a certain amount of water converts to hydrates, it forms a sufficiently thick layer over the water phase, serving as a significant mass-transfer barrier to further hydrate growth [1,2]. It is unclear, though, whether the growth of additional hydrates is controlled by the transport of the guest (water) or the host molecule through the crystal film. In order to store methane gas using hydrates, the absolute gas amount trapped in hydrates must be high while the total artifact (combined weight of hydrate and matrix material) of the system must be low; that is, the hydrate-carrying porous medium must be saturated/supersaturated with water, so that the majority of the water is converted into hydrates. Initially, reports showed that hydrate yield increases only when the pores are fairly saturated with water [3,4]. Because of the higher matrix/water ratio, there is consequently less gas in the system. This is because there is less gas stock in the system. It has recently been demonstrated that increasing the body of water/matrix ratio and consequently, the compound yields (absolute methane carrying capacity) may be achieved more quickly by using dry water or reactive carbons [5,6].

Technical Report

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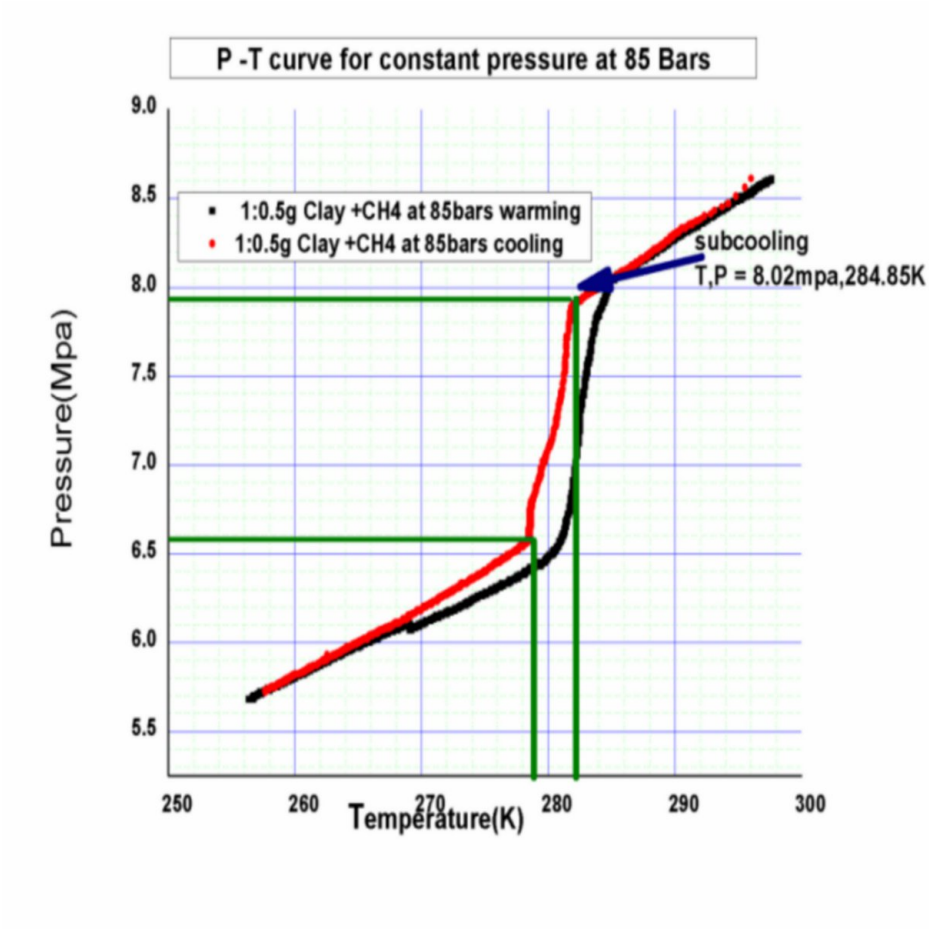


FIGURE 1: P-T curve of clay with an Rw ratio of 1-0.5 at 85 bars of methane gas

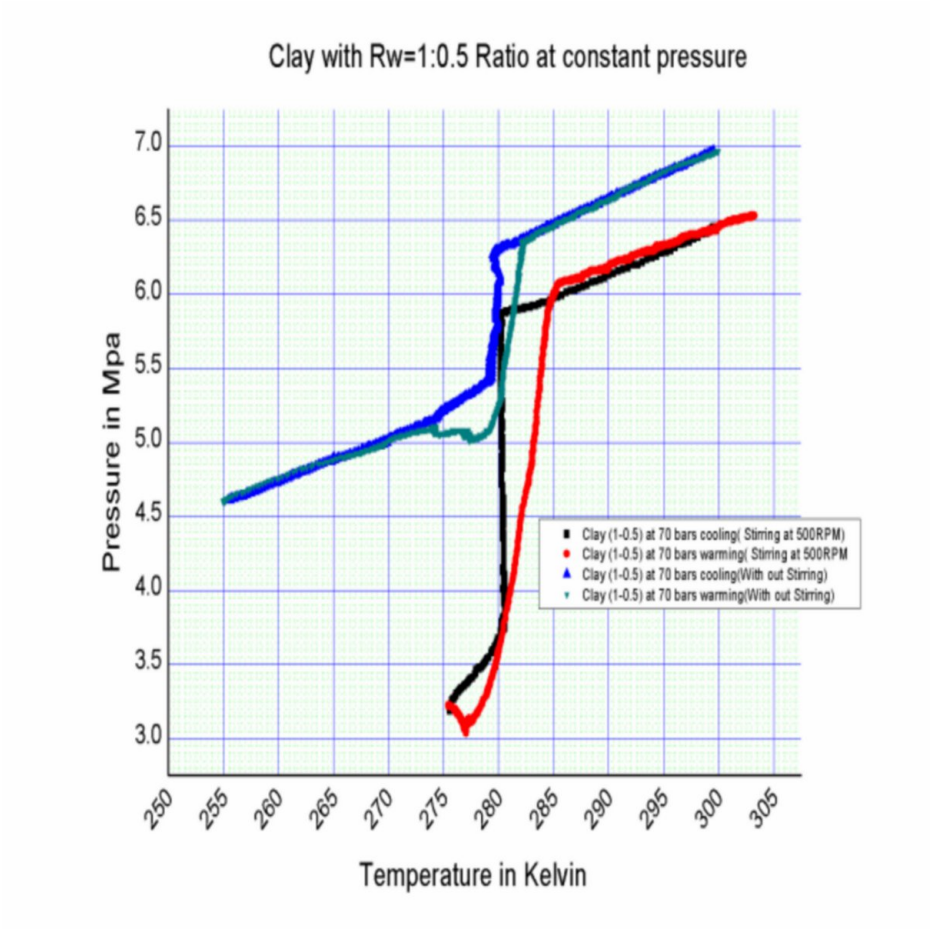


FIGURE 2: P-T curve of clay in non-stirred and stirred reactors of methane gas at points of sub-cooling temperature

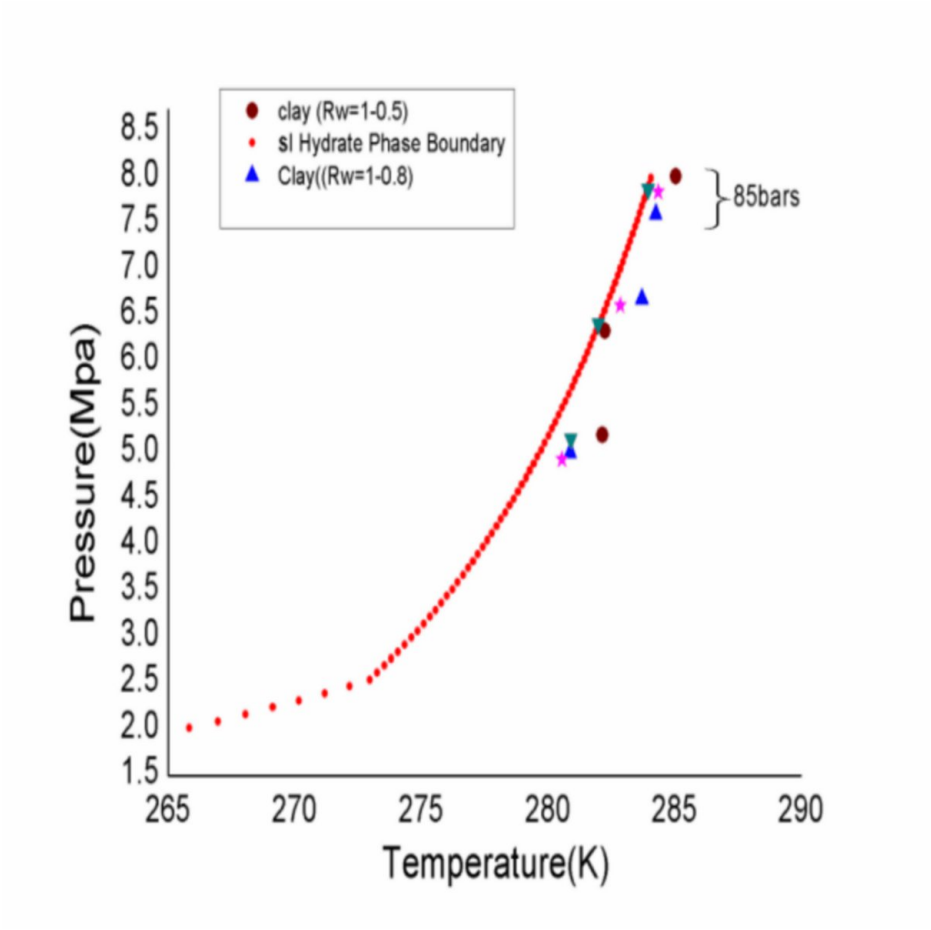


FIGURE 3: Comparison of dissociation points of clay with an Rw ratio of 1-0.5 at 85 bars of methane gas vs CSM

CSM, Colorado School of Mines

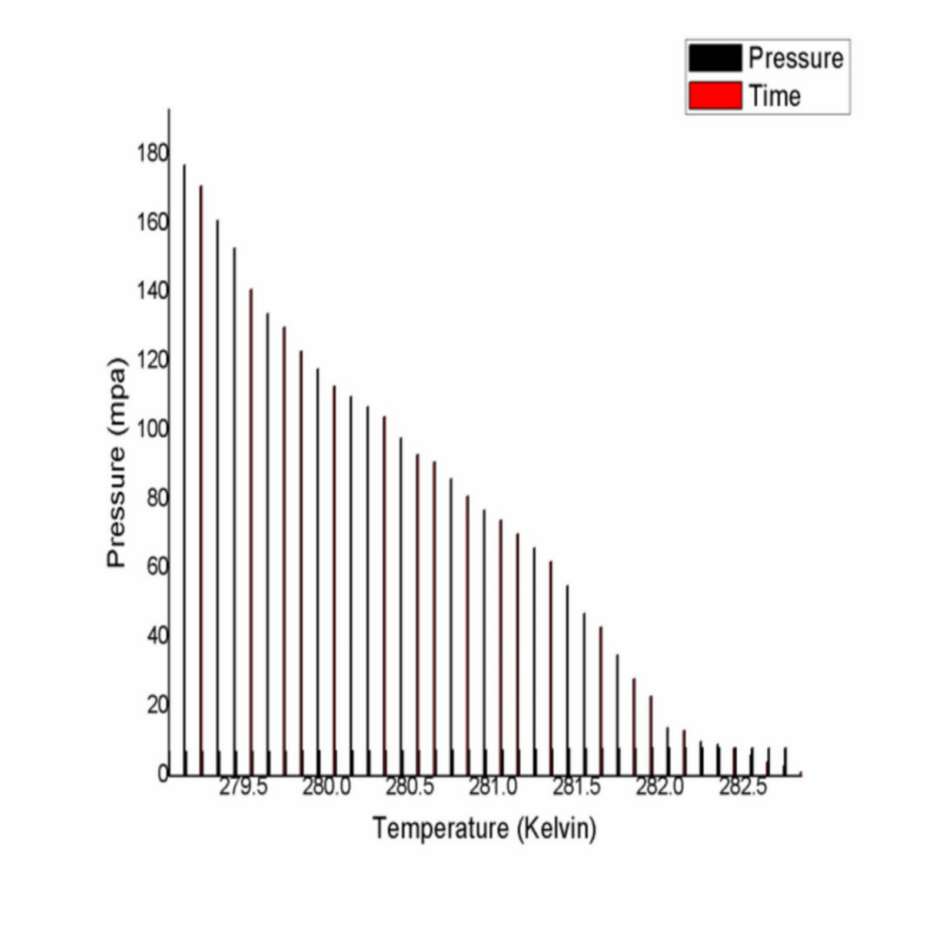


FIGURE 4: Rate of hydrate growth from sub-cooling temperature

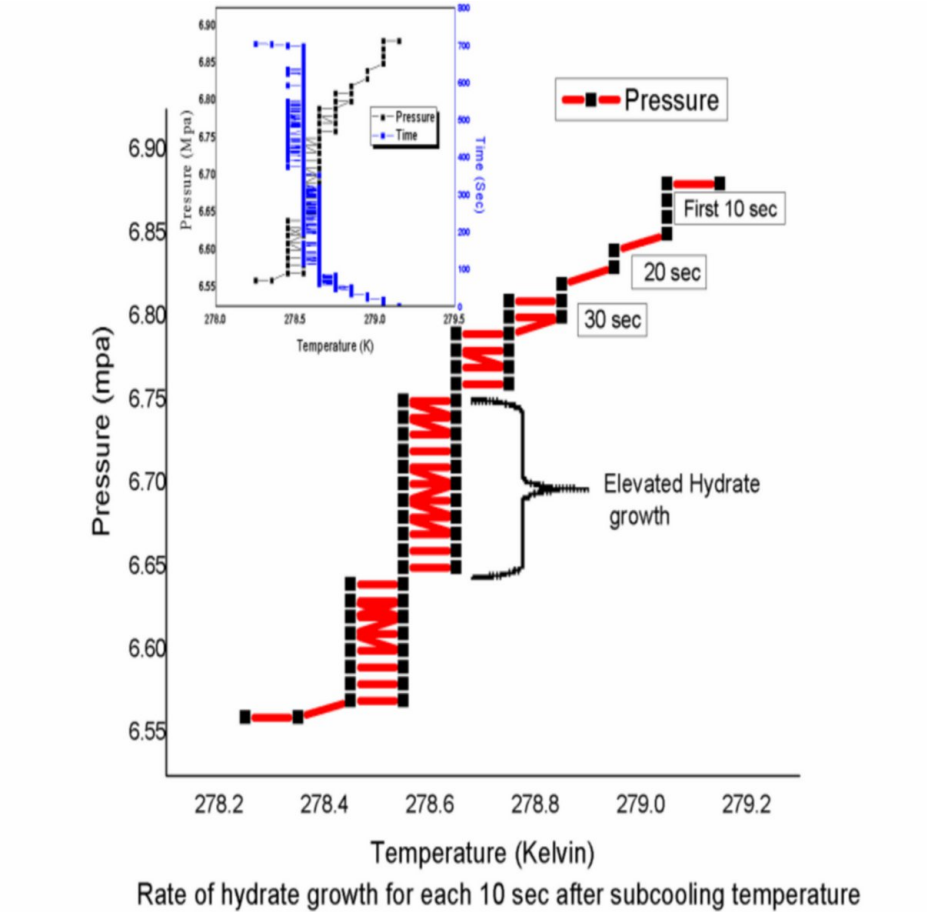


FIGURE 5: Rate of hydrate growth of clay for each 10 sec from sub-cooling temperature

Clay sediment	Pressure	Formation kinetics (min)	% yield
0.5 Ratio	85 bars	240	70 ± (5)
0.8 Ratio	85 bars	240	17 ± (2)

TABLE 1: Variation of yield and kinetics for clay at two different ratios

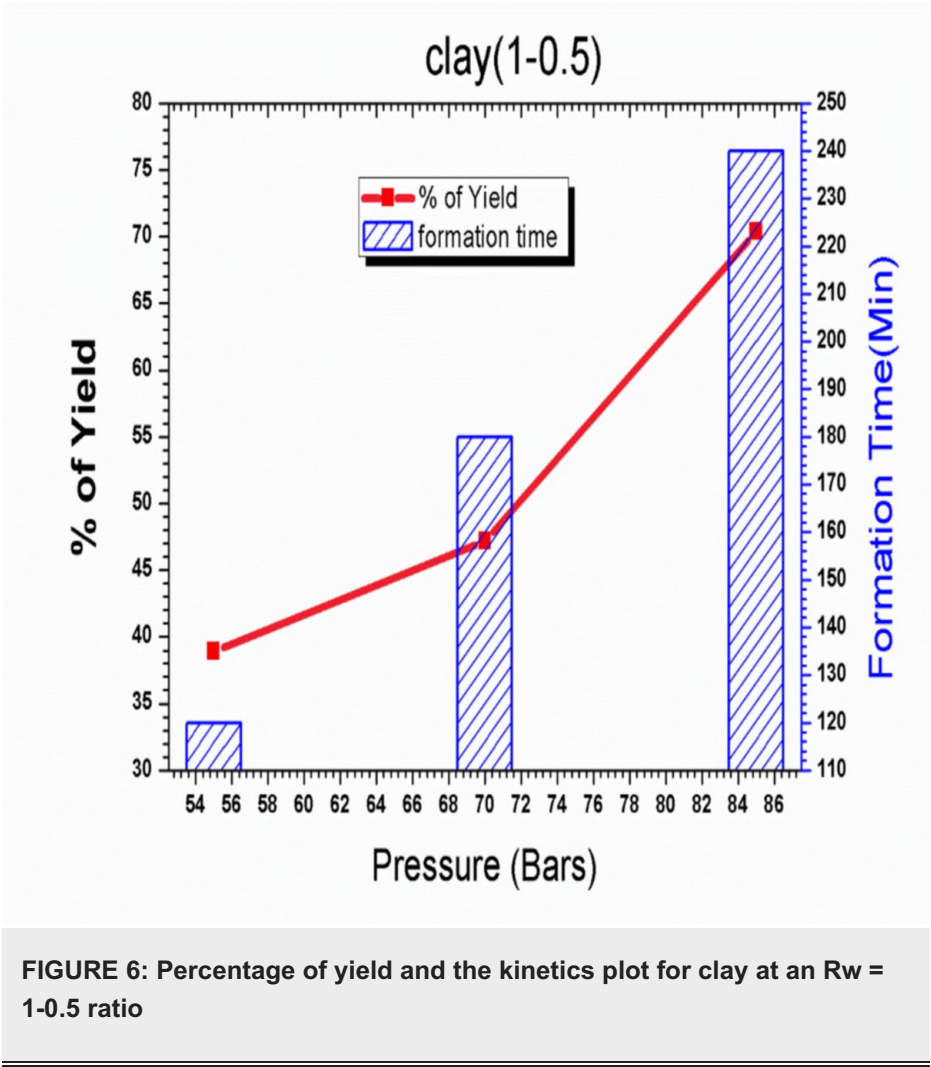
Methane hydrate formation with clay at constant pressure

Gas hydrate production is significantly impacted by the media used for hydrate arrangement. It was also suggested by Gunali et al. that the methane series hydrate formation within the medium would be more difficult the smaller the media's particle size.

The establishment and dissociation of the media used to arrange gas hydrates have a significant impact on their production. Gunali et al. also proposed that the formation of methane series hydrates within the medium becomes more difficult as the particle size of the media decreases. The main summary of this paper is on the yield, formation kinetics and rate at which the formation of the methane hydrate occurs using additives. The formation of gas hydrate kinetics is presented in two parts, kinetics and growth analyses with sediment at different concentrations. The methane gas hydrate using clay at a constant pressure of 85 bars with different weight percentages has been studied. In this paper, a serial of experiments are done in comparison with literature studies. When the reactor system is kept at constant temperature and pressure, the concentrations of the aqueous solutions of additives impact the storage capacity of natural gas (NG) in hydrate [4]. The presence of small quantity of foreign material on the hydrate formation was identified, and C.S. Zhang et al. offered solutions to a few issues pertaining to the

quick and abundant storage of NG in hydrate [4]. A series of studies conducted for this work demonstrate that adding more additives significantly reduced the shaping kinetics of methane hydrate. When the sample's water content is zero, or pure water, the establishment time for methane hydrate was short as much as 77 min from our previous tests conducted by Radhika et al. [7,8], whereas upon the addition of additives, it increased to 240 min as shown in Table 1, which is relevant to studies done by Zang [4], for each 10 sec from sub-cooling temperature.

Discussion



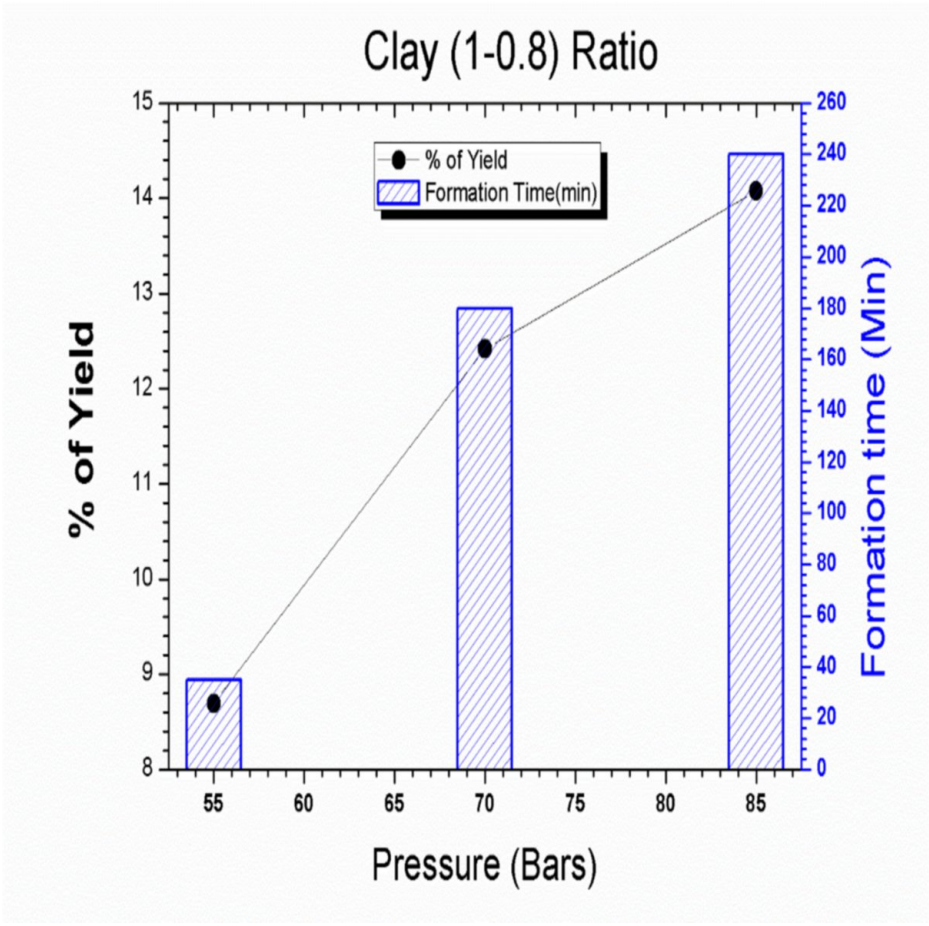


FIGURE 7: Percentage of yield and the kinetics plot for clay at an $R_w = 1-0.8$ ratio

Discussion of outcomes

The methane series gas uptake experimentation was completed in order to obtain a superior inclination of the foreign addable actions throughout the methane hydrate formation.

The studies on force, firmness and porousness unmake the clay construction and reflect the loss of sediment strength on hydrate dissociation because of the inter-corpucle electric repulsion, which was already reflected in the previous literary study. As the gas hydrate expedient forms, available at the link of the speck, and tightens the sediment supporting structure, it works on stability loss [6,7]. The dissociation temperature in clay from the Figures 1-4 for the former ratio changes from 275.1 K to 284.89 K compared to Colorado School of Mines Gem standard values. Hence, the time for chemical change of the hydrate changes slightly [7,8].

From our results, Figure 5 shows how fast the hydrate growth for each 10 secs after sub-cooling temperature for clay at 1:0.5 ratio is taken. After dissociation from Figure 6 and Figure 7, hydrate strengths of sediments decreases significantly, indicating the reduction of hydrate growth in the increased water ratios, as shown in the Table 1. Encouragingly, given the high hydrate yield, it may also be the primary cause of the hydrate flexure's growth at higher drives. From our results, we show that the rate of formation is not uniform once it is set to cooling. Rather, after sub-cooling the rate of formation increases when it is almost reaching to saturation which shows a different behavior. This might be because of memory effect affecting clay at the initial stages.

Conclusions

Methane gas hydrates render placement activity in clay was investigated. The methane hydrate formation experiments with five cooling rates were used in the methane hydrate formation experiments from 279.2K to 278.2K. The commendation times of methane hydrate formation with each cooling rate were measured for comparison. In comparison to the other stages, the hydrate rate at the third stage was rapid. We discovered that for the same initial modality, the faster the cooling rate, the greater the temperature

reduction, resulting in a shorter nucleation time. However, in a water-rich scheme, the hydrate reckoning factor narrows and the kinetics are relatively slow. Despite this there is no epoch-making gain or decrement during the clay's formation period for slanted water systems in two quantitative relation. The reason for these conclusions in the clay-based systems was the dynamics of these permeable media, which led to increased chemical compound yields in comparison to water-rich instrumentality and was similar to our previous clay data-based results. The chilling rate has an impact on methane figuring rate as well, which has to be further studied throughout.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Radhika Ikkurti

Acquisition, analysis, or interpretation of data: Radhika Ikkurti

Drafting of the manuscript: Radhika Ikkurti

Critical review of the manuscript for important intellectual content: Radhika Ikkurti

Supervision: Radhika Ikkurti

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue.

Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue.

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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