PSThermogenic Gas Hydrate System and Models of Gas Hydrate Occurrence Patterns*

Linyun Tan[1], Arthur H. Johnson[2], and Lijun Cheng[1]

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[1]Chongqing Institute of Geology and Mineral Resources, Chongqing, China (674773105@qq.com)
[2]Hydrate Energy International, Kenner, LA

Abstract

Gas hydrate formation is mainly controlled by the temperature, and gas concentration. Only if the gas is oversaturated within the gas hydrate stability zone (GHSZ) can gas hydrate form. Based on these ideas, this article gives a model of a thermogenic gas hydrate system, concluding that a good combination of source rock, reservoir rock and cap rock is indispensable for gas hydrate formation. In this system the good conduits and cap rock may be the most important factors because the concentration of gas from deeper sources and the locations where the gas could accumulate are both based mainly on these two factors. Then, on the basis of the model, this article presents the highly idealized interaction between structural hydrocarbon traps, which include reservoir-associated water together with oil and gas superimposed by different bases of gas hydrate stability zones, and predicts that there would be four types of occurrence patterns for gas hydrate in the world. Lastly, this article gives a model of occurrence patterns for different traps in the differential entrapment.

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重庆地质矿产研究院
Chongqing Institute of Geology and Mineral Resources

Thermogenic Gas Hydrate System and Models of Gas Hydrate Occurrence Patterns

Linyun Tan[1,2,3], Arthur H. Johnson[4] and Lijun Cheng[1,2,3]

(1) Key Laboratory for Shale Gas Resource & Exploration, Ministry of Land and Resources, Chongqing Institute of Geology and Mineral Resources, Chongqing 400042, China;
(2) Chongqing Engineering Research Center for Shale Gas Resource & Exploration, Chongqing Institute of Geology and Mineral Resources, Chongqing 400042, China;
(3) Chongqing Shale gas Research Center of State Key Laboratory of Petroleum Resource and Prospecting, Chongqing 400042, China.
(4)Hydrate Energy International, Kenner, LA.
E-mail: 674773105@qq.com; Cell: +86-13983021525

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Abstract

Gas hydrate formation is mainly controlled by temperature, pressure, and gas concentration. Only if the gas is oversaturated within the gas hydrate stability zone (GHSZ) can gas hydrate form. Based on these ideas, this article gives a model of a thermogenic gas hydrate system, concluding that a good combination of source rock, reservoir rock and cap rock is indispensable for gas hydrate formation. In this system good conduits and cap rock may be the most important factors because the concentration of gas from deeper sources and the locations where the gas could accumulate are both based mainly on these two factors. Then, on the basis of the model, this article presents the highly idealized interaction between structural hydrocarbon traps, which include reservoir-associated water together with oil and gas superimposed by different bases of gas hydrate stability zones; and predicts that there would be four types of occurrence patterns for gas hydrate in the world. Lastly, this article gives a model of occurrence patterns for different traps in the differential entrapment.

Objectives

The gas concentration is the core factor which should control the formation of gas hydrates in the environments of appropriate temperature and pressure (which is termed the "gas hydrate stability zone" or GHSZ).

Therefore, this paper presents research on what are the primary controls on gas accumulation in the sediments and concludes with a system for gas hydrate formation and accumulation.

In addition, on the basis of the model of gas hydrate system, this paper attempts to predict the occurrence patterns for gas hydrates in the sediments. These results would be helpful for future exploration.

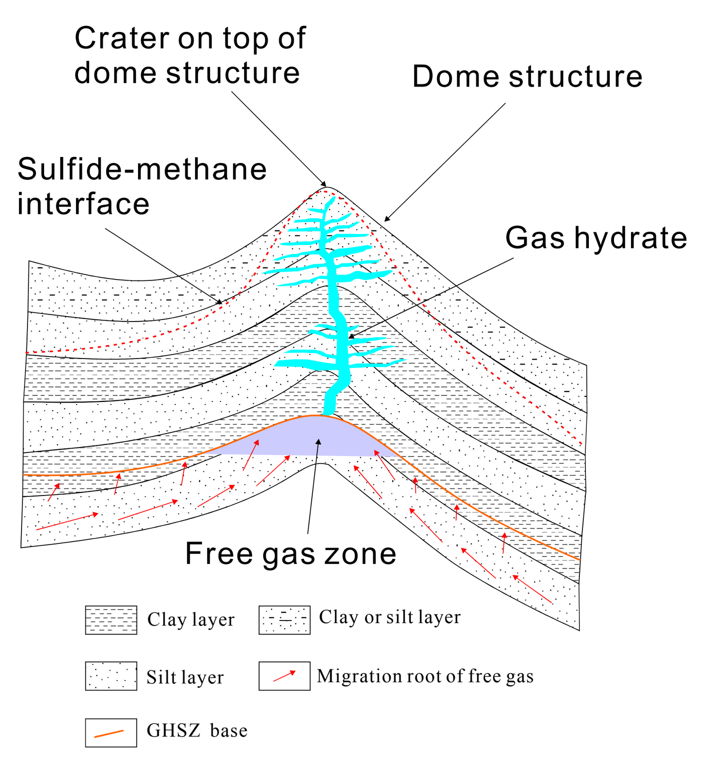

Figure 1. Carton of shallow gas hydrate formation (Modified from Luan et al., 2008)

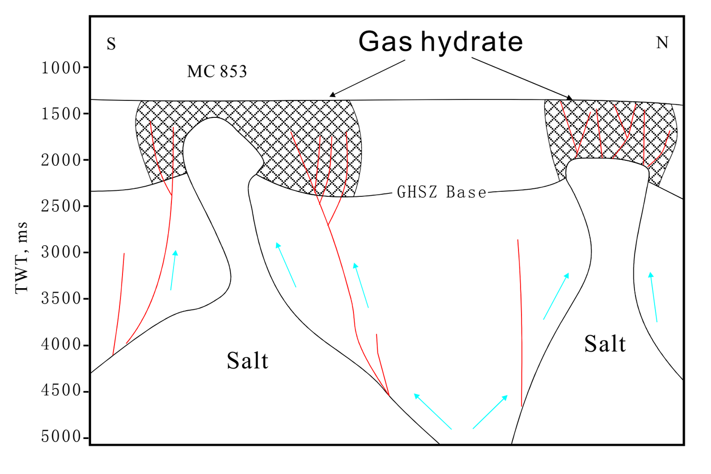

Figure 2. A model for the distribution of gas hydrate at Mississippi Canyon Block 853 (hatched areas). (From Milkov and Sassen, 2001).

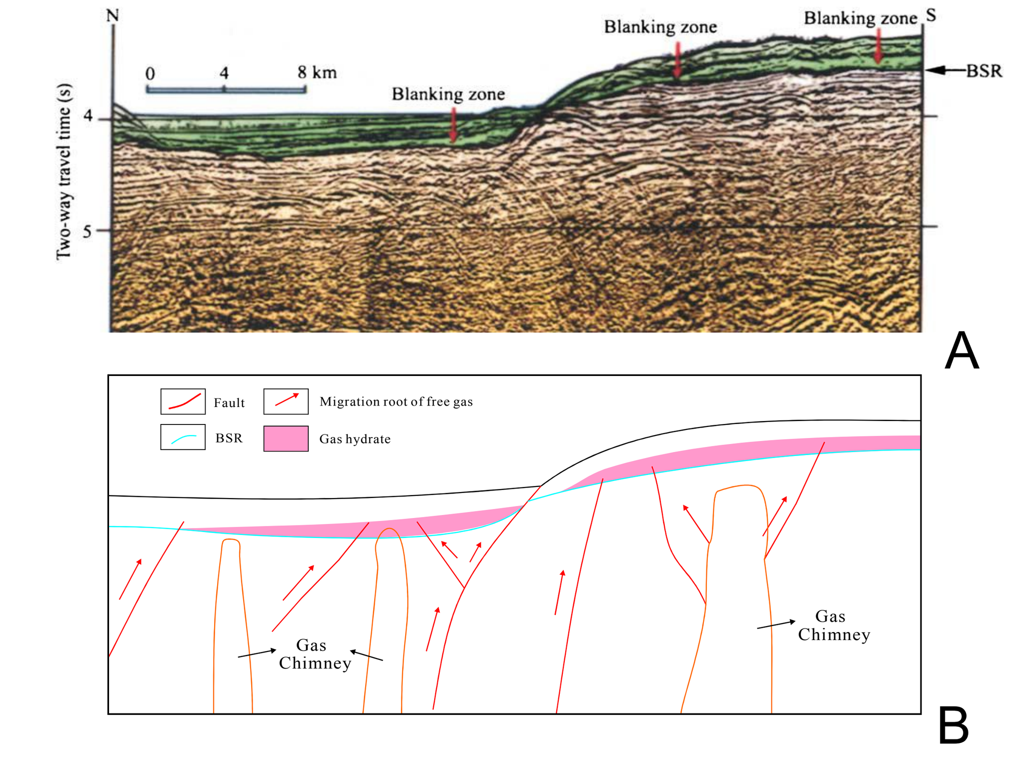

Figure 3. Figure 3A is a seismic profile in the Xisha Trough of the South China Sea showing active faults and Bottom Simulatig Reflectors (BSRs) (From Wu et al., 2005). Figure 3B is an interpretation of Figure 3A.

These are the examples of active faults or fractures providing good conduits for upward gas migration. If the gases trapped in the GSHZ are oversaturated, the gas hydrates would form.

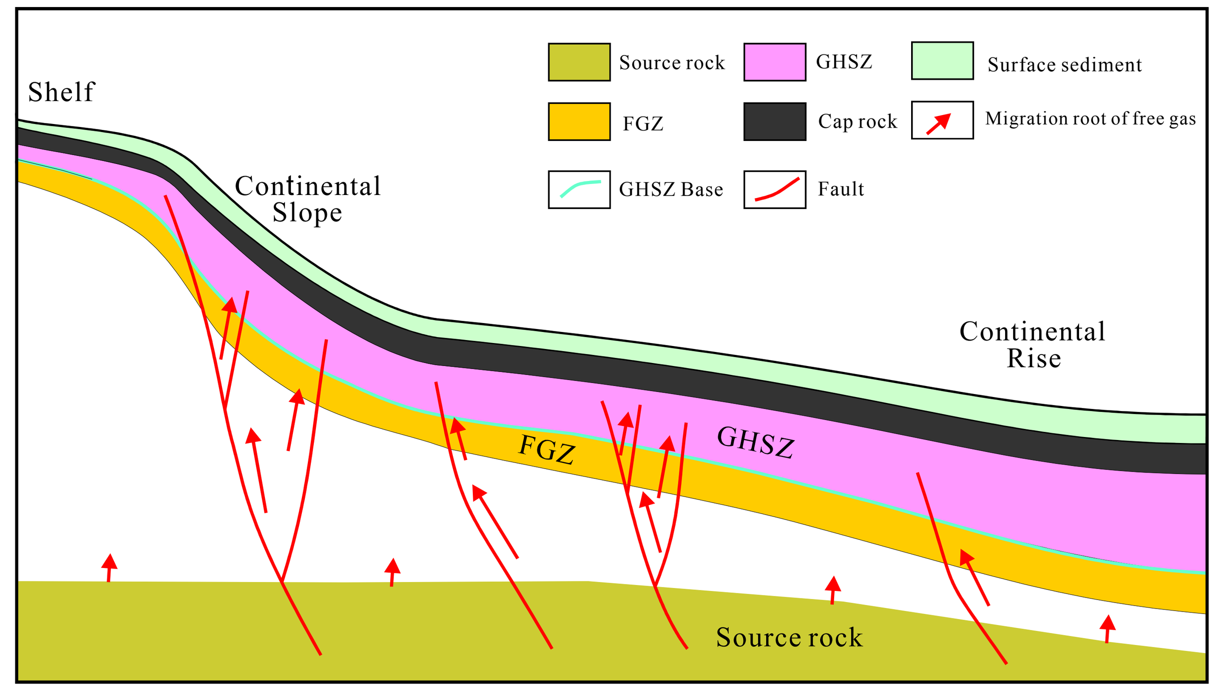

Figure 4. The model of a gas hydrate system. The gases from the source rock migrate upward along the active faults and may be trapped by the cap rock. If the gas concentration increases and reaches the threshold in the GHSZ, gas hydrates would form.

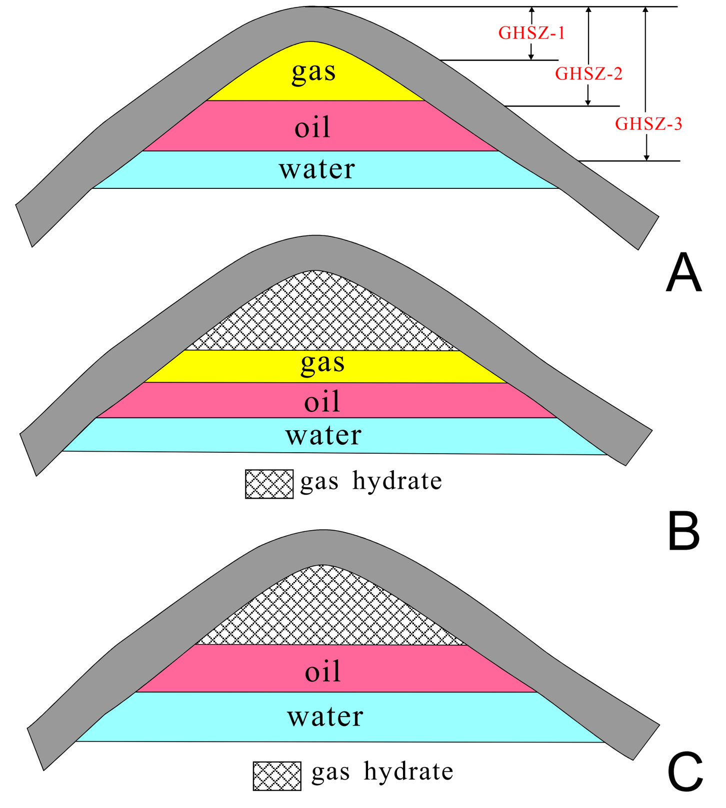

Figure 5. The two types of occurrence patterns of gas hydrates in the sediments when there are originally three kinds of fluids including gas, oil and water in the trap.

Figure 5A shows the different bases of GHSZ. For GHSZ-1, gas hydrates would be in contact with gas directly and there are gas hydrates, gas, oil and water from the top to the bottom in the trap (Figure 5B); for GHSZ-2 or GHSZ-3, gas hydrates would be in contact with oil directly and there are gas hydrates, oil and water from the top to the bottom in the trap (Figure 5C).

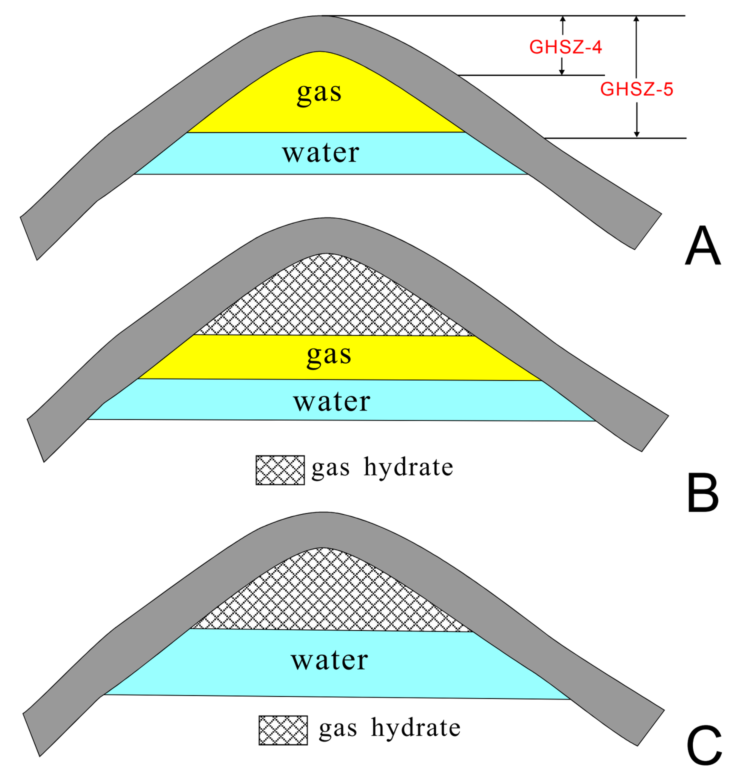

Figure 6. The two types of occurrence patterns of gas hydrates in the sediments when there are originally only gas and water in the trap.

Figure 6A shows the different bases of GHSZ.For GHSZ-4, gas hydrates would be in contact with gas directly and there are gas hydrates, gas and water from the top to the bottom in the trap (Figure 6B); for GHSZ-5, gas hydrates would be in contact with water directly and there are gas hydrates and water from the top to the bottom in the trap (Figure 6C).

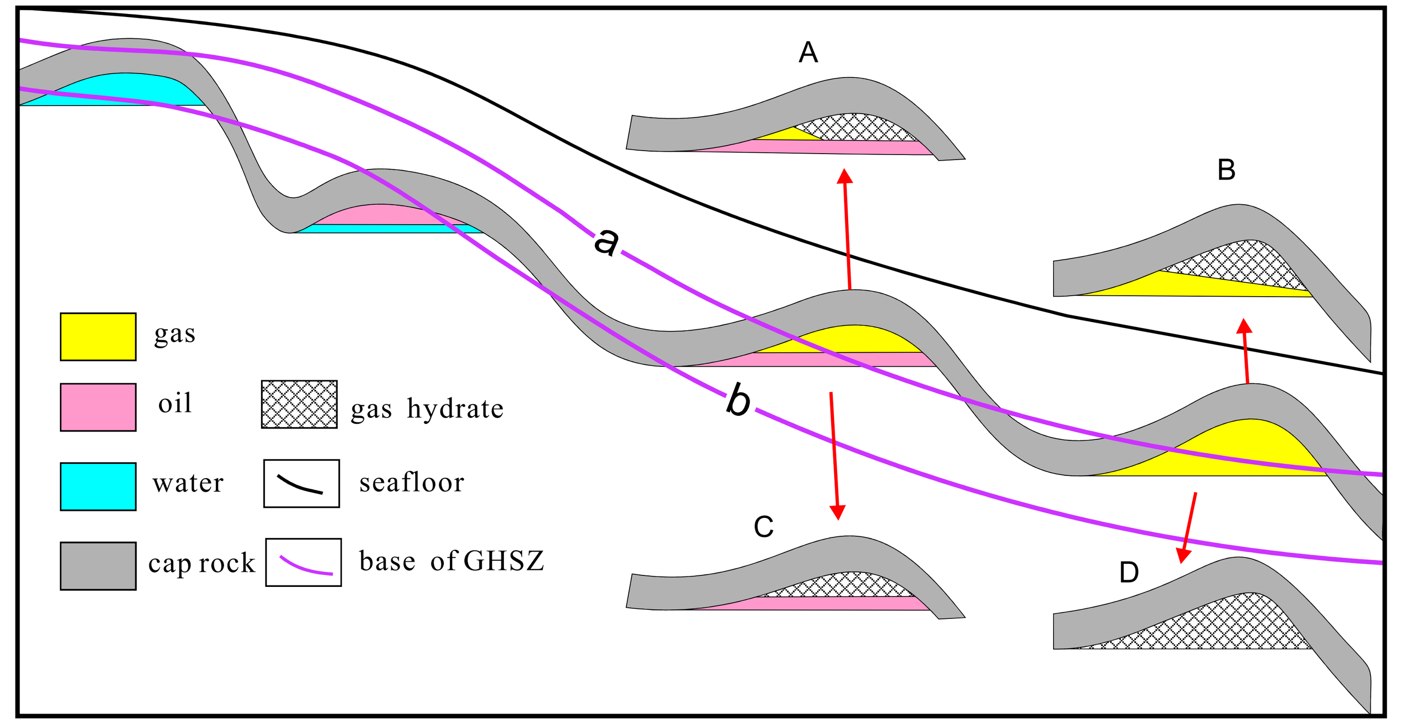

Figure 7. The occurrence patterns of gas hydrates in different traps of the differential entrapment. It is changed as the base of GHSZ changes. If the base of GHSZ is 'a', the occurrence patterns of gas hydrates in the traps are 'A' and 'B'; But if the base of GHSZ is 'b', the occurrence patterns of gas hydrates in the traps would be 'C' and 'D'.

Conclusions

A good combination of source rock, reservoir and cap rock is very important for gas hydrate formation and accumulation. Good conduits and cap rock may be the two most important factors because the concentration of upward-migrating gas and the locations where the gas could accumulate are both mainly controlled by them.

Four types of occurrence patterns for gas hydrates in the sediments are described. With different original fluids in the trap and variation in the base of the GHSZ, gas hydrates could contact with free gas, oil or water underlying it, respectively.

In the traps of differential entrapment, the occurrence patterns in different traps would be distinct and would vary with the base of GHSZ change.

Discussion

Though many researchers have investigated the factors that control the formation and accumulation of gas hydrates (Davidson et al., 1978; Makogon, 1982; Kvenvolden, 1988; Collett, 1993, 1997; Pecher et al., 1998, 2001; Majorowicz and Osadetz, 2001; Bangs et al., 2005; Tan, 2012), most of them are only applicable to a limited area . A problem is that there is still a lack of enough actual drilling data in the world for gas hydrates, especially in some areas that are likely to have substantial hydrate deposits. It will be very important to make a comprehensive study and verify the existing theory with additional drilling data step by step. It will be necessary to study neighboring areas from where gas hydrates have been drilled and compare gas hydrate samples in order to verify the models. In summary, the theories of gas hydrate system proposed by researchers are based on the present data and technology; they should be revised and improved as the science for gas hydrate exploration progresses.

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