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Gas hydrates

Abstract

Gas hydrates have been discovered in natural setting in 1960 in Siberian permafrost, and then was found in continental slope later. Gas hydrate or calthrate is an ice-like substance that has a very high concentration of natural gas; calthrate needs a specific condition of pressure and temperature to form and to stabilize. This specific condition is found in permafrost and continental slopes where hydrate deposit is more important than in permafrost. It is believed that gas hydrate is the most important natural gas reserve, but its extraction is extremely difficult and the emission of methane within the gas hydrates represents a dangerous treat to the environment because methane is hundred times more effective to greenhouse than carbon. The present work is a brief overview of gas hydrate covering its nature, origin, distribution and its potential in term of energy.

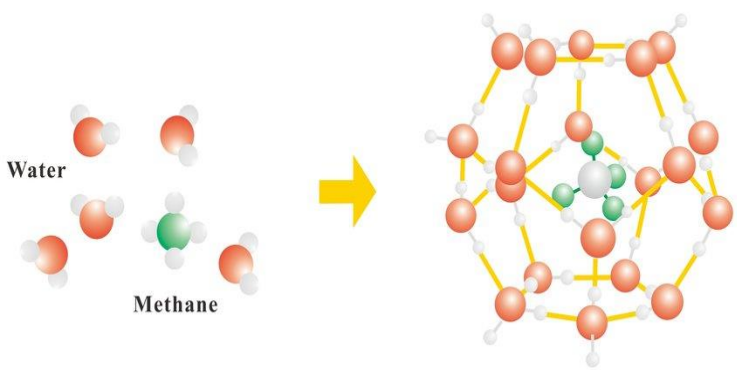
1. Introduction

As the world population increases, demands on energy increase, our society and civilization are always in search of potential sources of energy to fulfill this increasing demand because the reserve on oil is limited. This trend seems to be a door to new horizons in term of energy, consequently gas hydrate is believed by a lot of scientists, corporations and governments from all around to be a promising future in resources of energy, because it is a combustible material which can be used like conventional oil. Gas hydrates called also calthrates has been a found during experimental works by two chemists: Humphrey Davy and Michael Faraday whom discovered ice-like substance during their experimental work in 1810.In 1930 gas-miners start to notice an ice-like material obstructing their pipelines, in 1960 solid gas hydrate was discovered in Siberian permafrost by scientists. Between 1982 and 1992, gas hydrates was found in marine sediments following an extensive scientific researches .Since it was recognized that they are found in permafrost and in marine offshore sediment. In oceanic domain gas hydrates is just an important marine resource.

2. Characteristics of a gas hydrates

Gas hydrates is an ice-like material that contains a high concentration of natural gas that is generally methane but other gases like butane or propane could be also found in gas hydrates. To explain this in easy way; gas hydrate is a substance essentially formed by molecule of methane entrapped within water molecules that form cage (Fig 1 A).

Not only Gas hydrate contains methane but the concentration is very high: one cubic meter of hydrates represents around 160 cubic meters of natural gas.



A

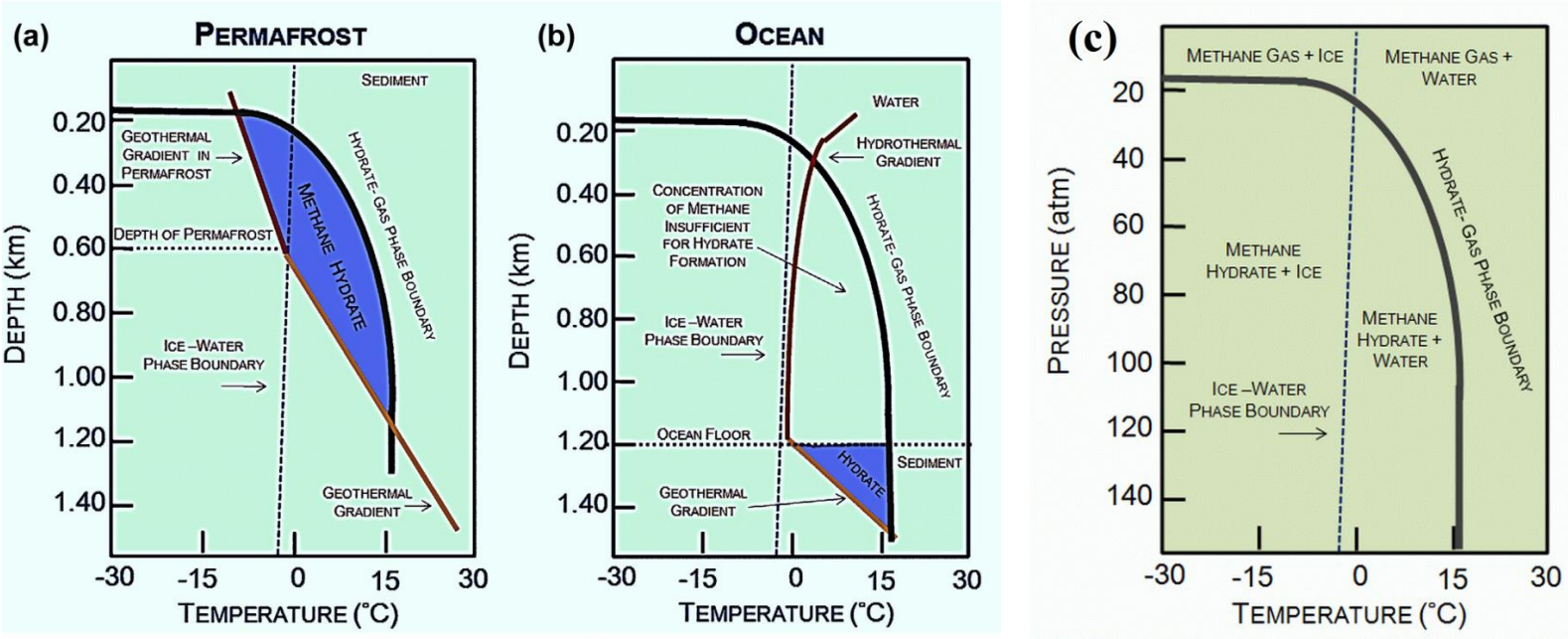
Cui, Y., et al.

B

http://www.methanegashydrates.org/galleries/7

Fig 1.A.Entrapment of methane in water molecules. B. A burning gas hydrates.

As said before gas hydrates are found both in permafrost and marine sediments, they require a specific environment and condition in terms of pressure and temperature to maintain their stability. Once this condition is not maintained, hydrates lose their equilibrium phase and the structure breaks then the methane trapped inside the cage of water molecules will leaks and the gas hydrates will start to melt until only water will be left because the methane will vaporize. This specific condition is called equilibrium phase or equilibrium zone (Fig 2) because it is a range of high pressures and low temperatures; concisely, hydrate needs a low temperature and high pressure to form and to stabilize, it has its own geothermal gradients in permafrost and in ocean where the condition of low temperature and high pressure can be found and respected naturally(Fig 2) but the hydrates-gas phase boundary which determines the range and the limit of temperature and pressure that allow the formation of hydrates is the same both in ocean and in permafrost . This hydrates-gas phase boundary is the indication of the condition of pressure and temperature on which we can conserve the gas hydrate in its stabilized form.



http://large.stanford.edu/courses/2010/ph240/harrison1/

Fig 2.a.condition of formation methane hydrates in the permafrost:b. condition of formation of methane hydrates in ocean and c. phase diagram for methane hydrate formation.

The figures above explain very well the range of temperature of and pressure related to depth that allows the formation of methane hydrate or calthrate. Because our main interest here is the ocean domain so the condition of stability of gas hydrates in the ocean in our main interest. By this way this kind of environment is found along the continental margin where the condition of stability of gas hydrates is respected especially the continental slope that has all the component required for gas hydrates to from, both passive and active margin can be a subject of hydrates deposit but we must keep in consideration that not every continental margins have gas hydrates because the formation of gas hydrate itself requires methane to be trapped inside the water molecules which implies the need of sources of methane that is an hydrocarbon .

3. Formation of methane

Like other hydrocarbons, methane requires organic matters to form, the decay of these organic matters along different processes will then form methane that will form later under the required condition of low temperature and high pressure: gas hydrate. These organic matters that are remains of organisms in the sea or from land are then carried or deposed by/in the sediment. Sediment load plays here an important role because not only it carries organic matter from lands but it carries also nutrients for the ecosystem in the continental margin which the remains has been deposed in the seafloor and went through a methanogenesis processes. In general we have two processes to from methane from organic

matters. Biogenic processes which forms biogenic methane and thermogenics processes to form thermogenic methane .But these two processes is also linked to a process called biothermogenics methanogenesis**.**

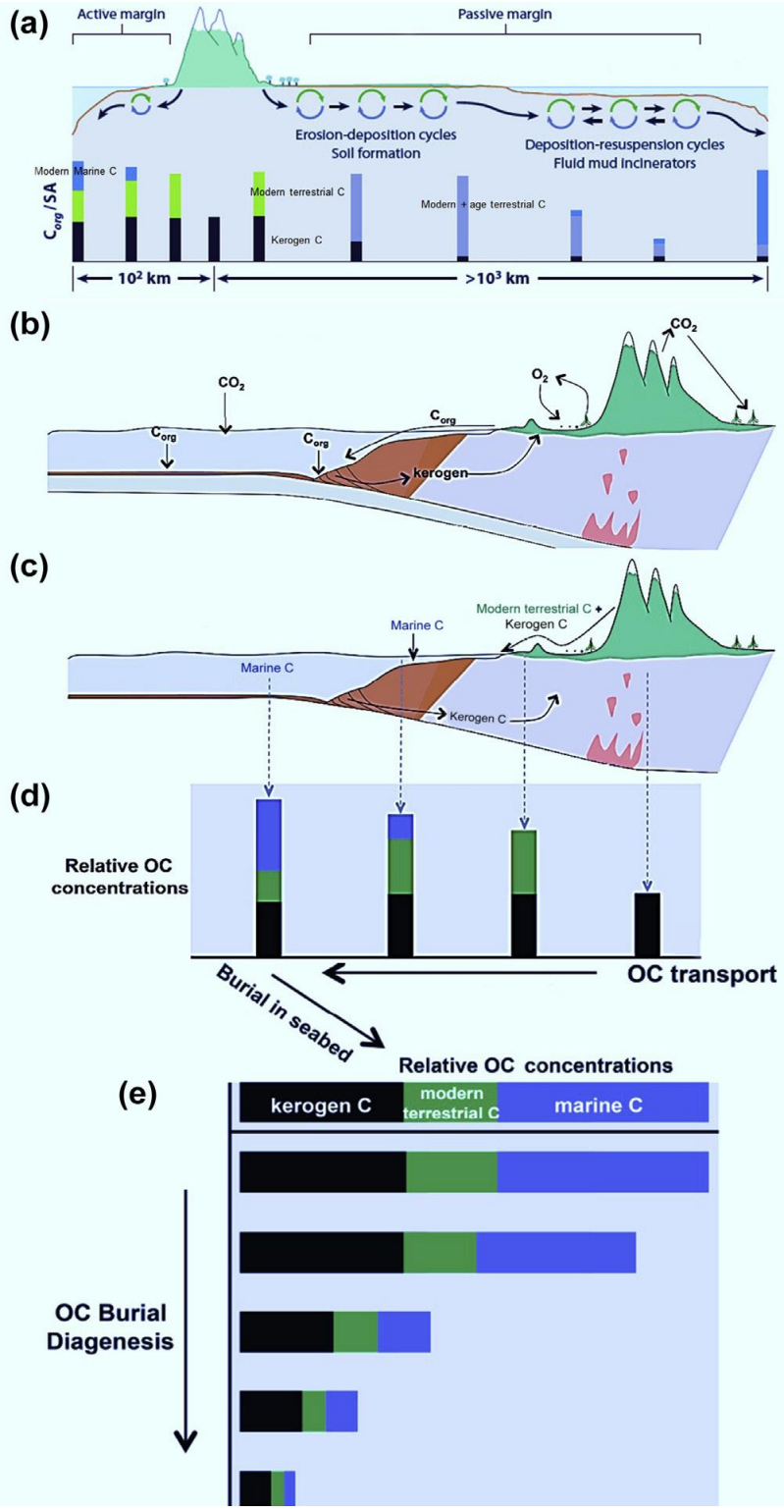


Fig 3. Distrubution of organic matters in continental margins. (a)different features contrasting active and passive margin. (b).(c)Active margin carbon cycle.(d) kerogen formation and diagenesis of organic matter.(e)Burial phase and diagenesis.

Source: Geological Controls for Gas Hydrate Formations and Unconventionals . Chap: Tectonics and gas hydrates.

Biogenic methanogenesis is a process where microbial activity is involved in formation of methane from the organic matter they are consuming within the sediment. In contrast; thermogenic methanogenesis is related only to the thermal condition during the burial of the sediment which decomposes organic matter slowly under high pressure which mimics a high temperature. Biogenic processes are faster than thermogenic processes and both can be involved at the same time to the formation of any methane hydrates.

Exceptionally we can also take in consideration the formation of gas hydrates related to marine volcanic activities such as mud volcanoes. Several mud volcanoes are related to the deposition of gas hydrates. We know that mud volcanoes can carry an important amount of methane with it and is also a great source of nutrient for microorganism that may depose in the seafloor's sediment to undergo through methanogenesis processes.

Indeed, gas hydrate needs water, organic matters from which we have methane that was produced from methanogenesis and all of this should be under the condition of stability that is low temperature and high pressure.

4. Location, types and volume of gas hydrates

In the ocean domain, gas hydrates are found along the continental slope where the condition of equilibrium of hydrates is respected within the sediment and even in the surface of sediment and in land within the permafrost (fig.3).

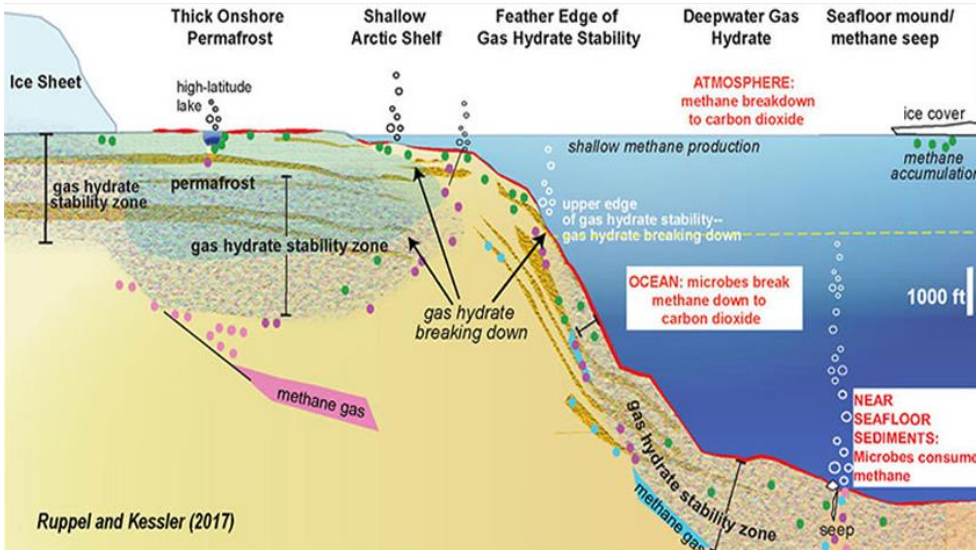


Fig.3. Locations of gas hydrate in the permafrost and continental slope related to the stability zone and all the processes involved in the formation of gas hydrates.

Gas hydrates are hydrocarbons as well as fossil fuel, it hasn't been used yet and it is the most important reserve in fossil fuel .It is the largest natural gas resources (fig.4) known of our planet because it represents the double of the conventional fossil fuel; 10000 (10^{15} t) of carbon for gas hydrates and 5000 (10^{15} t) of carbon for conventional fossil fuel.

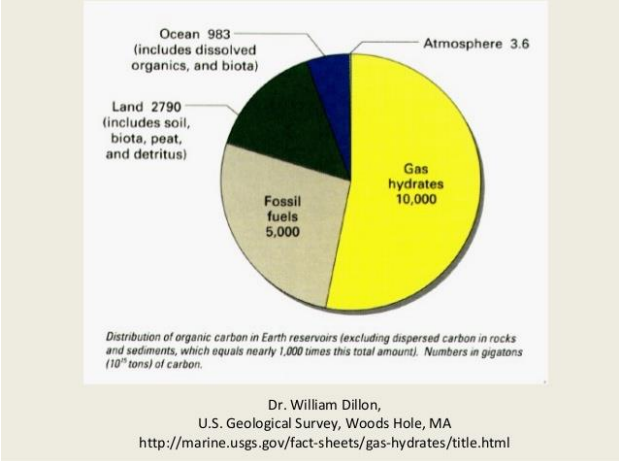
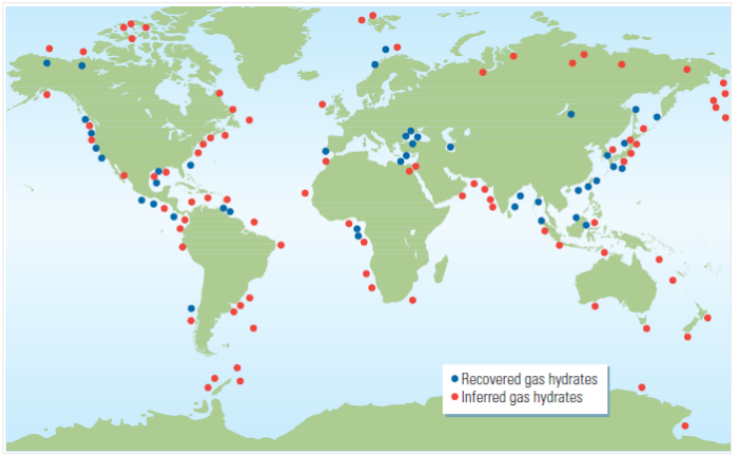


Fig .4 . Distribution of organic carbon in Easth reservoirs.

Several depositions of gas hydrates have been found since the discovery of hydrates through different expeditions, explorations and scientific researches: some have been sampled and some are considered after geological or geophysical obvious evidences. Then those reserves have been mapped around the world (fig.5).



Map of global hydrate distribution

Red dots show locations where hydrate has been found on continental margins (Oilfield Review)

http://www.oil-gasportal.com/technologies/unconventional-oilgas/fundamentals/

Fig.5 .Global distribution of gas hydrates, which represent those who have been sampled and those which have deduced from geological or geophysical evidences.

5. Limits

Although of the high potential of gas hydrates in term of energy resources of the future, major problems has been discussed around it. First we have the environmental issue, methane is known as a gas that is extremely effective than carbon dioxides in term of greenhouse effect, it is thought to be hundred times stronger than the carbon dioxide when it is released in the atmosphere, the use of such gas may asset an important environmental issue and a serious treat toward the climate and the ecosystem. It is even believed by some scientists that methane from gas hydrate had caused a mass extinction in the past. The risk of the use of gas hydrates may just lead us to deal with the most important environmental crisis that our civilization has never seen before.

The next one is the extraction problem, as it was said earlier, once we pass behind the equilibrium phase of hydrate; the structure breaks, melts and the methane gas is released. When the hydrate is extracted from the sea floor, during the ascension of the sample; a huge amount of the hydrate melts along its way until it reaches the surface and only a tiny part is left if the sample is big enough and extracted fast enough but at the same time the melting process will continue eventually until the sample becomes just a water left by the melting unless the condition of stability is recovered manually. Two solutions has been proposed and tested: conservation of the hydrate equilibrium phase during the whole extraction or the extraction of methane in situ where gas hydrates are deposed, but the two are extremely costly that they will overtake the economic interest and both are not well developed because scientists is still in the testing phase.

6. Conclusion

Gas hydrate is an ice-like substance found in continental slope and permafrost that has a very high concentration of natural gas that is generally methane, it is considered as the most important natural gas reservoirs because the estimation of gas hydrates around the world is about 10000(10^{15} t) of carbon which is important than any other fossil fuel. Hydrate requires a specific condition of pressure and temperature to form and this is what makes the extraction extremely difficult nowadays because of the technological limit and the cost of the extraction even if it has been proved to be possible. On the other hand, methane that is mainly the source of energy within the gas hydrate is hundred times more effective than carbon dioxide in term of greenhouse effect is a major environmental issue related to the use of this kind of source of energy.

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