Methane hydrate

Ferian Anggara

Permen ESDM No. 5 Tahun 2012

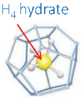
- Pasal 1

Dalam Peraturan Menteri ini yang dimaksud dengan:

1. Minyak dan Gas Bumi Non Konvensional yang selanjutnya disebut Migas Non Konvensional adalah Minyak dan Gas Bumi yang diusahakan dari reservoir tempat terbentuknya Minyak dan Gas Bumi dengan **permeabilitas rendah (*low permeability*)** antara lain *Shale oil, Shale Gas, Tight Sand Gas*, Gas Metana Batubara, dan *Methane-Hydrate* dengan teknologi tertentu seperti *fracturing*.

Methane hydrate

- Gas hydrates are solid crystalline compounds in which gas molecules are encaged inside the lattices of ice crystals.
- Such deposits occur in two distinctly different geologic settings where the necessary low temperatures and high pressures exist: in permafrost regions and in deep ocean sediments
- Even by the most conservative estimates, the total quantity of gas in hydrates may surpass, by a factor of two, the energy content of the total fuel fossil reserves recoverable by conventional methods



Clathrate

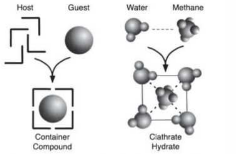
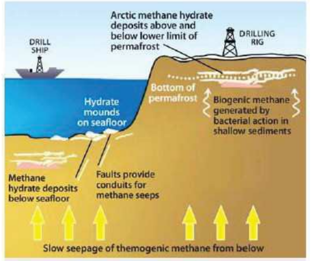


Figure 2.2. Natural gas hydrates are container compounds. Left: host molecules and guest. Right: In clathrate hydrates, water molecules form the host structure that accommodates the guest, in this case methane. The interaction between liquid water and hydrocarbon is weak (dashed line, top) while the interaction between the hydrate host structure and the hydrocarbon is strong. Once the compound is formed, it is difficult to remove the guest without breaking the structure. This diagram is not representative of the actual crystal structure of hydrate. For crystallographic models see Sloan (1998) and Max, (2003).

Clathrate: no hydrogen bonding

Max et al., 2006



Methane hydrate pressure-temperature phase

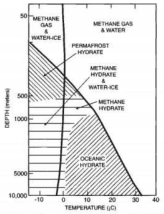
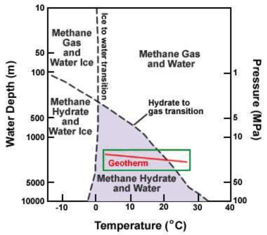
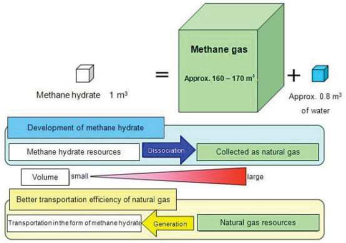
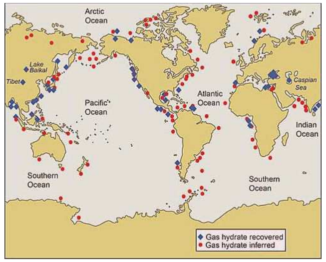


Figure 2.1. Diagrammatic methane hydrate pressure-temperature phase diagram. After Kvenvolden (1988) and Pellenbarg and Max (2000, 2003, Fig. 2). Permafrost and oceanic hydrate P-T fields delineated.





CODE	LOCATION	DESCRIPTION
P2	**Middle America Trench (Costa Rica)**	
	DSDP Leg 84, Site 565	Inclusions in mud & muddy sand
	ODP Leg 170, Site 1041	Disseminated and sheets
P4	**Middle America Trench (Guatemala)**	
	DSDP Leg 67, Site 497	Inclusion in sediment
	Site 498	Cement in coarse vitric sand
	DSDP Leg 84, Site 568	Inclusion in mudstone
	Site 570	Laminated ash; massive core
P5	**Middle America Trench (Mexico)**	
	DSDP Leg 66, Site 490	Laminated ash and mud
	Site 491	Inclusions in mud
	Site 492	Laminated ash
P7	**Eel River Basin (CA, USA)**	Layers, nodules in mud
P8	**Cascadia Basin (Oregon)**	
	DSDP Leg 146, Site 892	Aggregates, layers in silt
	Hydrate Ridge	Layers, massive in carbonate crust
P17	**Okhotsk Sea (Russia)**	
	Paramushir Island	Layers in ooze
P18	**Okhotsk Sea (Russia)**	
	Sahkalin Island	Layers in silt and clay
P20	**Japan Sea (Japan)**	
	ODP Leg 127, Site 796	Crystals in sand with clay
P24	**Nankai Trough (Japan)**	
	ODP Leg 131, Site 808	Fragment in wash core
P31	**Peru-Chile Trench (Peru)**	
	ODP Leg 112, Site 685	Fragments in mud
	Site 688	Grains in mud



Physical condition that control MH in an oceanic setting

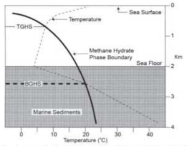
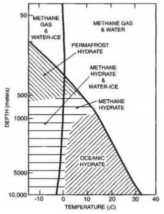


Figure 3.1. An example of physical conditions that control presence of gas hydrate in an oceanic setting is shown in this temperature versus depth plot. We assume a water depth of 2 km. The standard methane hydrate phase boundary (solid line) is plotted by converting depth to equivalent pressure. Gas hydrate will be stable to the left of this phase boundary curve (where temperatures are colder and pressures higher than the phase limit), whereas free gas and water will be stable to the right of the curve. A temperature/depth curve (dashed) typical of the western North Atlantic is plotted in the water column, which is connected to a typical geothermal gradient below the seafloor, indicating temperatures in the sediments. The intersection of the phase boundary and temperature curve in the water column defines the top of gas hydrate stability (TGHS) and the intersection below the seafloor, defines the depth of the base of gas hydrate stability (BGHS) at this idealized location. Courtesy of MDS.



Max et al., 2006

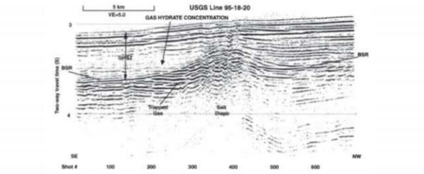


Figure 3.18. Seismic reflection profile across a salt diapir off the southeastern United States. The BSR rises above the diapir for thermal/chemical reasons and creates a gas trap at the base of the GHSZ as diagramed in Figure 3.17. Main gas trapping is indicated by the strong reflections beneath the BSR to the southeast (left) of the diapir, and greatest gas hydrate development is interpreted to exist above that gas concentration on the basis of the weaker reflections (blanking).

Max et al., 2006

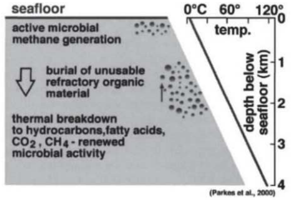


Figure 3.10. Conceptual diagram indicating that, although much methane is generated by bacteria at shallow subbottom depths, the thermal breakdown of refractory material at depth can also provide nutrients for bacteria that are active at greater depths. Adapted from Parkes et al. (2000).

Max et al., 2006

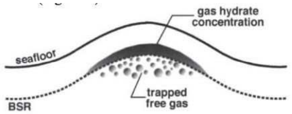
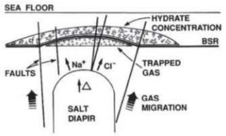


Figure 3.12. Idealized diagram of gas hydrate concentration (shaded area) at a seafloor flexure. As the base of the GHSZ, marked by the BSR, tends to follow an isotherm and the thermal gradients generally remain fairly constant, the base of the GHSZ will tend to parallel the seafloor. Thus a flexure will cause a culmination at the base of the GHSZ and create a gas trap and hydrate concentration.

Max et al., 2006



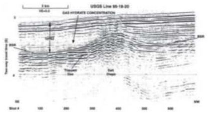


Figure 3.17. Diagram showing a gas trap formed by doming of the base of the GHSZ above a salt diapir. The greater thermal conductivity of salt compared to sediment, which creates a warm spot, and the inhibitor (antifreeze) effect of the ions dissolved from the salt both serve to raise the base of the GHSZ over the diapir to form the gas trap.

Max et al., 2006

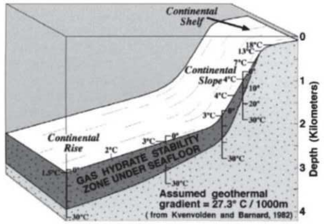


Figure 3.2. Conceptual drawing of gas hydrate stability zone on a passive continental margin.

Max et al., 2006

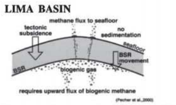


Figure 3.21. Diagram suggesting processes where the seafloor is subsiding, but deep source biogenic gas still creates a methane flux at the ocean bottom.

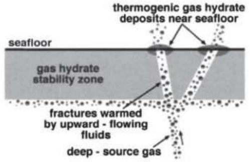


Figure 3.15. Effects on gas migration and gas hydrate formation by fluid flow through fractures.

Max et al., 2006

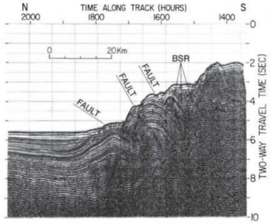


Figure 3.20. Seismic reflection profile across the tectonic accretionary wedge north of Haiti. The situation is like that diagramed in Figure 3.19.

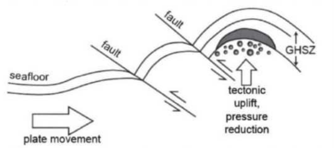


Figure 3.19. Diagram showing that plate motion at collision zones will continuously wedge newly arriving material under earlier-arrived sediments, resulting in uplift as well as folding of earlier sediments. The uplift results in reduction of pressure, which causes dissociation of gas hydrate, release and trapping of gas at anticlines, and concentration of gas hydrate above the trapped gas (shaded area).

Max et al., 2006

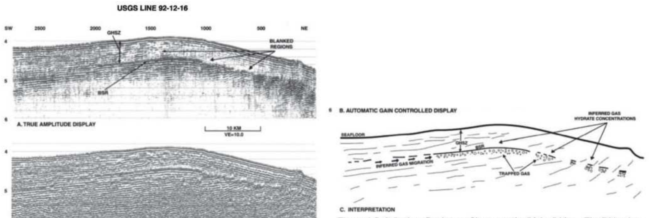
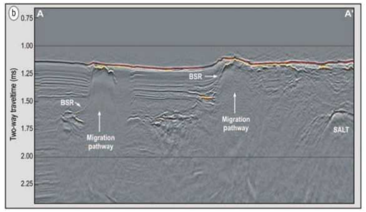
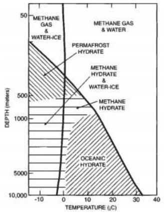


Figure 3.7. Seismic reflection profile across the Blake Ridge. The Ridge is a sedimentary drift that is migrating to the southwest. Also see figures 6.1 & 6.2.

Max et al., 2006

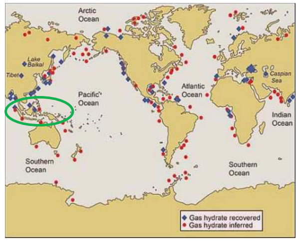




BSR: Bottom Simulating Reflector

Caused by the impedance contrast of high velocity sediments containing hydrates and the underlying free gas zone

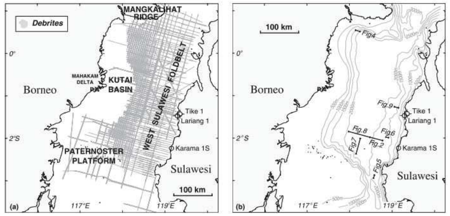
Methane hydrate resources in Indonesia



- Total: 625 TcF, luas areal: 22.125 km²
- Terbesar → Sulawesi Utara: 233 TcF; 8.200 km²

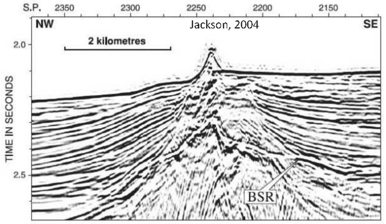
Sumber: BPPT,2012

Case study: North Makassar basin



Jackson, 2004

2D seismic data



BSR: Bottom Simulating Reflector

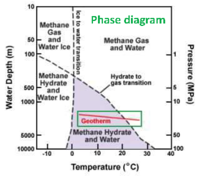
- The east side of the Makassar Strait is a significant, new gas hydrate province containing considerable volumes of methane.
- The total gas in place calculated for the most prospective area was 80 Tcf of 67 Tcf was from gas hydrates and 13 Tcf was from free gas at the BSR
- Main problem: How to dissociate/ to produce methane economically from deep water environment ?

Hydrate dissociation for gas production

1. depressurization, in which the pressure is reduced to a level lower than the hydration pressure *PH* at the prevailing temperature,
2. thermal stimulation, in which the temperature is raised above the hydration temperature *TH* at the prevailing pressure, and
3. the use of inhibitors (such as salts and alcohols), which causes a shift in the *PB-TH* equilibrium through competition with the hydrate for guest and host molecules

Jackson, 2004

Methane hydrate production



"Primary Production"

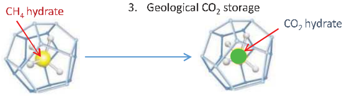
Lowering pressure or temperature

1. Rapid dissociation → free methane and water
2. Solid sediment → liquid → formation instability
3. Submarine slumping, landslides or subsidence → production equipment damage

"CO_2 Injection"

Replacing methane by CO_2 injection

1. Maintaining hydrate structure → CO_2 hydrate
2. Maintaining formation stability
3. Geological CO_2 storage



End