Lightweight & Innovative Approaches to Natural Gas Hydrate (NGH) Exploration & Production

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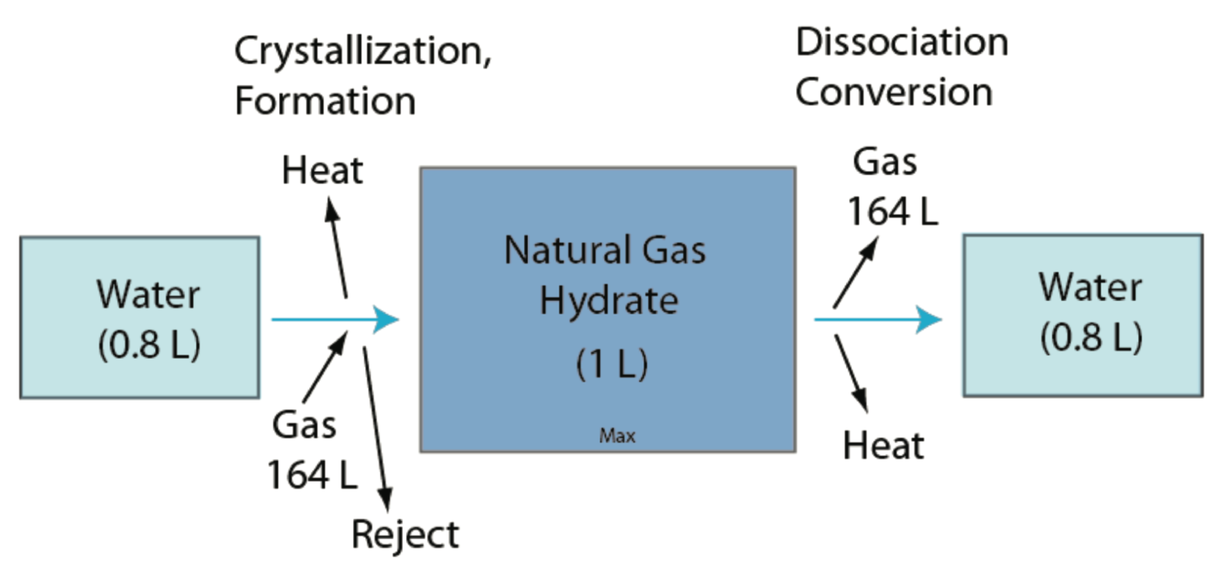
Atlantic Ireland 2019

The Basic Equation



Gas Flux

Prospects for the formation of large concentrations of NGH are good because the root of gas flux and migration that could naturally rise toward the seafloor can exist over the whole history of a thick, deepwater sediment pile.

The critical moment for conventional hydrocarbons is often a relatively short period of time in which fluid hydrocarbon generation, migration paths, and geological trap coincide in time and space to produce hydrocarbon concentrations.

In contrast, gas generation and upward migration of natural gas from both thermogenic and biogenic sources can take place as part of all conventional hydrocarbon critical moments in a deepwater basin. In addition, gas produced by long-standing mechanisms such as repeating thermal and structural events in a sedimentary wedge formed by plate collisional processes can also migrate into the gas hydrate stability zone (GHSZ).

Gas Migration

Gas migration will take place along faults and other fastways, by perocolation within permeable horizons, and by diffusion. Migration will be a pervasive tendency because of the buoyancy effect, with upwelling of gas exploiting all pathways. Structural events will probably have the effect of promoting or periodically accelerating gas migration to the extent that these could be considered to be NGH critical events.

NGH Formation

When free gas or sufficiently high concentrations of dissolved gas in pore fluids reaches the gas hydrate stability zone (GHSZ), NGH will spontaneously nucleate. The rate of NGH crystallization will be dependent on the rate and amount of natural gas arriving at at gowth sites.

There appears to be no low-pore fill barrier to NGH crystallization because high pore filling is common and even then the rate at which a dissociation front propagates in production tests, indicates that some sort of micro-porosity remains even after pore filling of over 80%.

The physical character and geological setting of NGH in a deepwater marine permiable sedimentary host bed is very different from conventional hydrocarbon accumulations, and also from the other unconventional gas resources, coalbed methane and shale.

Although much research remains focused on basic attributes of the NGH system, we regard the present state of knowledge, and the few production tests that have been carried out to represent a body of knowledge that indicates our focus should shift to establishing exploration and production models that will allow for production of the NGH resource.

There needs to be a new perspective about drilling and producing NGH.

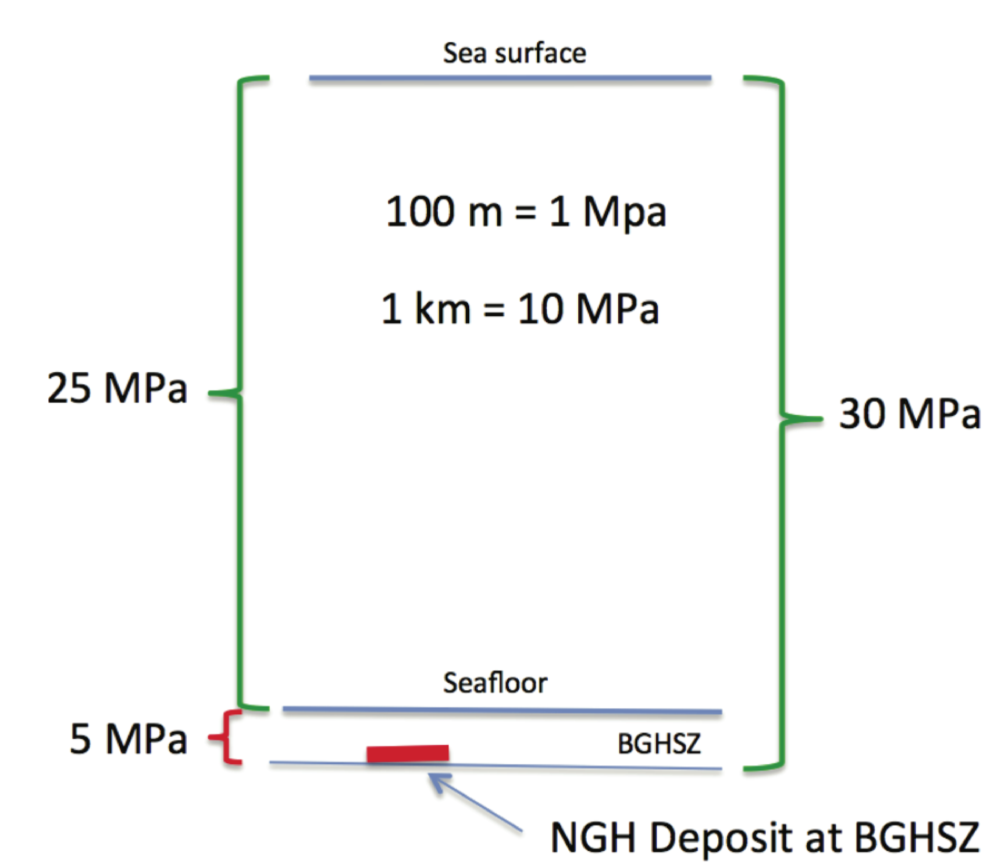
RISK

NGH is inert within its reservoir as a crystalline solid
Temperature and pressure are lower than deepwater conventional
Conversion must be induced
Amount and pressure of gas in reservoir can be controlled
Very low risk of any leak from depressurization conversion system
Very low risk of leak to atmosphere
Little risk of chemical & oil pollution
Mechanical instability of geology self-sealing - rapid conversion close-down
Major drillships and high cost operations unnecessary
Produced gas and water from NGH is relatively pure: dilutes pore water
Introduction of chemicals not necessary
Fracking probably not necessary

Well Control

Drilling and processing of gas and other well production, mainly water and particulate matter,, is much easier to do because the pressure differential between the formation (under depressurization) and the seafloor can be very low.

Pressure in the well can be conrolled. It may be possible to maintain the pressure in the producing wells at aboutthe same as at the seafloor, or to cycle the well pressures both higher and lower the seafloor pressure, if desired.



Exploration Opportunities

NGH only occurs at relatively shallow depths below the seafloor. Drilling will be carried out in the same partially consolidated marine sediments worldwide. Seismic interpretation techniques are now adequate for discovery and valuation.

Production Opportunities:

Although NGH production will begin using "off-the-shelf" technology, innovation will lead to new technology that will bring down costs and increase efficiency in the same way that led to the shale-reservoir breakthrough.

Reservoir and production conditions are much more benign for NGH than for deepwater gas deposits. Much less robust equipment is required for drilling, producing, and processing NGH-derived natural gas.

Major innovation and cost cutting will be generally in the fields of drilling, wellbore lining technology, and reservoir management with an emphasis on long-term sand control and adaptive mechanical stability during NGH conversion to its constituent gas and water.

It Makes Sense to Move Everything to the Seafloor:

Because of the relatively benign characteristics of NGH, virtually all activities, including drilling, which can essentially be treated as open hole drilling, can be moved to a seafloor industrial installation. These installations will be assembled, operated, and serviced entirely underwater, with drilling, site provision and maintenance leveraging emerging technology in a less robustand expensive manner. Gas production from the seafloor to the sea surface can use new pattern risers that will take advantage of the cooler, lower and controllable pressure, and less toxic gas product than has to be contained within conventional gas risers. A new, integratedapproach to drilling NGH deposits and production can optimize NGH opportunities to substantially lower exploration and development costs.

While NGH-bearing sands are in deepwater, they are confined to depths beneath the seafloorof 1.2 kilometers or less. As a result, they will not be significantly above hydrostatic pressure, and temperatures will be less than 30 ^{o}C. Drilling will be through semi-consolidated sediment without liquid hydrocarbons. Thesecharacteristics mean that high capability drillships are not needed.

References

Max, M.D. & Johnson, A.H. 2016. Exploration and Production of Oceanic Natural Gas Hydrate: Critical Factors for Commercialization. Springer International Publishing AG, 405pp..

Max, M.D. & Johnson, A.H. 2014. Hydrate Petrleum System Approach to Hydrate Natural Gas Exploration. Petroleum Geoscience 20(2). Geological Society of London (Published in Online First 21 March 2014), doi 10.1144/petgeo2012-049, 187-199.

Max, M.D., Johnson, A.H. & Dillon, W.P. 2013. Natural Gas Hydrate - Arctic Ocean Deepwater Resource Potential. SpringerBriefs in Energy, 113pp.

Max, M.D., Johnson, A. & Dillon, W.P. 2006. Economic Geology of Natural Gas Hydrate. Springer, Berlin, Dordrecht, 341pp.