WOC1

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Methane Hydrates and Their Prospects for Gas Industry

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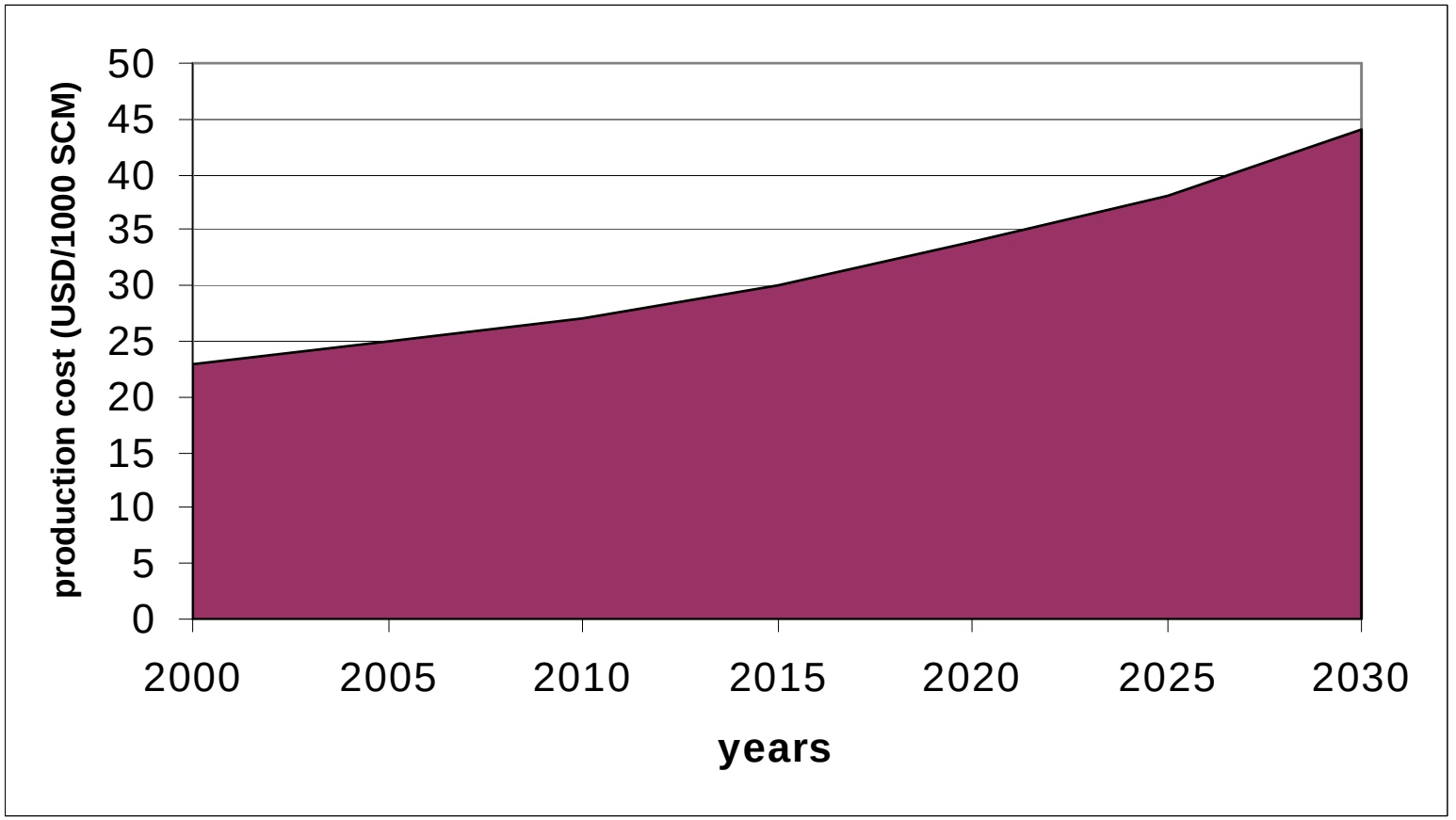
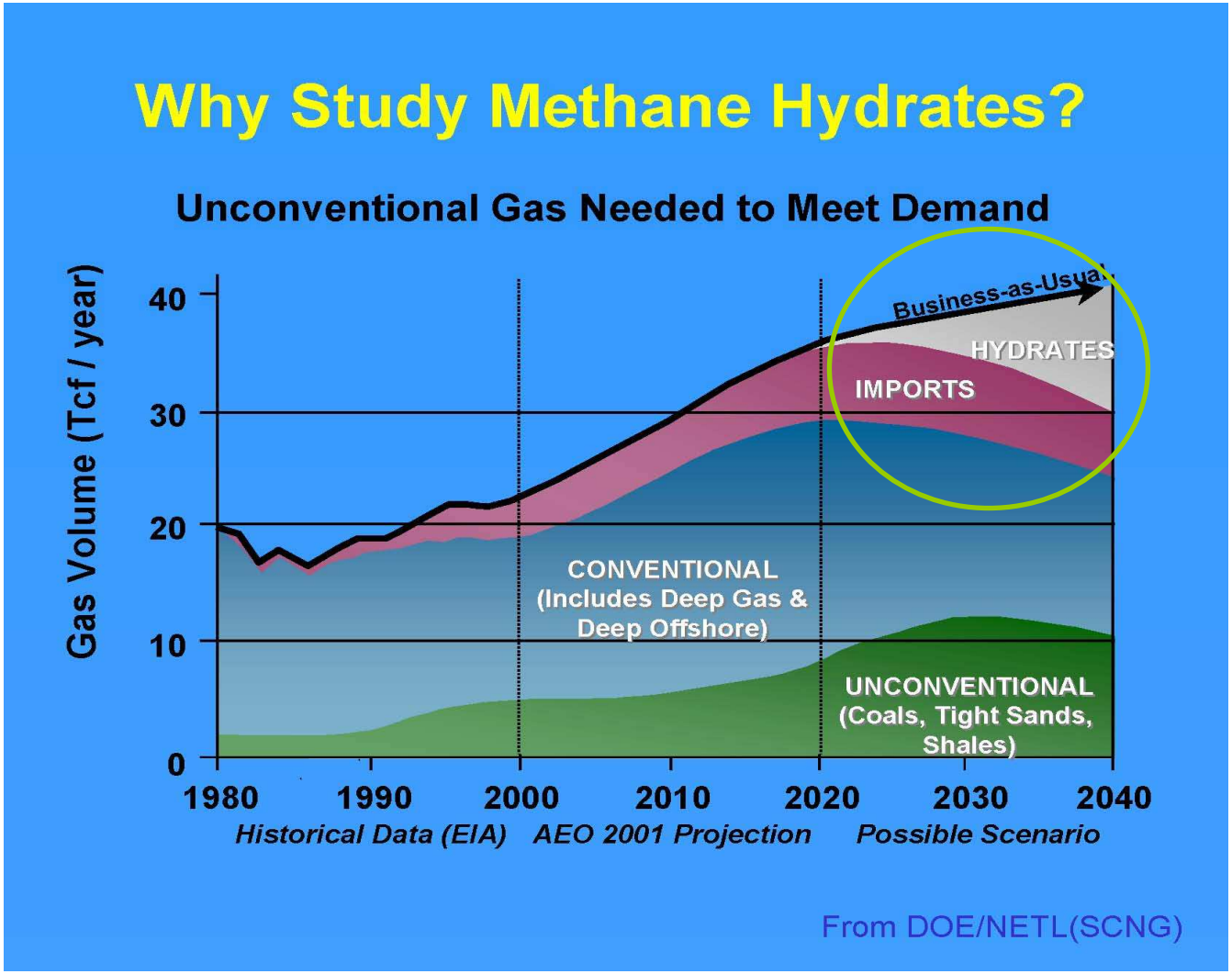
Global natural gas production cost trend (IGU WOC1, 2003)

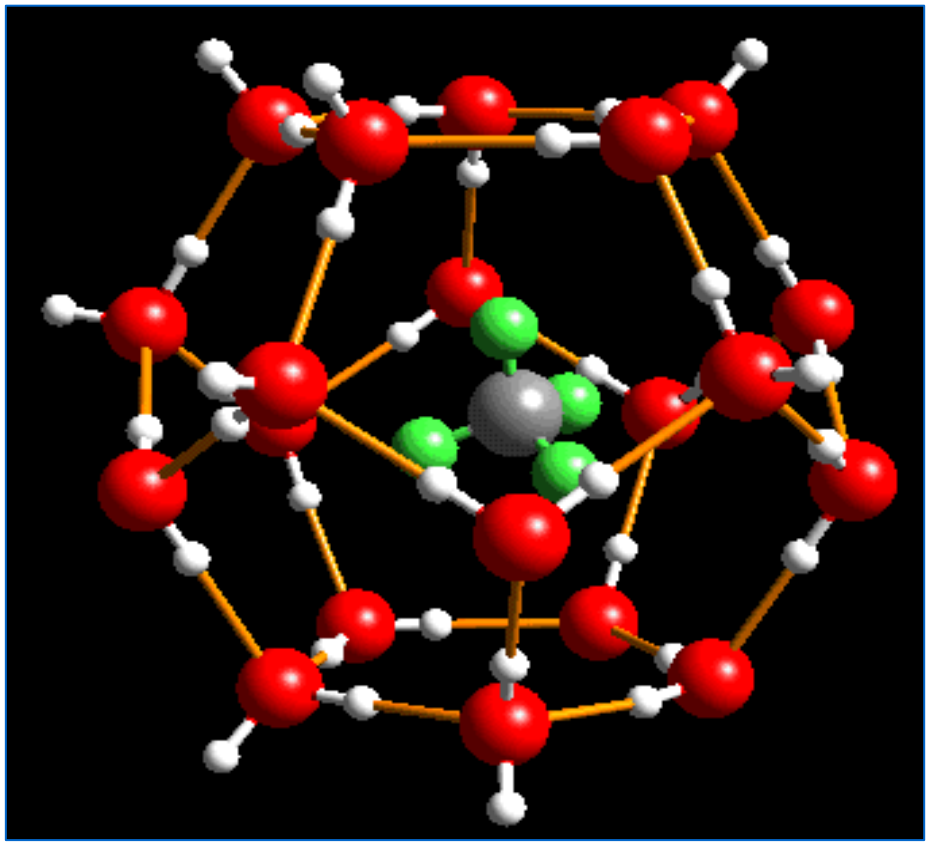


Production cost can double by year 2030 due to resource base structure change

Natural gas consumption and sources of gas in the USA



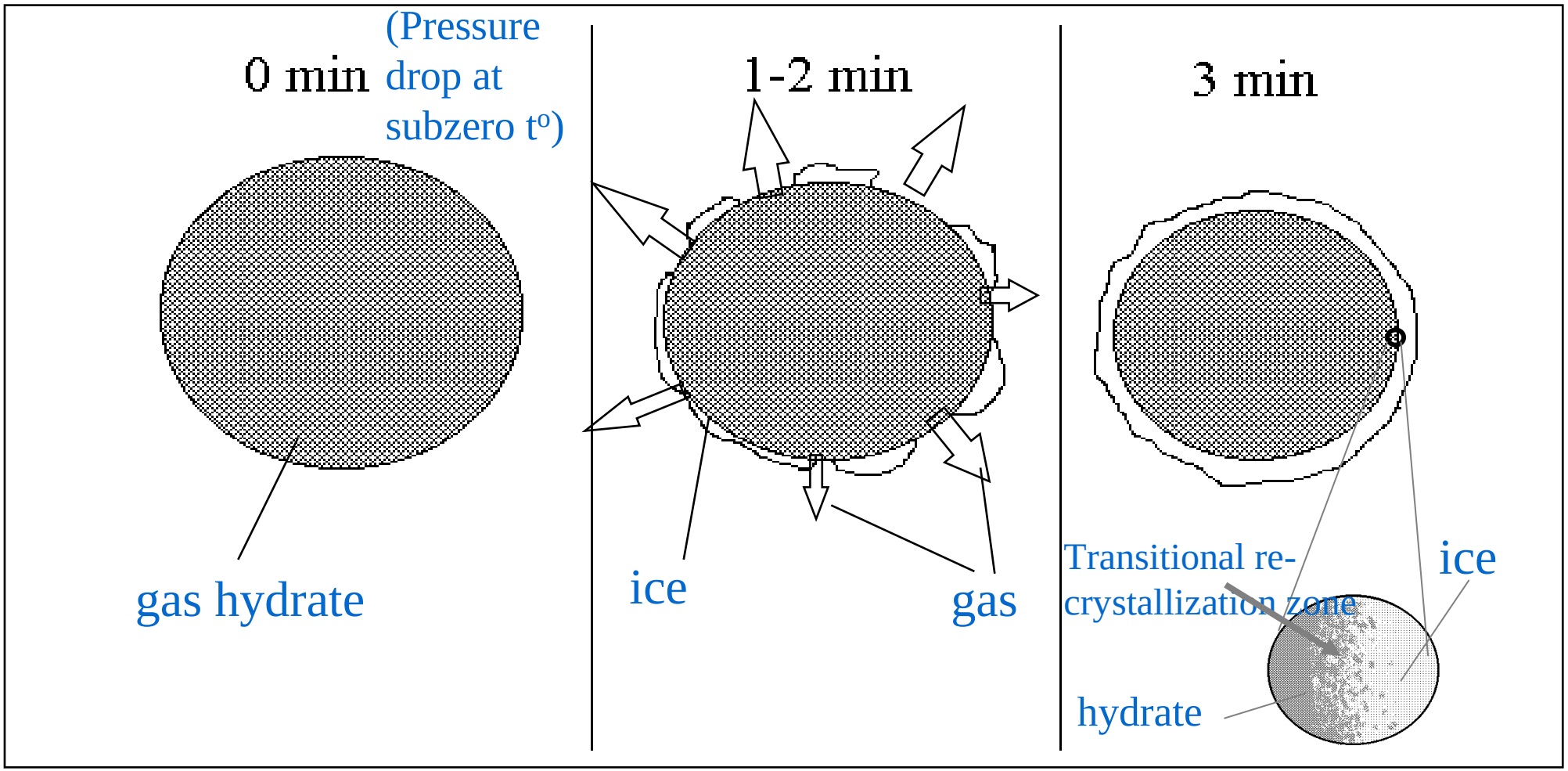
What are gas hydrates?



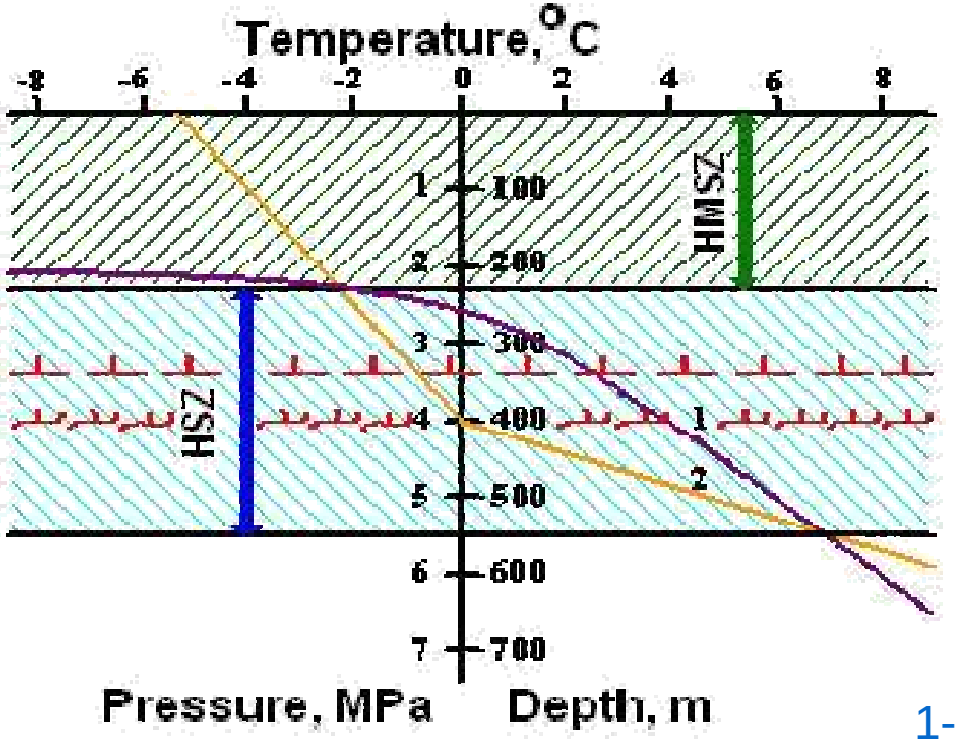
Main properties of gas hydrates, important for natural gas industry:

- One volume of methane gas hydrate contains up to 164 volumes of methane and 0,8 m^3 of clear water.
- Gas hydrate self-preservation phenomenon allows to store gas in hydrates at atmospheric pressure and ambient (-5 - -10^oC) temperature.
- Hydrates accumulate great quantities of natural gas in shallow depth in the Earth, cementing sediments.
- CH_4 hydrate density is lower, but CO_2 hydrate density is higher than sea water density.
- Submarine hydrates create environment for photosynthesis-less life.

Formation of self-preserved methane hydrate particle (temperature -5 ÷ -15°C)



Methane hydrate stability zone (HSZ) and hydrate metastability zone (HMSZ)



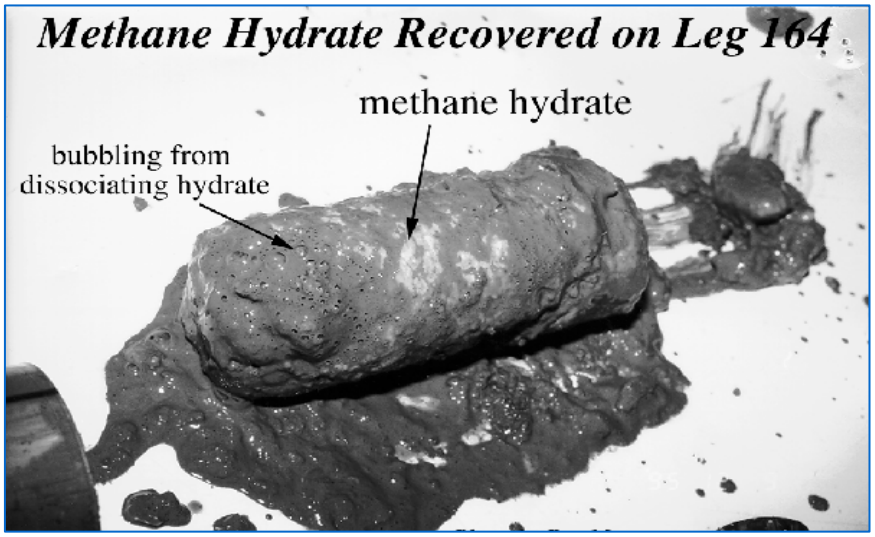
hard-frozen sediments boundary (permafrost)

cryolithozone boundary

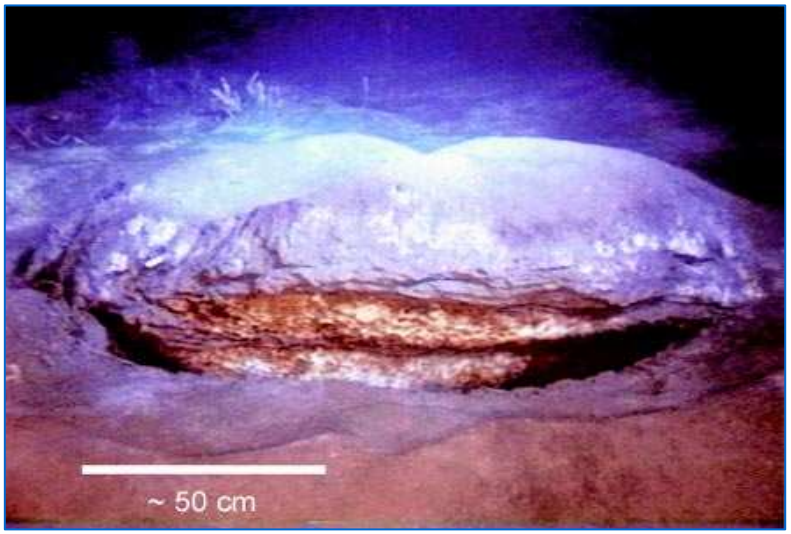
1- methane hydrate P/T equilibrium curve

2 – P/T distribution in geologic section

Hydrates in sediments



Offshore drill core

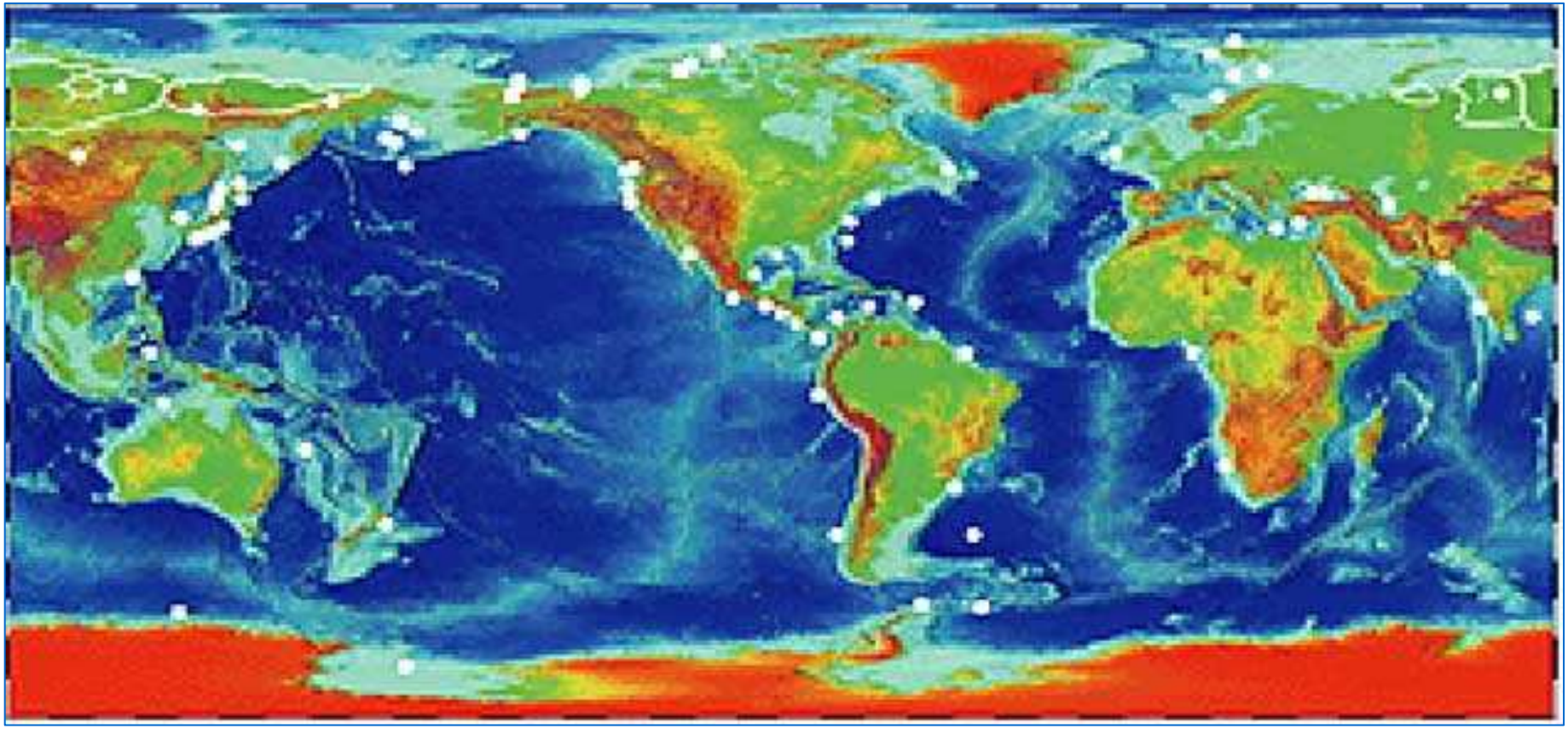


Hydrate accumulation on sea floor

Subpermafrost hydrate-containing drill core

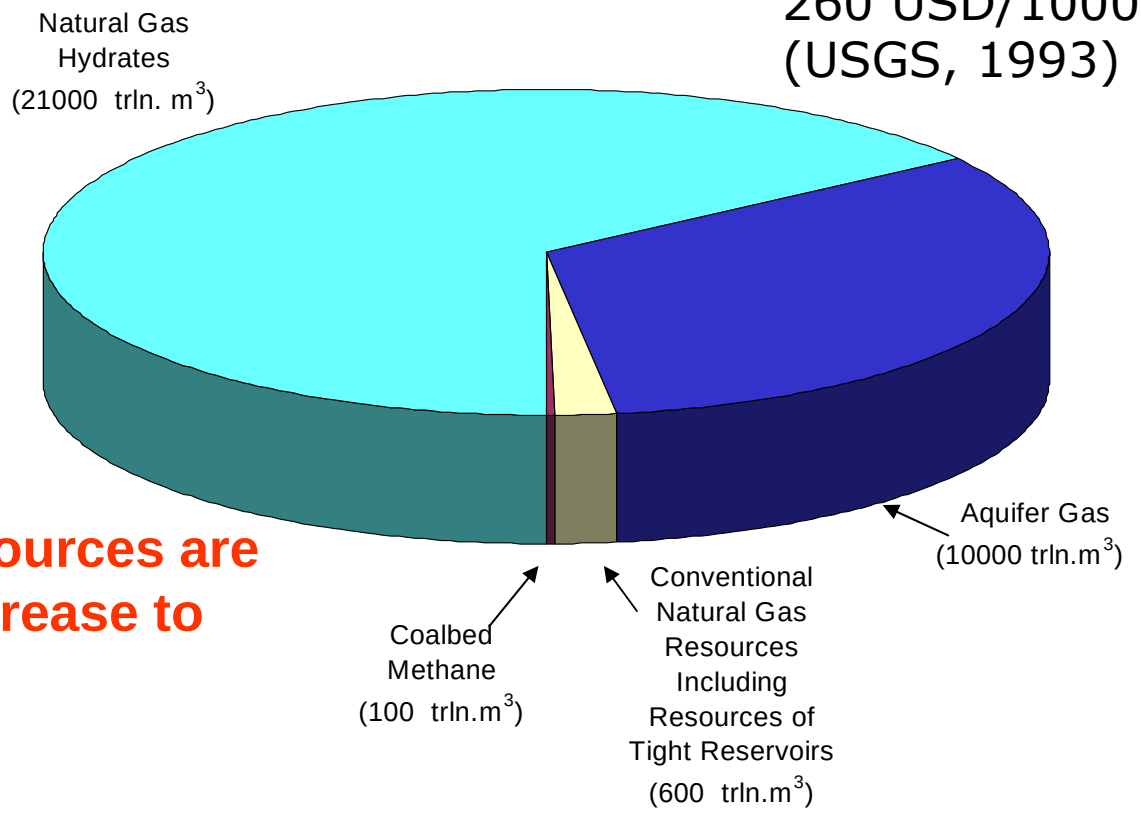
Subbotom hydrate-containing sediment

Locations of known gas hydrate occurrences in the world



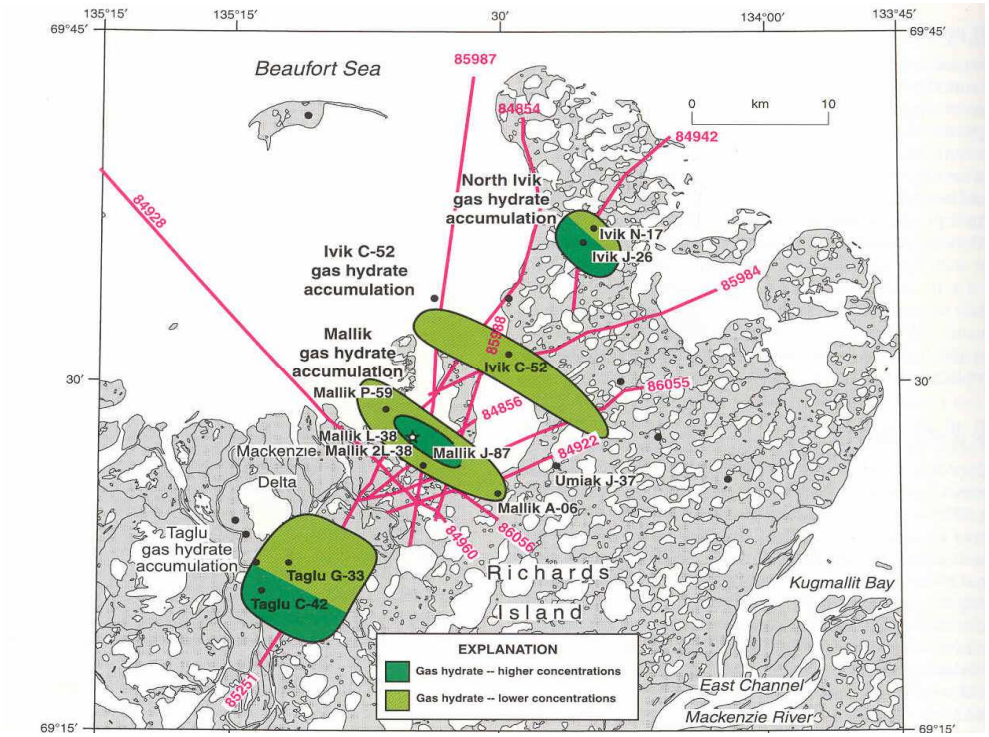
Natural gas resources in the Earth crust down to depth 4,5 km. (Combined data from VNIGRI (Russia) and USGS (USA)

Production cost of submarine hydrates 160-260 USD/1000 SCM (USGS, 1993)



Now hydrate resources are supposed to decrease to 2500 TCM.

Exploration and production of gas from hydrates (Mackenzie Delta project, Canada)



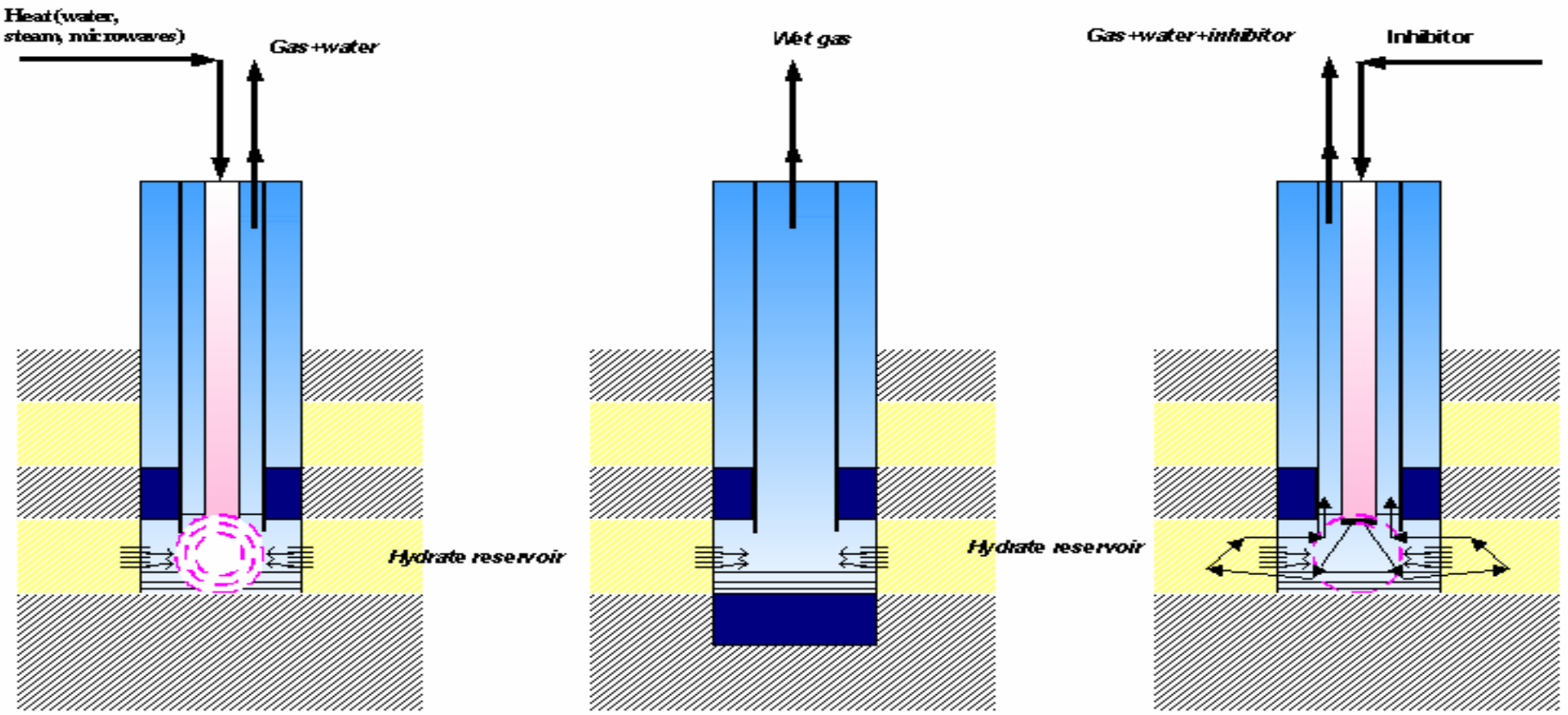
Explored gas hydrate fields

Resource assessment

Gas hydrate accumulation	Area of gas hydrate accumulation (km^2)	Volume of gas within hydrate per square km ($x\ 10^6\ m^3$)	Total volume of gas within the hydrates of each gas hydrate accumulation ($x\ 10^6\ m^3$)
Mallik	10.27 41.08	4835 1469	49 656 60 347 Total 110 003
Ivik C-52	46.61	921	42 928
North Ivik	15.01 9.48	1187 531	17 817 5034 Total 22 851
Taglu	26.07 38.71	351 58	9151 2245 Total 11 396

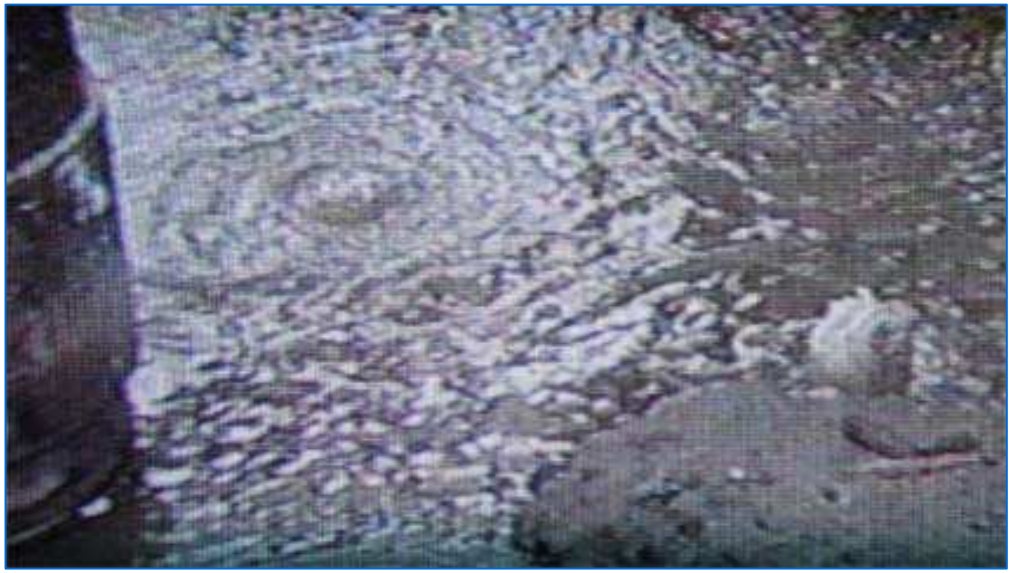
Probable initial production cost:
25-30 USD/1000 SCM

Three methods of gas production from hydrates



Heat injection | Depressurization | Chemical injection

Geohazards



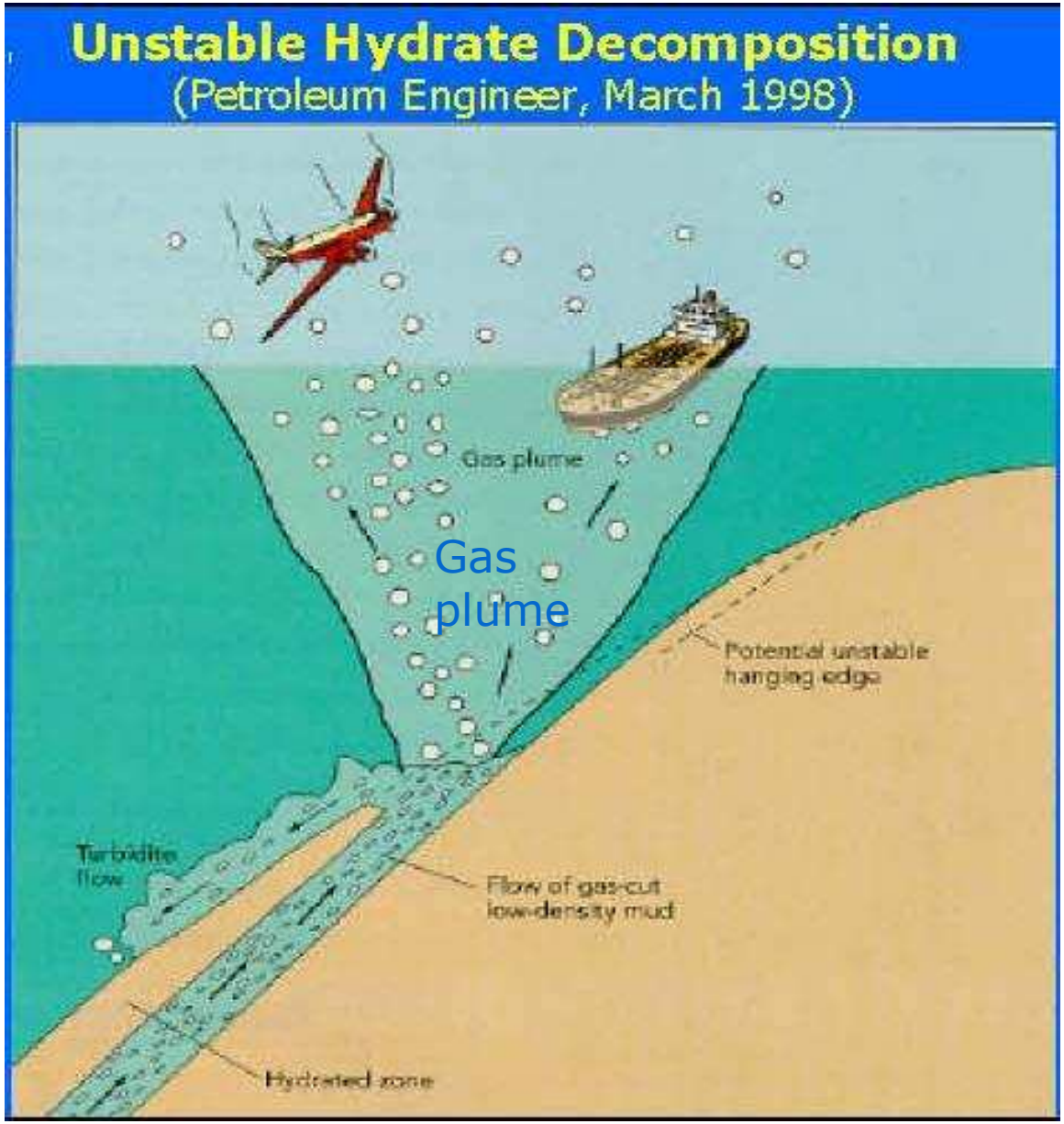
Methane bubbling form shallow permafrost hydrates around gas production well in West Siberia (Russia)

Gas fire from permafrost hydrates when drilling monitoring well

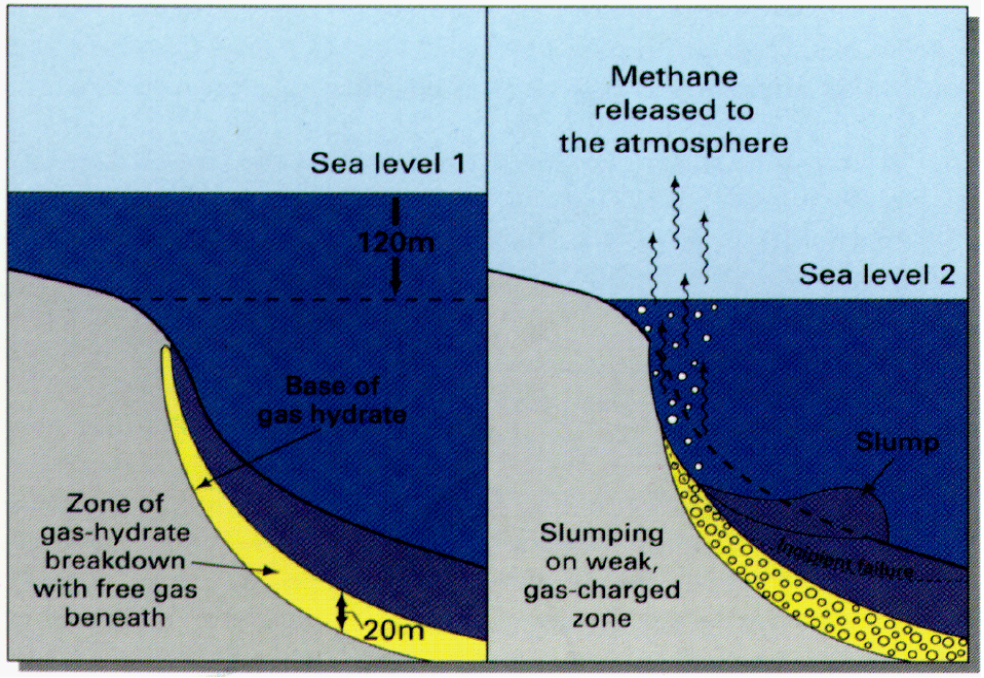
Geohazards

Methane release from submarine hydrates can result to ship sinking and low-flying plane explosion.

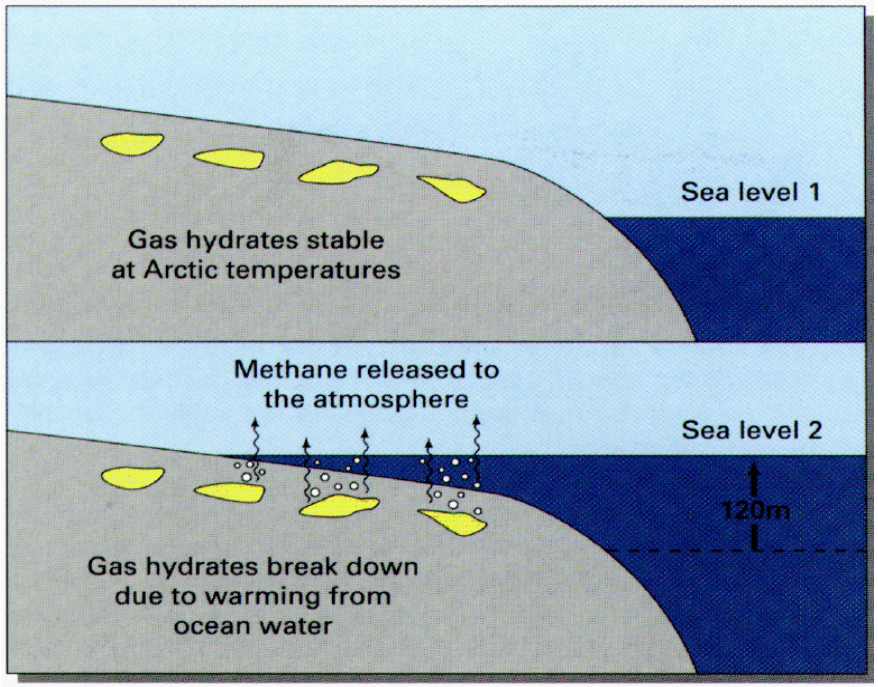
Submarine landslide can destroy offshore production facilities



Gas hydrates and greenhouse gases emissions



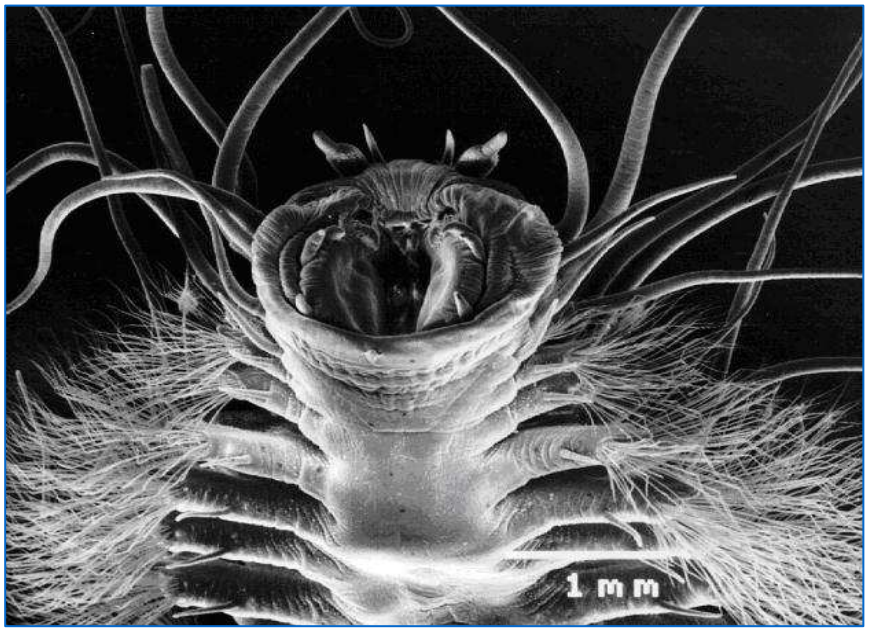
Methane release from hydrates to atmosphere if sea level reduction



Sea-level rise causes relatively warm ocean water to cover cold Arctic strata. The resulting breakdown of stable gas hydrates within the sediment releases gas into the atmosphere.

Methane release from hydrates to atmosphere if sea level rise

Gas hydrates – medium for new forms of life



“Ice worm” (portrait)

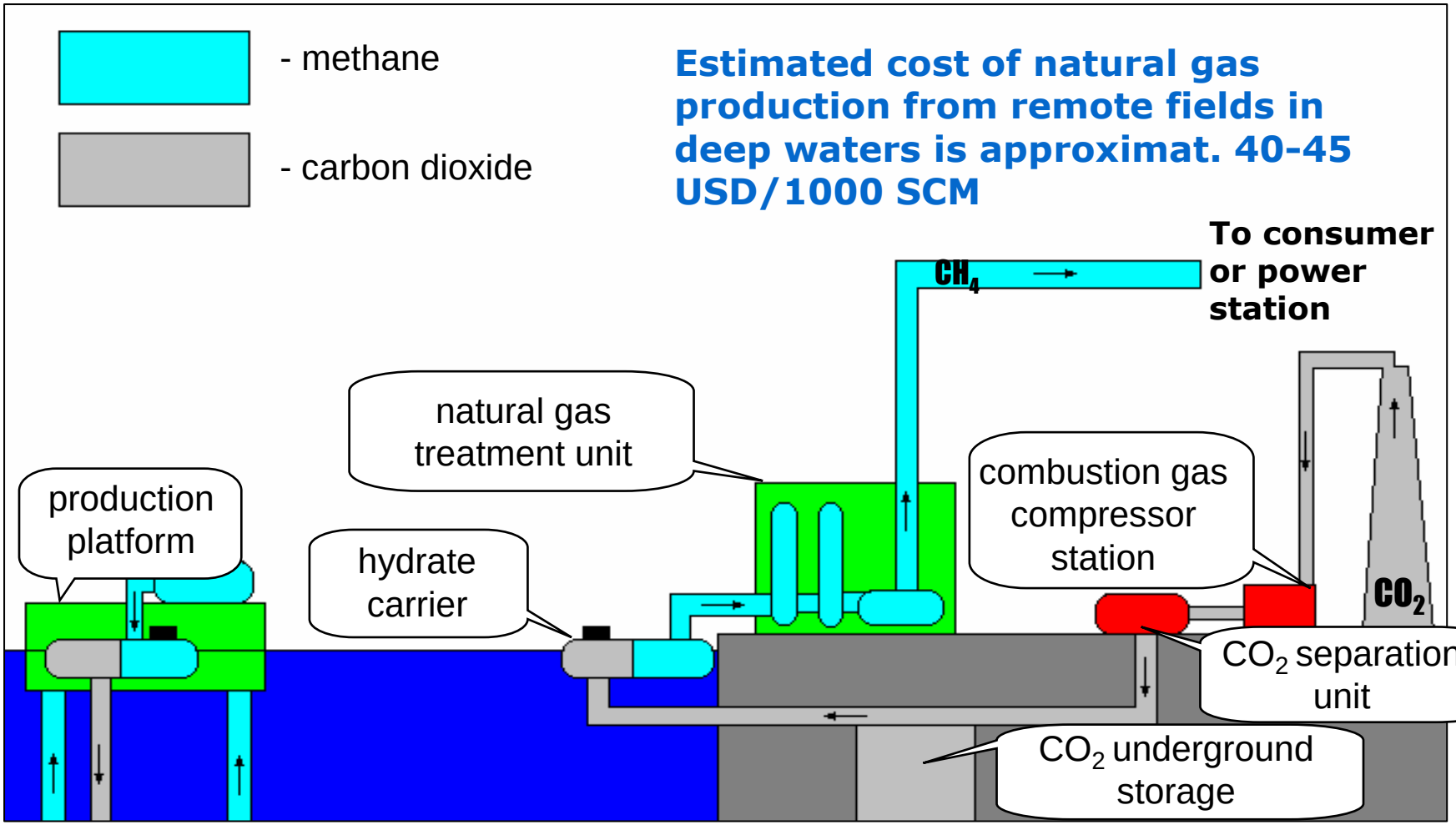
Submarine colony of “Ice worms” in hydrate accumulation (Mexico Gulf)

Gas Hydrate Technologies for Natural Gas Industry

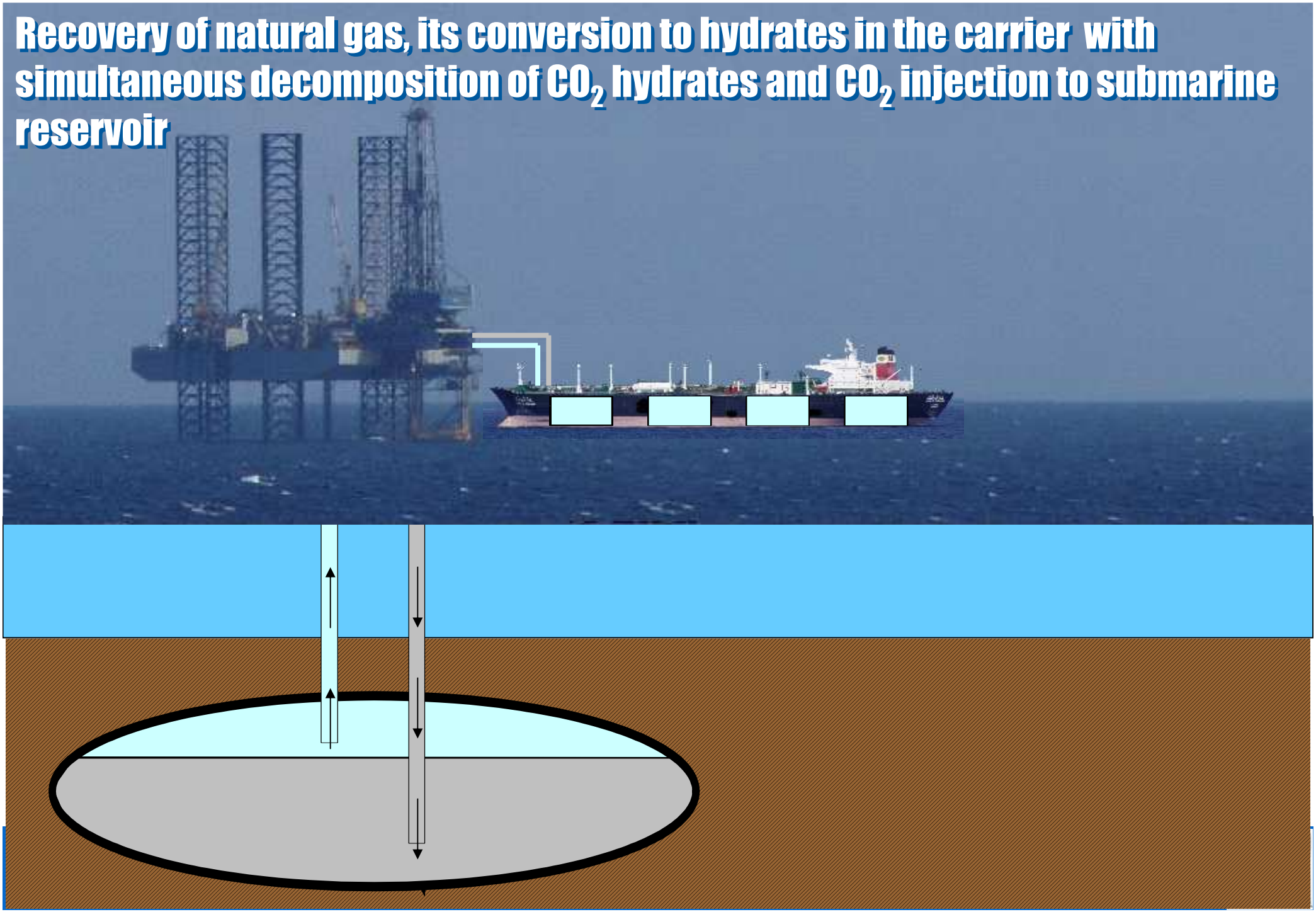
Gas hydrate technologies could be applied for:

- Remote and deep-water offshore natural gas fields development.
- Continental small and medium gas fields development.
- Marine transport and trade of natural gas (competitor to LNG)
- Natural gas and drinking water supply to remote consumers
- Peak sheaving natural gas storage close to large consumers
- Seasonal natural gas storage in areas with irregular consumption

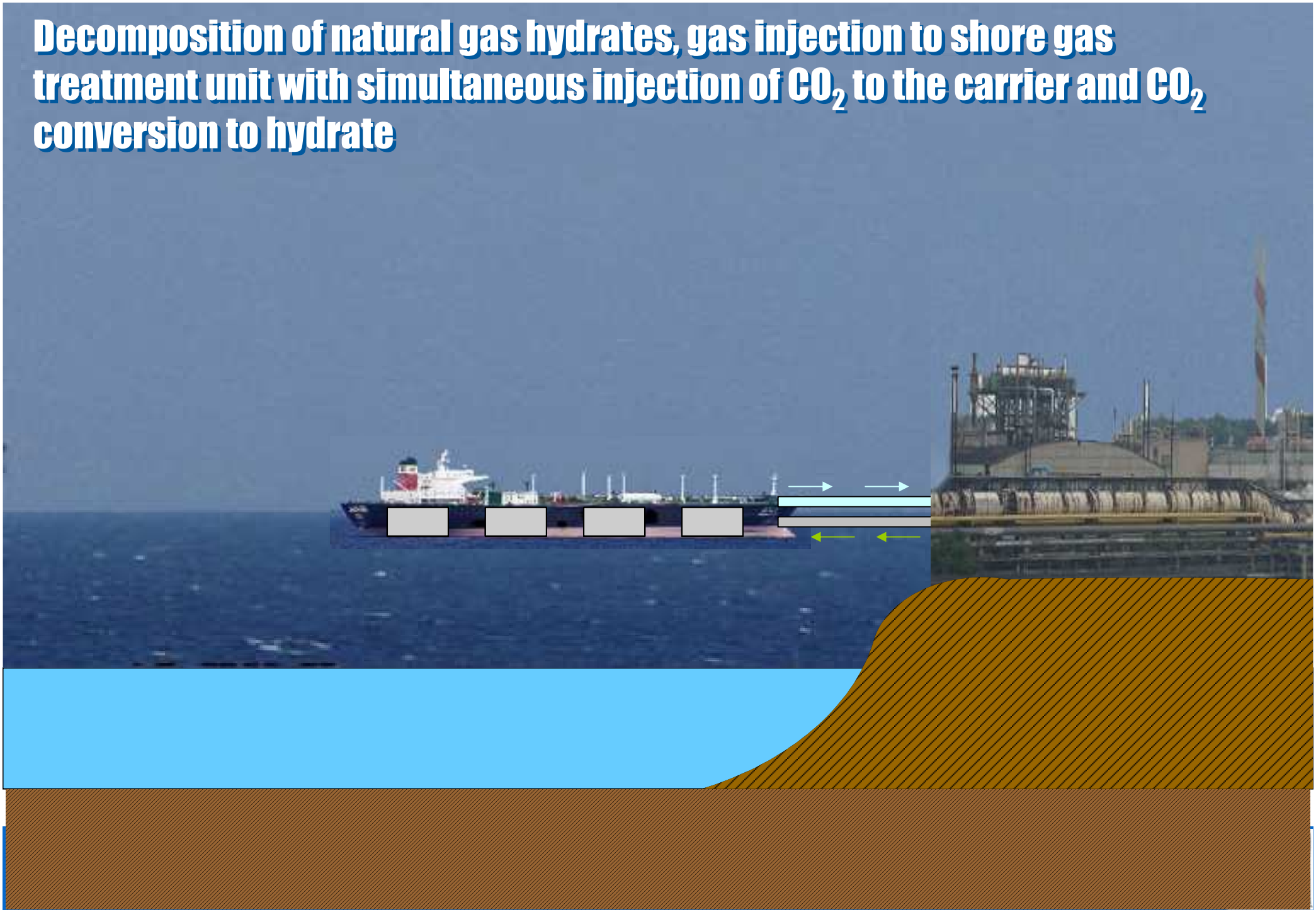
Concept of natural gas production and CO_2 sequestration using gas hydrate technologies



Recovery of natural gas, its conversion to hydrates in the carrier with simultaneous decomposition of CO_2 hydrates and CO_2 injection to submarine reservoir



Decomposition of natural gas hydrates, gas injection to shore gas treatment unit with simultaneous injection of CO_2 to the carrier and CO_2 conversion to hydrate



Gas hydrate technologies: Gas transportation

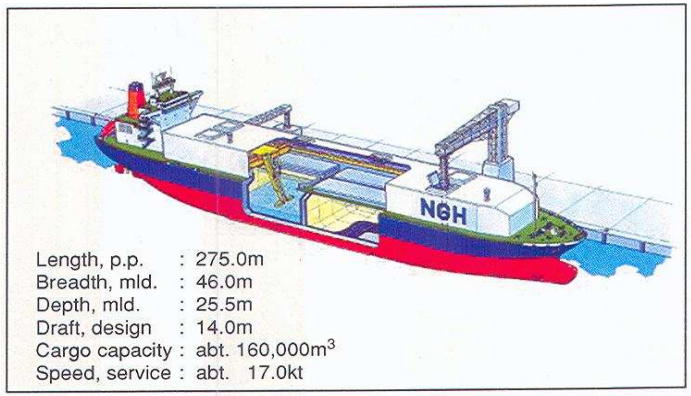
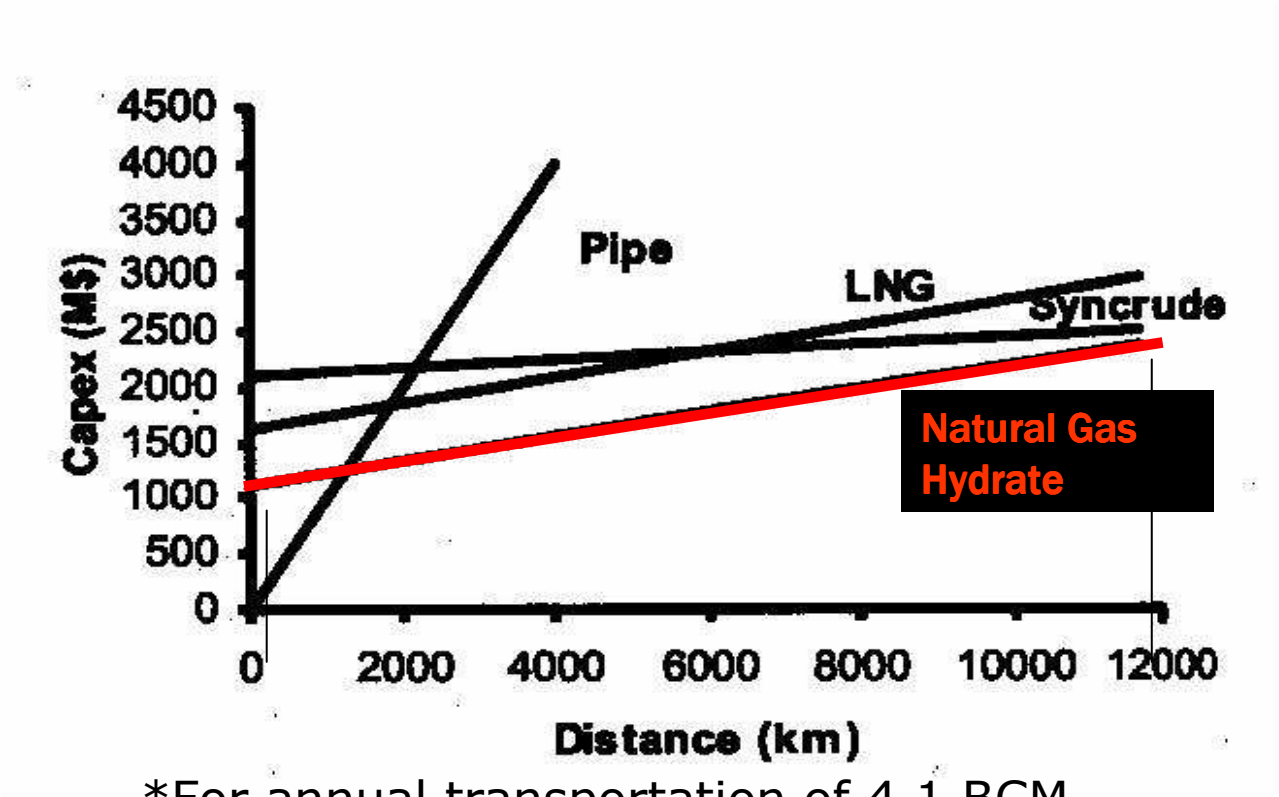


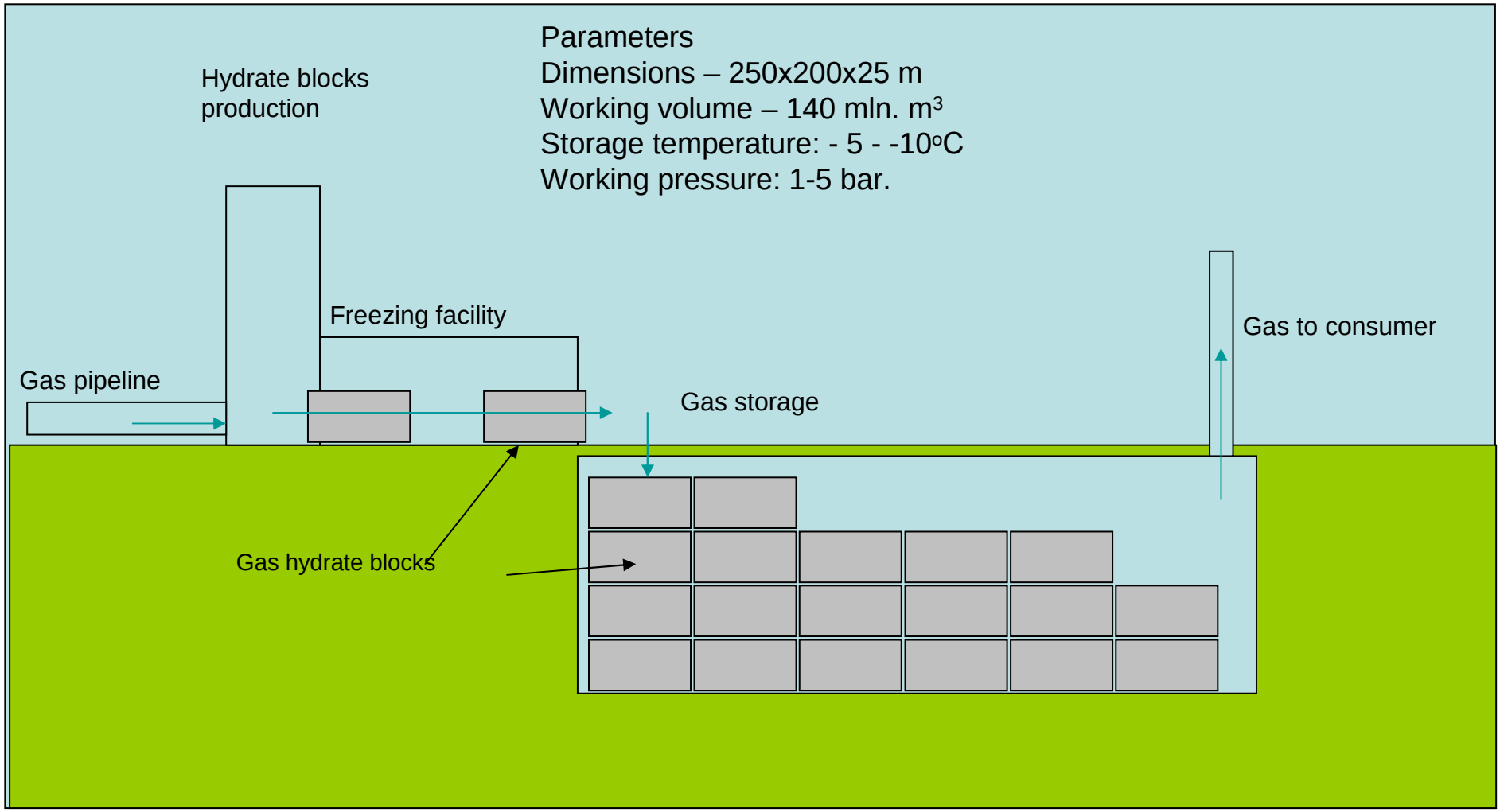
Image of marine hydrate carrier of Mitsui Corp. (Japan)

CAPEX for different methods of natural gas transportation (data of Norwegian University of Science and Technology, 2002)*



*For annual transportation of 4,1 BCM

Gas hydrate technologies: Gas storage. (project of natural gas storage, Russia)



CONCLUSIONS

- Total number of resources is decreasing (down to 2500 trln.m^3), but commercial prospects of gas production from gas hydrate deposits are growing (production cost varies from 25 to 260 USD/1000 m^3).
- Discovery of new phenomenon – gas hydrate self-preservation, explains hydrate existence in shallow permafrost and opens new commercial prospects for storage and transportation of methane in hydrate form at atmospheric pressure (25% less in CAPEX then equal LNG).
- Gas hydrates are of considerable geohazard when drilling and production of oil and gas in permafrost regions.
- Natural methane hydrates could be great source of methane for global worming is sea level change, but there are no visible reasons for this change.
- Methane hydrates could be of great geohazard for deep water oil and gas production due to submarine landslides along contact between hydrate-containing and underhydrate sediments.
- New technologic concepts of commercial natural gas storage and transport in hydrate form open new prospects for deep water natural gas production and CO_2 sequestration (natural gas production in remote deep-water gas fields is estimated as 40-45 USD/1000 m^3)
- Construction of gas hydrate storages can solve the problem of irregular natural gas supply to remote small consumers.

International activity on gas hydrate R&D

National gas hydrate programs acting since:

1995 - Japan

1996 - India

1999 - USA (Second Program)

2000 - Germany

2001 - S.Korea

2001 - China

ACKNOWLEDGEMENT

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