Centre for Offshore Research and Engineering (CORE)

at Maritime Institute @ NUS

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Some Challenges in Deepwater Technology

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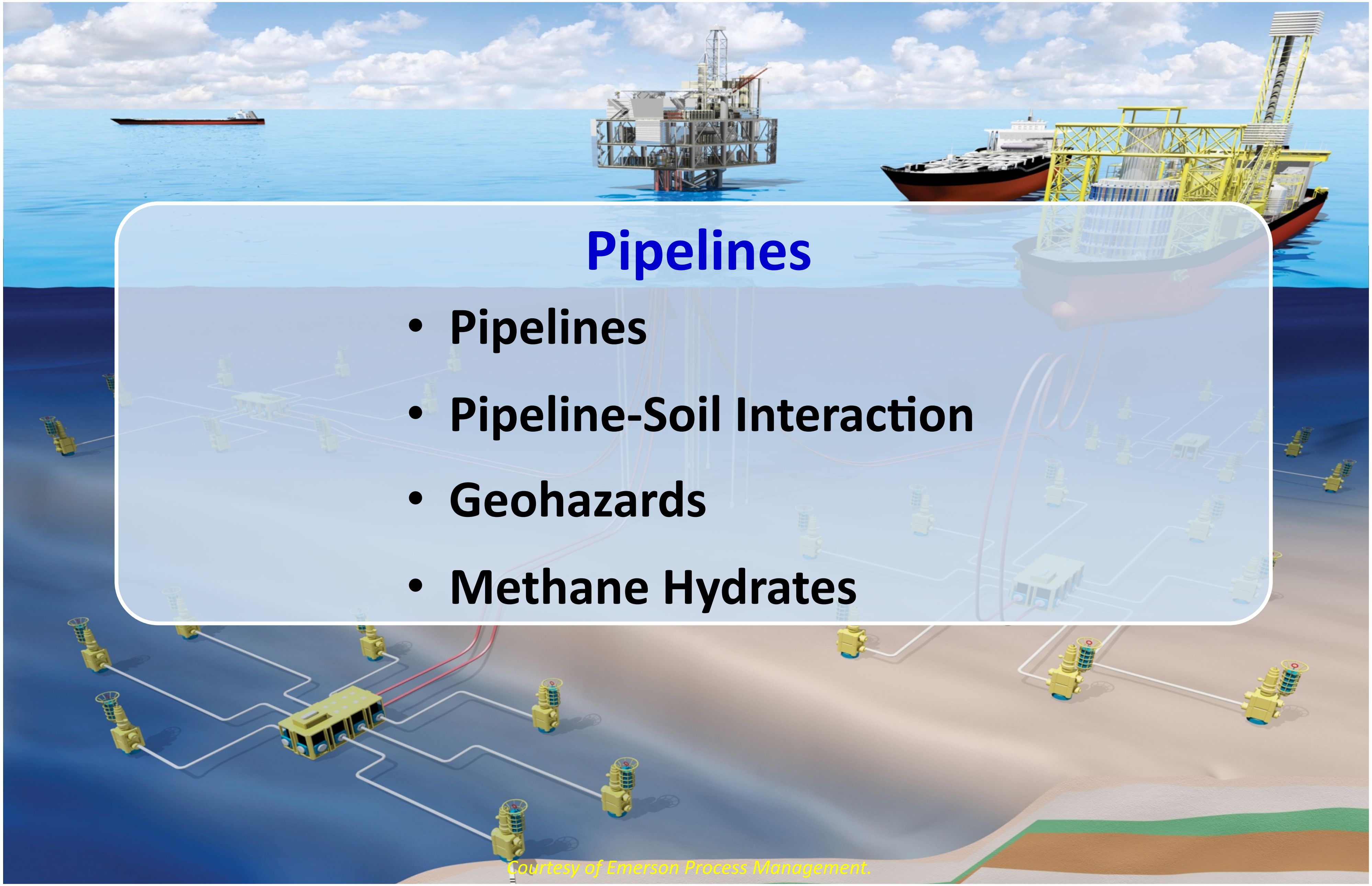
Pipelines

- Pipelines
- Pipeline-Soil Interaction
- Geohazards
- Methane Hydrates



Courtesy of Emerson Process Management.

Research in underwater pipelines

Why it matters:

Every offshore petroleum project includes pipelines

Pipelines are a major component of project cost

Several major players in the marine pipeline industry have offices and construction bases in Singapore and nearby

Singapore and nearby countries have pipelines of their own

How NUS approaches research:

Look for worthwhile problems that are intellectually serious and difficult (but not impossible)

Keep close to the marine pipeline industry and identify problems that are a high priority to them

Look at long-term developments as well as medium and short-term

Resistance to lateral movement

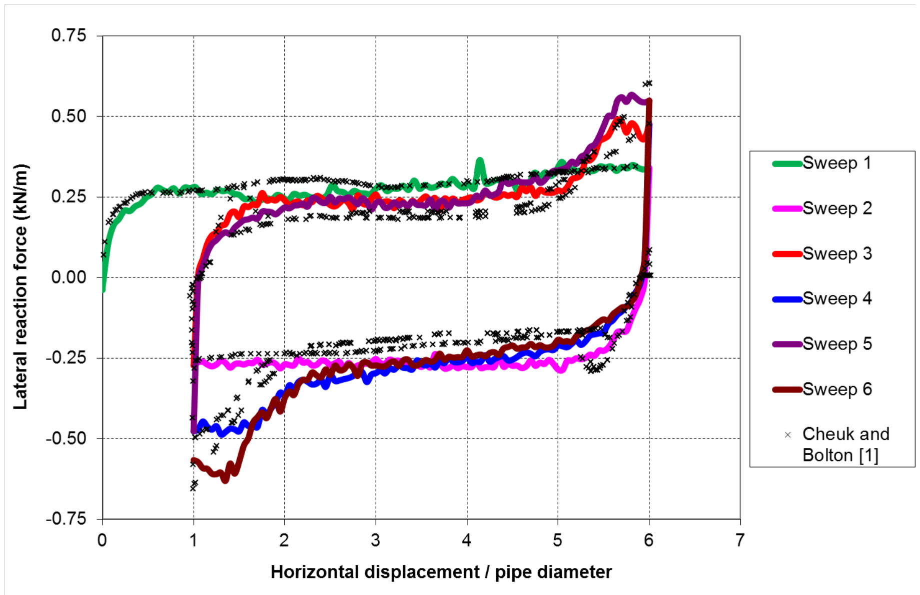
Why it matters:

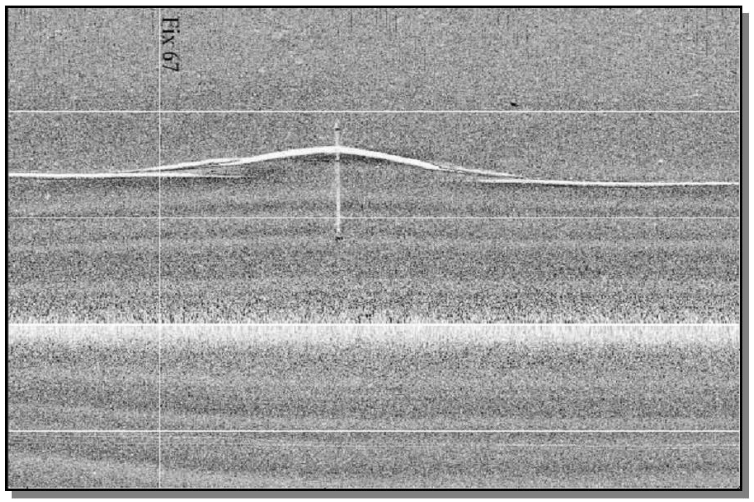
Seabed pipelines usually rest on the seabed and are only lightly embedded

If a pipeline moves, it may bend, buckle, and leak

Sometimes one wants a pipeline to be able to move (but not too far), so that lateral buckling can relieve axial forces, and so that impacts from trawl gear and anchors can be resisted

The cost of stabilising a pipeline against lateral movement is enormous: one project in Australia is currently planning to dump 3.9 million tonnes of rock, at a cost close to 1000 million AUD





Catenary riser interaction with the seabed

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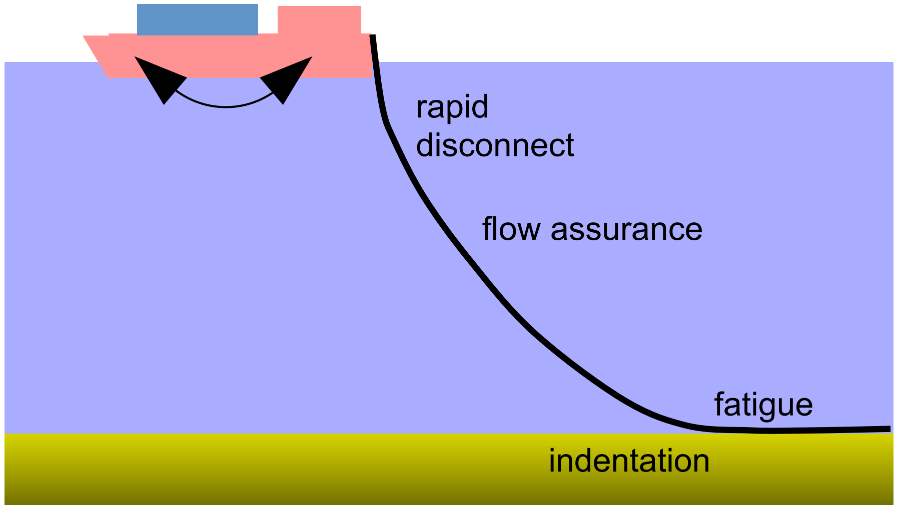
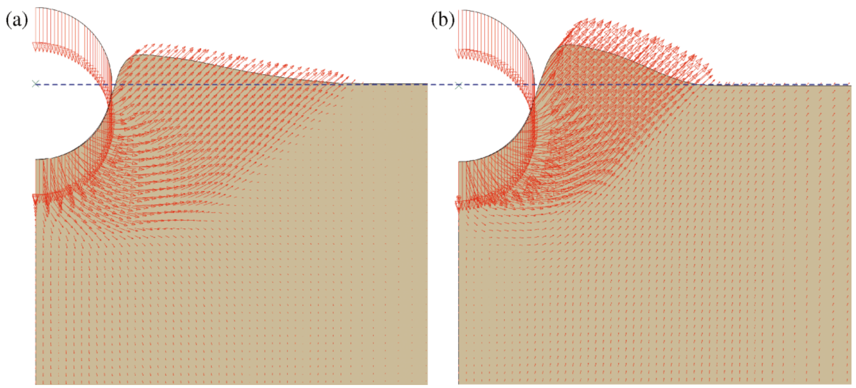
Why it matters:

The length where the riser reaches the seabed is a fatigue hotspot

The pipe resists being pushed down into the seabed and lifted out again

The bending stress range is particularly large, and depends strongly on the local interaction with the seabed





Overtrawlability of pipeline bundles

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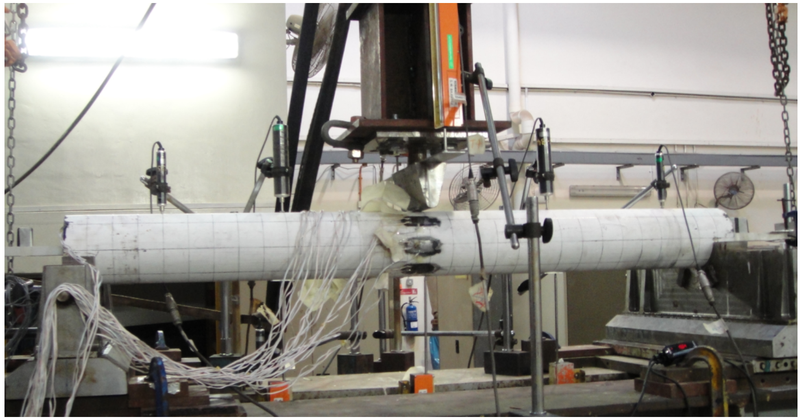
Why it matters:

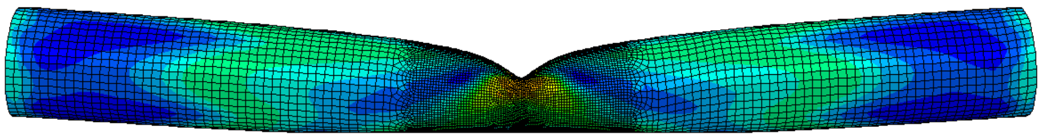
Seabed pipelines less than 16 inches (406 mm) diameter usually are trenched so that they are safe against impact by trawl gear

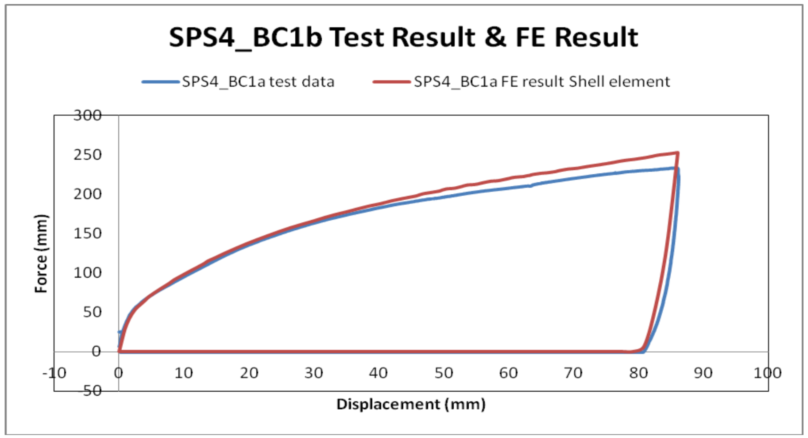
Trenching is expensive, and a frequent source of disputes and claims

It would be commercially attractive if it could be shown that smaller pipelines do not need to be trenched

trawl scars in 400 m water depth







Changes in the seabed due to hydrate dissociation

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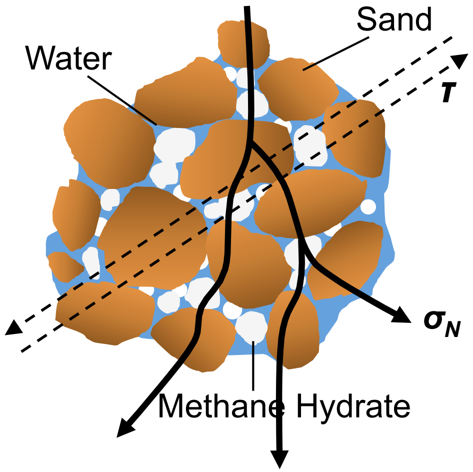
Why it matters:

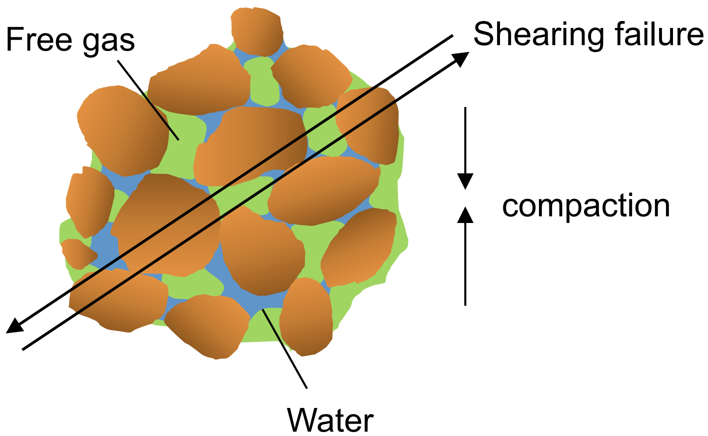
- 90 % of the seabed can contain gas hydrate, in layers several 100 m thick
- The solid hydrate increases the soil's strength, but its removal by dissociation severely weakens the soil:
  - reduction in bearing capacity (load redistribution)
  - reduction in shear strength (excess pore pressure reduces effective stress)
- Dissociation caused by changes in temperature regime (hot pipeline, well)

Stable hydrate:



Hydrate carries normal- and shear stress

Hydrate dissociated:



Soil severely weakened

Dissociating hydrate affects

- **Foundations in deep water:**

  - Piles:

  friction reduction on interface – axial failure

  areal weakening of soil – lateral/moment capacity reduction

  - Suction caissons:

  if dissociation within caisson – cancelation of required under pressure due to expanding gas

- **Drilling operations:** (*both actual field problems offshore Sabah)*

  - Conductor casing capacity:

  on which BOP is mounted, casings hung into before/during cementing

  - Casing – cement bonding:

  cement hydration heat causes dissociation leading to gas intrusions

Consequences can be severe – assessment of H dissociation effect is vital.

NUS gas hydrate testing facility

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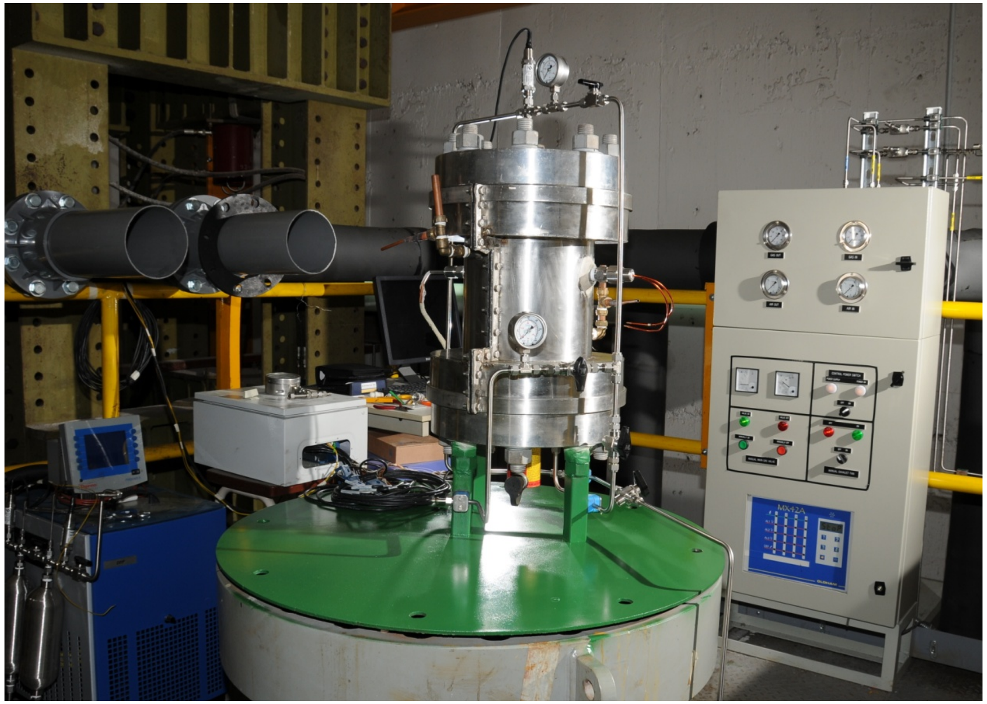
- Worldwide first apparatus in which 2 dissociation modes (*P*, *T*) are combined
- First setup which applies gamma ray transmissivity measurements
- One of the leading facilities in Asia



Measurement capabilities:

- local temperatures $T(r,t)$
- dissociated gas $V_{gas}(t)$
- associated water $V_w(t)$
- vertical strain $\varepsilon_z(t)$
- radial density changes $\rho_z(r)$
- electrical conductivity $\kappa(t)$

First burning hydrate in SEA

Testing capabilities:

- Dissociation around a heated miniature pile (*T* up to 60°C)
- Pressure up to 20 MPa (2000 m water depth)
- Vertical effective stress of up to 5.5 MPa

Deepwater production of gas from gas hydrates

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Worldwide, hydrates contain 700 years of gas consumption at the current rate

Unfortunately, hydrates are not found in Singapore waters (because the sea is too shallow and too warm)

Other locations are luckier: Japan and Korea are working on major programmes to test the production of gas in deep water (800 m in the Nankai Trough)

NUS research in Singapore has made a significant contribution by demonstrating that a combination of depressurisation and downhole heating is far more efficient than depressurisation alone

The drilling and floating production vessels that will be required are a great opportunity for Singapore industry