Pressure coring in marine sediments: Insights into gas hydrate systems and future directions

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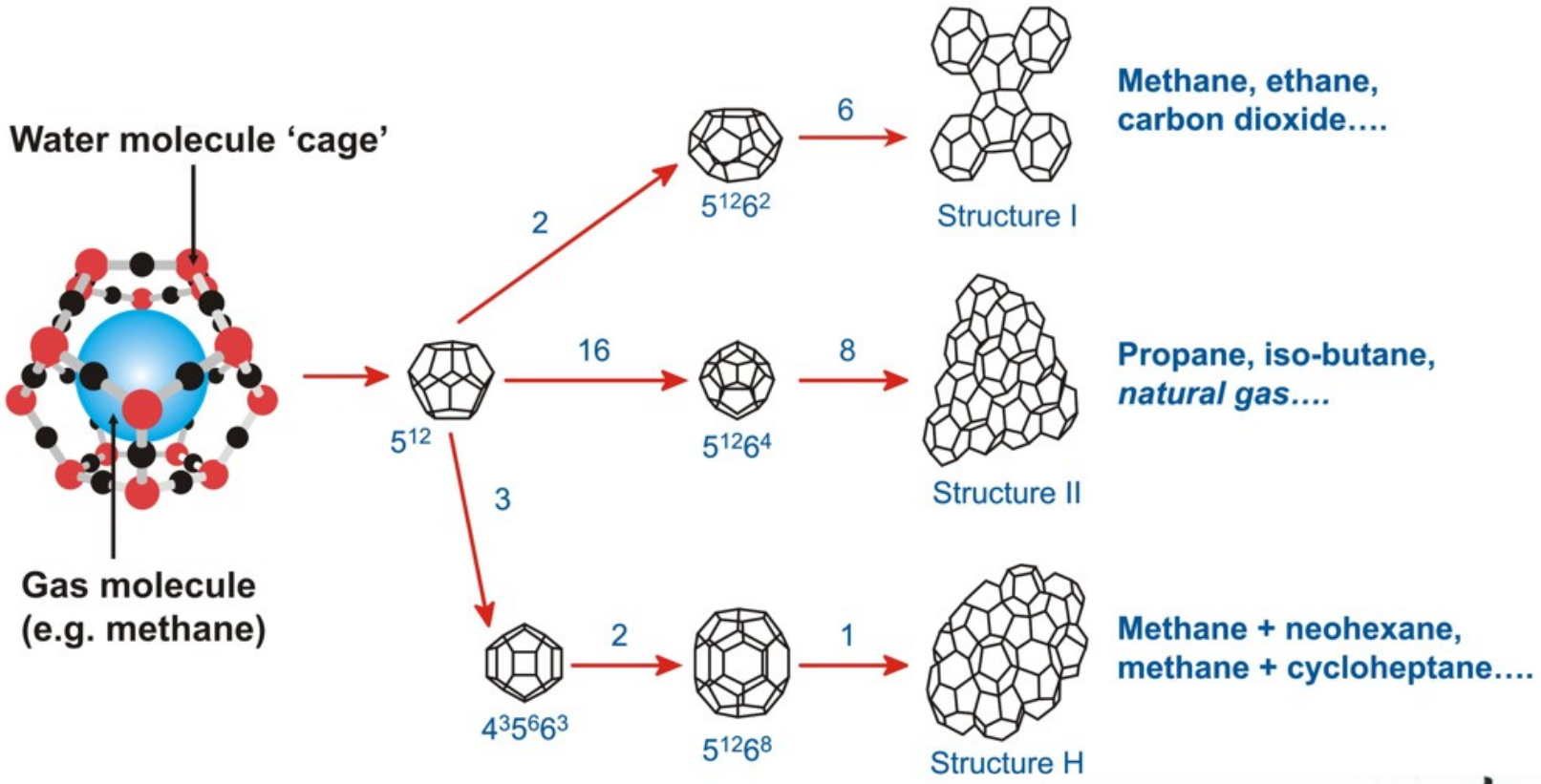
Gas hydrates



Sloan et al. 2003 *Nature*

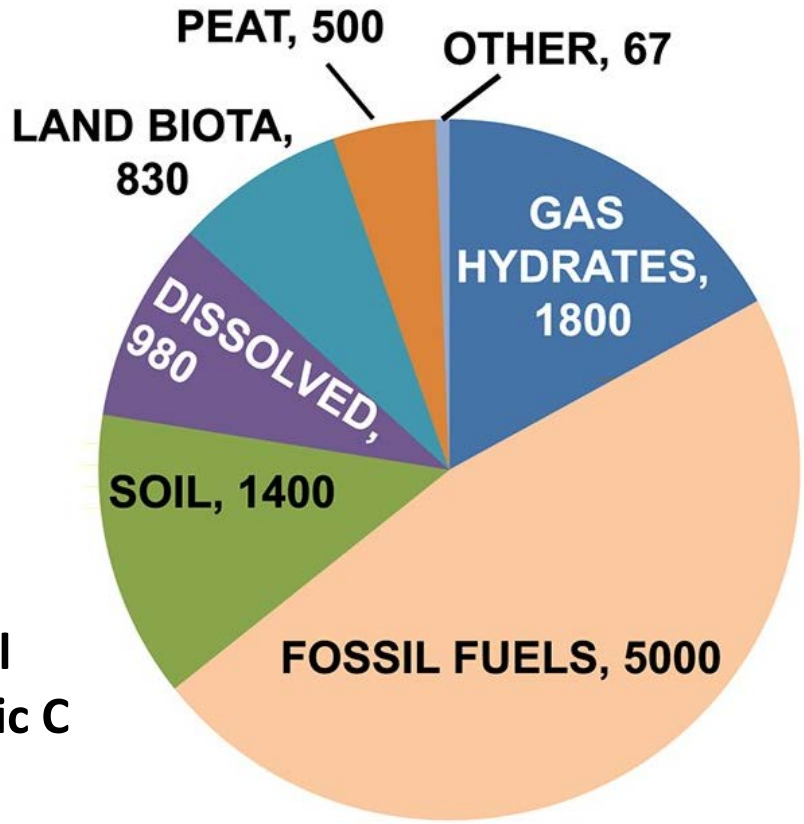
~160x volume at atmospheric conditions

USGS

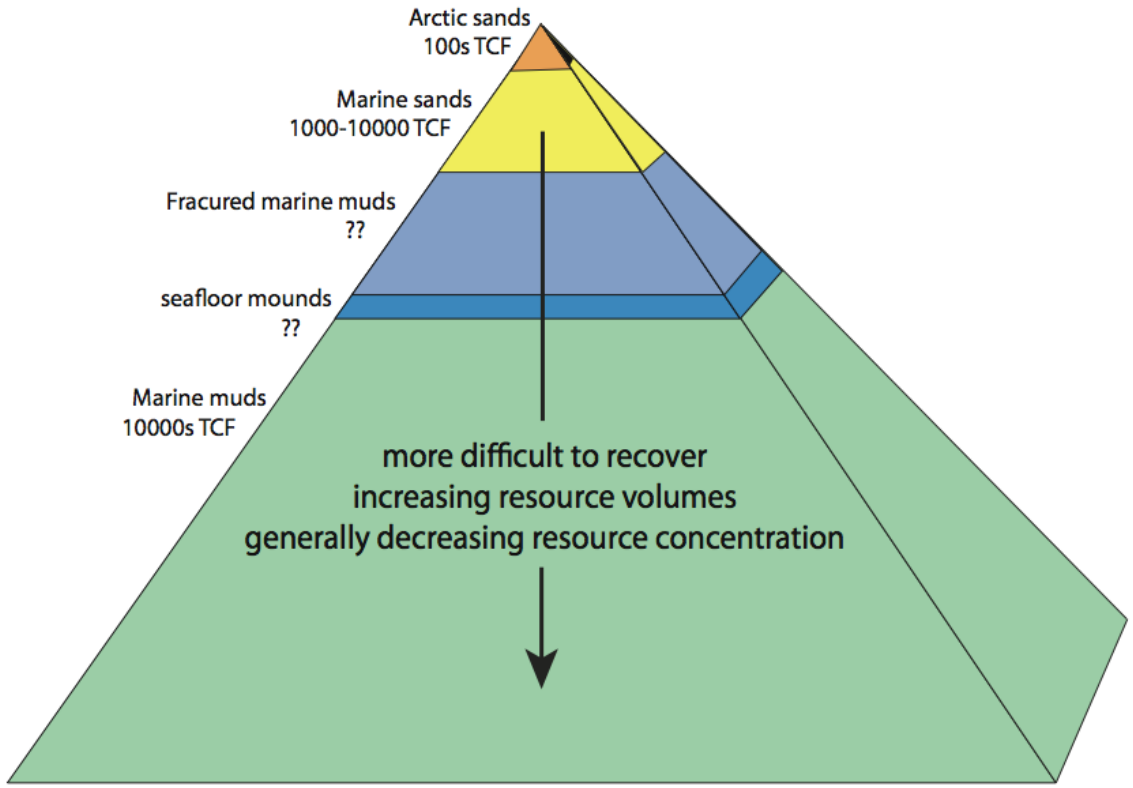
Gas hydrates

- Link to ocean and atmosphere C pools
- Potential role in climate feedbacks

- Potential energy resource
- Potential for CO_2 storage



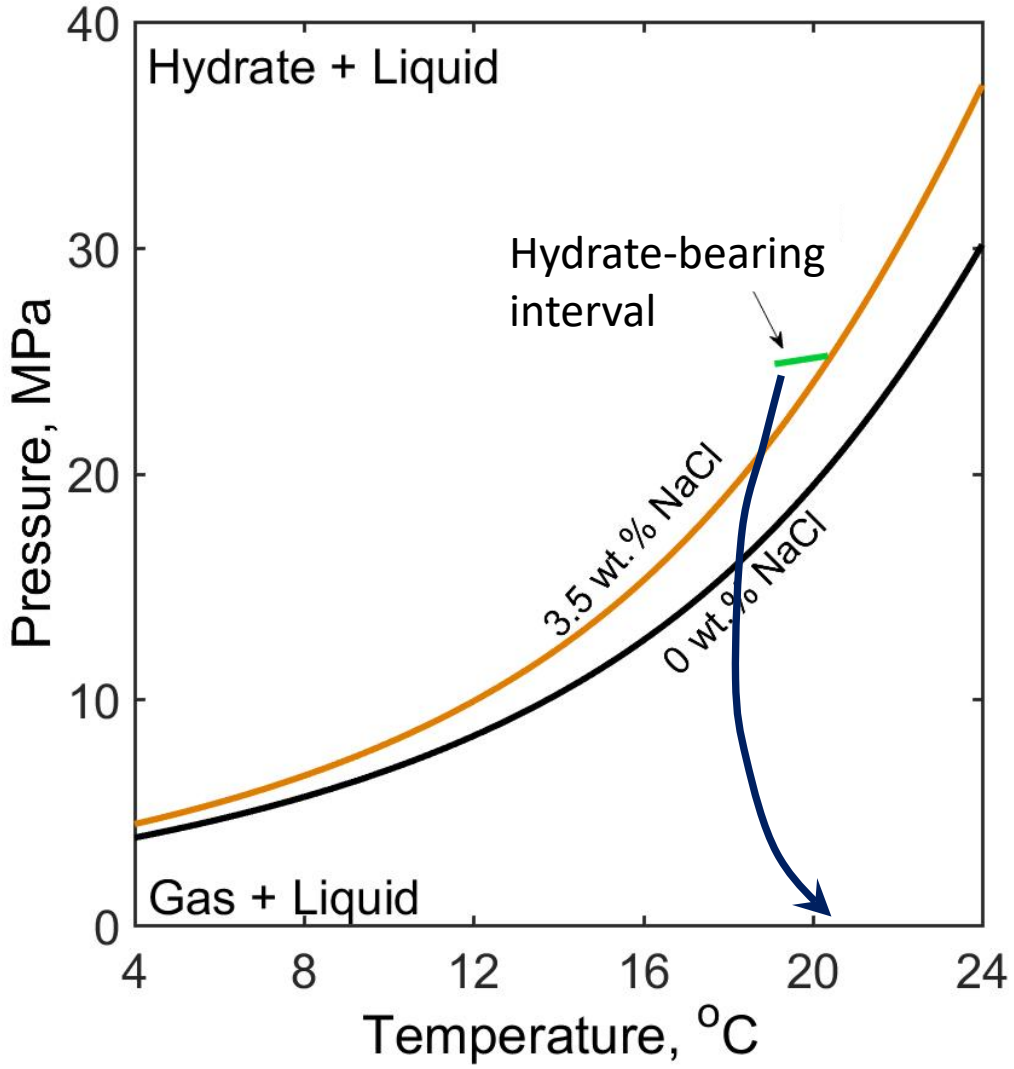
Global organic C pools



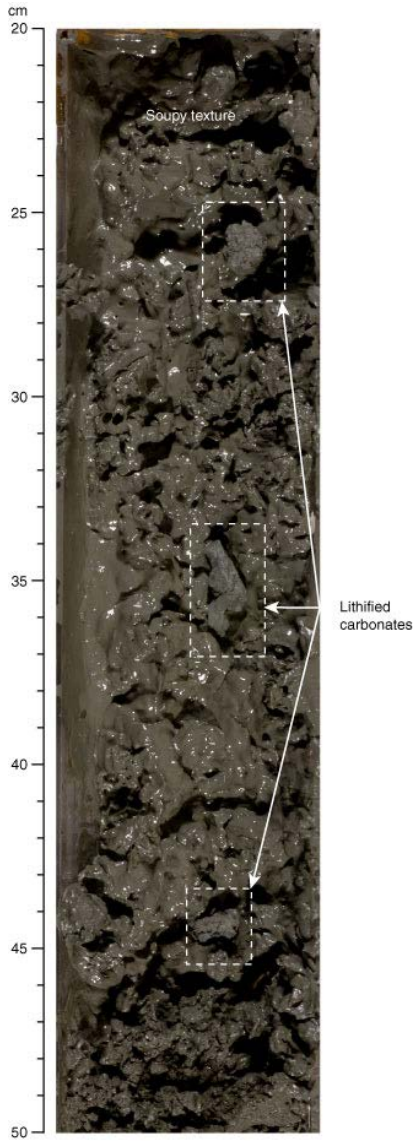
Ruppel and Kessler, 2017 *Rev. Geophys*.

Boswell and Collett, 2011*, Energy Environ. Sci*

Challenge of pressure coring



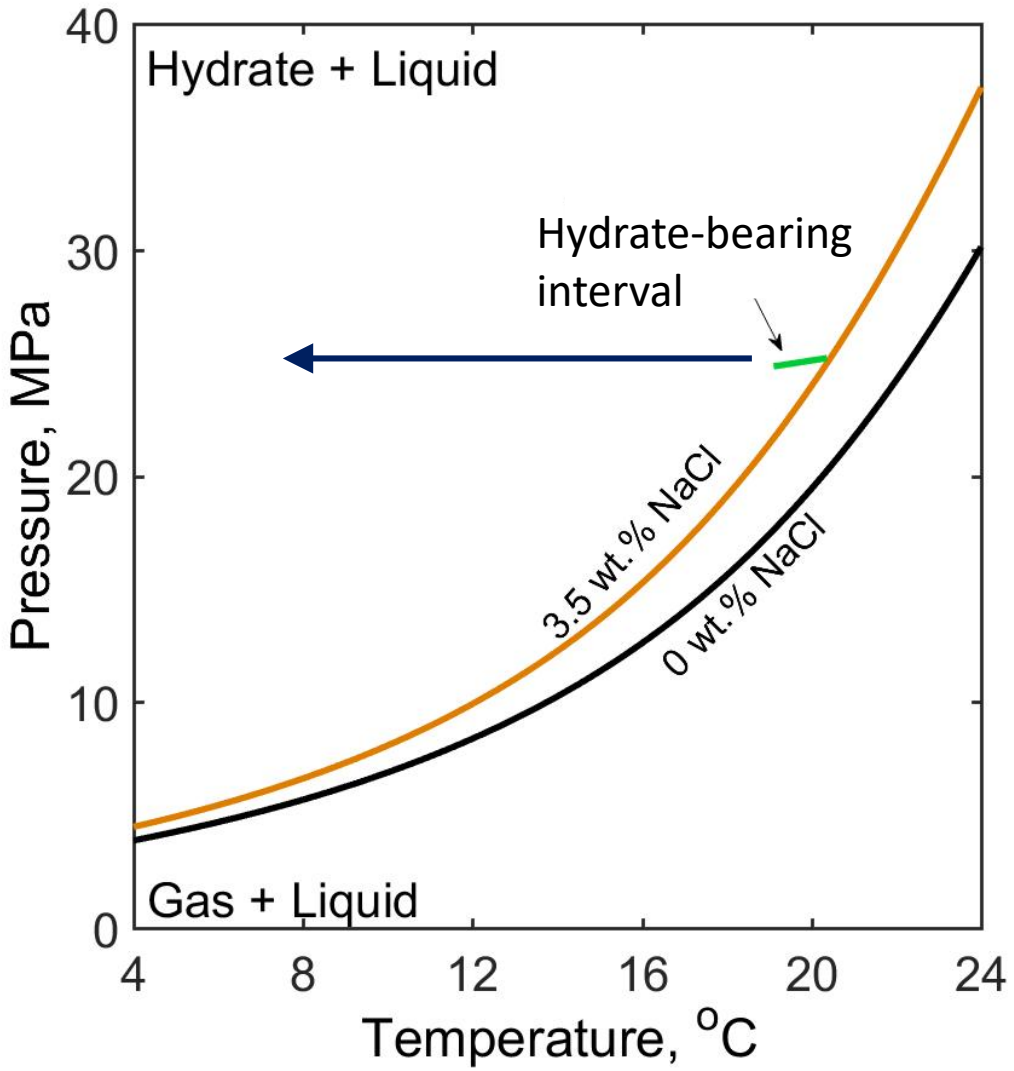
Conventional coring



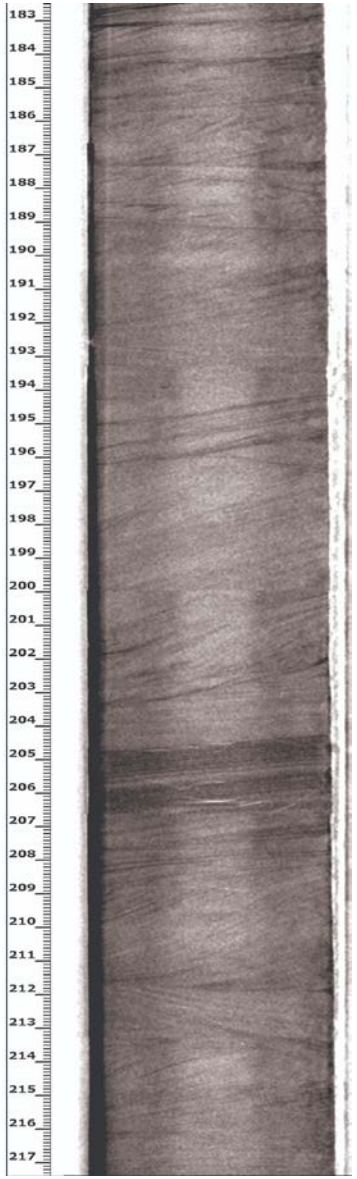
- Hydrate dissociates
- Almost all gas lost
- Sediment disturbance
- Pore water anomalies
- Temperature anomaly

Expedition 311 Scientists, 2006 *Proc IODP*

Challenge of Pressure Coring

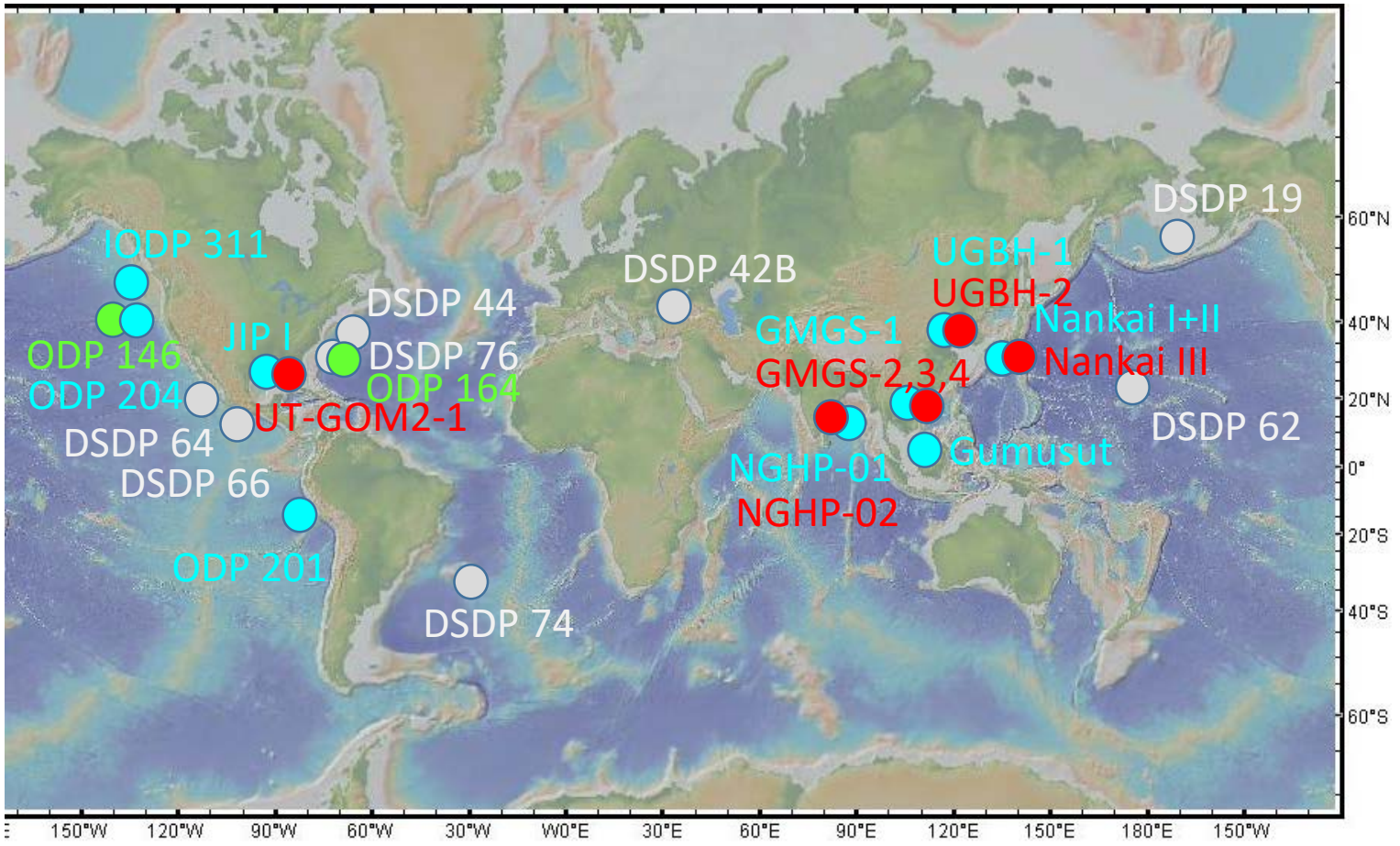


Pressure coring



- Hydrate intact
- Dissolved gas present
- Sediment fabric preserved
- Pore water reflects in situ concentrations

Development of pressure coring

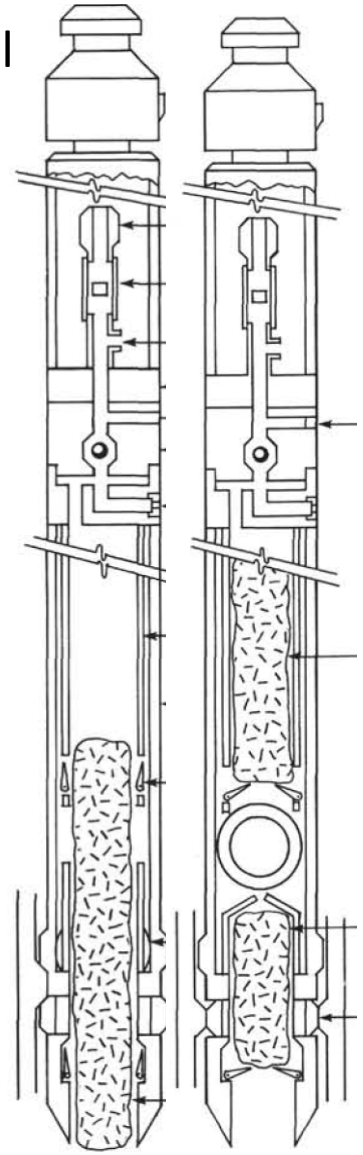


Little success — Gas quantification — Physical props. — Advanced

1970s/1980s 1990s 2000s 2010s

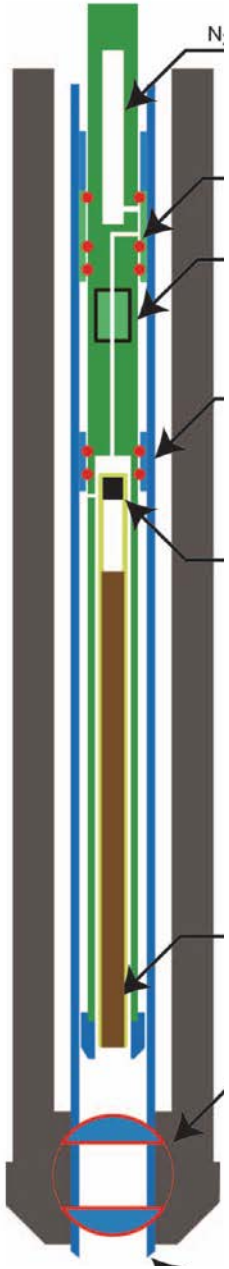
How do pressure cores work?

Pressure Core Barrel



Kvenvolden et al., 1983, *DSDP 76*

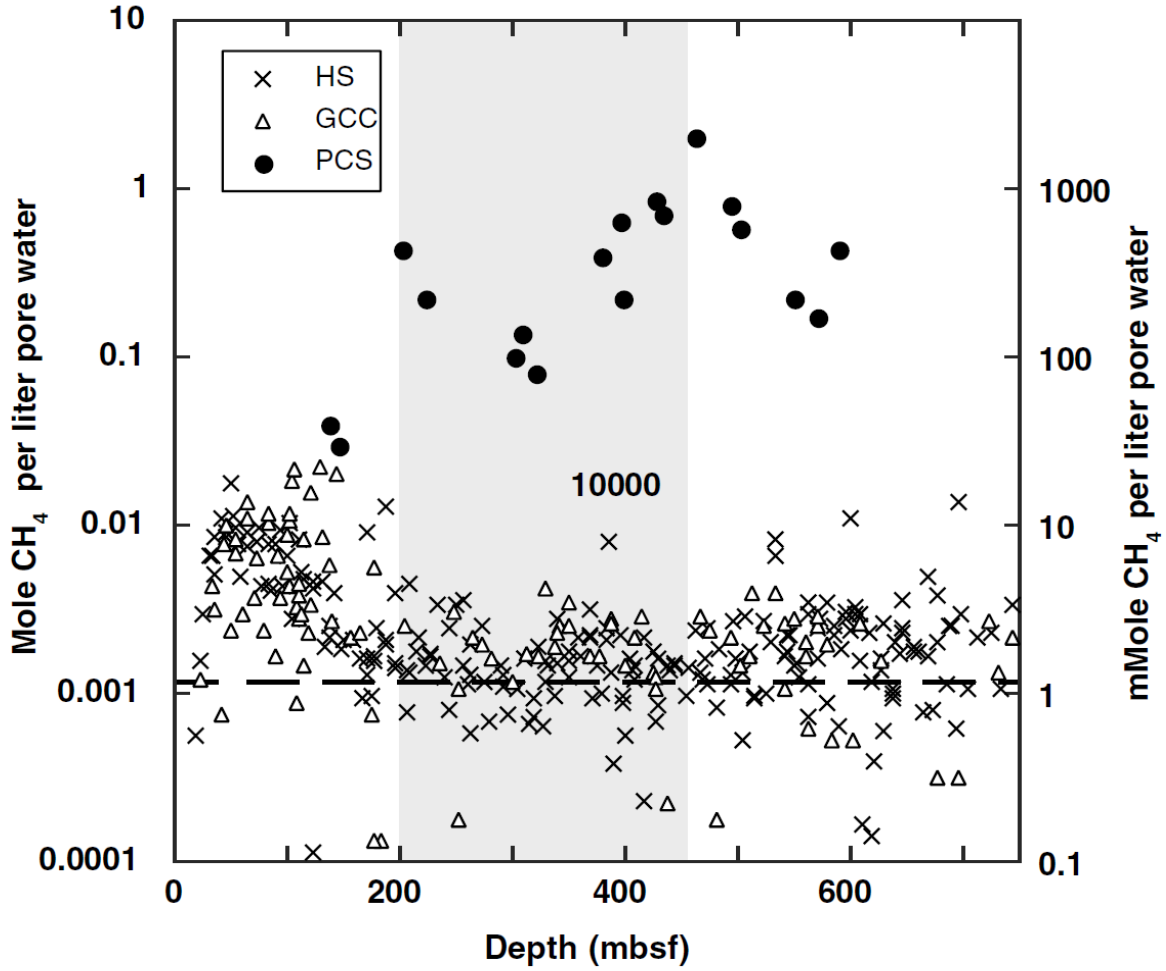
Hybrid Pressure Core Sampler



Kubo et al., 2014, *Sci. Drilling*

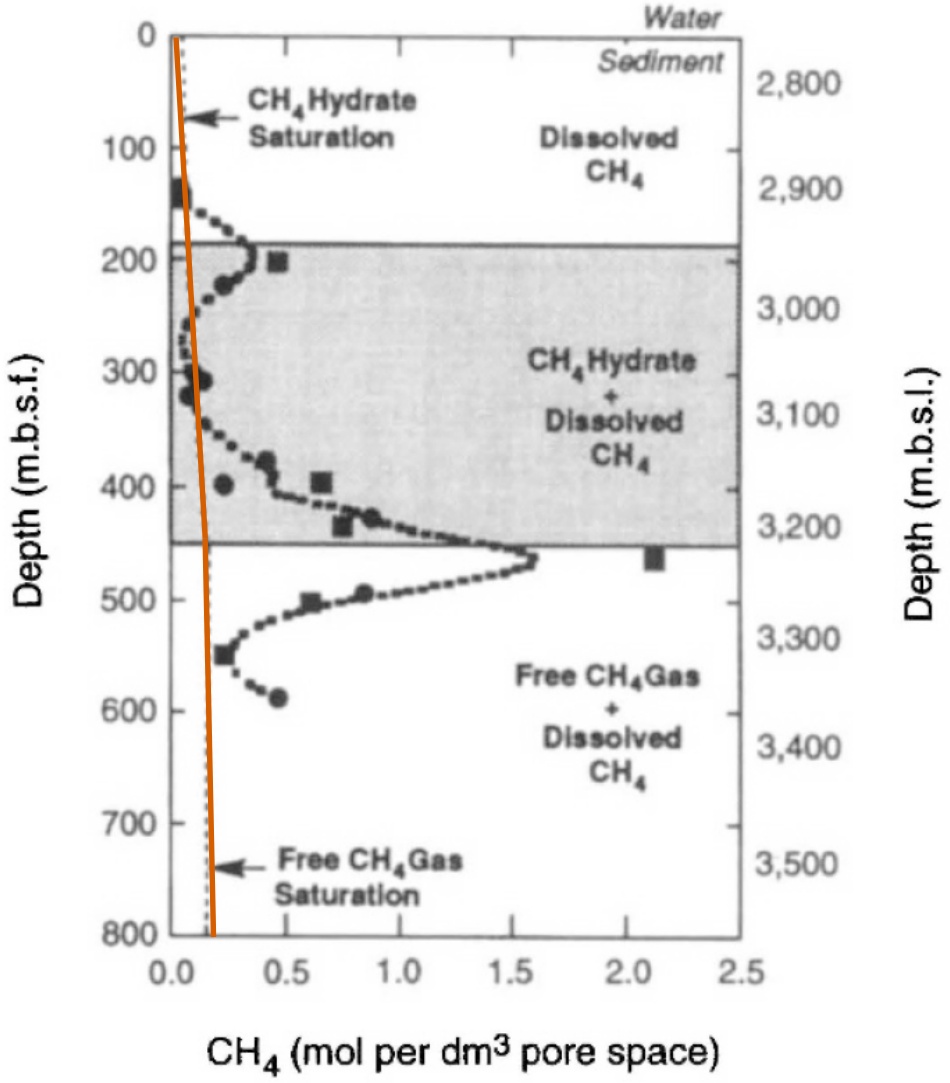
In situ methane concentration, hydrate saturation

> 99% of CH_4 typically lost in conventional coring (ODP 164)



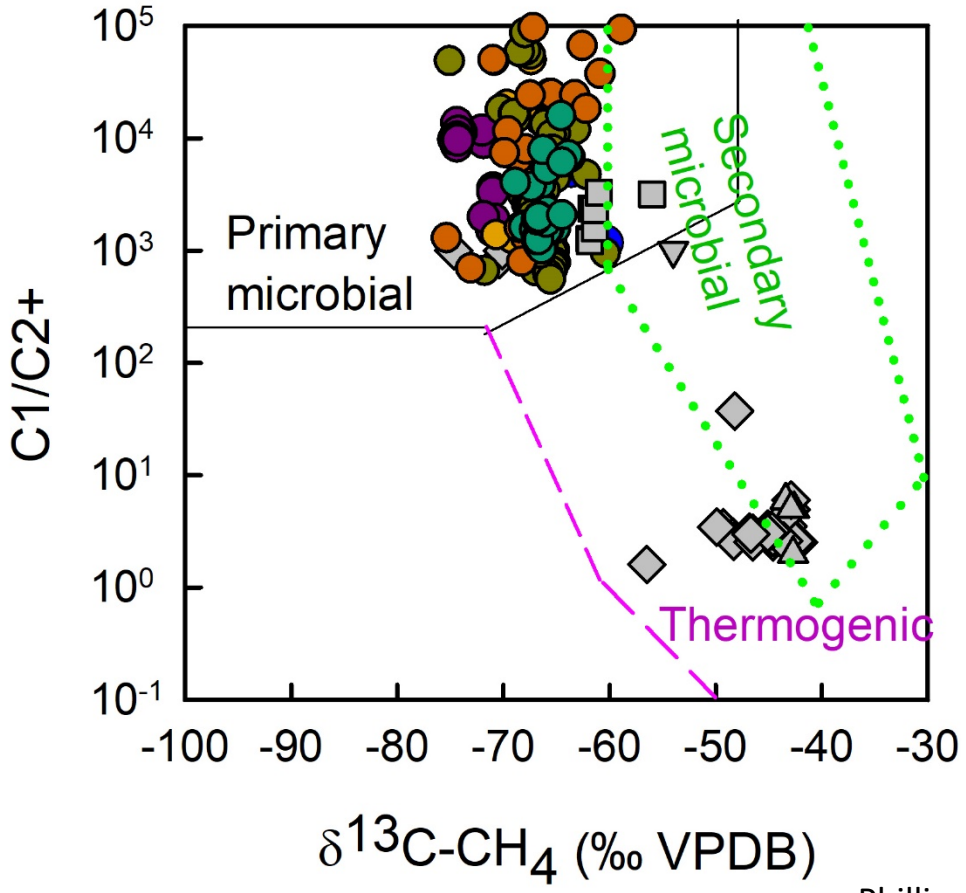
Paull et al., 2000, *Ann. NY Acad Sci*

Comparison to CH_4 solubility (ODP 164)



Dickens et al., 1997, *Nature*

Gas composition



- Gulf of Mexico silt reservoir (UT-GOM2-1)
- Gulf of Mexico hemipelagic (JIP I)
- Blake Ridge hemipelagic and fracture (ODP 164)
- Hydrate Ridge fracture and hemipelagic (ODP 204)
- Bay of Bengal/Andaman Sea fracture and hemipelagic (NGHP-01)
- Bay of Bengal sand reservoirs (NGHP-02)
- Gulf of Mexico seeps
- Barkley Canyon seeps
- Norwegian Sea seeps
- Nigeria seeps

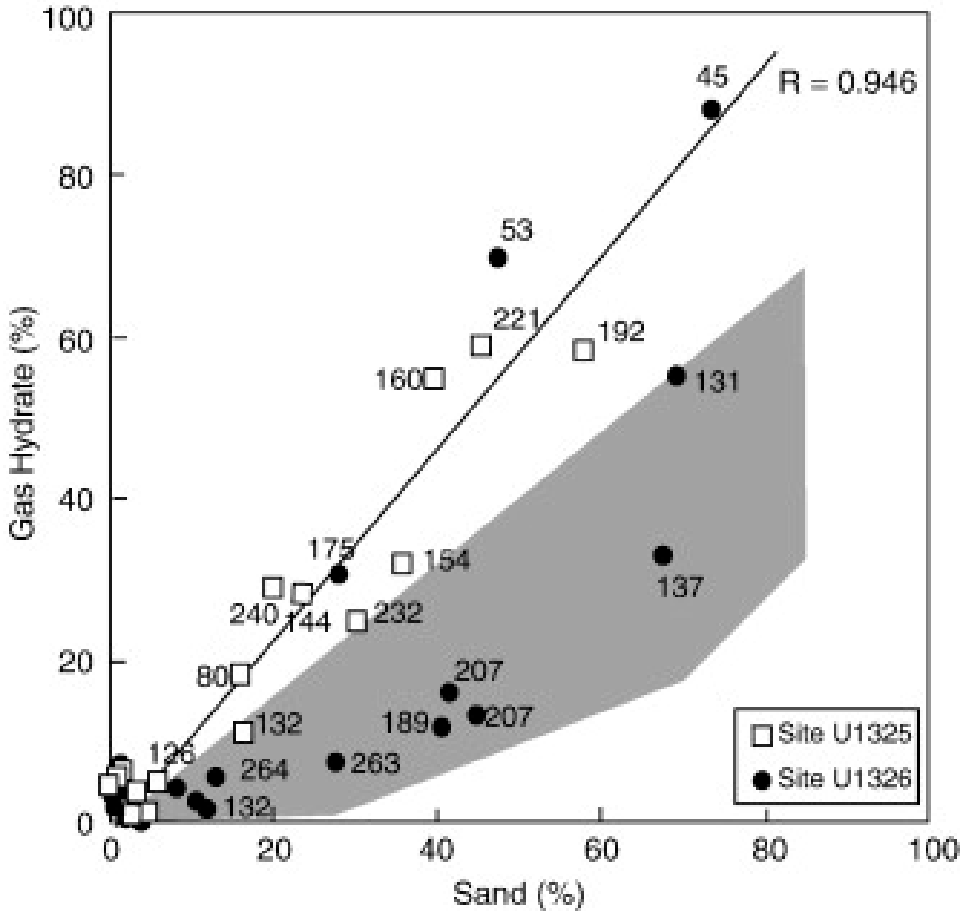
How do high concentrations of microbial methane form?

Genetic classification from Milkov and Etiope, 2018 *Org Geochem.*

Phillips et al., in revision, *AAPG Bull;* Lorenson et al., 2008, *JMPG;* Lorenson and Collett, 2000; *Proc ODP;* Claypool et al., 2003, *Proc ODP;* Lorenson and Collett, 2018 *JMPG*; Dixit et al., in press, *JMPG*; Brooks et al., 1984 *Science*; Brooks et al., 1986 *Org Geochem*; Sassen et al., 1999a *GCAGS*; Sassen et al, 1999b *Org Geochem*, Sassen et al., 2001a *JMPG*; Sassen et al., 2001b *Geology*, Pohlman et al., 2005 *Org Geochem*; Lein et al., 1999 *Geo-Mar Lett*; Ginsburg et al., 1999 *Geo-Mar Lett*; Cunningham and Lindholm, 2000 *AAPG Memoir 73*

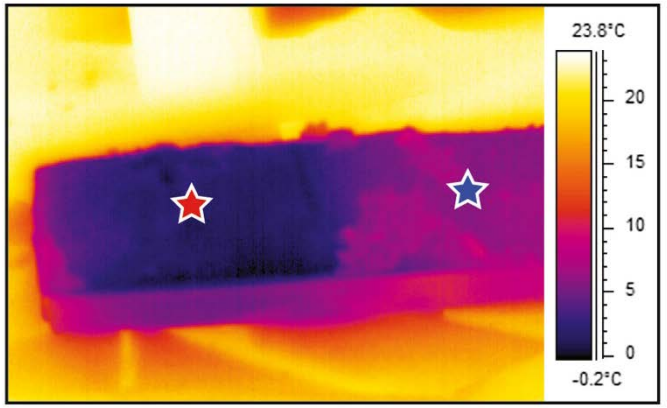
Lithologic control of hydrate saturation

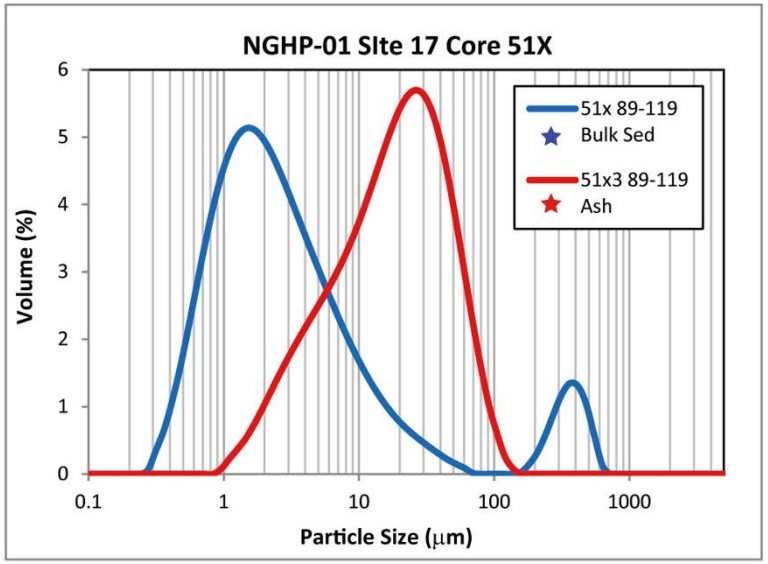
Cascadia margin turbidites (IODP 311)



Torres et al., 2008, *EPSL*

Andaman Sea ash layers

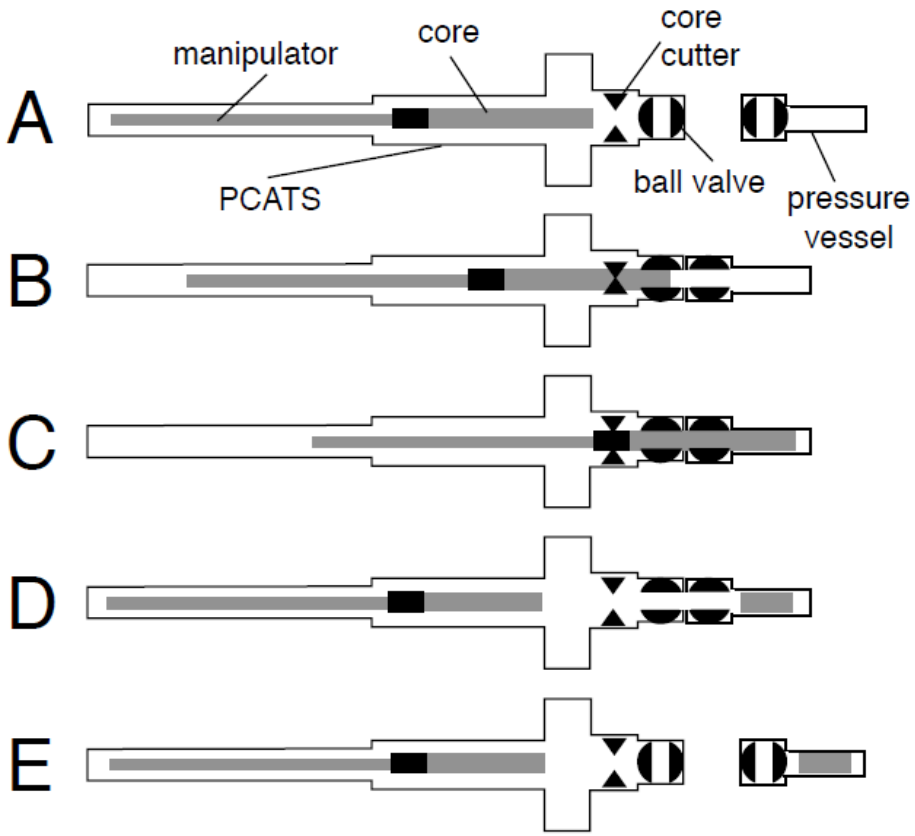




Rose et al., 2014, JMPG

Pressurized core analysis and transfer

Pressure Core Analysis and Transfer System (PCATS), Geotek, Inc



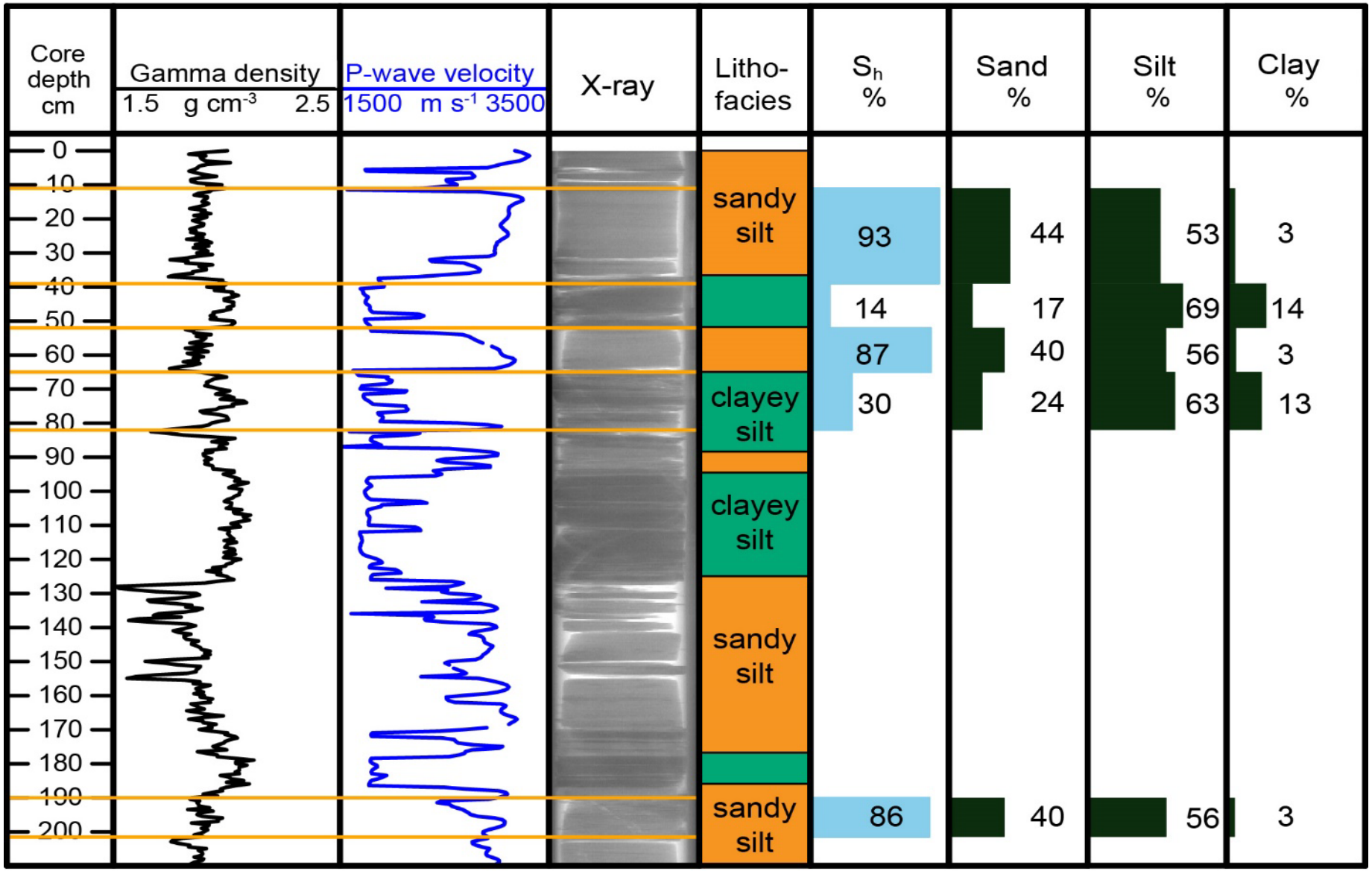
Schultheiss et al., 2011, *ICGH*

- Cores can be scanned for
  - P-wave velocity,
  - gamma ray density
  - X-ray CT

- Pressurized cores can be transported to shore, stored, and analyzed at multiple labs

In situ properties

Gulf of Mexico channel levee (UT-GOM2-1)



Phillips et al., in revision, *AAPG Bull.*

Reservoir/seal geomechanical properties

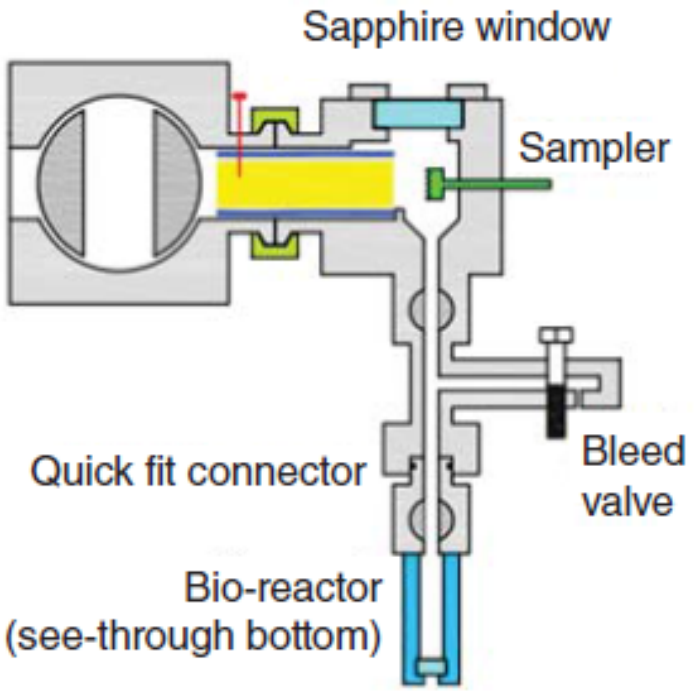
- Permeability
- Compressibility
- Shear strength
- Stiffness
- Consolidation

- What are these properties in hydrate-bearing sediments before and after dissociation?
- Can we economically and safely produce hydrate?
- How are hydrate deposits charged with gas?

Yoneda et al., 2017, *JMPG*

Future directions – microbial processes

- Capability to sample and cultivate microbes without depressurization
- Can better target limits of life and better understand microbial methane production

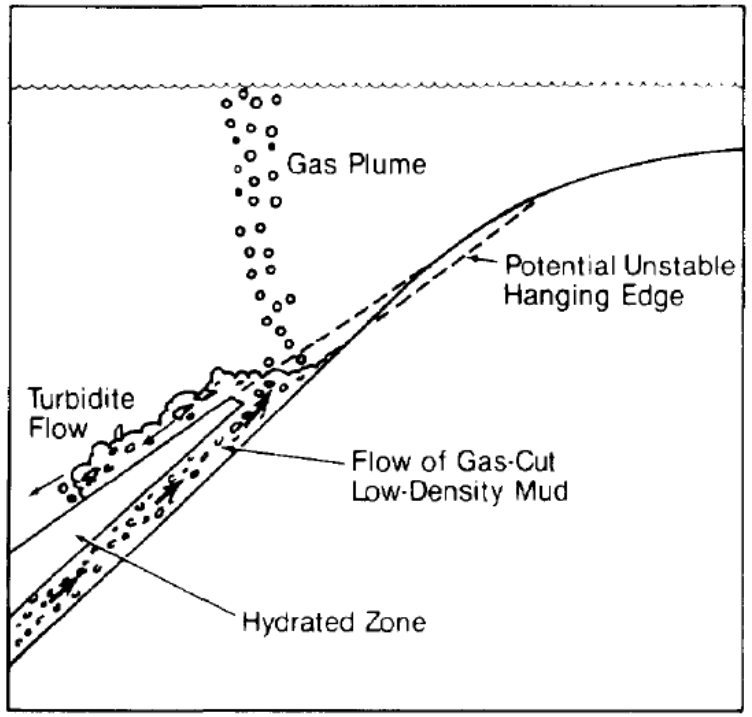


Santamarina et al., 2012, *Sci. Drilling*

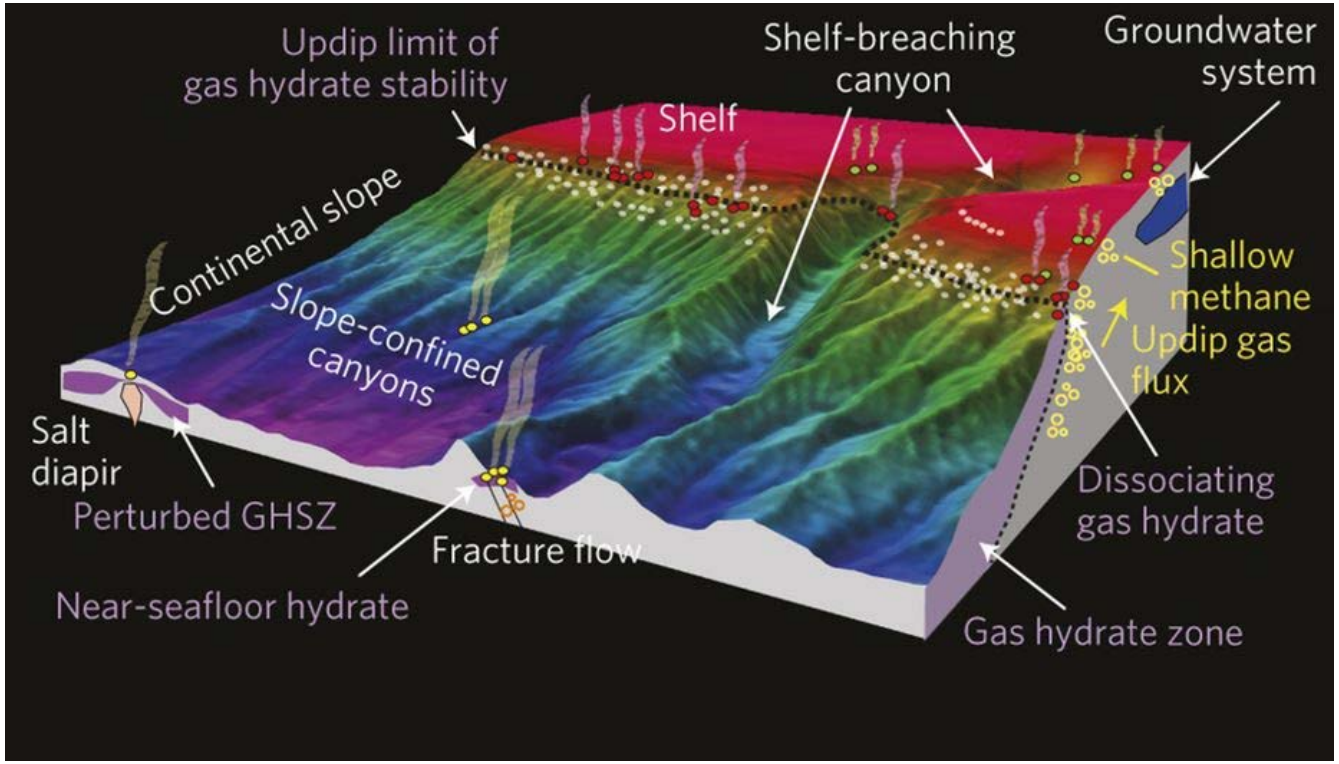
Ongoing efforts by Georgia Tech, USGS, Oregon St, UT-Austin

Future directions – slope stability

- What is the distribution of hydrate and free gas at updip stability?
- How does this affect slope stability?



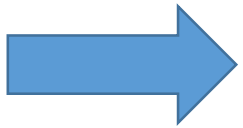
McIver, 1982 *AAPG Bull.*



Skarke et al., 2014 *Nat. Geosci.*

Summary

- Pressure coring and analysis tools have allowed for characterization:
  - Gas hydrate concentration
  - Gas hydrate composition
  - Physical properties
  - Geomechanical properties



Linked to specific lithologies

- Scientific drilling programs were critical in the development of this technology
  - DSDP, ODP, IODP, multiple national hydrate expeditions

- Pressure coring has potential for increasing understanding:
  - Subseafloor biosphere
  - Submarine slope failures