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
Gas hydrates

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

- Potential energy resource
- Potential for CO₂ storage


Challenge of pressure coring

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

Conventional coring

Expedition 311 Scientists, 2006 Proc IODP
Challenge of 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 CH₄ typically lost in conventional coring (ODP 164)

Comparison to CH₄ solubility (ODP 164)

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

Dickens et al., 1997, *Nature*
Gas composition

How do high concentrations of microbial methane form?

Genetic classification from Milkov and Etiophe, 2018 Org Geochem.

Phillips et al., in revision, AAPG Bull; Lorensen et al., 2008, JMPG; Lorensen and Collett, 2000; Proc ODP; Claypool et al., 2003, Proc ODP; Lorensen 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)

Andaman Sea ash layers

Torres et al., 2008, EPSL

Rose et al., 2014, JMPG
Pressurized core analysis and transfer

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

• 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

Schultheiss et al., 2011, ICGH
In situ properties

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

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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?
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?

Mclver, 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

• 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

Linked to specific lithologies