

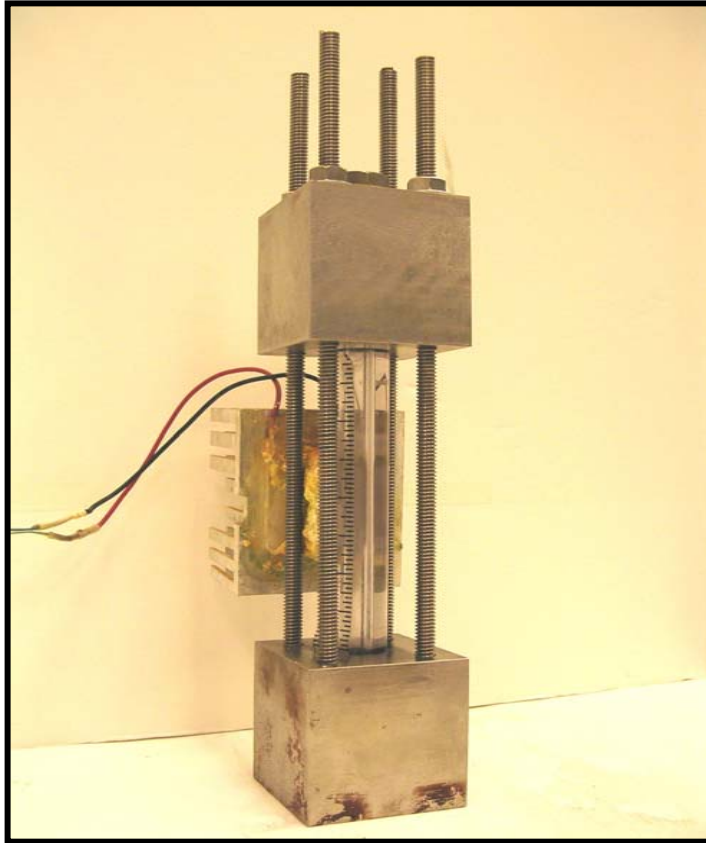
**Cells and Instrumentation  
for  
Gas Hydrate Research**

# Cell for surface and particle-level studies



- Height: 760mm
- OD/ID: 115/63.5mm
- Max. pressure: ~ 30MPa
- Features
  - Optical observation
  - Microscale 1D testing
  - Mineral substrate-hydrate interaction
- Properties
  - Bonding strength
  - Raman spectroscopy
  - Displacement ( $\delta$ )

# Capillary cell



- Length: 100mm
- OD/ID: 18/6mm
- Max. pressure: 10MPa
- Features
  - Local control of hydrate formation
  - Optical observation (phase transformation)
- Properties
  - P-wave velocity ( $V_p$ )
  - Temperature (T)

# Oedometer cell (low fluid pressure)



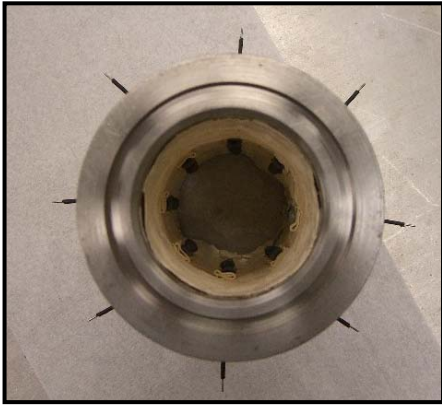
- Diameter: 100mm
- Max. pressure: ~ 3MPa
- Features
  - Zero-lateral displacement
- Properties
  - Effective stress ( $\sigma'$ ) / no pore pressure ( $u$ )
  - S-wave velocity ( $V_s$ )
  - Complex permittivity ( $\epsilon^*$ )
  - Displacement ( $\delta$ )

# Oedometer cell (high fluid pressure)

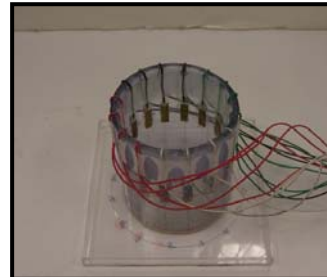
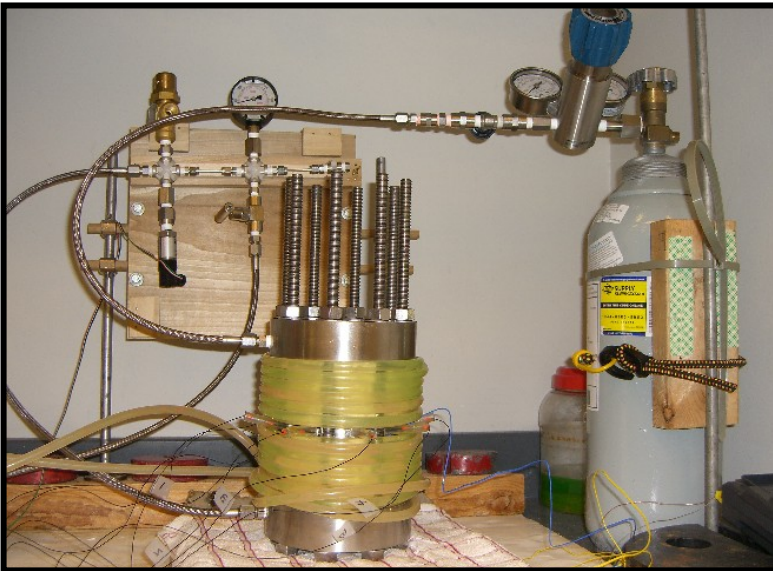


- Length: 150/240mm
- OD/ID: 100/60mm
- Max. pressure: ~ 20MPa
- Features
  - Zero-lateral displacement
  - Control effective stress
  - Gas-dissolved fluid preparation
  - Buffering / reaction chamber
- Properties
  - Effective stress ( $\sigma'$ ) / pore pressure ( $u$ )
  - P-wave ( $V_p$ ) and S-wave velocity ( $V_s$ )
  - Displacement ( $\delta$ )

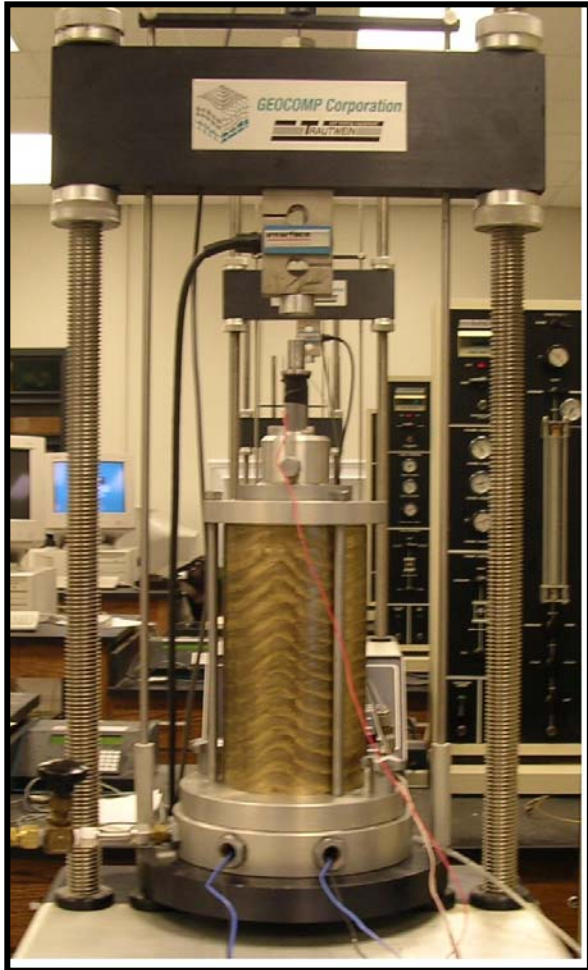
# Oedometer cell with ERT



- Length: 150mm
- OD/ID: 100/60mm
- Max. pressure: ~ 20MPa
- Features
  - Spatial evolution of resistance
- Properties
  - Temperature (T)
  - Electrical resistance ( $\Omega$ )

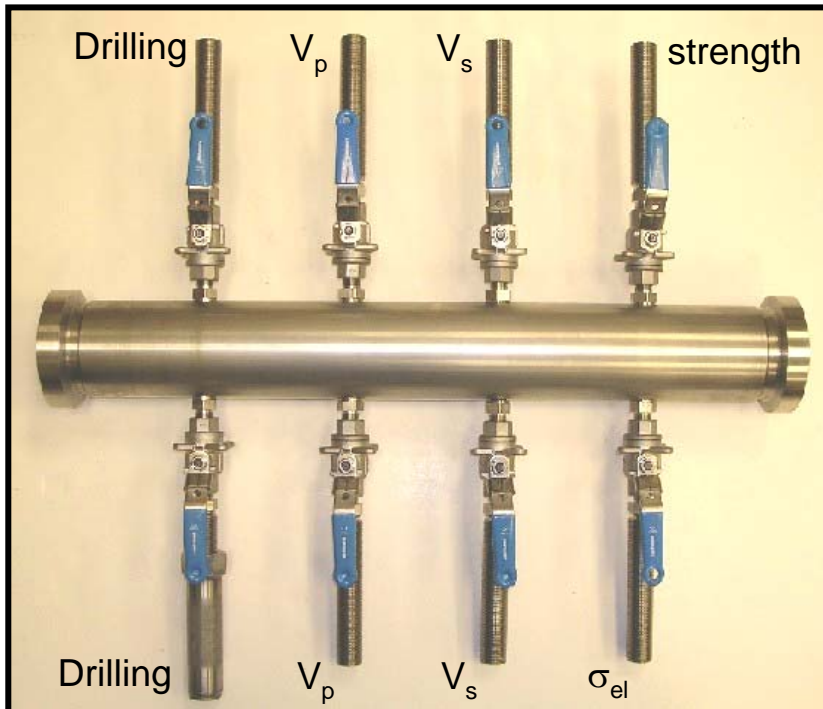


# Triaxial cell



- Diameter: 35mm
- Max. pressure: ~ 2MPa
- Features
  - Isotropic consolidation
  - Deviatoric stress
- Properties
  - Stress-strain response ( $\sigma - \epsilon$ )
  - Lateral deformation ( $\delta$ )
  - Temperature (T)

# Instrumented pressure testing chamber (IPTC)



- Length: 690mm
- OD/ID: 90/65mm
- Max. pressure: ~ 25MPa
- Features
  - Compatible with pressure core
  - Production simulation
- Properties
  - P-wave ( $V_p$ ) and S-wave velocity ( $V_s$ )
  - Pressure
  - Strength ( $S_u$ )
  - Electrical resistance ( $\Omega$ )
  - Temperature (T)



# Instrumented pressure testing chamber (IPTC)

S-wave



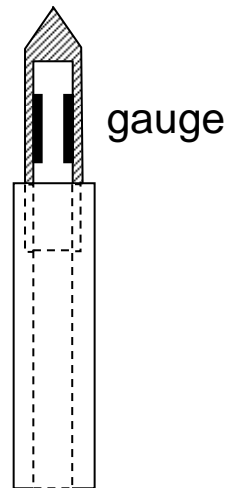
P-wave



Resistance

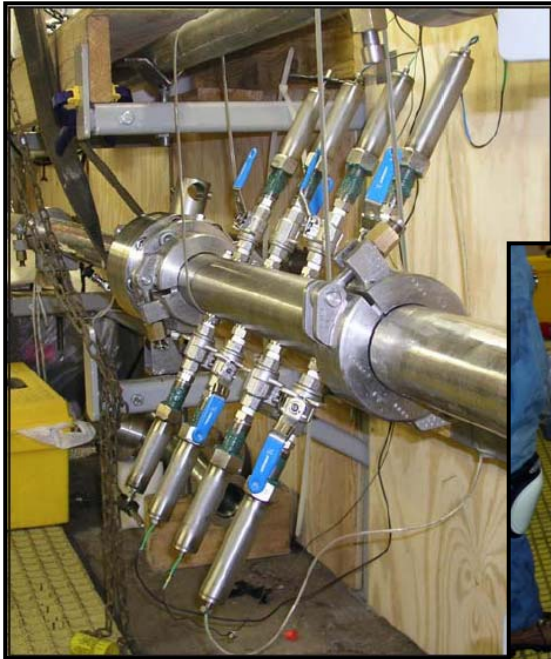


Strength



[Rod diameter=8mm]

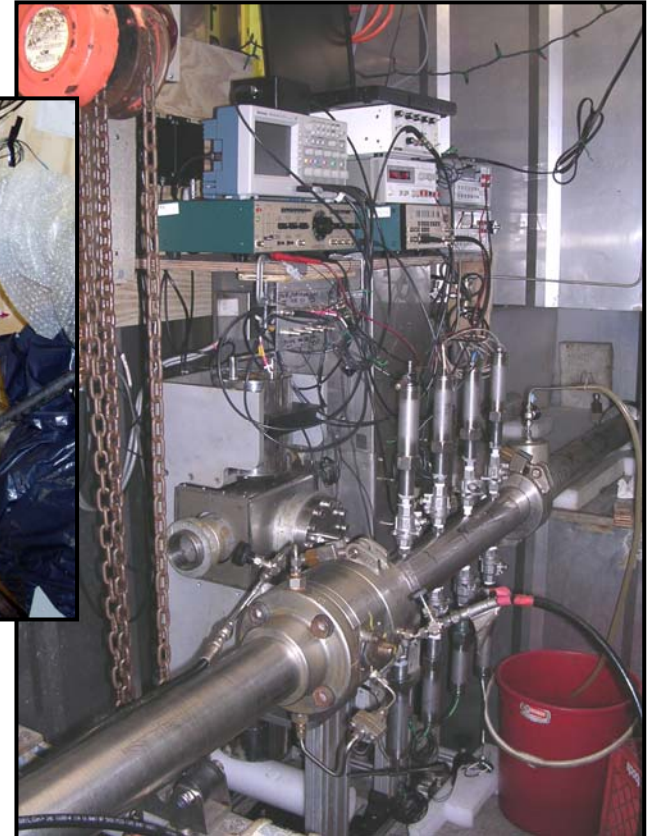
# Instrumented pressure testing chamber (IPTC)



2005 Gulf of Mexico



2006 Singapore



**Measurements / instruments  
in most chambers**

# Elastic wave velocity

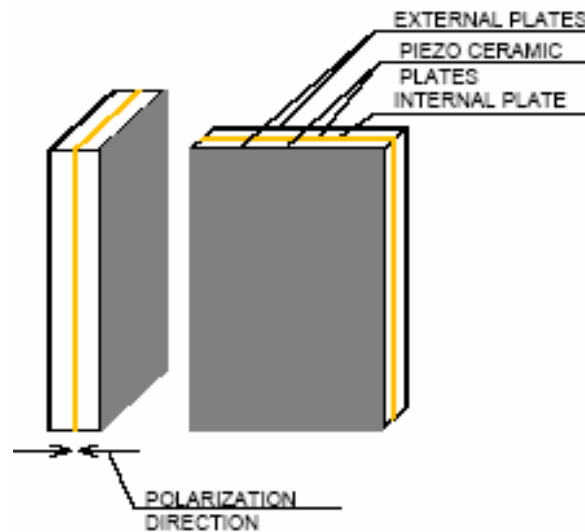
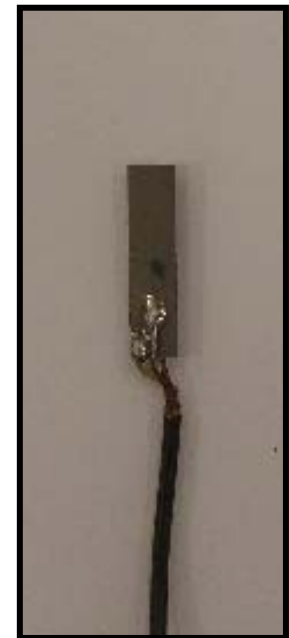
## P-wave velocity ( $V_p$ )

piezoelement (3mm diameter)



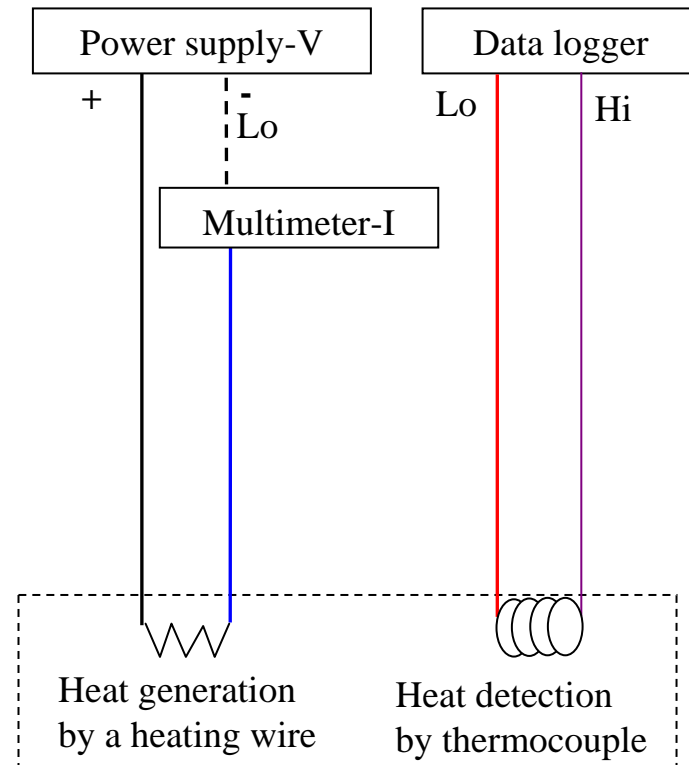
## S-wave velocity ( $V_s$ )

piezocrystal (4mm width)



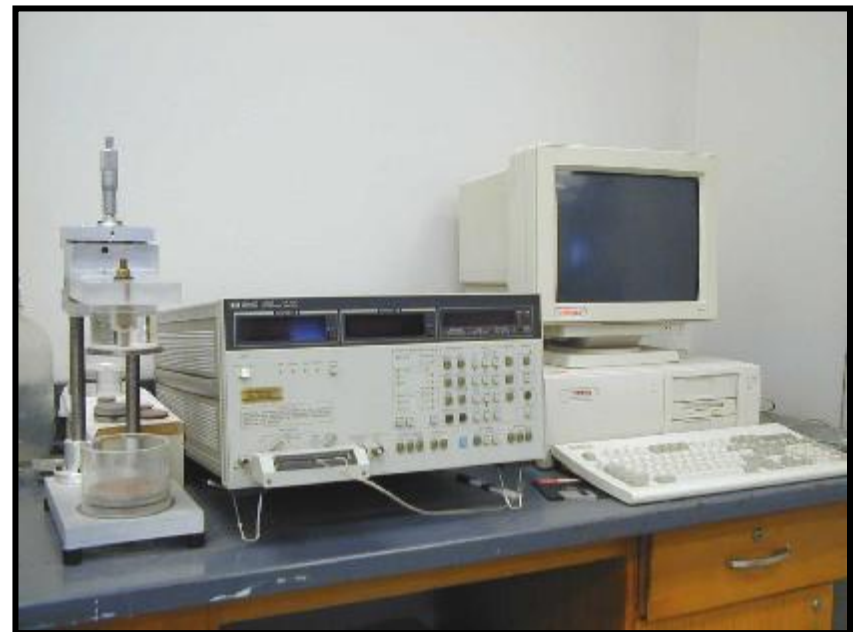
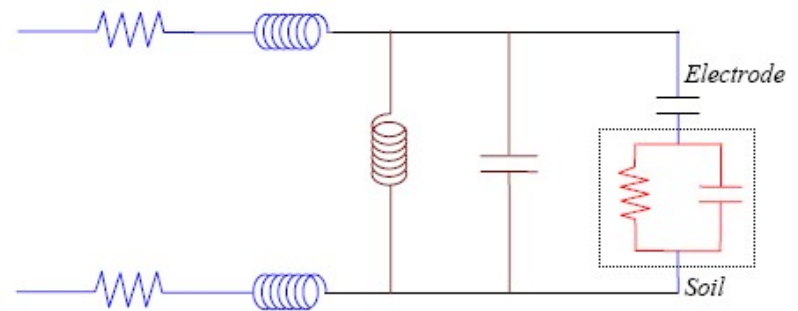
# Thermal conductivity ( $k$ )

Thermal probe

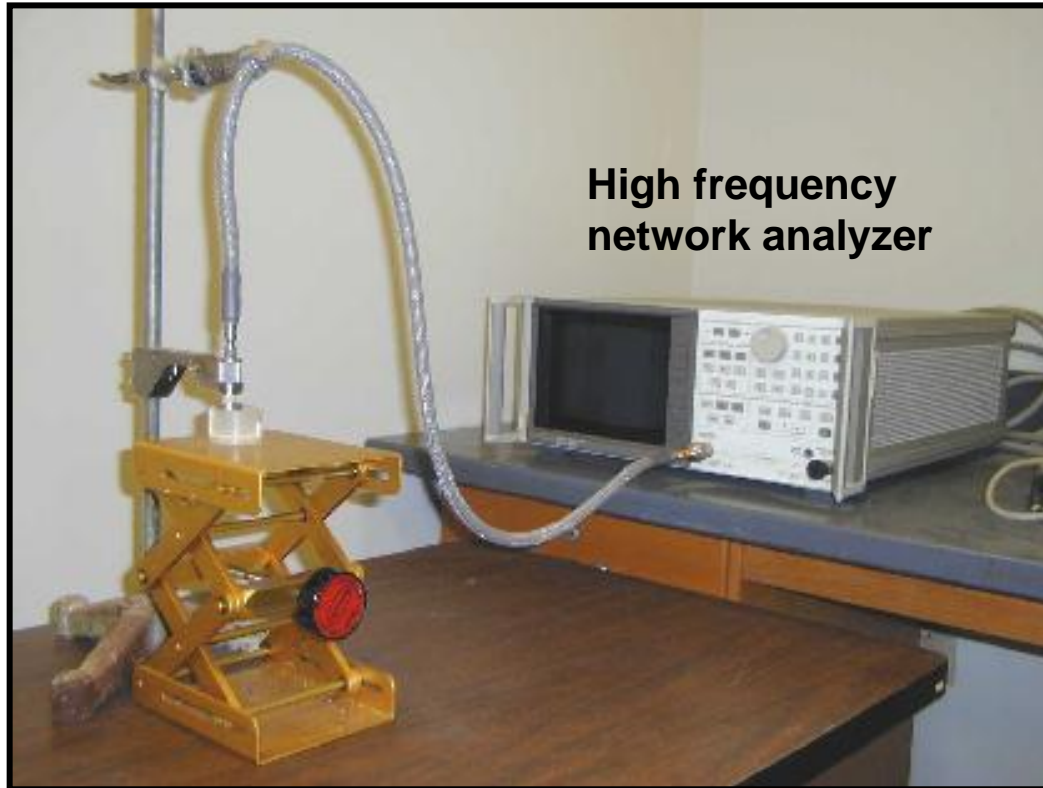


# Electrical resistance ( $\Omega$ )

Needle probe



# Dielectric permittivity and electrical conductivity



# Strength ( $S_u$ )

Mini-cone probe

