Geomechanical Performance of Hydrate-Bearing Sediments in Offshore Environments

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TEXAS A&M
THE HAROLD VANCE DEPARTMENT OF
PETROLEUM ENGINEERING

Objectives

- Create capability to describe geomechanical behavior of hydrate bearing sediments in the ocean, by
  - Developing a knowledge base and
  - Developing a quantitative predictive capability
- Determine the envelope of hydrate stability under typical oceanic conditions where oil and gas production occurs

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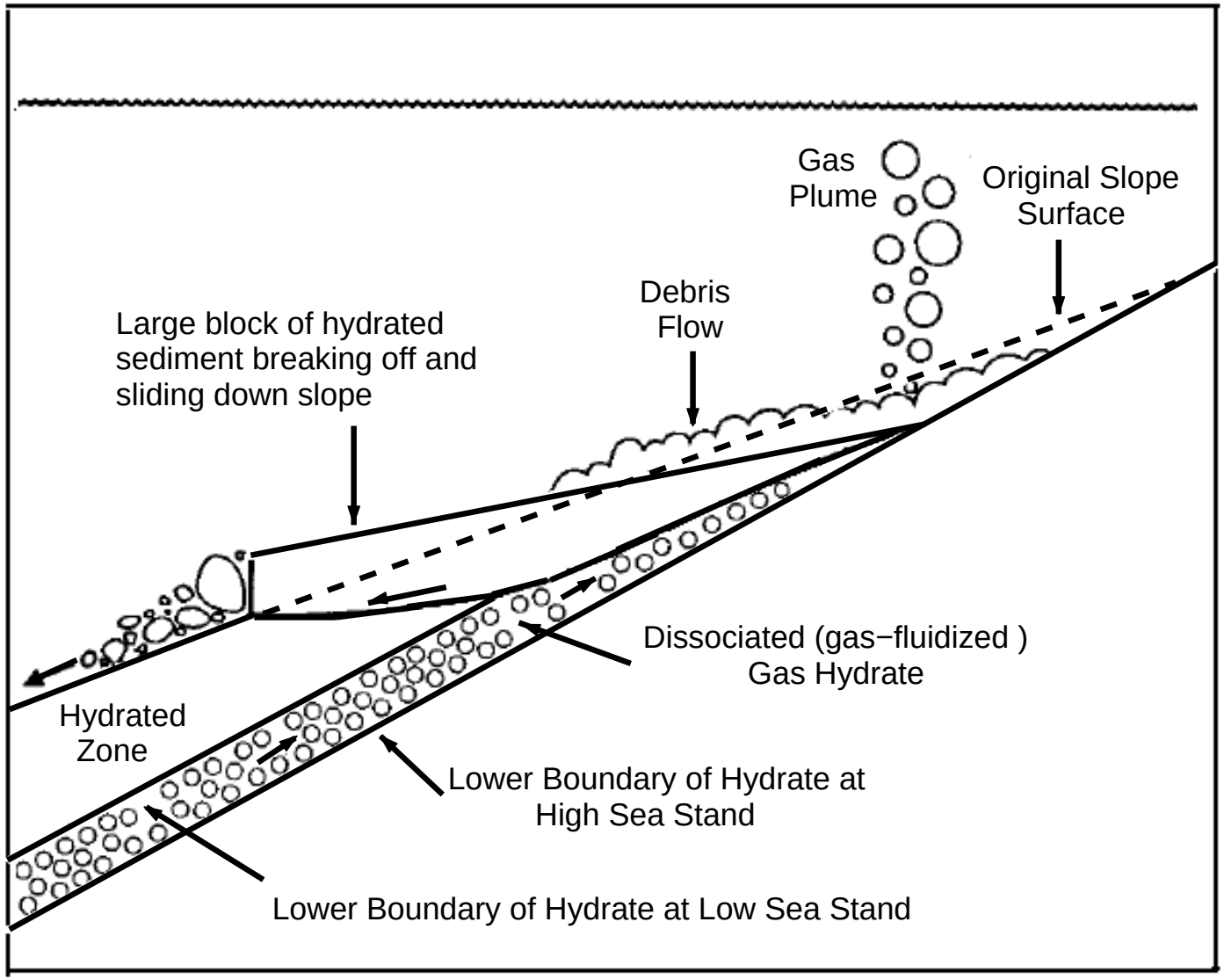

Figure 1. Diagram showing the effects of gas hydrate dissociation on oceanic hill slope failures and gas release. Adapted from McIver (1982).

Participating Organizations

- Texas A&M University (TAMU)
  - Stephen Holditch and Yuri Makogon
- Lawrence Berkeley National Laboratory (LBNL)
  - George Moridis
- University of California at Berkeley (UCB)
  - Ted Patzek and Dmitriy Silin
- Schlumberger (SLB)
  - Dick Plumb and Pat Hooyman

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Phase I – Fundamental Studies and Model Development

Task	Title	Group
1	Research Management Plan	TAMU
2	Technology Status Assessment	TAMU
3	Fundamental Studies Part I	
3.1	Pore Scale Geomechanics Studies	UCB
3.2	Planning for Development of Constitutive Models	SLB
3.3	Description of hydrate sediments in the ocean	TAMU
3.4	Methodology to create synthetic hydrate sediment samples in lab	TAMU
4	Development of Geomechanics Model	LBNL

Phase I Milestones

TAMU	**Completion of literature survey on typical sediments containing gas hydrates in the ocean**	**Sept 2006**	**We have completed the literature review. All papers and reports have been found and we have prepared a report summarizing the literature**
TAMU	**Completion of recommendations on how to create sediments in the laboratory**	**Sept 2006**	**The information has been summarized in this report**
TAMU	**Demonstration that typical sediments can be created in a repeatable manner in the laboratory and gas hydrates can be created in the pore space**	**Nov 2006**	**This milestone is still in progress although we have made substantial progress. We may not have it completed before we begin Phase II. However, it will be one of the first things we do for Phase II.**
UCB	**Development of a conceptual pore-scale model based on available data and reports**	**July 2006**	**This milestone has been completed. After trying testing several approaches, we have selected the one based on most comprehensive contact mechanics.**
UCB	**Testing the developed concepts on simple configurations and verification of the result against known measurements and observations**	**Sept 2006**	**The approach has been tested on simple and not very simple configurations of grains. Right now we are in the middle of incorporation of tangential forces. There is a chance that this work will continue into October, subject to obtaining a relevant data set.**

Phase I Milestones

LBNL	**Completion of FLAC3D routines**	**Aug 2006**	**Completed**
LBNL	**Completion of TOUGH-Fx/HYDRATE modifications and extensions**	**July 2006**	**Completed**
LBNL	**Completion of the TOUGH-Fx/FLAC3D interaction interface**	**Sept 2006**	**Completed**
LBNL	**Component integration and final testing of the coupled geomechanical numerical model TFxH/FLAC3D**	**Oct 2006**	**Completed**
SLB	**Demonstration that Petrel can be used to develop an earth model for providing data to the TOUGH-Fx/FLAC3D**	**July 2006**	**Surfaces have been exported to FLAC. We have demonstrated that surfaces can be transferred to FLAC 3D**

Phase II – Modeling and Laboratory Measurements

Task	Title	Group
5	Research Management Plan	TAMU
6	Fundamental Studies Part II	UCB
7	Laboratory Studies of Basic Rock Properties	
7.1	Thermodynamic and kinetic measurements	TAMU
7.2	Large scale geomechanical and geophysical measurements	LBNL
7.3	High P – Low T triaxial cell with simultaneous CT X-ray imaging	LBNL
7.4	Determination of the geophysical signature of hydrates in porous media and the effects of stress	LBNL
4	Well bore Modeling	SLB

Phase III – Integration of Models and Data

Task	Title	Group
9	Research Management Plan	TAMU
10	Predictive Studies	
10.1	Effect of structure weight near platforms	UCB/LBNL
10.2	Effect of heat exchange with wells and pipelines	UCB/LBNL
10.3	Effect of gas production from the hydrates	TAMU
10.4	Potential long term damage to wells and pipelines	UCB/LBNL
10.5	Integration of studies in 10.1 through 10.4	TAMU
10.6	Study of well bore stability	SLB

Research Results at Texas A&M

- In Phase I, we have documented the literature concerning all public records concerning cores and sediments recovered during gas hydrate, deep water scientific cruises.
- We have also documented the different laboratory experiments where properties of gas hydrates in cores have been made

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TAMU Results

- We have been building equipment for testing cores containing gas hydrates in preparation of Phase II of this project.
- We will be investigating the kinetics of hydrate formation and dissolution in cores, the morphology of the crystals, and the electrical properties of the cores as the hydrates form and dissolve.

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TAMU – Phase II

- Complete task to finalize recipes and demonstrate sample preparation
- Conduct laboratory testing with samples
- Continue literature review to keep information updated
- Begin making runs using the Petrel – ToughFx – FLAC3D combined model to start our evaluation of continental slope

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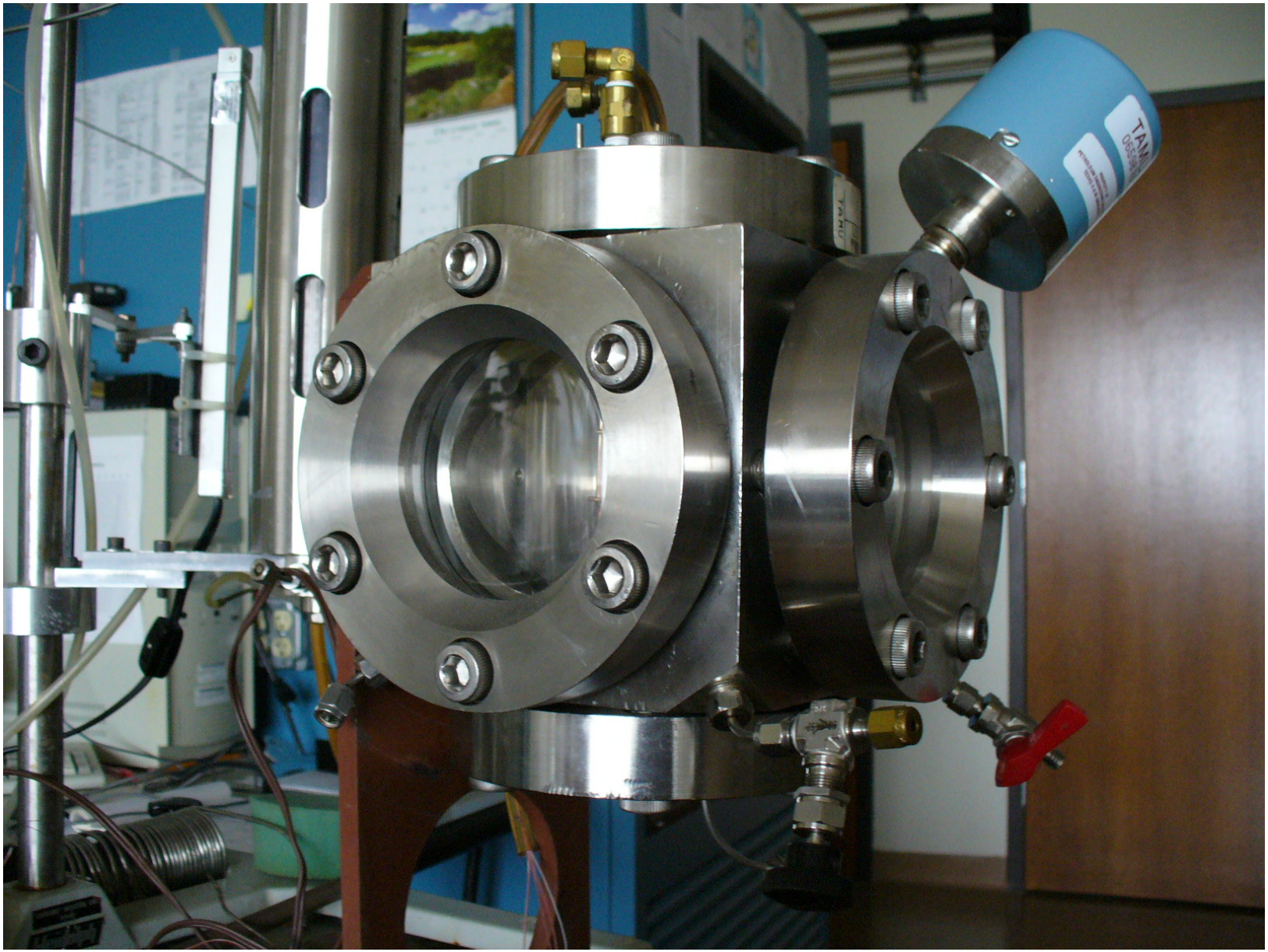
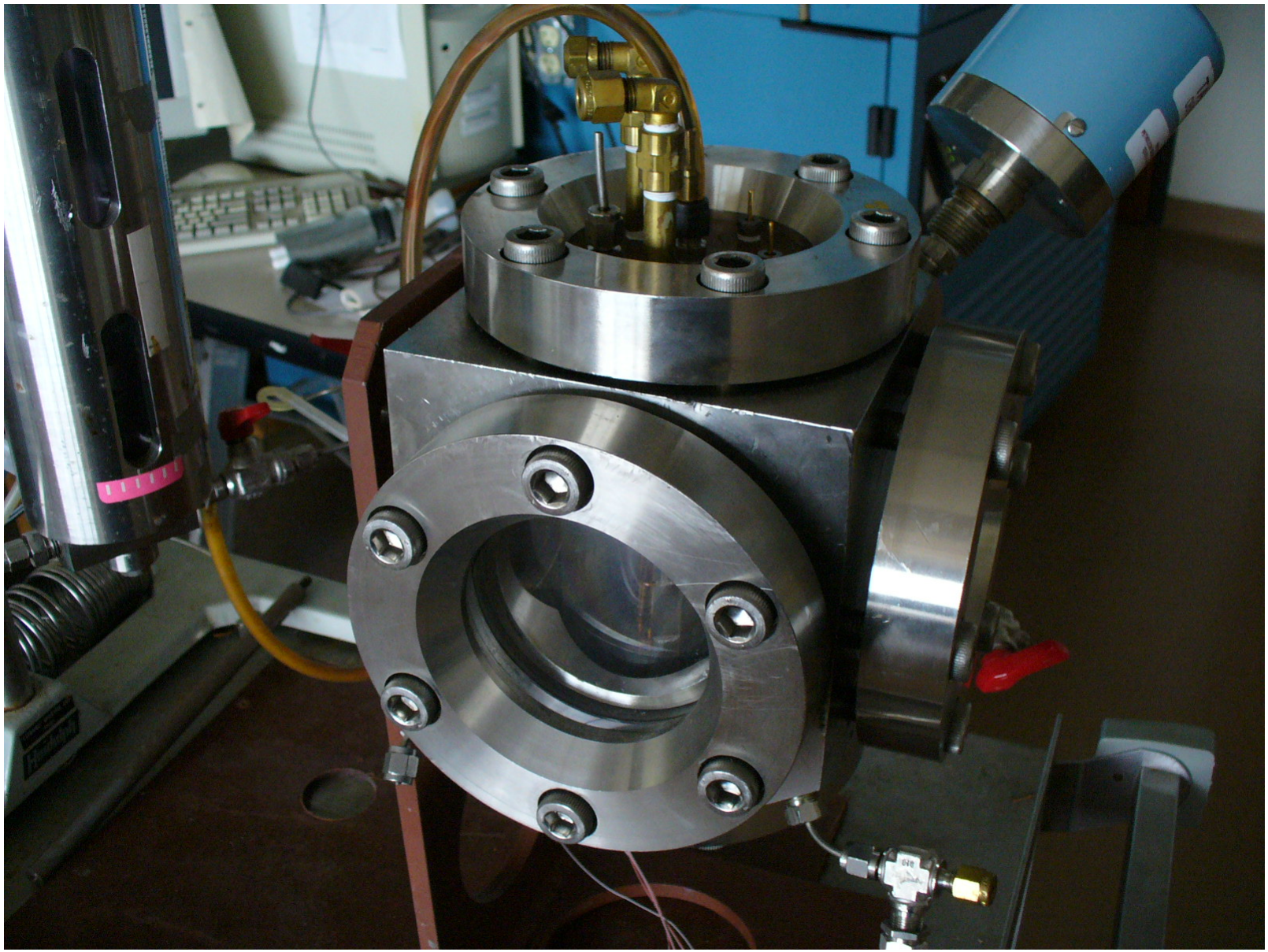
Cell for study micro morphology of crystals. P=350 bar

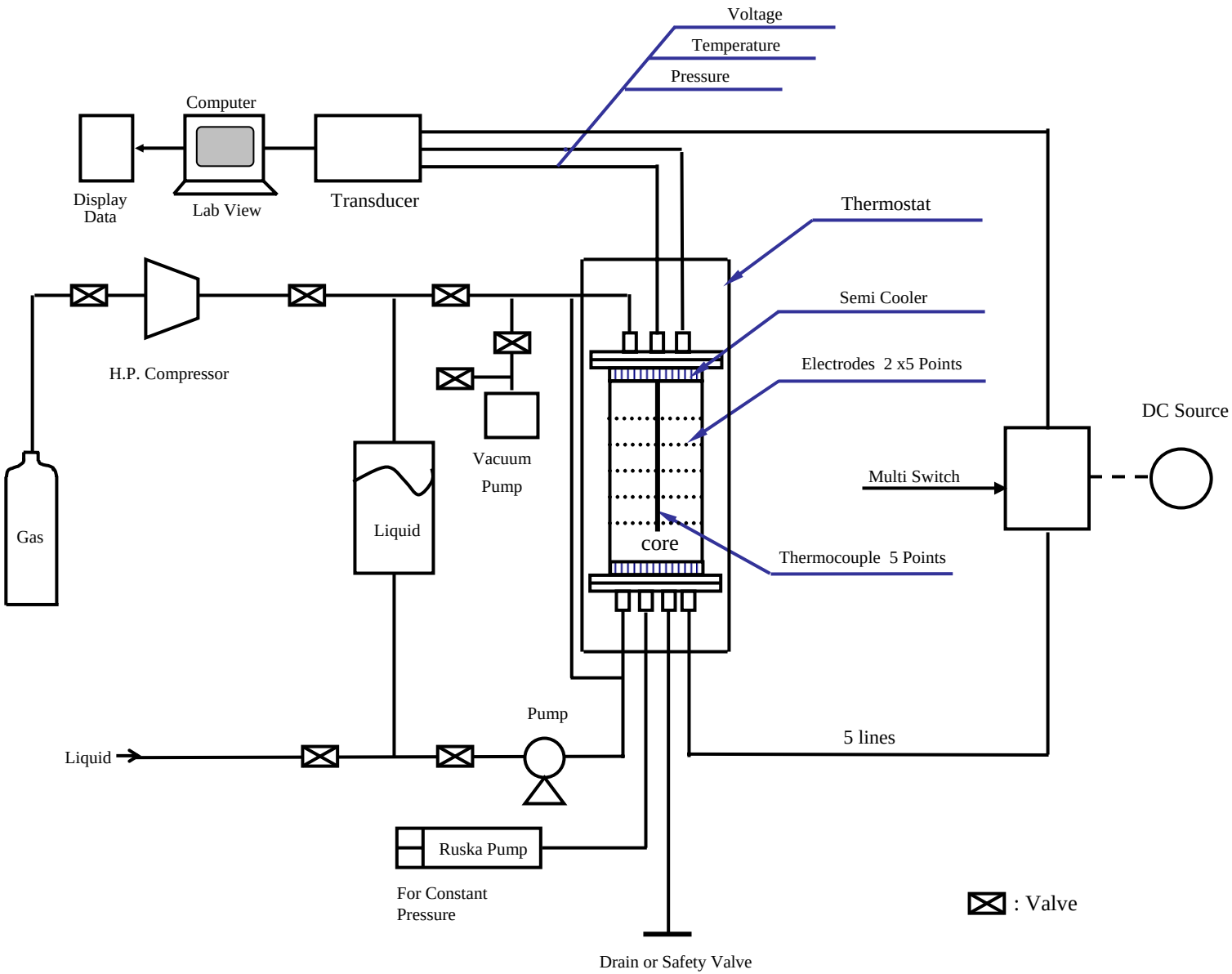
Cell for study hydrates in porous media. P=300 bar



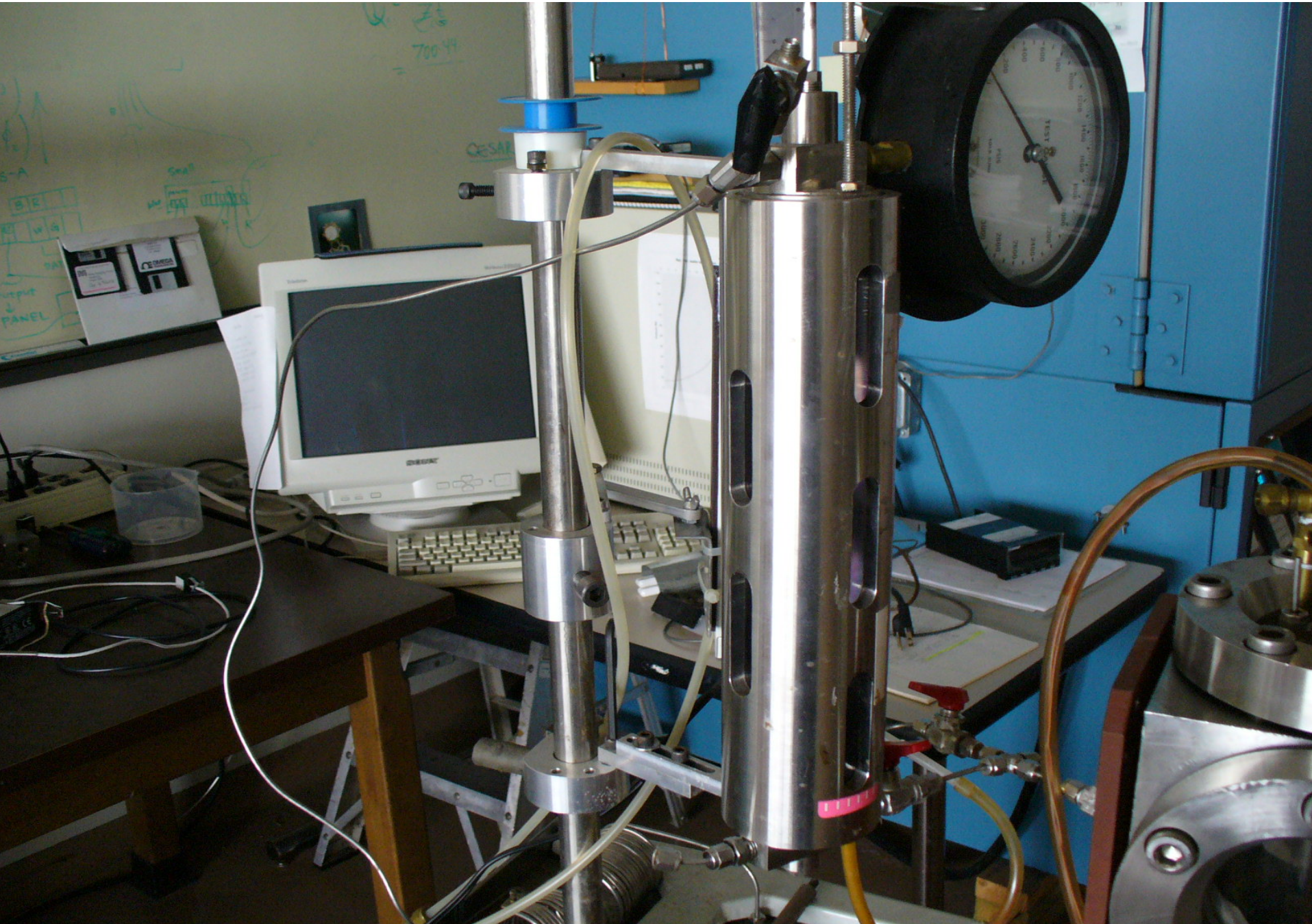
Cell for study hydrates in the porous media. P=300 bar



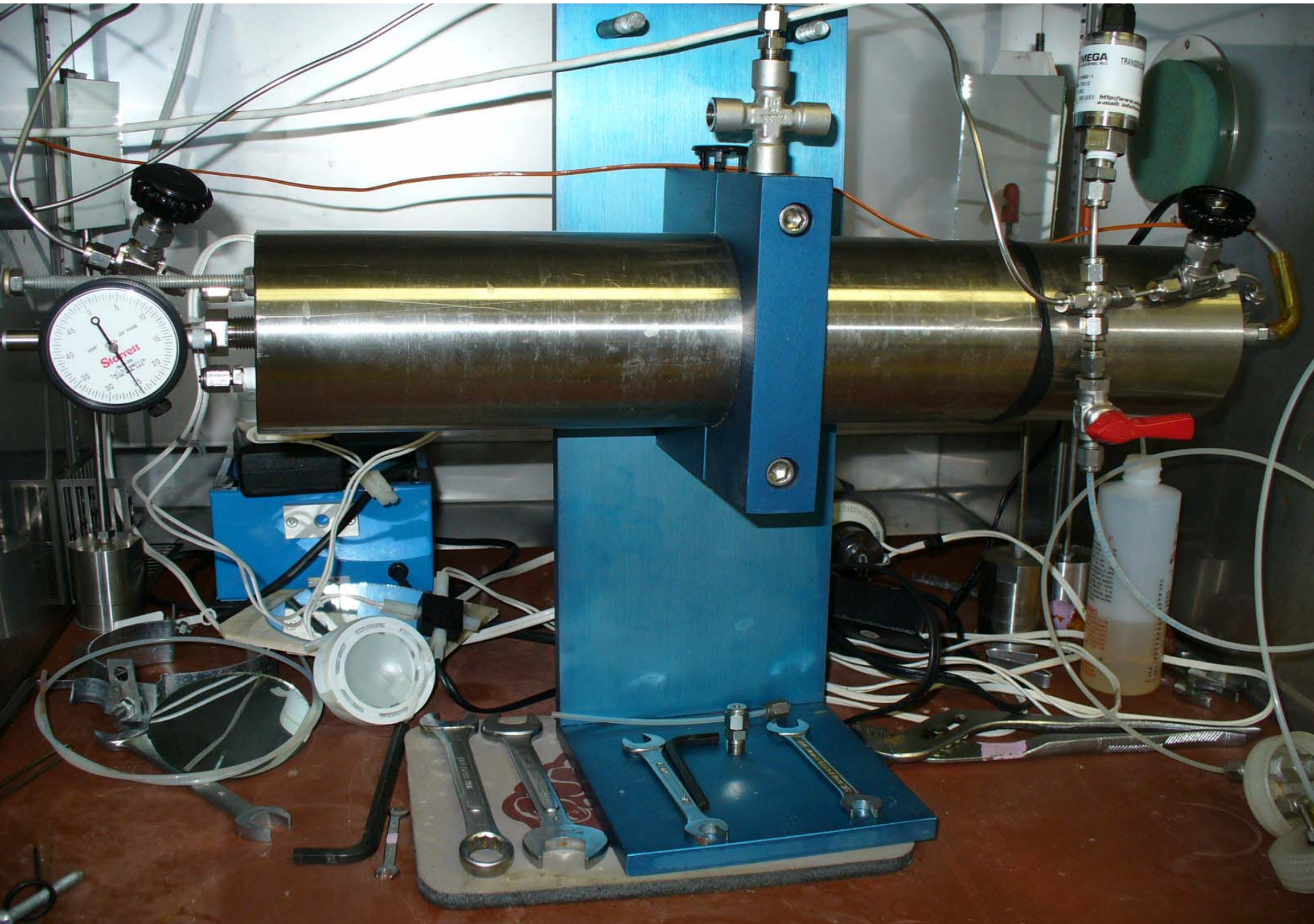
Cell for study hydrate in porous media - Schematic Diagram



Cell for study gas solubility in solutions. P=400 bar



Cell for study hydrate properties in porous media. P=500 bar



Thank you !

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