# Overview of Gas Hydrate Research at the Mallik Field in the Mackenzie Delta, Northwest Territories, Canada

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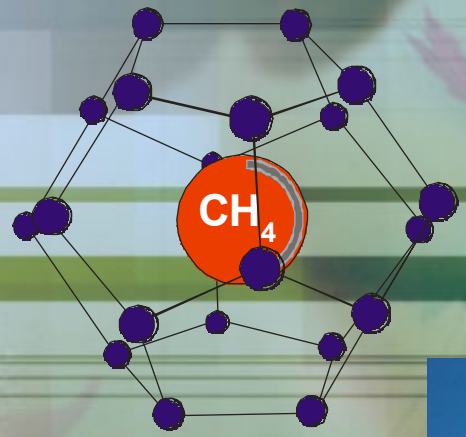
## Abstract

The Mallik gas hydrate field, located at the northeastern edge of Canada's Mackenzie Delta, occurs within a sequence of Tertiary sediments in an area underlain by over 600m of permafrost. With data available from the original discovery well in 1971/72, and a scientific research well program in 1998, gas hydrate occurrences have been well documented. Quantitative well log determinations and core studies reveal at least 10 discrete gas hydrate layers from 890 m to 1106 m depth, exceeding 110 m in total thickness. High gas hydrate saturation values, which in some cases exceed 80% of the pore volume, establish the Mallik gas hydrate field as one of the most concentrated gas hydrate reservoirs in the world. Beginning in December 2001 and continuing to March 2002, a production research well program was completed that include drilling of a 1200 m deep main production research well and two nearby science observation wells. The research program represents a collaboration between the Geological Survey of Canada, the Japan National Oil Corporation, GeoForschungsZentrum Potsdam, the U.S. Geological Survey, the U.S. Department of Energy and the Gas Authority of India Ltd/Oil and Natural Gas Corporation Ltd. The Geological Survey of Canada is

coordinating the science program for the project and JAPEX Canada Ltd is the designated operator for the fieldwork.

Primary objectives of the Mallik 2002 production research well program are to advance fundamental geological, geophysical and geochemical studies of the Mallik gas hydrate field and to undertake advanced production testing of a concentrated gas hydrate reservoir. Full-scale field experiments will monitor the physical behavior of the hydrate deposits in response to depressurization and thermal stimulation. The observation wells will facilitate cross-hole tomography experiments (before and after production testing) as well as long term monitoring of in situ formation conditions. A wide ranging science and engineering research program will include collection of gas-hydrate-bearing core samples and downhole geophysical logging. Laboratory and modeling studies undertaken during the field program, and subsequently as part of a post-field research program will document the sedimentology, physical/petrophysical properties, geochemistry, geophysics, reservoir characteristics and production behavior of the Mallik gas hydrate accumulation.



# Mallik Gas Hydrate Research Well Program

## Mackenzie Delta, NWT

**S. Dallimore, T. Collett, T.Uchida, M. Weber, H. Takahashi, and the Mallik Science Team**

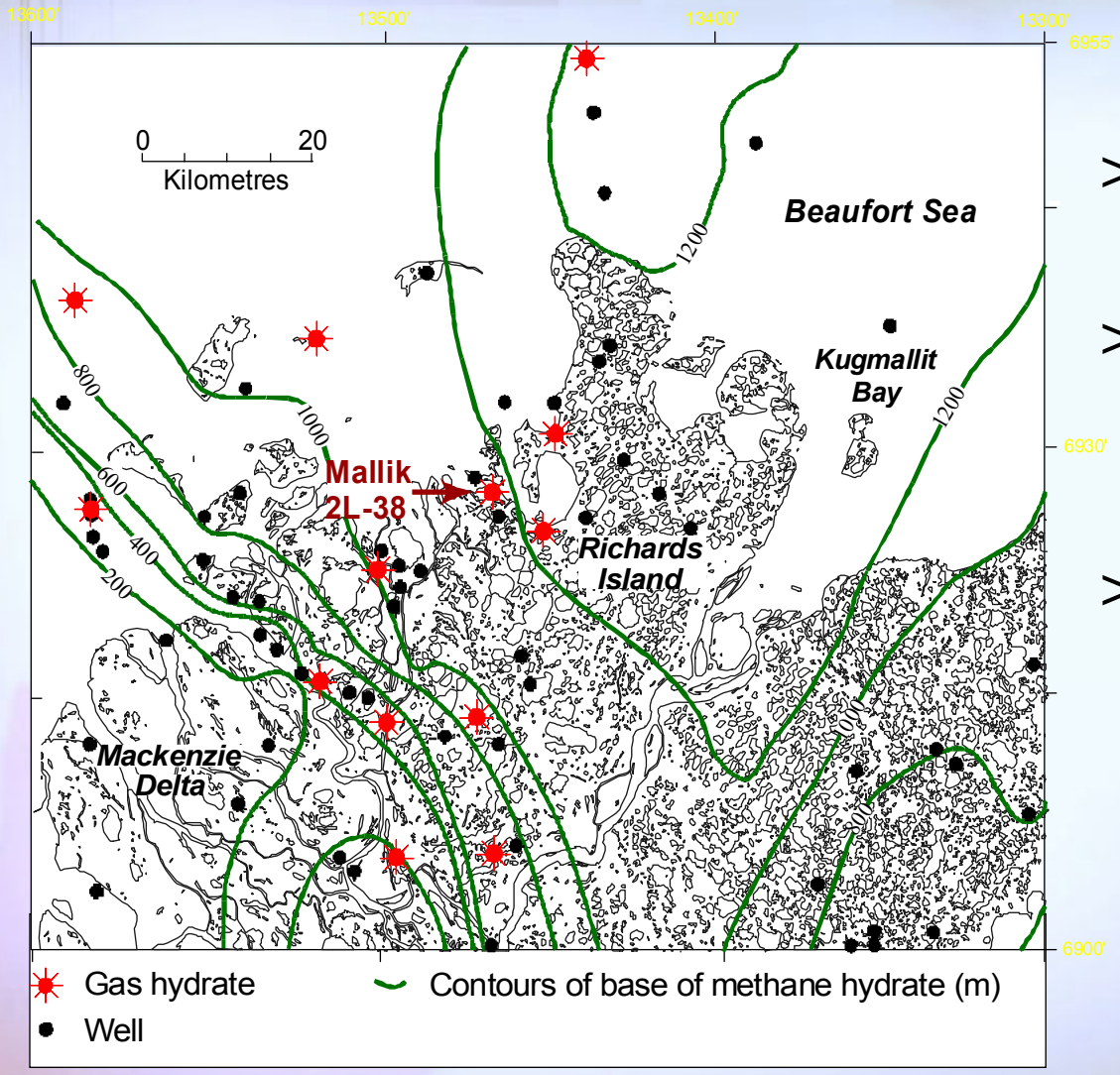
# Outline of Presentation

- Brief overview of gas hydrates in the Mackenzie Delta
- 1998 Mallik 2L-38 Research Well Program
- **Review of technical program for 2002 Mallik Production Research Well Program**
- Lessons learned and future outlook for collaborative gas hydrate research in the Arctic

# Why the Mallik Site?

- One of the most concentrated gas hydrate reservoirs known to date with pore space hydrate concentrations >80%
- Extensive baseline engineering, geological and geophysical knowledge
- Accessible onshore location allows for cost efficient operations
- Geology and gas hydrate reservoir conditions have similarities to many offshore deposits in terms of sediment properties and formation temperature and pressure regime
- Ideal location for fundamental science investigations

# Gas Hydrates in the Mackenzie Delta

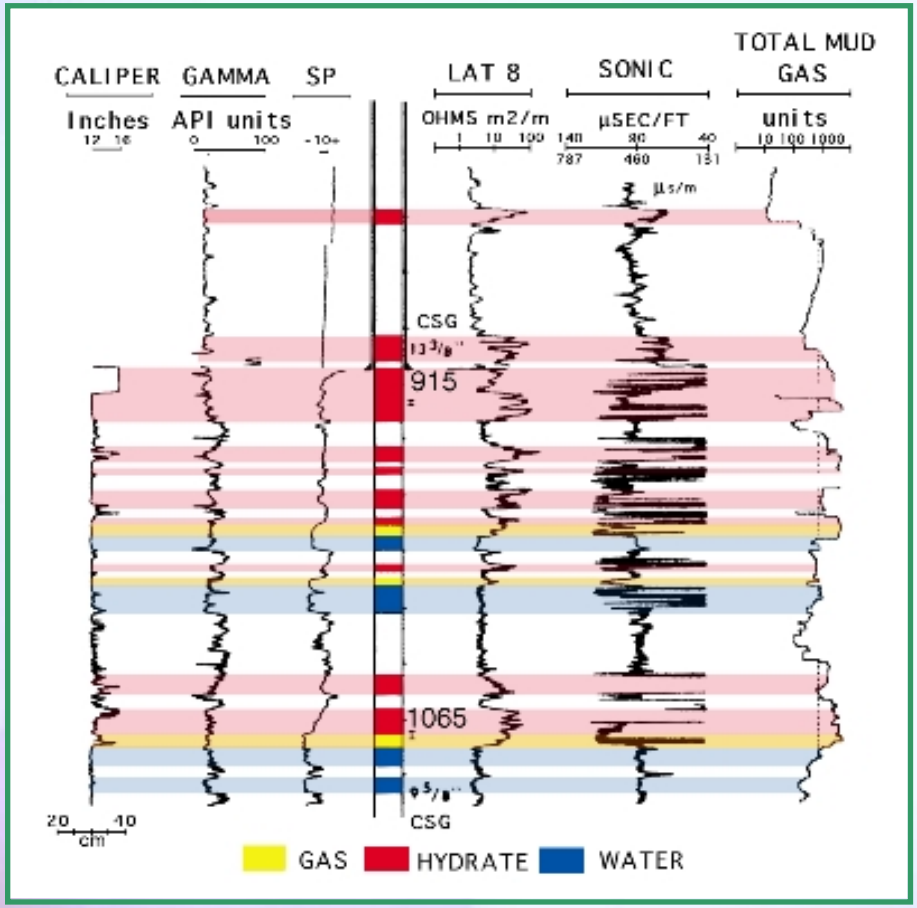


>600m permafrost

>1200m to base of methane hydrate stability field

>20% of onshore wells drilled in 70's and 80's encountered hydrates

# IOL Mallik L-38




**1971/72 Discovery Well**

- Well log indications of gas hydrate from 870-1100m
- Interpreted free gas leg at base of hydrate stability field
- Hydrate occurrence within unconsolidated sediments of the mid-Tertiary, Richards Formation

# 1998 Mallik 2L-38
# Gas Hydrate Research Well

JAPEX/JNOC/GSC MALLIK 2L-38 Gas Hydrate Research Well, Feb., 98

CH4

NWT

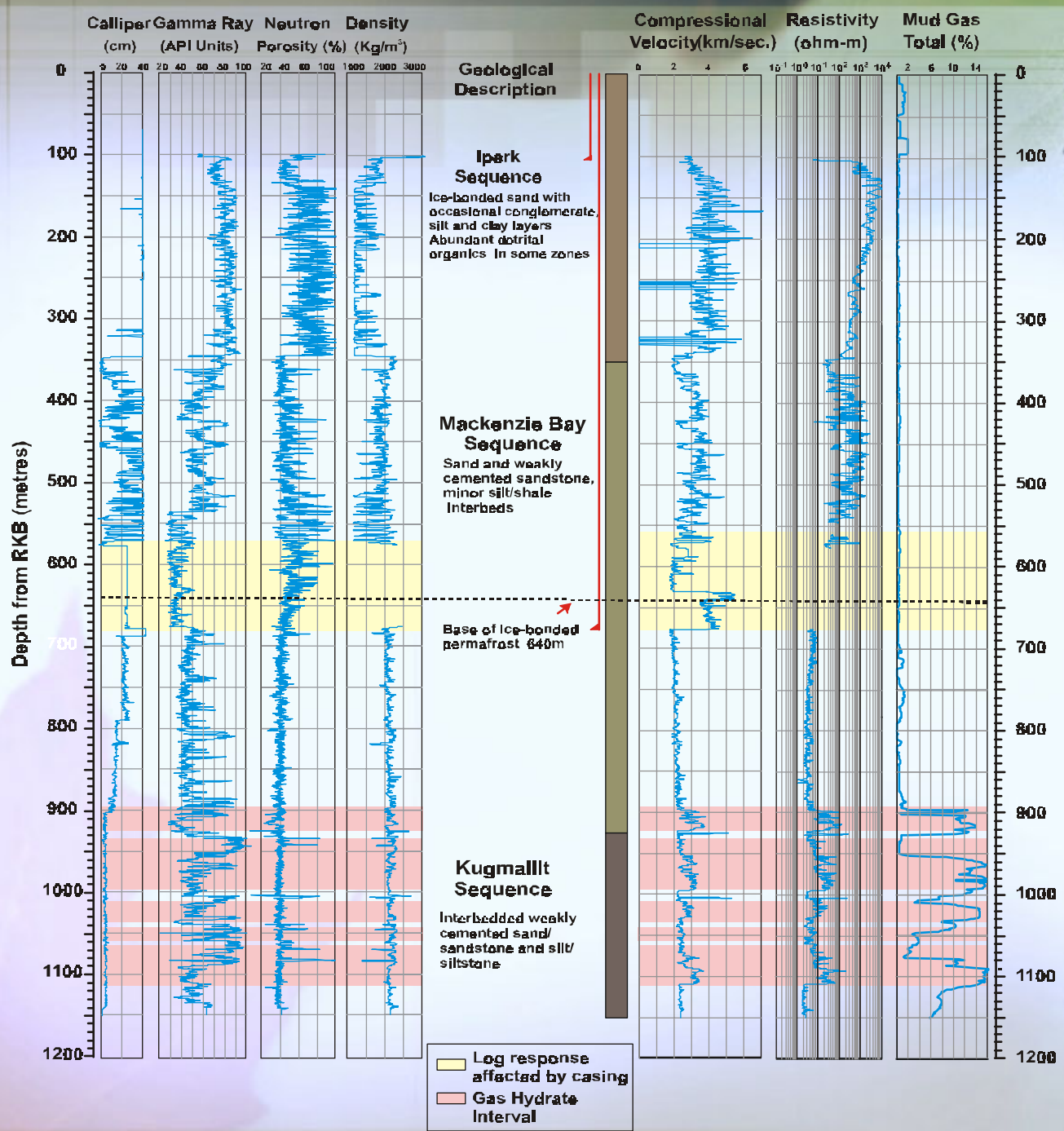
JAPEX

JNOC

CANADA 1842 GEOLOGICAL SURVEY - COMMISSION GÉOLOGIQUE

USGS science for a changing world

DEPARTMENT OF ENERGY UNITED STATES OF AMERICA


Calliper (cm)
Gamma Ray (API Units)
Neutron Porosity (%)
Density (Kg/m³)
Geological Description
Compressional Velocity(km/sec.)
Resistivity (ohm-m)
Mud Gas Total (%)
Depth from RKB (metres)
Ipark Sequence
Ice-bonded sand with occasional conglomerate, silt and clay layers Abundant detrital organics In some zones
Mackenzie Bay Sequence
Sand and weakly cemented sandstone, minor silt/shale Interbeds
Base of Ice-bonded permafrost 640m
Kugmallit Sequence
Interbedded weakly cemented sand/ sandstone and silt/ siltstone
Log response affected by casing
Gas Hydrate Interval

# Resource Potential

*****Mallik Gas Hydrate 3,700 bcf in place**

Mackenzie Delta / Beaufort Sea – Discovered Resource Ranked by Pool Size

| | GAS (billion cubic feet) | | | | | |
|---|---|---|---|---|---|---|
| | >2000 | 1000-2000 | 500-1000 | 100-500 | 10-100 | <10 |
| ONSHORE | TAGLU | PARSONS | NIGLINTGAK | ADGO<br>GARRY N.<br>GARRY S.<br>HANSEN<br>TUK M-09<br>YA YA S. | IKHIL<br>MALIK<br>MINUK<br>PELLY<br>REINDEER<br>TITALUK<br>UNAK a<br>UNAK b<br>YA YA N. | |
| OFFSHORE | | AMAULIGAK<br>ISSUNGNAK | KENALOOAK | MINUK<br>NETSERK<br>UKALERK | AMERK<br>ARNAK<br>ISSERK<br>ITIYOK<br>KADLUK<br>KIGGAVIK<br>NEKTORALIK | NERLERK<br>W. AMULIGAK |

Taken From: Petroleum resources of the Mackenzie Delta and Beaufort Sea, 1994, Geological Survey of Canada, Bulletin 474

# International gas hydrate production research well

# Mallik 2002

## International Partnership

- Canada
  - Geological Survey of Canada
  - Industry (Imperial Oil, BP/Chevron-Texaco/Burlington)
- Japan
  - Japan National Oil Corporation
  - Japan Petroleum Exploration Company
- USA
  - U.S. Geological Survey
  - U.S. Department of Energy
- Germany
  - GeoForschungsZentrum Potsdam
- India
  - Ministry of Petroleum Geology and Natural Gas, Gas Authority India Ltd
- International Continental Scientific Drilling Program
  - Universities and research institutes in Japan, Canada, USA, Germany and China

# Mallik 2002
# Objectives:

## Establish the production response of a hydrate reservoir

- Controlled in situ ‘experiments’…….
- Constrained by science
- Multidisciplinary approach where possible (link geology, geochemistry, geophysics, reservoir/production engineering etc.)
- Where possible use laboratory work and modeling to guide the field work

# Mallik 2002 Objectives:

## Climate change & Geohazard Research

- Methane source, migration, flux……
- Flux studies of natural methane emissions and unique geomorphic features
- Regional geology and geothermal studies allow for geothermal modeling and stability assessments in the context of past geologic events and warming climate
- Research with industry to assess hazard issues related to drilling and production

# Mallik Gas Hydrate Production Research Well Program

## Management Structure

**Steering Committee: co-chairs Tezuka/Vincent**

- Management level responsibilities ($…etc)
- Voting allocations to partners (JNOC-2, GFZ-2, GSC-1, USGS-1, MOPNG, USDOE-0, Canadian Industry-0)

**Technical Committee: chair Dallimore**

- Technical and program planning
- Operational arm of the Steering Committee
- Four Teams: Science (Dallimore), Modeling (Collett), Production (Satoh), Operations (Takahashi)

# Operational Structure

Canadian Environmental Assessment

**Permitting**

Science License

JNOC

**GSC**

USGS

USDOE

GFZ

MOPNG

JAPEX

Imperial Oil

Canadian Industry

**Japex Canada Ltd.**

APA

CPE

**Permitting**

NEB (National Energy Board)

IRC (Inuvialuit Regional Corporation)

IANC (Indian and Northern Affair of Canada)

EISC (Environmental Impact Screening Committee)

Service Contractors / Suppliers

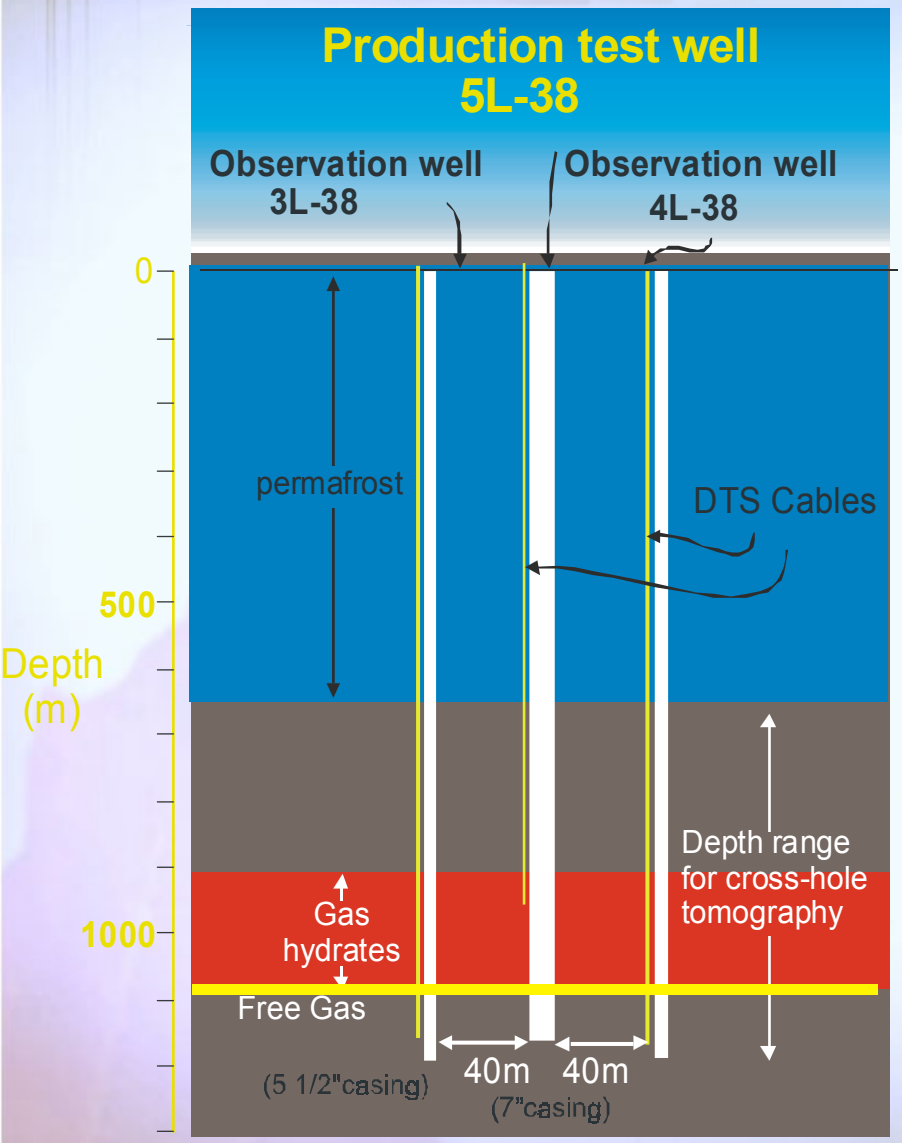
# Mallik 2002- Base Plan

Field program during **winter 2001/2002** with efforts to extend operational season

New vertical production research well: **Mallik 5L-38**

- Open hole/cased hole **geophysical logging program and surface geophysics**
- Dedicated **wireline coring program** through the gas hydrate zones and beneath the free gas zone
- Dedicated **wireline formation testing** and **production flow testing**
- **2 observation wells** to conduct cross hole seismic tomography and monitor temperature response of the formation to production: Mallik 3L-38 and 4L-38

# Mallik 2002




## 3 well concept enables a diverse and flexible program

- Controlled production experiments, with real time formation monitoring
- Access for experimental logging and cross hole geophysics
- Integrated permafrost and gas hydrate research program

# Base Plan Design

**Remember the challenges left from Mallik 2L-38…**

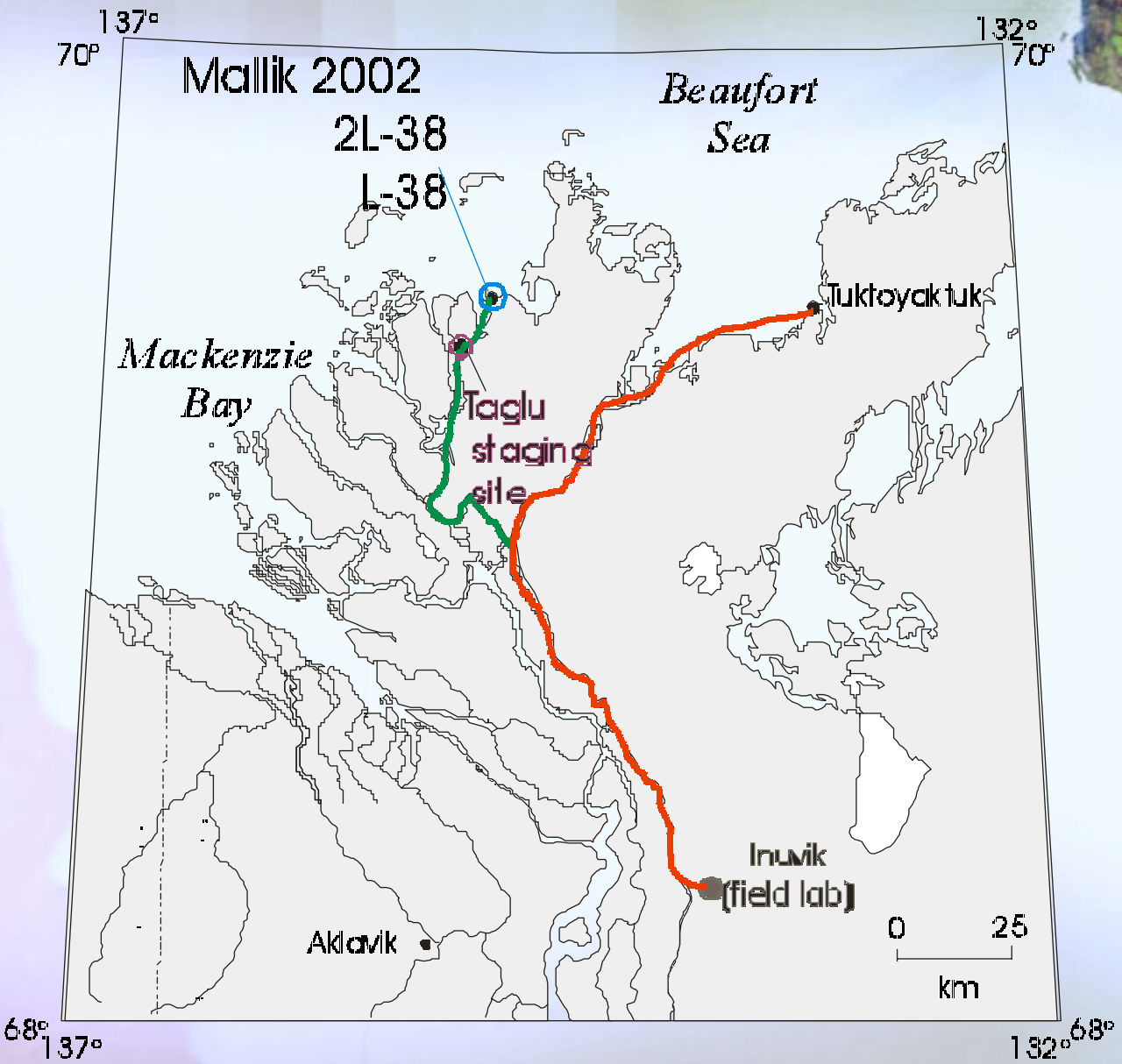
**Core**

- Improve core quality
- Priority to collect hydrate core samples between 950-1100m to examine porous media controls over hydrate distribution
- Priority to collect core samples beneath the base of hydrate stability field @1100m

**Collect high precision in situ temperature/geothermal/pressure field data**

**Research geophysics to improve spatial delineation and quantification of the gas hydrate and free gas layers**

# Ice Road Network



# Logistics Schedule

| | days | 2001 | | | | | | | 2002 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| Mobilize by road to Inuvik | | 18 truck | | | | | | | | |
| Mobilize equipment by road to Hay River | | 25 loads | | | | | | | | |
| Barge from Hay River to Inuvik | | 760 tons | | | | | | | | |
| Barge Material drill, camp and equipment from Inuvik toTaglu Staging site | | | | | | | | | | |
| Construct Ice road from Taglu to Site | | | | | | | | | | |
| Construct Location | | | | | | | | | | |
| Mobilize Staging Material from Taglu to Location | | | | | | | | | | |
| Rig up at Location | | | | | | | | | | |
| Construct Ice road from Taglu to South | | | | | | | | | | |
| Mobilize equipments for test well from South to Location ( Material C ) | | | | | | | | | | |
| Drill Observation Well #1- Mallik 3L | 16 | | | | | | | | | |
| Drill Observation Well #2- Mallik 4L | 14 | | | | | | | | | |
| Drill/Core Test-Well & Test - Mallik 5L | 49 | | | | | | | | | |
| Demobilize All Material & Clean up Location | | | | | | | | | | |

# Taglu Staging Site

760 tons of equipment staged in summer, mobilised to site in December 2001

# Mallik 3L, 4L, 5L

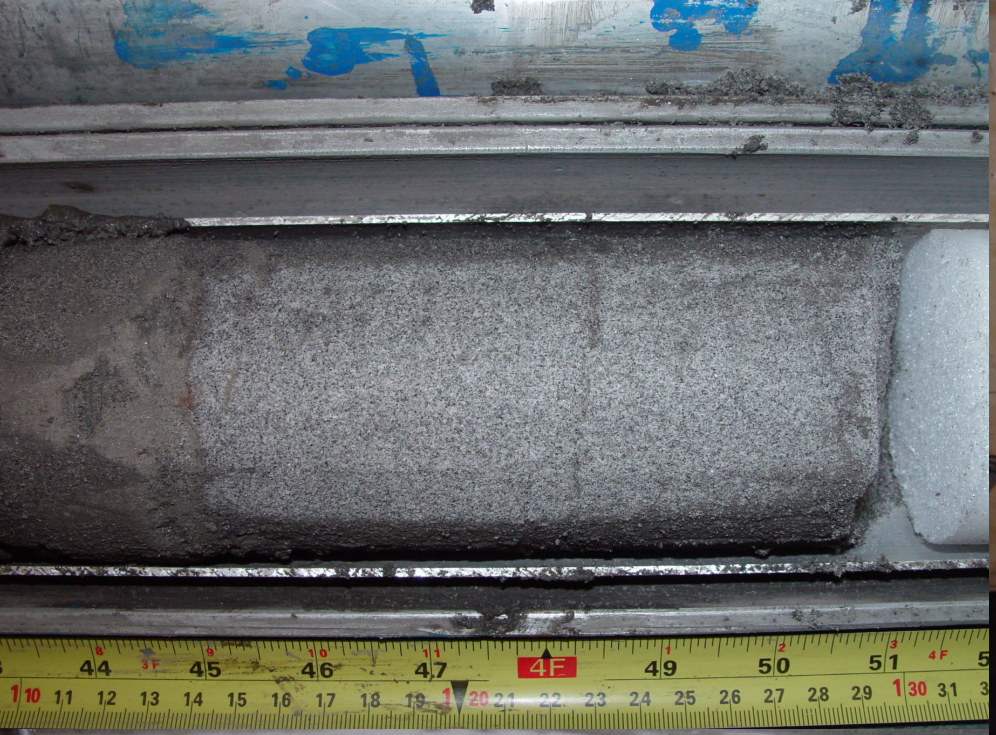
-Spud December 25

-Completion March 14

# Mallik 2002
# Review of field program

# CORING

- 3-inch wireline coring system
- Excellent hydrate recovery
- Transitions from hydrate to water/gas saturated intervals



# Geophysics Program

**Open Hole Well Logging**

- -deployment of advanced tools including NMR log, EPT, DSI, FMI, Pex

**Cased Hole Logging**

- -CHFR-RST

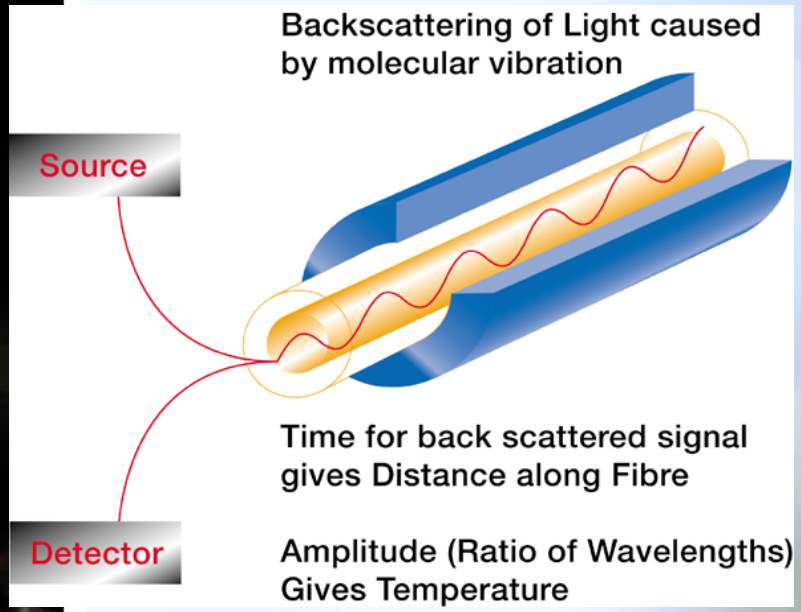
**X-hole Seismic Survey**

**VSP O-Offset and Walk-A-Way**

**3D Seismic Experiment**

**Passive Monitoring**

# Distributed Temperature Sensors



# *Production Testing*

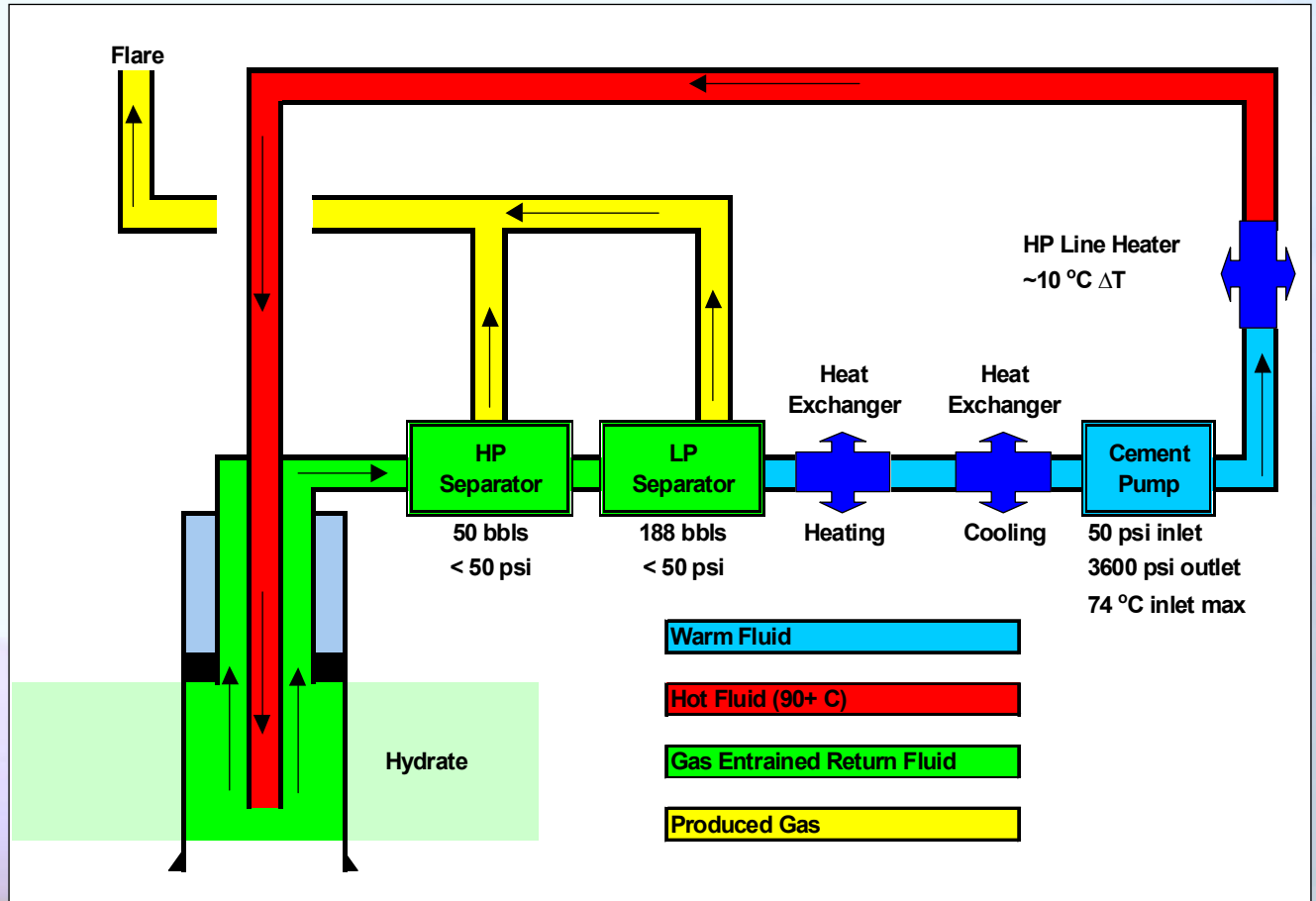
**Modular Formation Dynamic Tester (MDT)**

- Reservoir response to pressure stimulation
- Geomechanical/geothermal measurements at production interval

# Production Testing

## Thermal Stimulation Production Testing

- Reservoir response to temperature stimulation



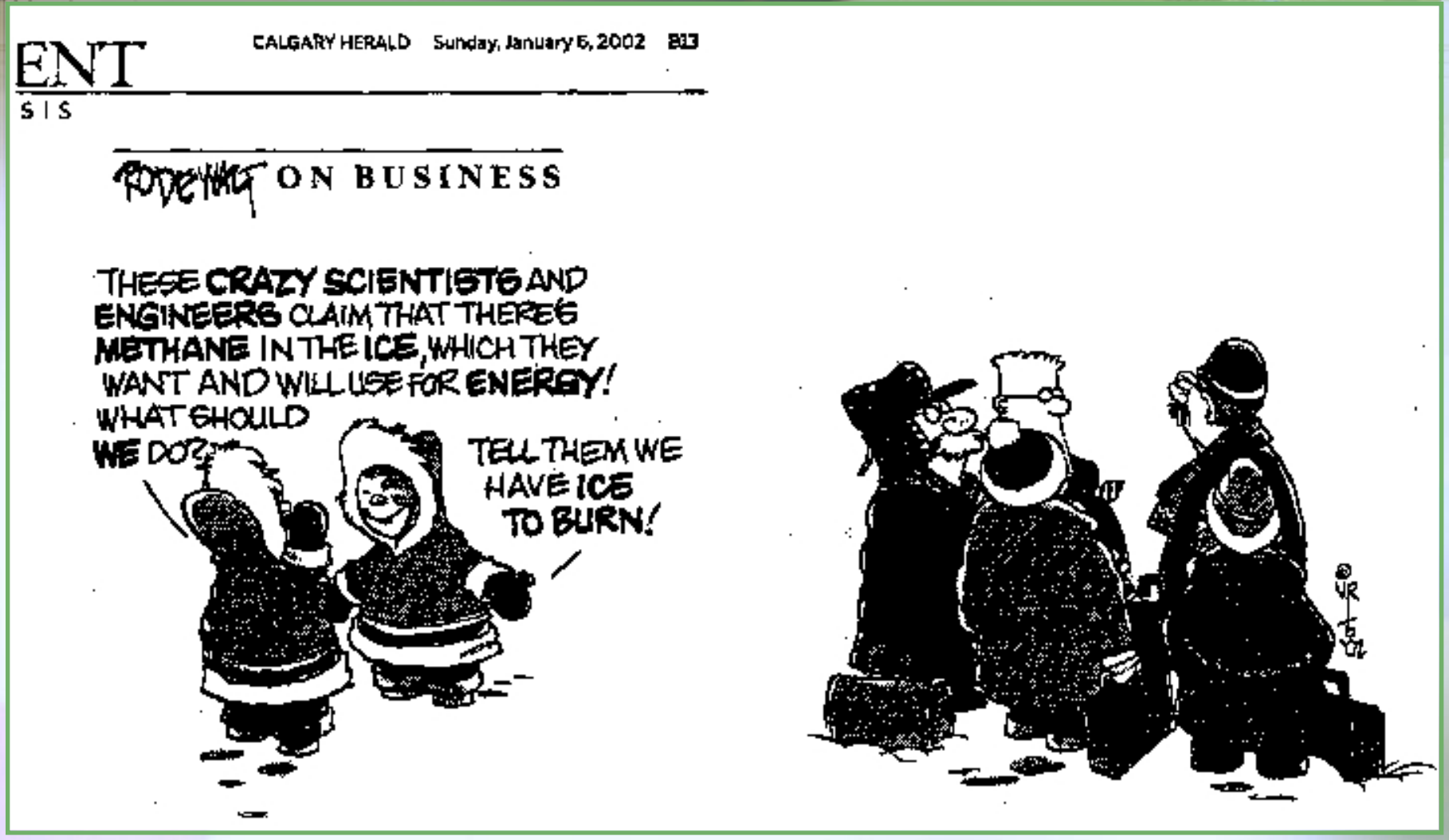
# *Production Testing*

**Monitoring of Dissociation**

**X-Hole Tomography Surveys-** time series data to map migration of dissociation interface

**Surface Seismic Surveys**- time series

**DTS-** measurement of formation temperature response to production and return to equilibrium after production

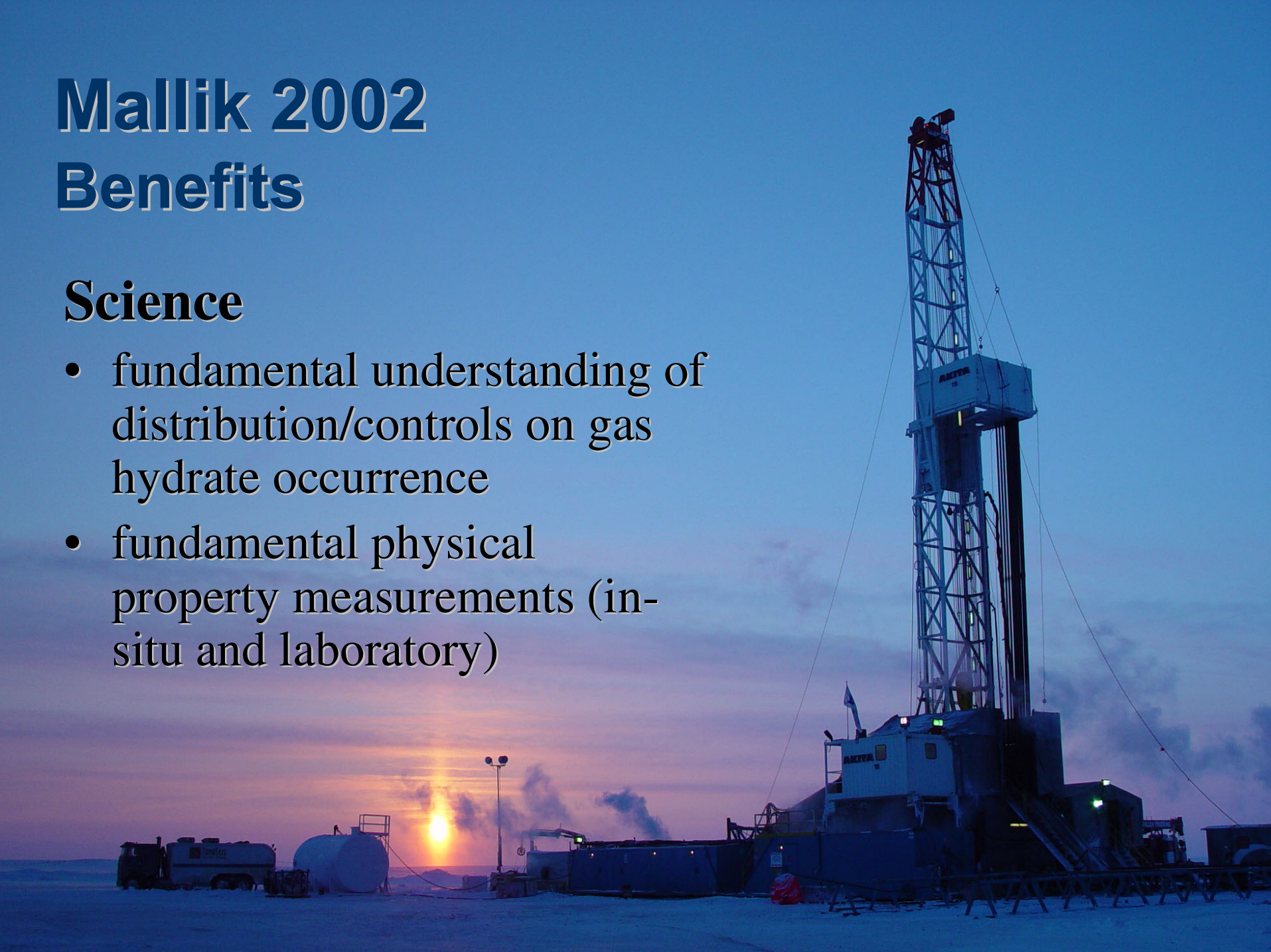



# What are the expected benefits?

# Mallik 2002
## Benefits

### Science

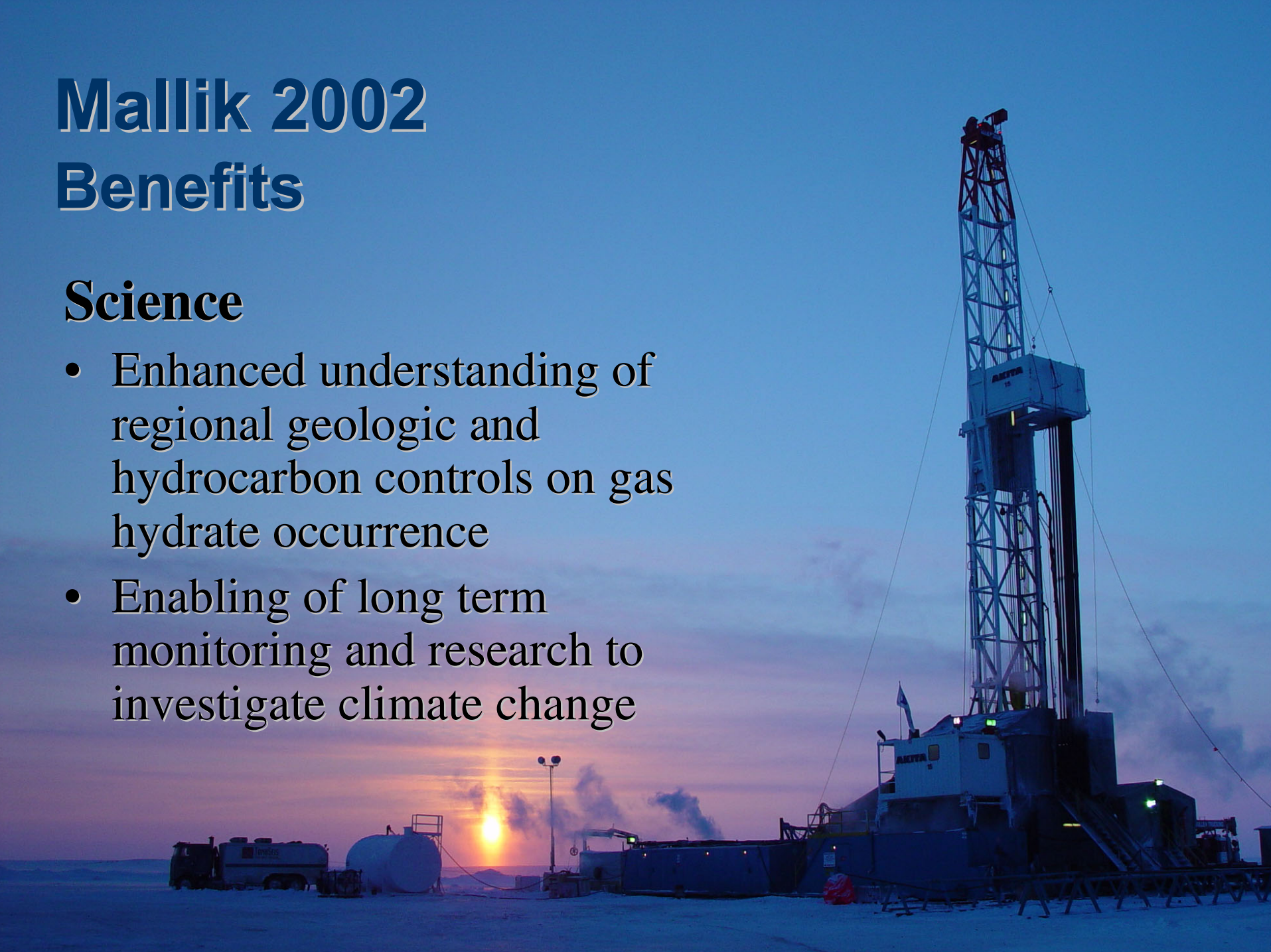
- fundamental understanding of distribution/controls on gas hydrate occurrence
- fundamental physical property measurements (in-situ and laboratory)



# Mallik 2002
## Benefits

### Science

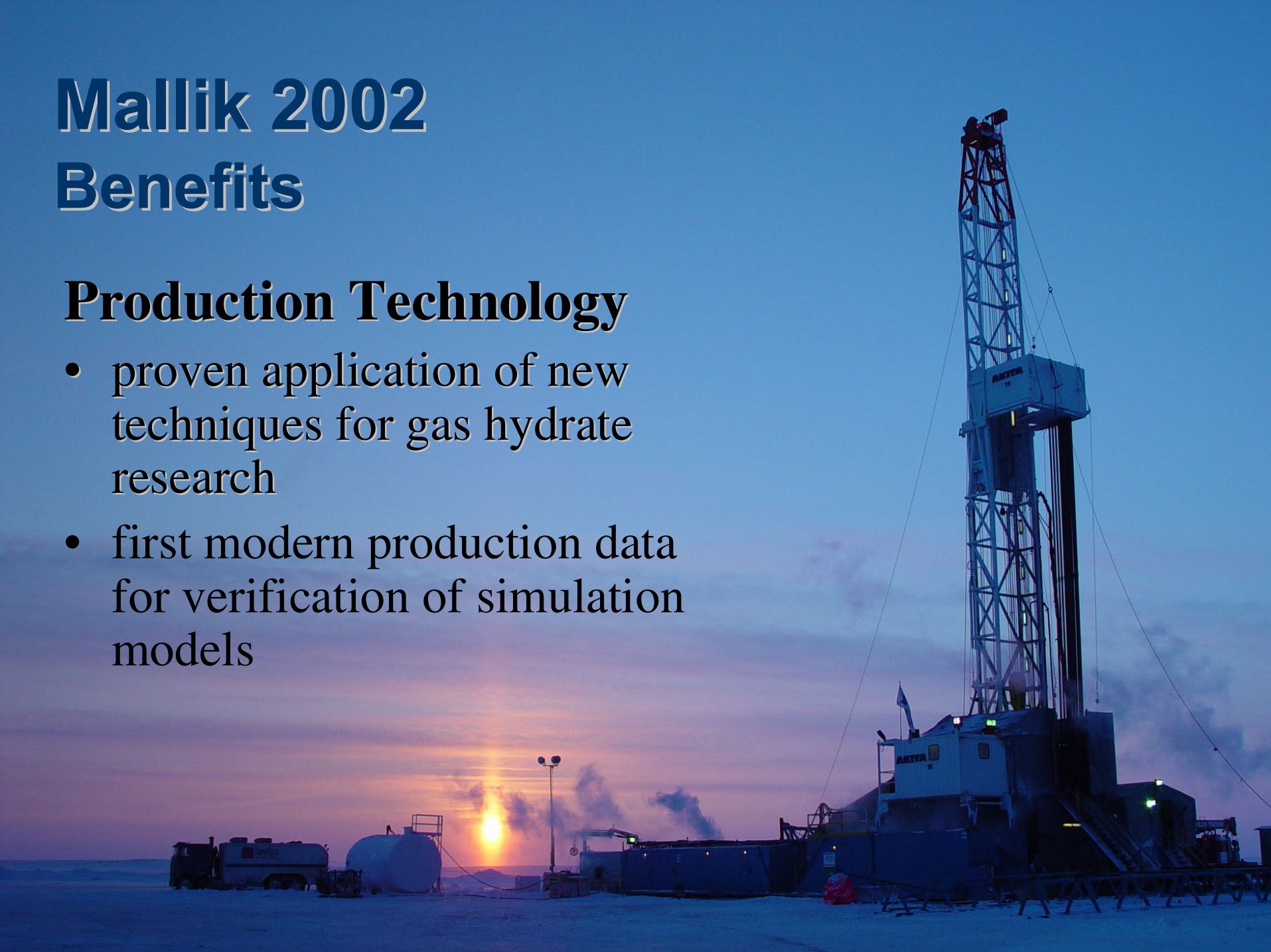
- Enhanced understanding of regional geologic and hydrocarbon controls on gas hydrate occurrence
- Enabling of long term monitoring and research to investigate climate change



# Mallik 2002
## Benefits

### Production Technology

- proven application of new techniques for gas hydrate research
- first modern production data for verification of simulation models



# Schedule for public release-2004

# Mallik 2002 Web Site

In the mean time…

http://www.gashydrate.com

http://www.icdp.gfz-potsdam.de