Characterization and Appraisal of Alaska North Slope Gas Hydrate Resource Potential

Hart Energy Conference

Houston, Texas
December 5-6, 2006

U.S. Department of Energy

bp

Robert Hunter

USGS science for a changing world

ASRC Energy Services
E & P Technology

Presentation Outline

- Project Overview
- Resource Characterization
- Stratigraphic Test Objectives
- Preliminary Conclusions

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Collaborative Research Team

U.S. Department of Energy

GOVERNMENT

NETL

Arctic & National Labs

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THE UNIVERSITY OF ARIZONA

UAF UNIVERSITY OF ALASKA FAIRBANKS

Unconventional Resource Determination

bp

ASRC Energy Services
E & P Technology

APA PETROLEUM ENGINEERING

INDUSTRY

3D Seismic & Well Data, Infrastructure

UNIVERSITIES

Research Innovation

Collaborative Research Approach

- Assess Gas Hydrate Resource Potential
- Maintain Focus with Dedicated External Team
- Use Alaska North Slope as Natural Laboratory
- Require Clear Decision GATES between Phases

Collaborative Research Approach

Assess Resource Potential in 3 Phases:

2003 – 04 1. Characterization and Modeling

2005 2. Schematic Regional Modeling

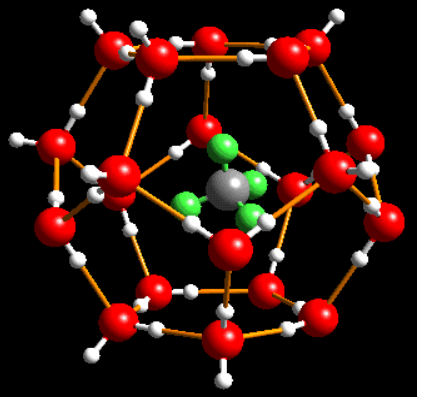
Current 3a. Acquire Stratigraphic Test Well Data

Possible Future? 3b. Acquire Additional Well Data Production Testing

Convert Risk to Resource?

Risk

- Known Risk to Oil Production Operations:
  - ✓ Significant Documented Drilling Risk
  - ✓ Formation in Wellbores &/or Flowlines
  - ✓ Dissociation may Destabilize Shallow Sediments



Resource

- Large GIP and Gas Storage Capacity
- Potential Resource Applications:
  - ✓ Fuel for Field Power, Compression
  - ✓ Injection/Pressure Support for Oil Reservoirs
  - ✓ Fuel for Potential Thermal Operations for Geographically-Coincident Viscous EOR
  - ✓ Gas Sales

- But … Unproven Technical & Commercial Viability

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Gas Hydrate Stability Zone
Alaska North Slope

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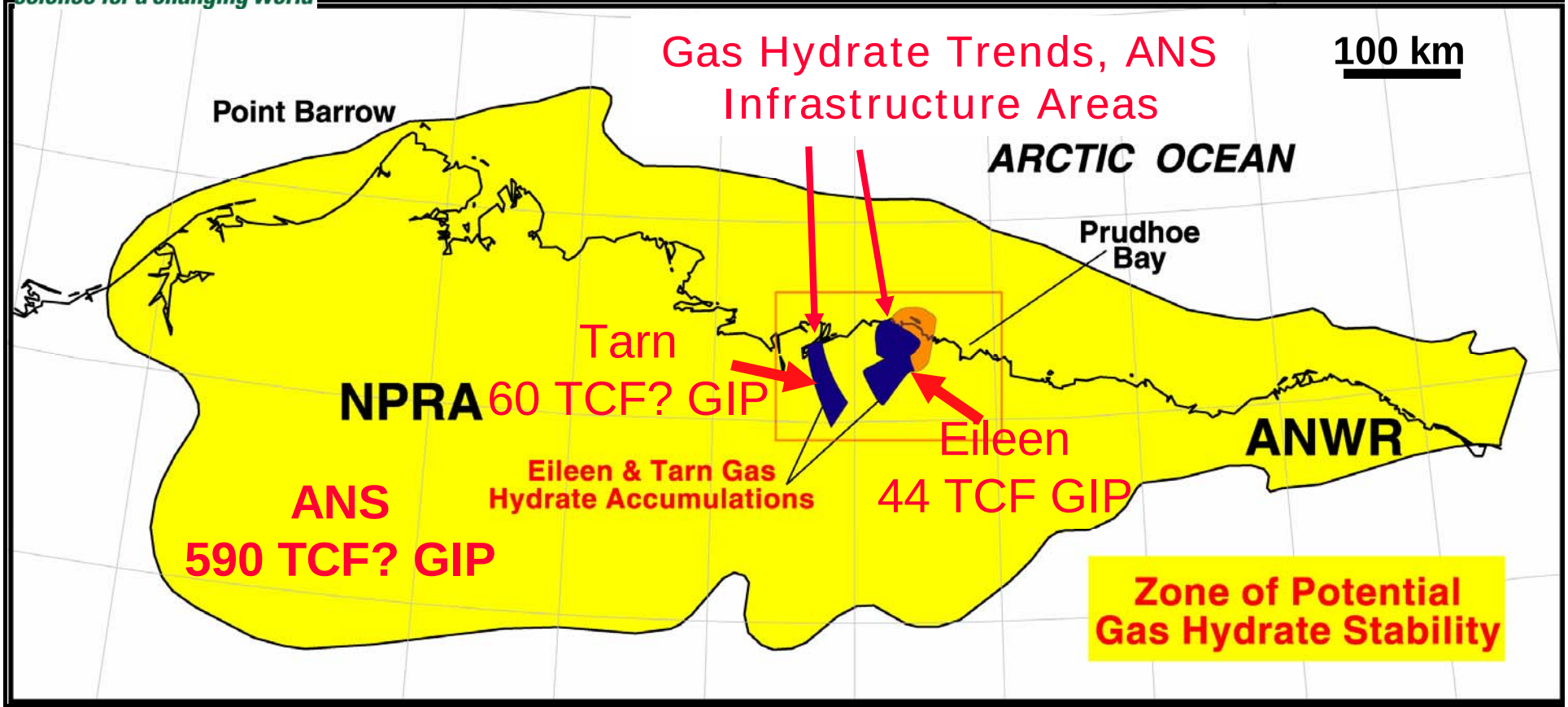
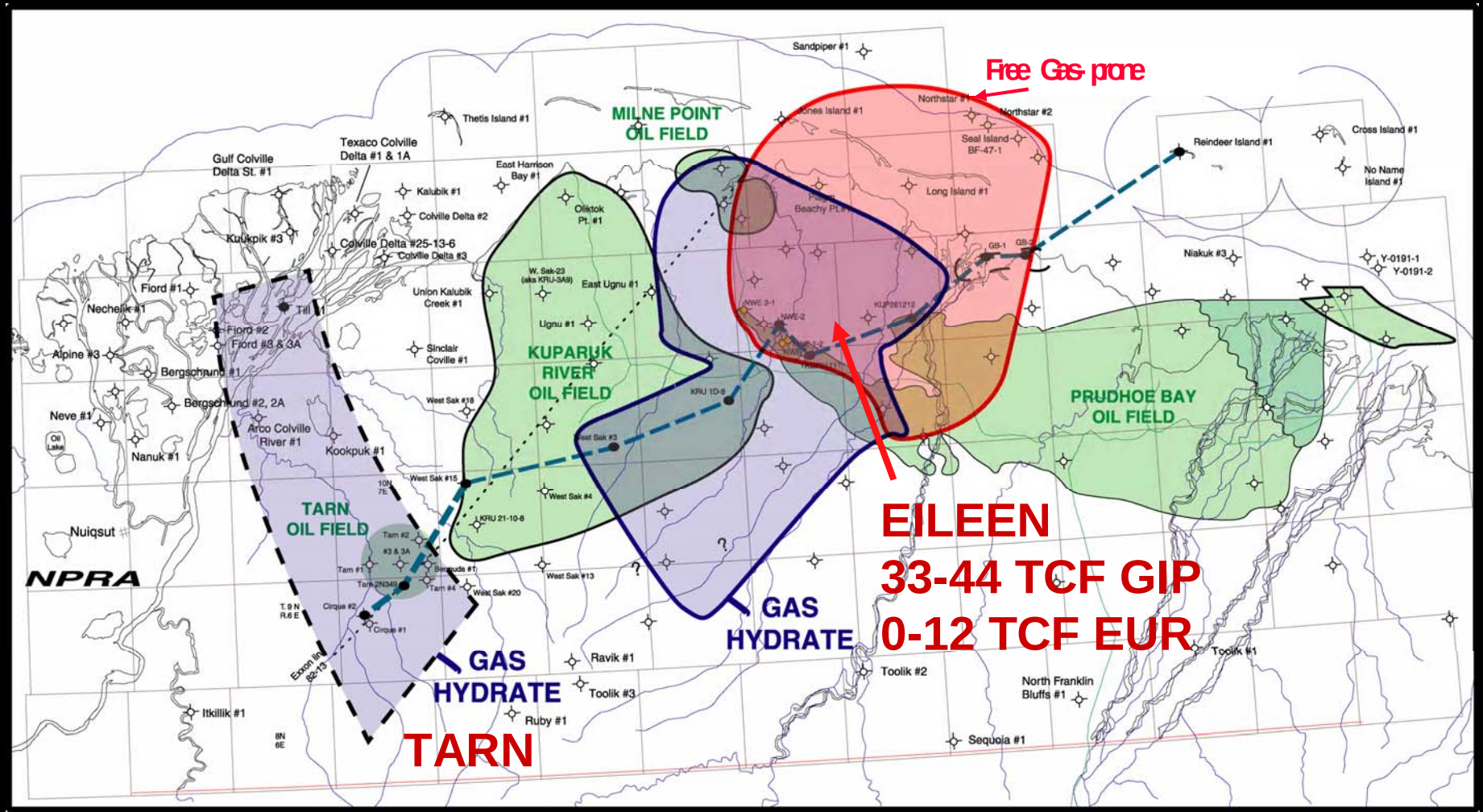


VOLUMES ARE GAS IN-PLACE (GIP) ESTIMATES

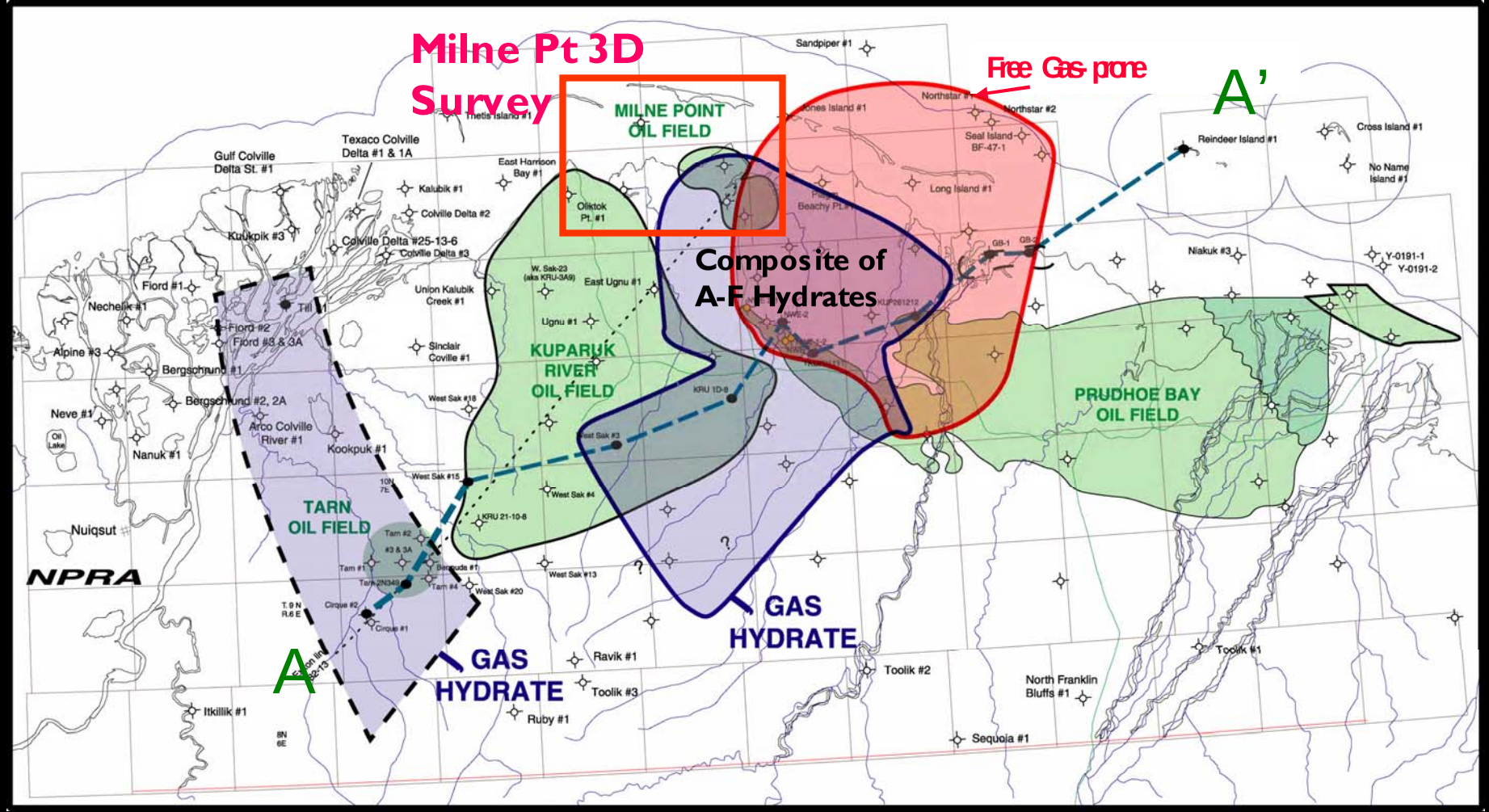
Petroleum System Required:

Gas / Water, Migration, Reservoir, Trap, Seal

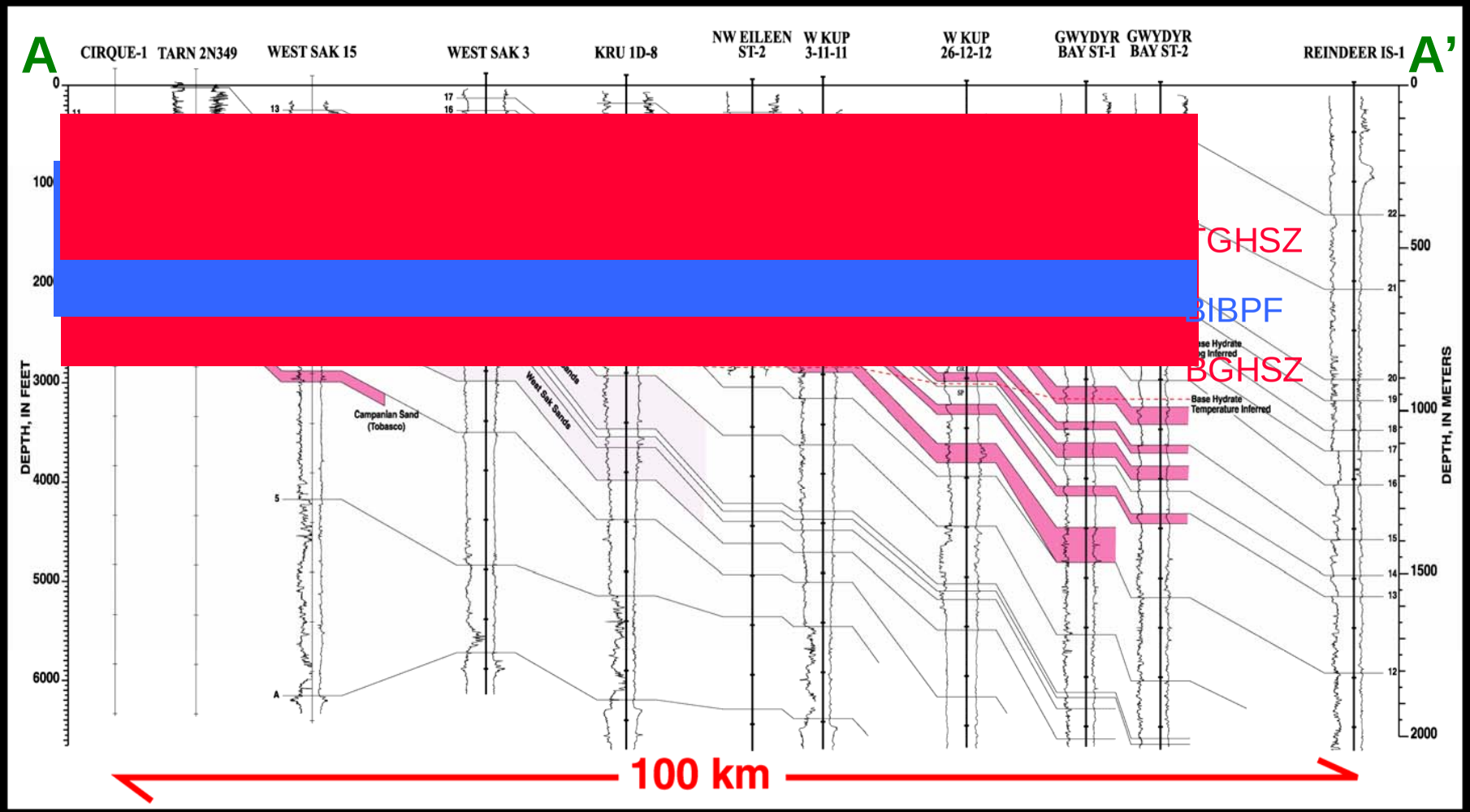
Eileen/Tarn Gas Hydrate Accumulations



Milne Point Gas Hydrate Accumulation



Eileen/Tarn Gas Hydrate Accumulations



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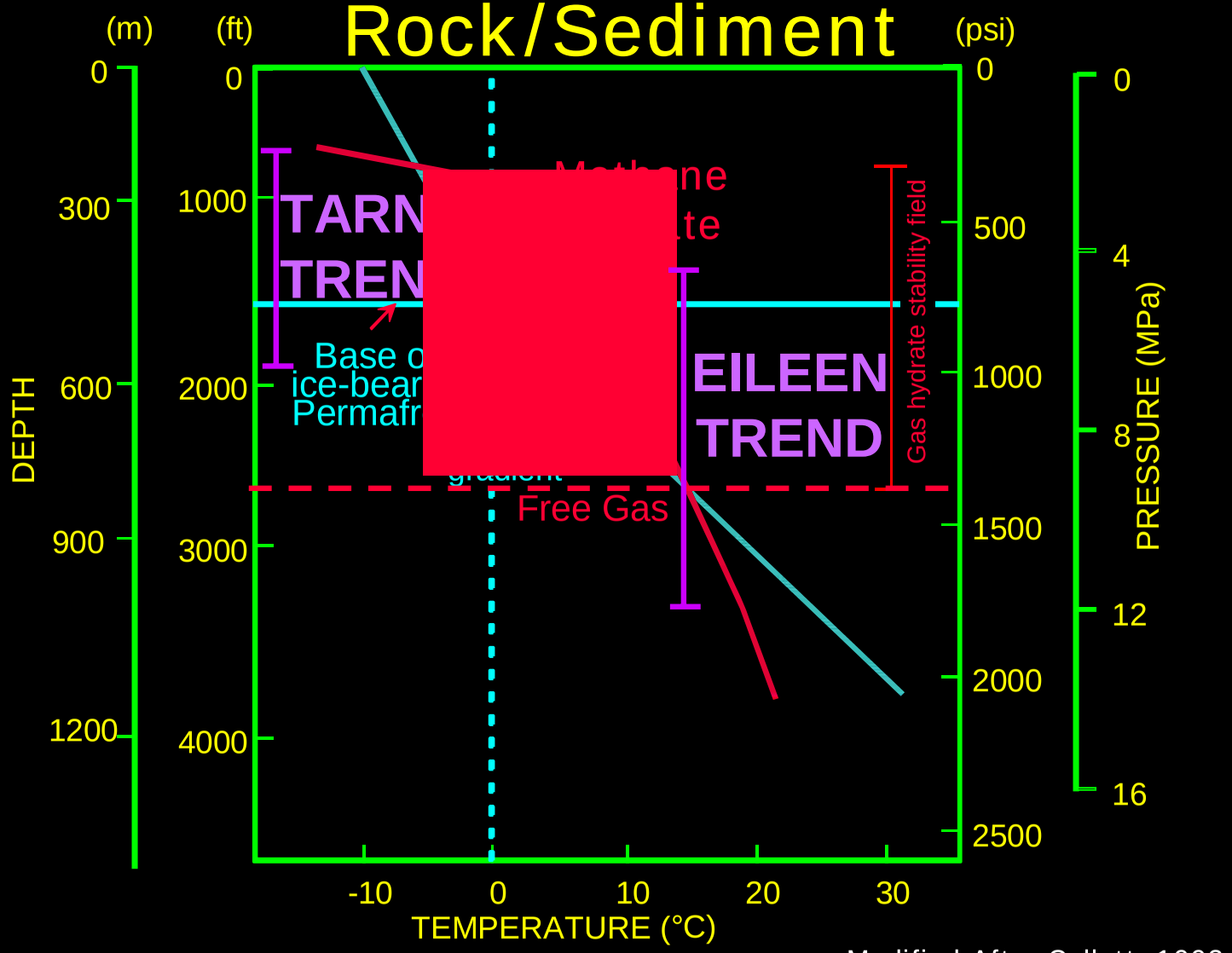
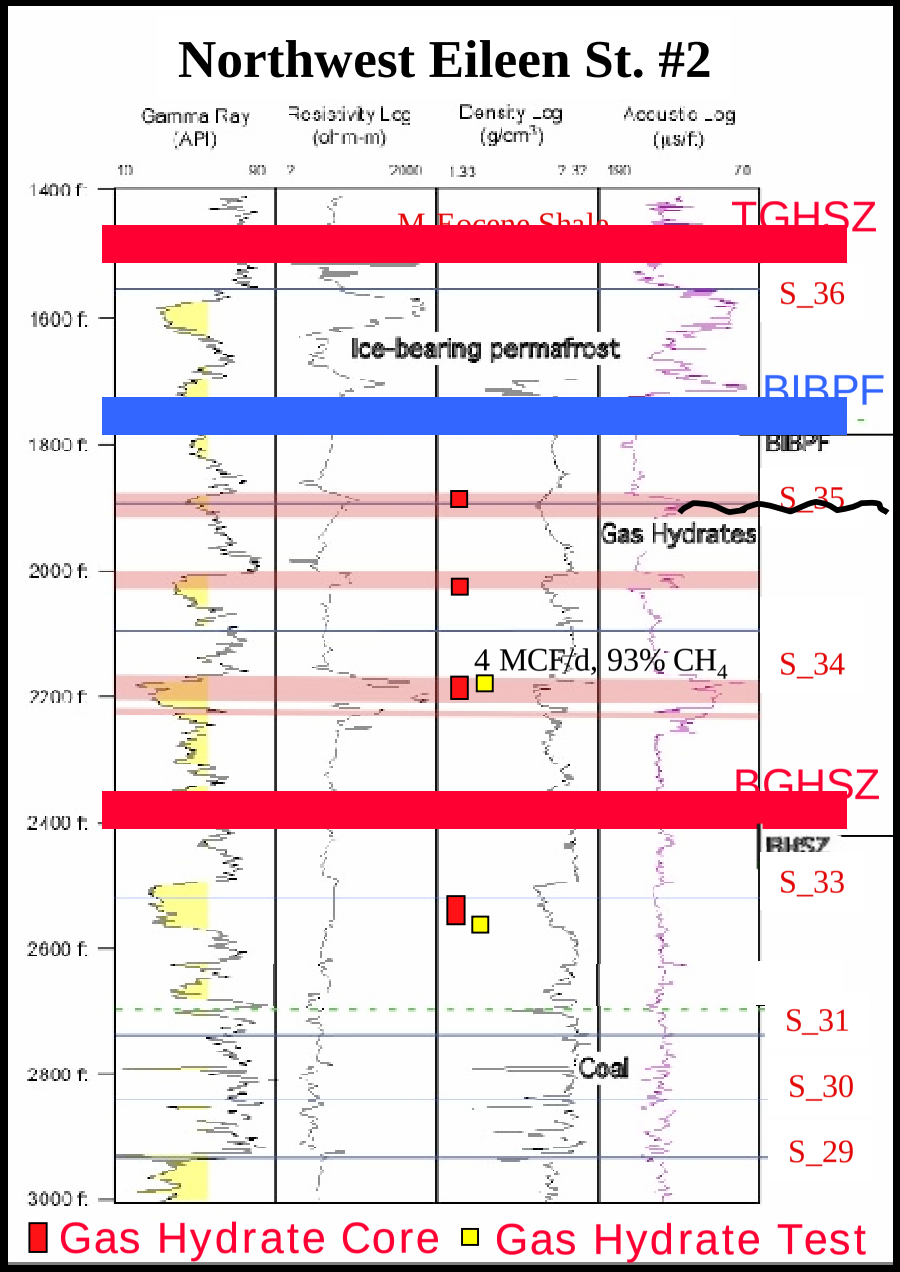
Alaska Gas Hydrate Resource
Methane Hydrate Stability Field



Modified After Collett, 1993

Eileen Trend Type Log

Sagavanirktok Fm.

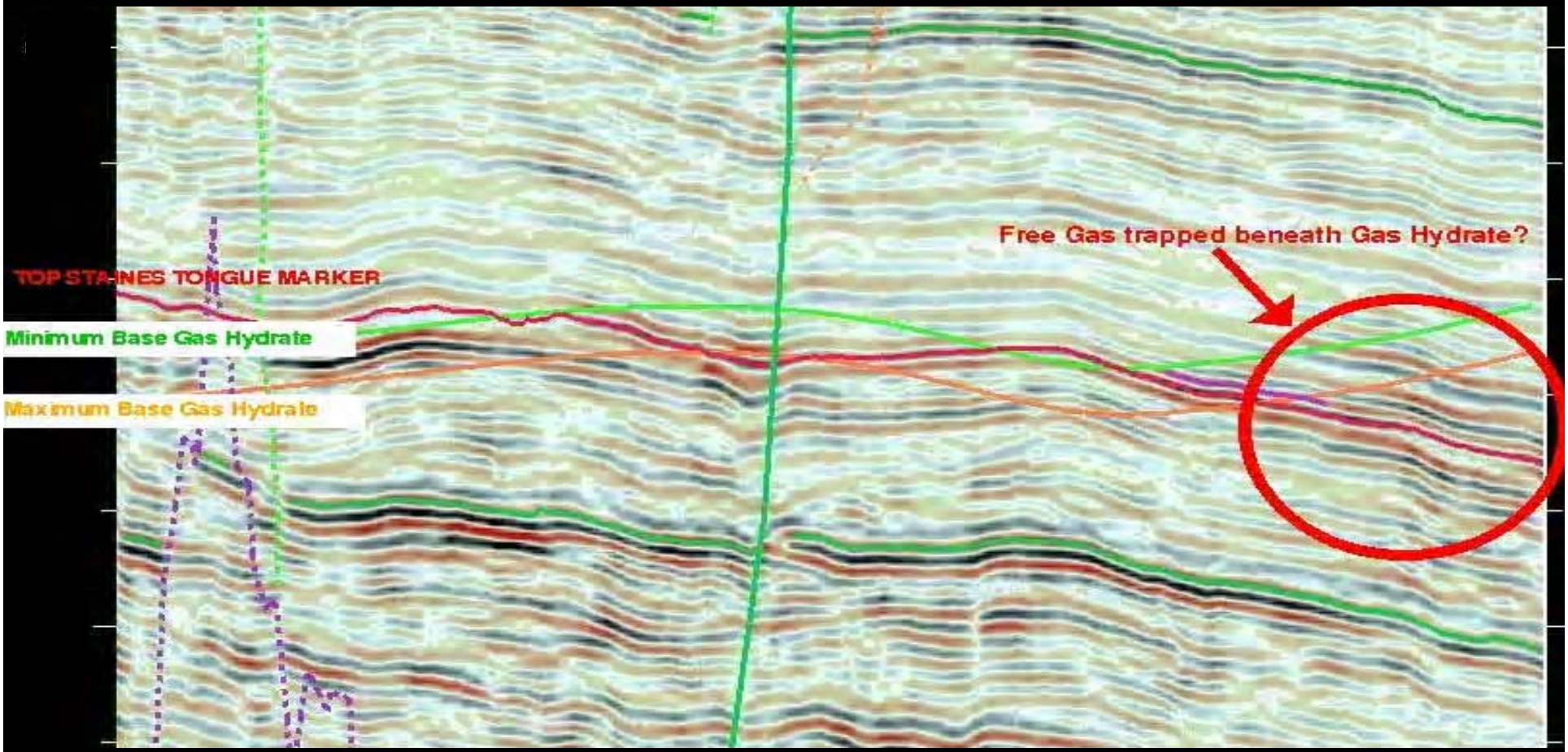


Ice-bearing permafrost

Gas hydrate stability zone

Free-gas, oil, or water

Seismic Amplitude Assessment



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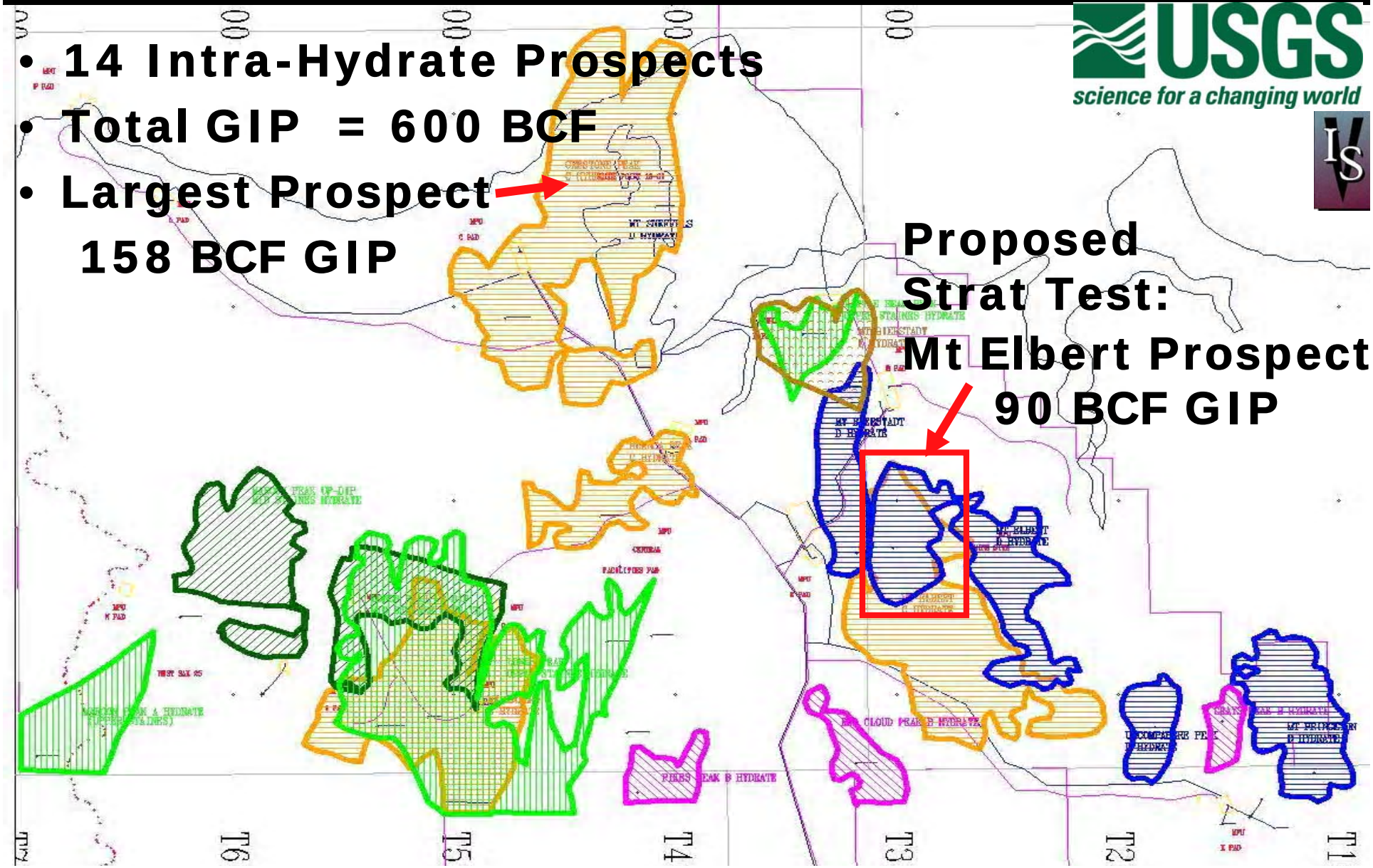
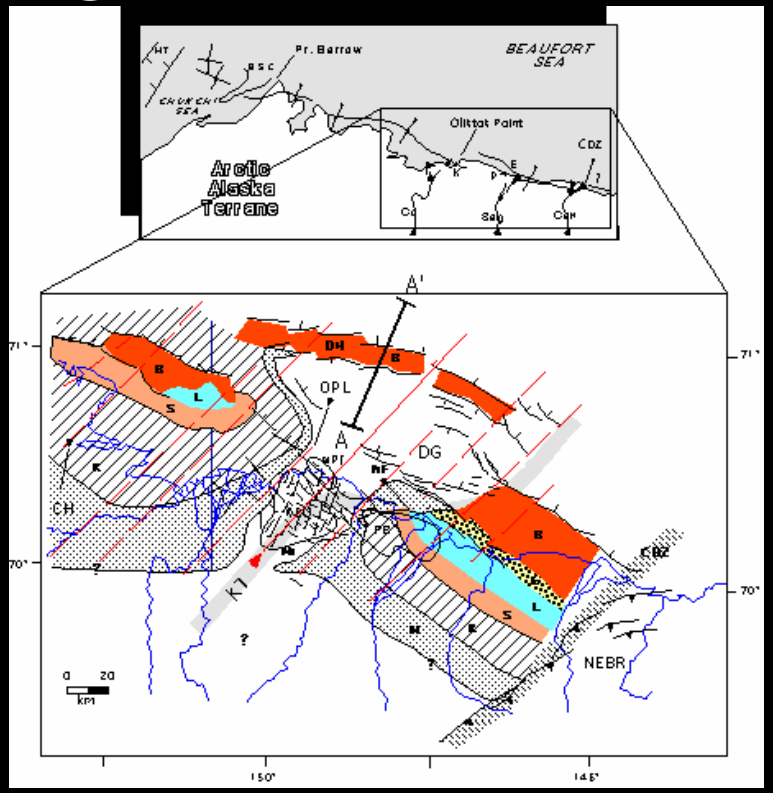
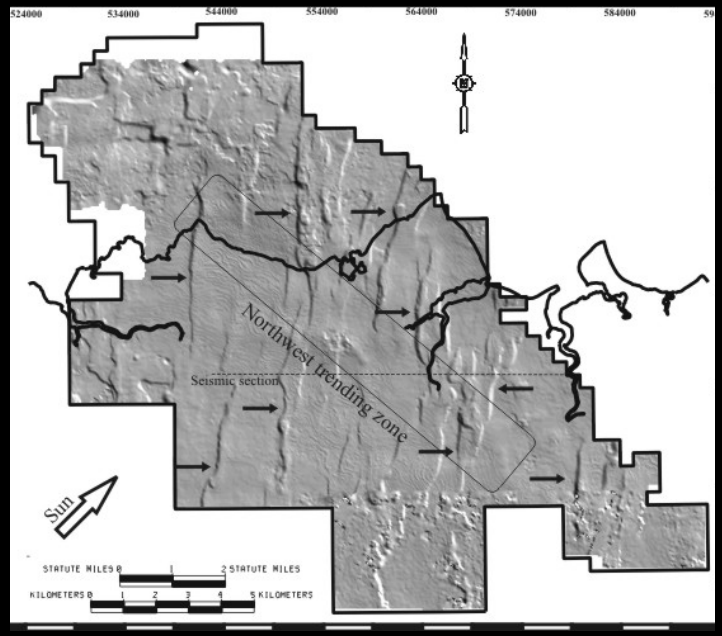
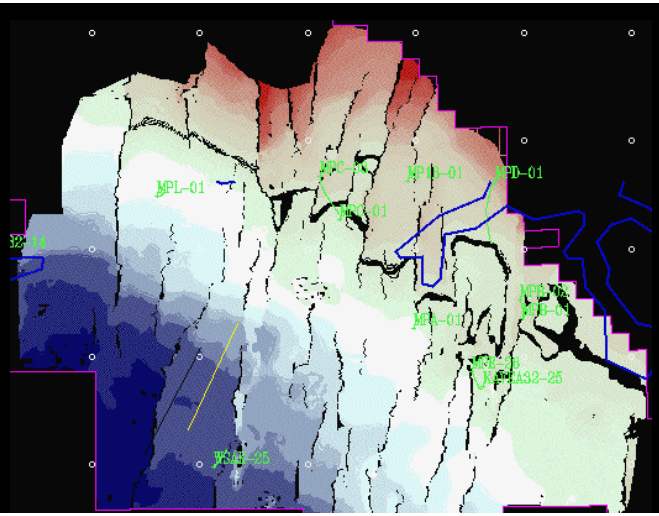
Gas Hydrate Prospect Mapping, MPU

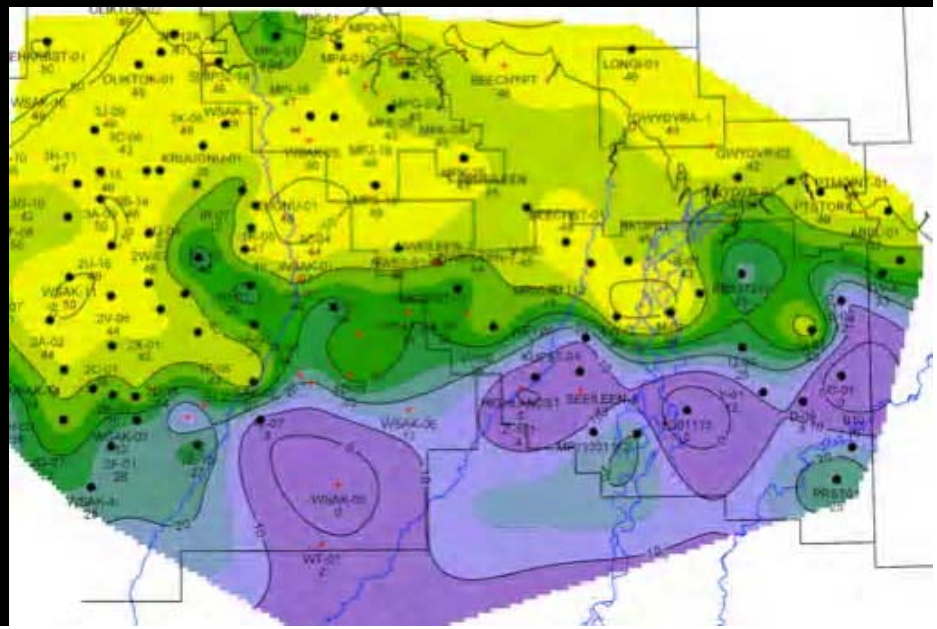


Regional & Eileen-trend Mapping





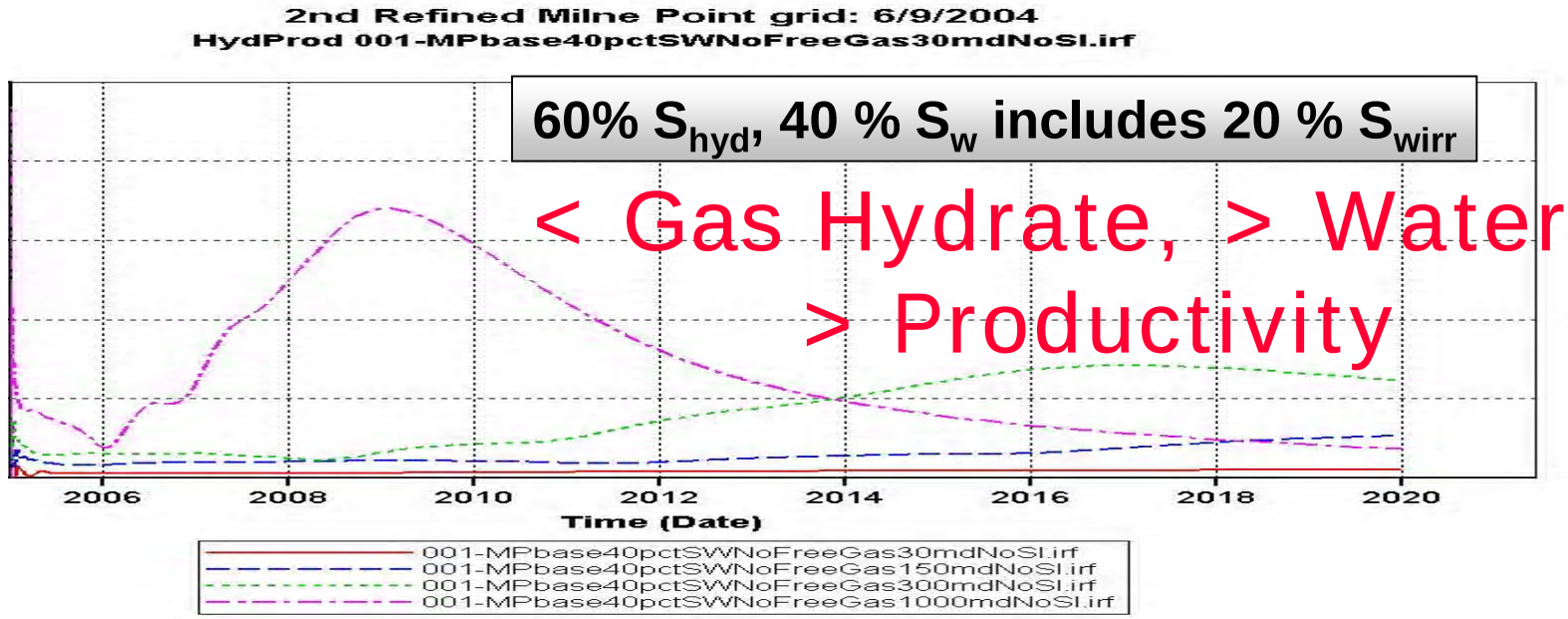


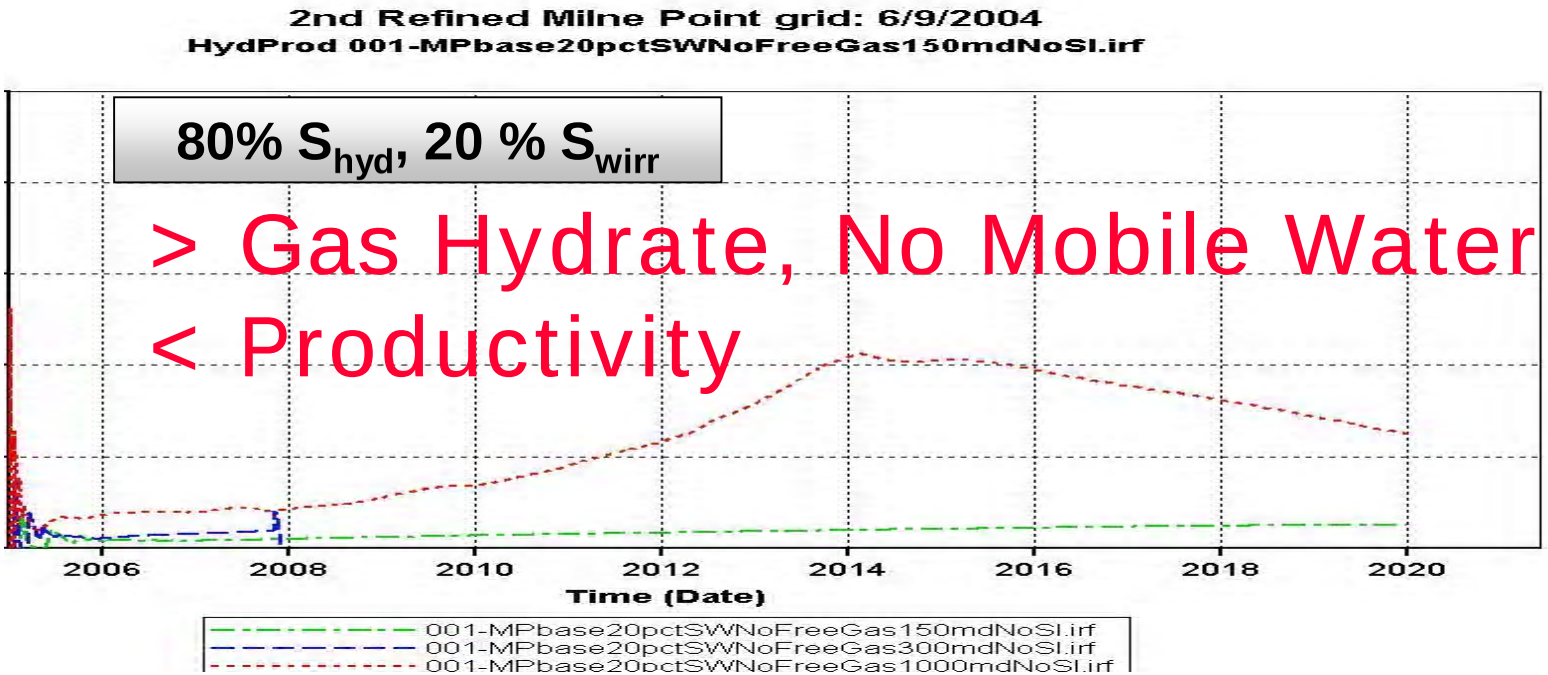


Reservoir Modeling

- Adapted Industry-Standard Reservoir Models to Gas Hydrate Phase Behavior
  - Used CMG-STARS and Special Inputs
  - Enabled Well/Field-Scale Modeling
- Developed Type-Well Cases/Ranges
  - Studied Pressure Response Variables
  - Evaluated Possible Analogs
  - Expanded to Regional Schematic Model

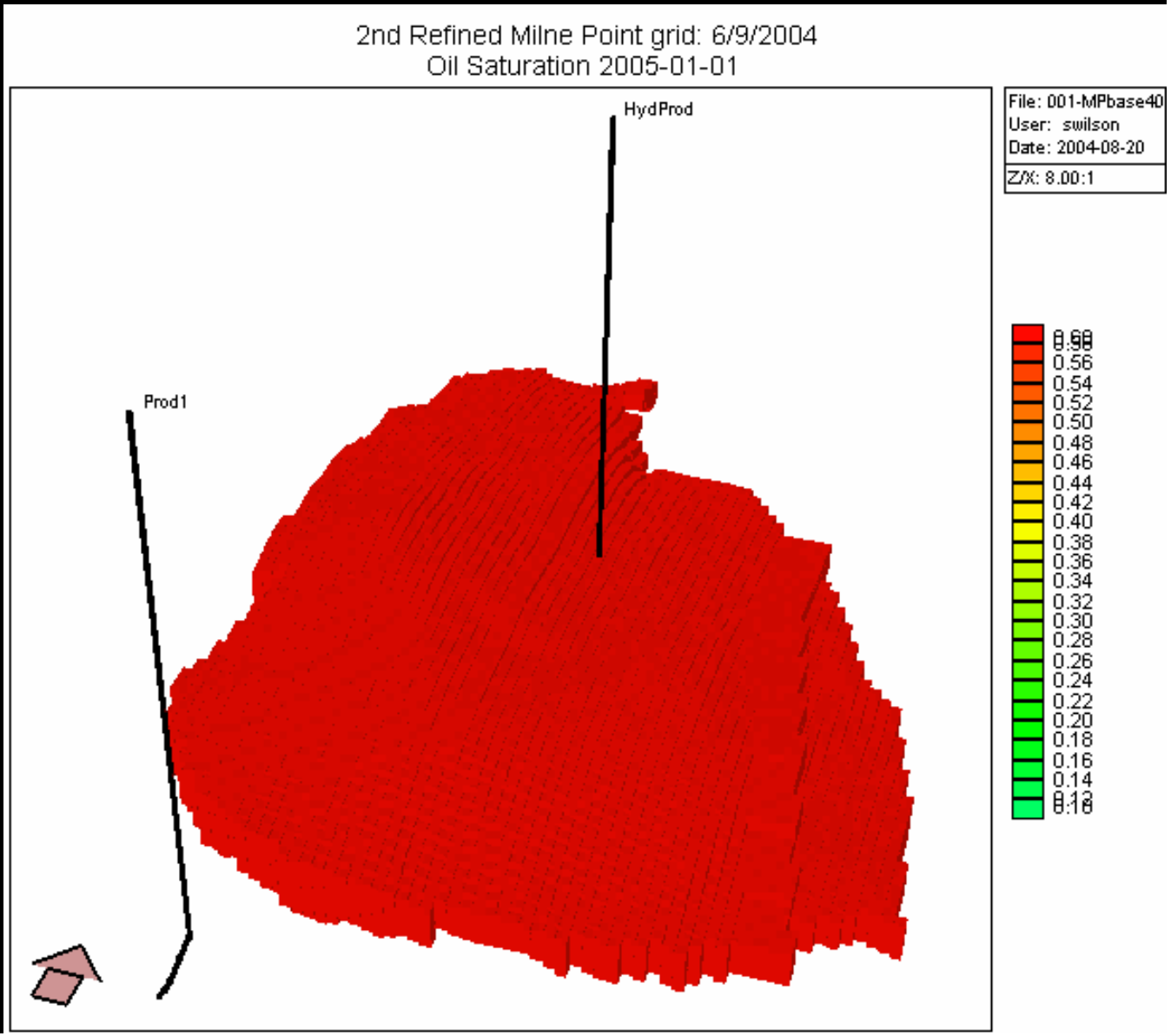
Intra-Hydrate Production Models



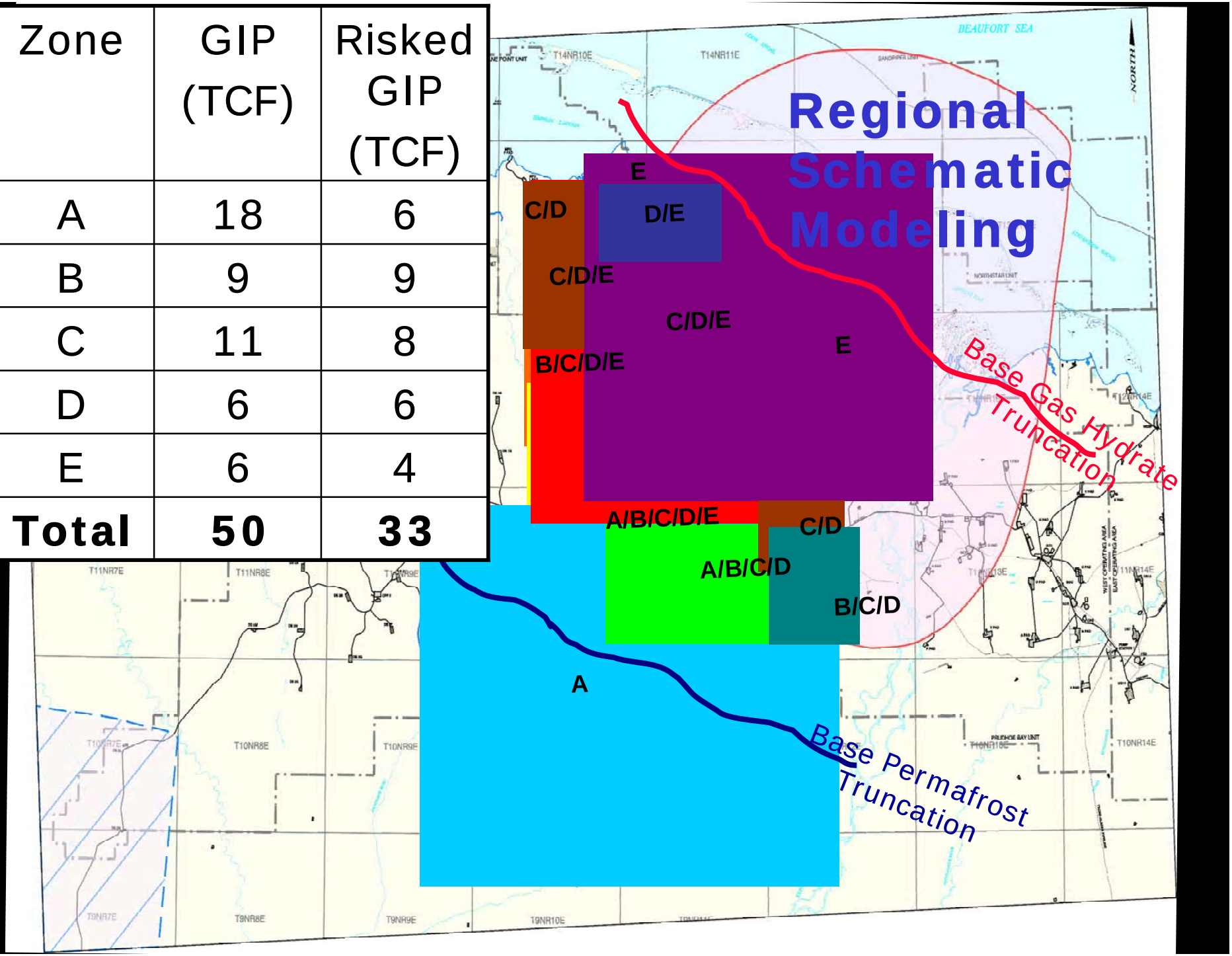


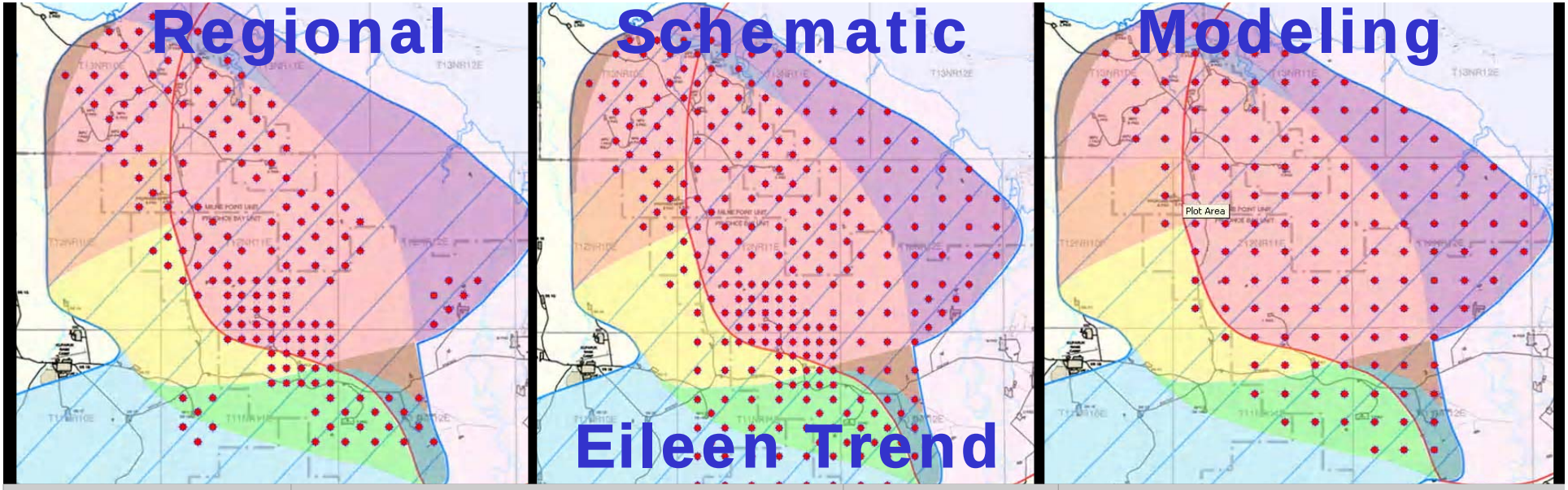
Intra-Hydrate Production Model

- 40% initial S_w
- Well Placement in Hydrate zone
- Initial S_w > S_{wirr}



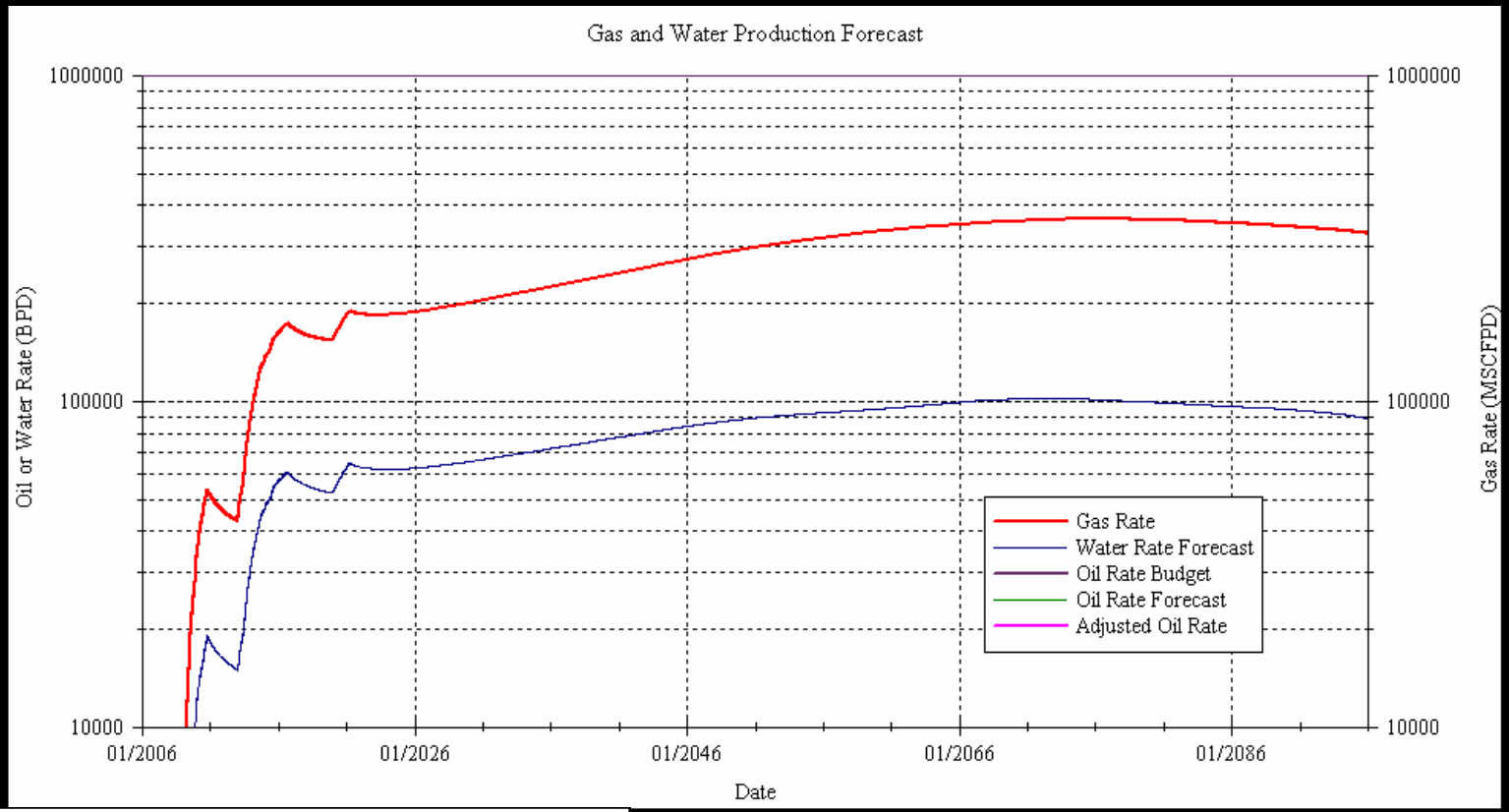
Zone	GIP (TCF)	Risked GIP (TCF)
A	18	6
B	9	9
C	11	8
D	6	6
E	6	4
Total	**50**	**33**

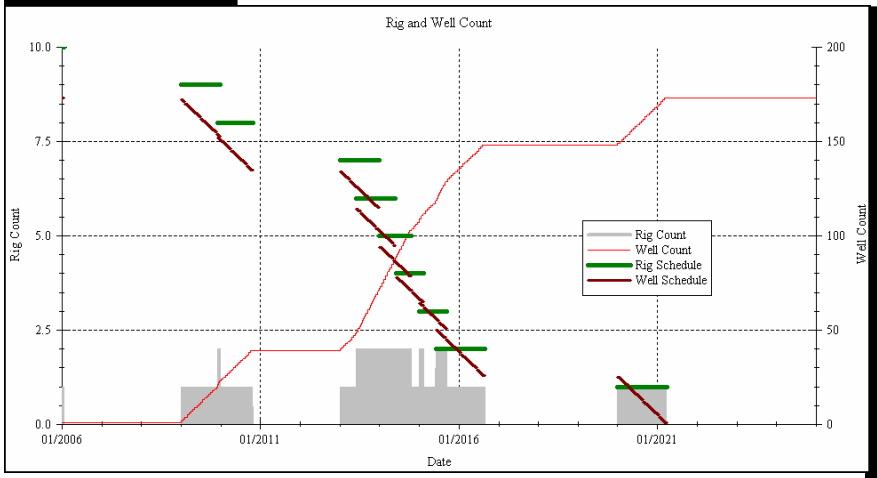


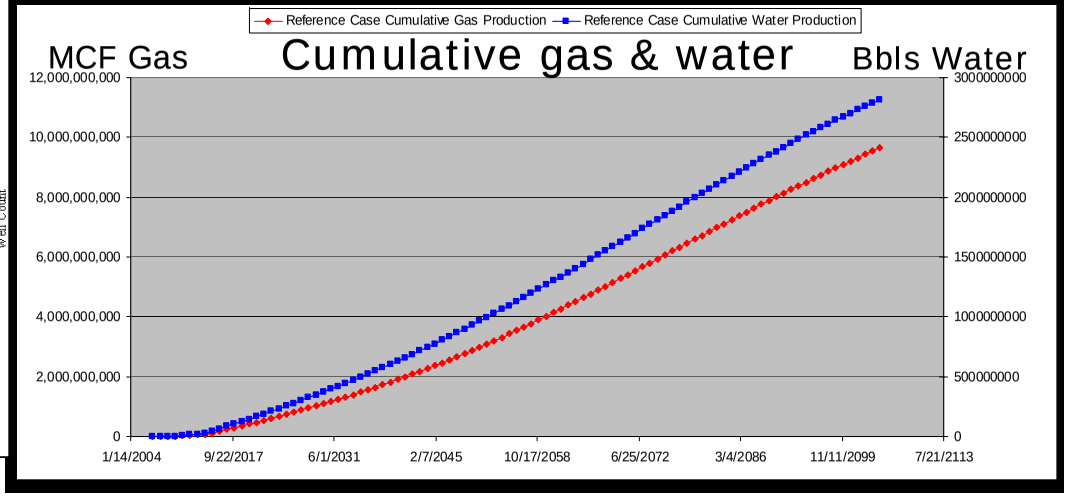


Case	Description	Well Count	Cumulative Gas, Time
Downside	Data and production testing negative	1-5	0 TCF
Reference	640 Acre development in “target” Area	172	2.5 TCF, 40 years 9.6 TCF, 100 years!!
Upside	Some 160 Acre infill development in field “target” Area & up-dip thermal &/or chemical methods applied	283	3.6 TCF, 40 years 11.8 TCF, 100 years!!

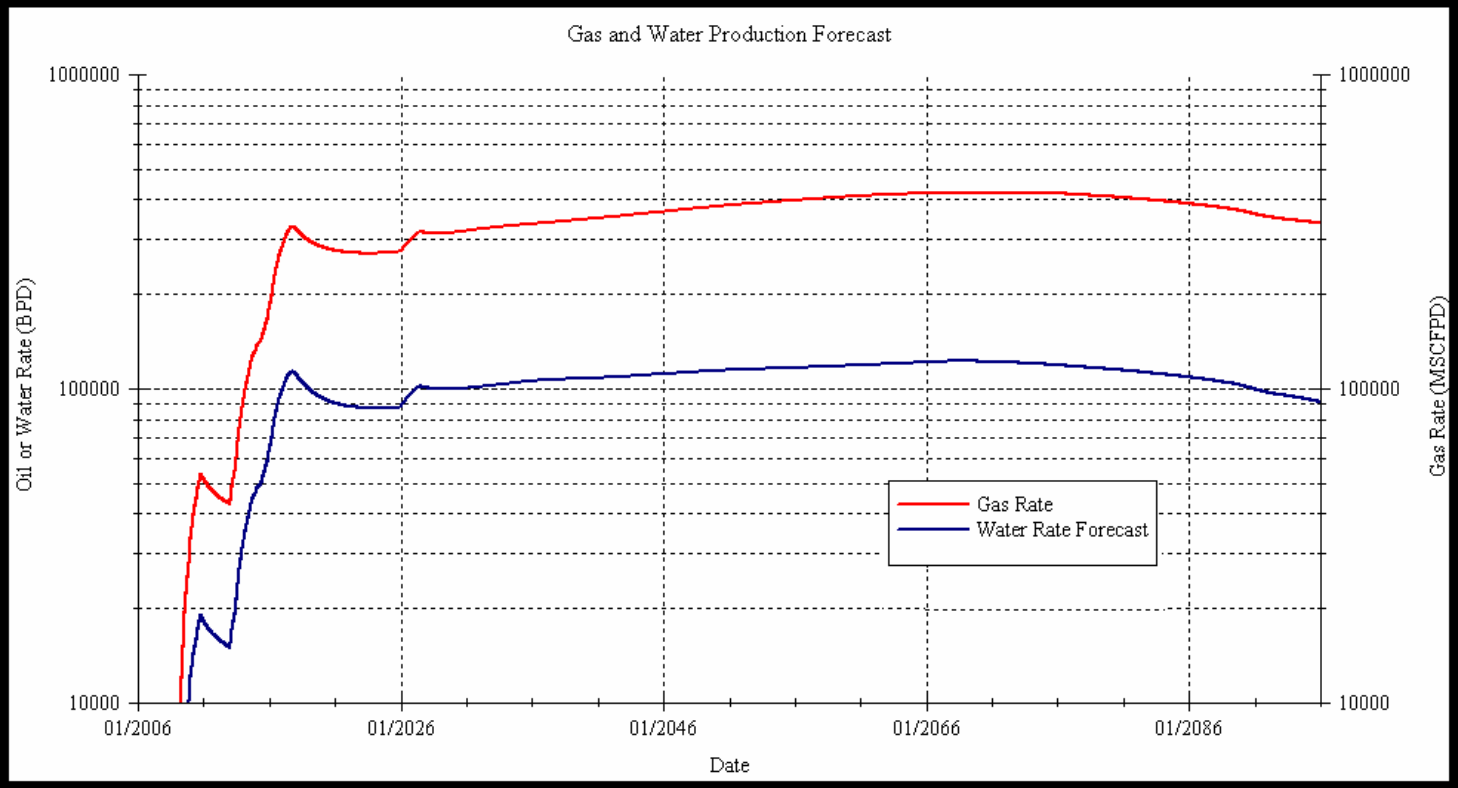
Reference Case Model

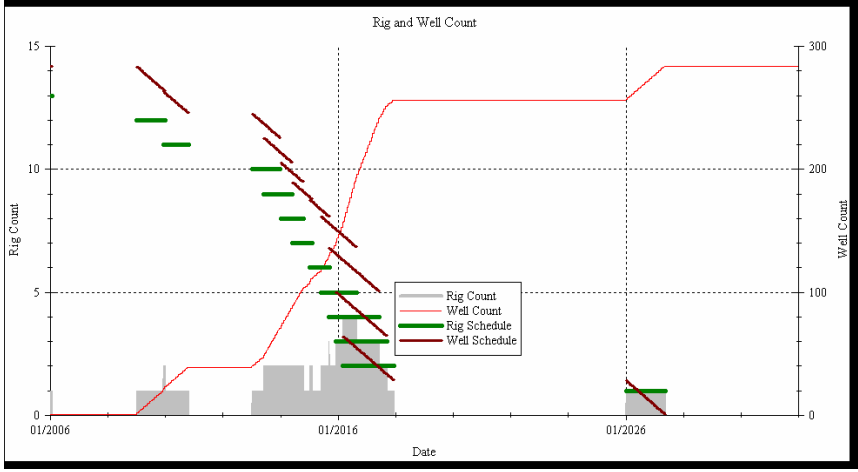


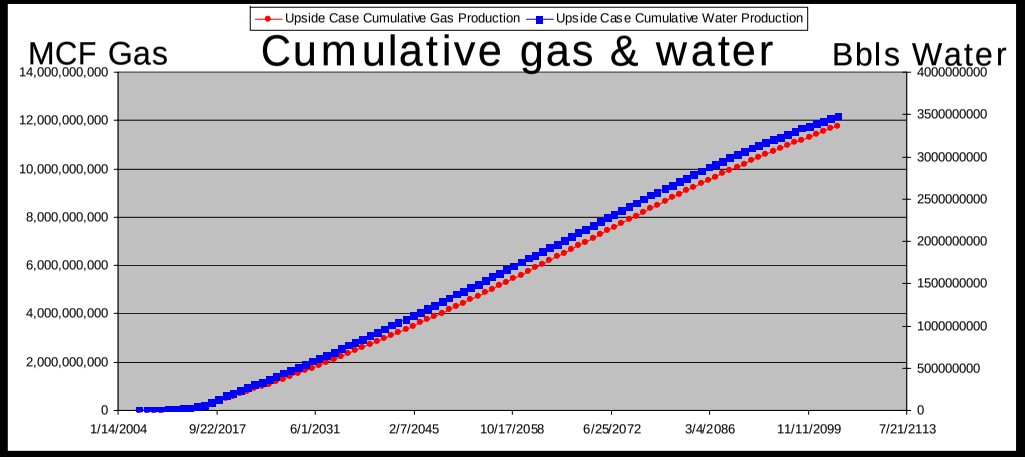




Upside Case Model







Downside Case Model

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Current Recommendations

- Phase 3a Stratigraphic Test: MPU MtElbert-01
  - Delineate Mt Elbert Intra-hydrate Seismic Prospect
  - Acquire Static Data: Core, Wireline, MDT Logging
  - Calibrate Development Models
- Evaluate Phase 3a Strat Test Data & Results
  - Lab Studies & Reservoir Model Calibration

Future

- Decision: Phase 3b Production Test Program
  - Identify Local Gas Use and Surface Facility Synergies
- Leading to ...
  - Revised Data Acquisition / Long-term Test Program OR
  - Research Closeout if Realize Downside Case

Gas Hydrate Resource Uncertainties

- Permeabilities: Initial and Dissociating
- Saturations: Initial and Dissociating
- Rates of Dissociation & Gas Production
- Rates of Associated Water Production
- Endothermic Effects of Production/Dissociation
- Production Technologies: Thermal, Sand Control, Artificial Lift, In-situ Combustion?

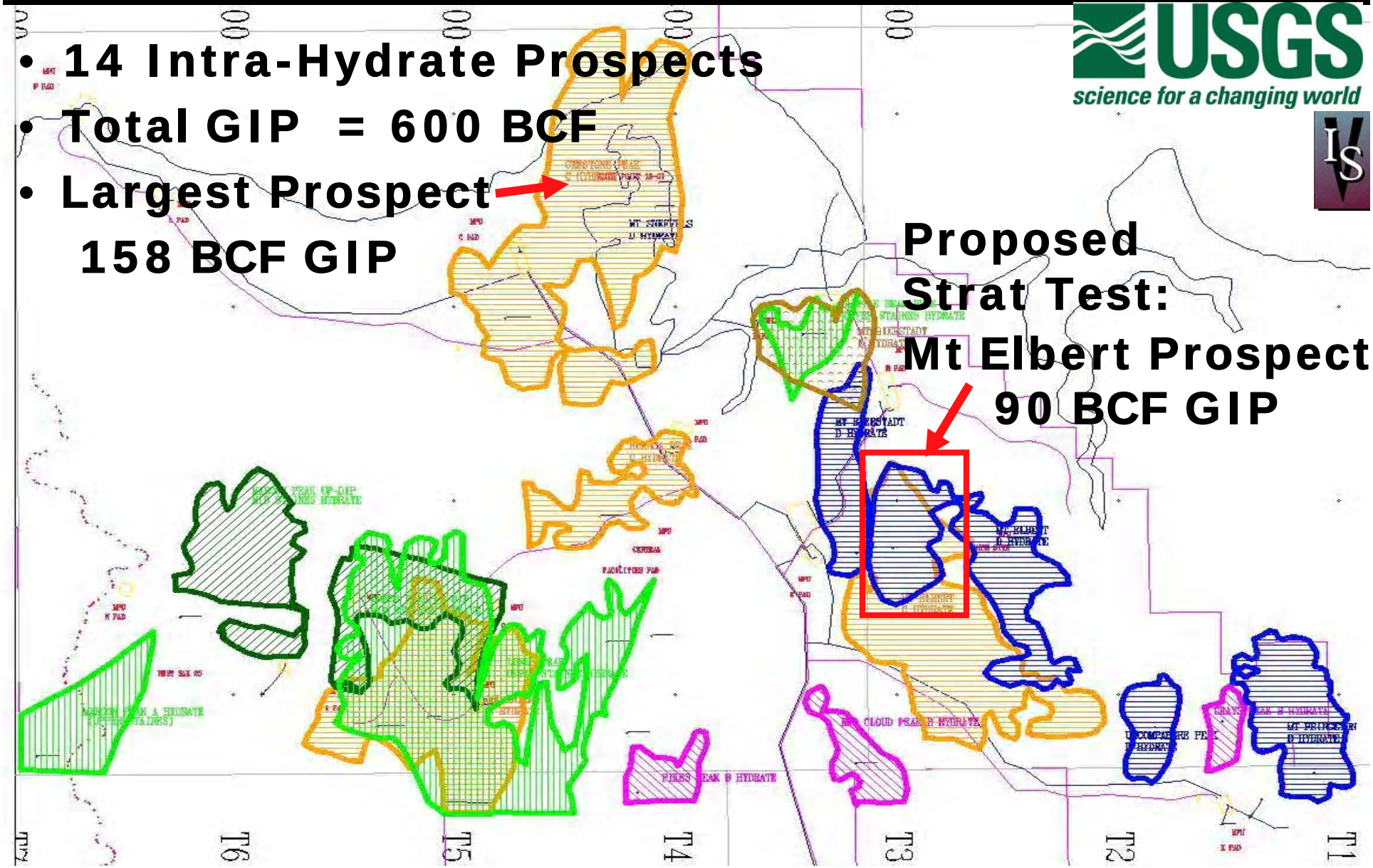
Uncertainty Mitigations

- Seismic Prospect Delineation – 3a
- Stratigraphic Test with Full Data Program – 3a
- Production Testing – 3b?

Mt Elbert-01 Data Acquisition Plans

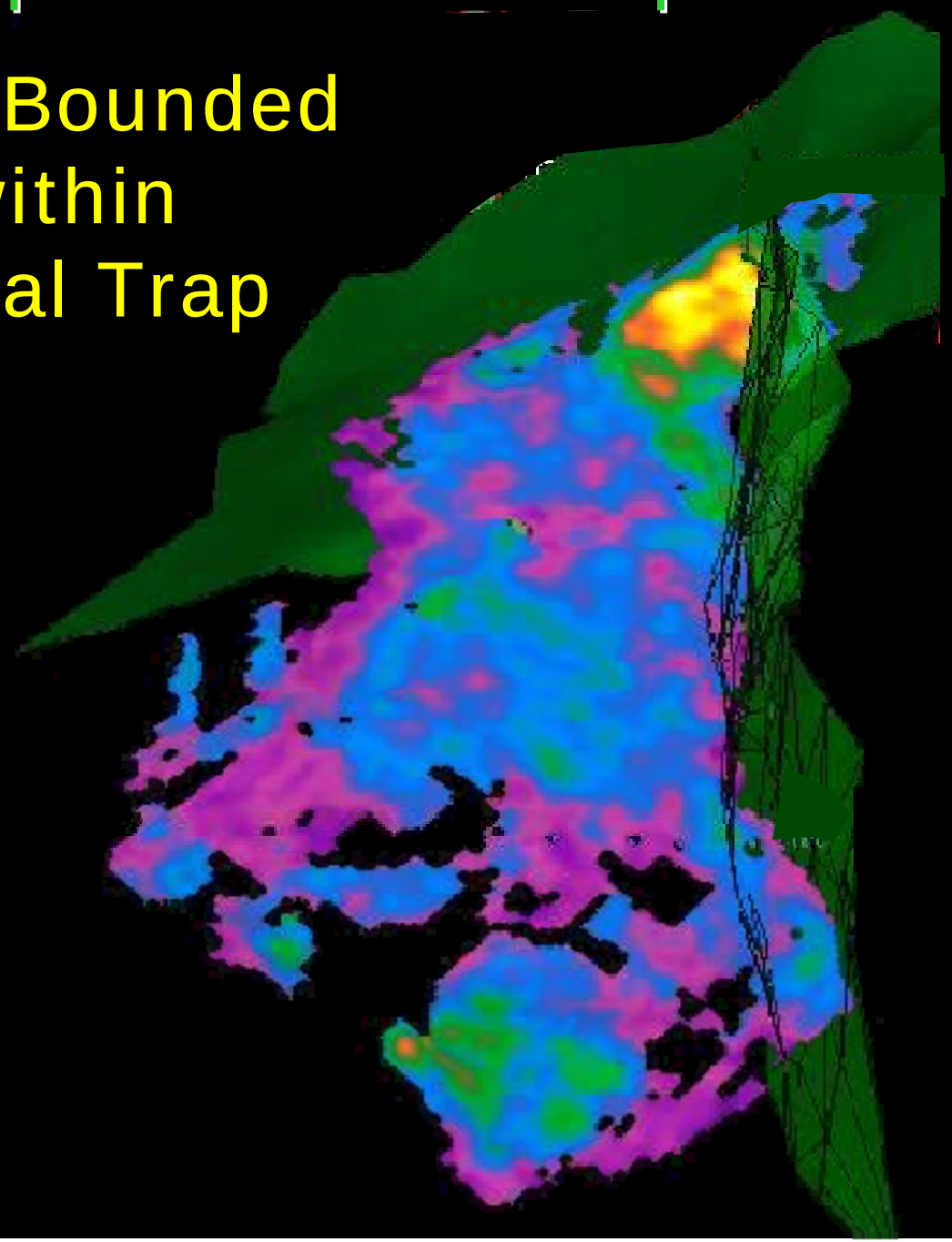
- Well and Ice Pad/Roads Permitted
- Well Scheduled to Drill January-February 2007
- 400-600’ Wireline-Retrievable Core
- Full Wireline Logging Program, 1,950’ – 4000’ GR/Res/N/D/ Dipole Sonic / NMR / FMI
- Full MDT Wireline Downhole Testing Program
  - 4 Open-hole Tests, 2 Zones, up to 10 hours per test
  - Contingency Liner for Cased Hole MDT Testing

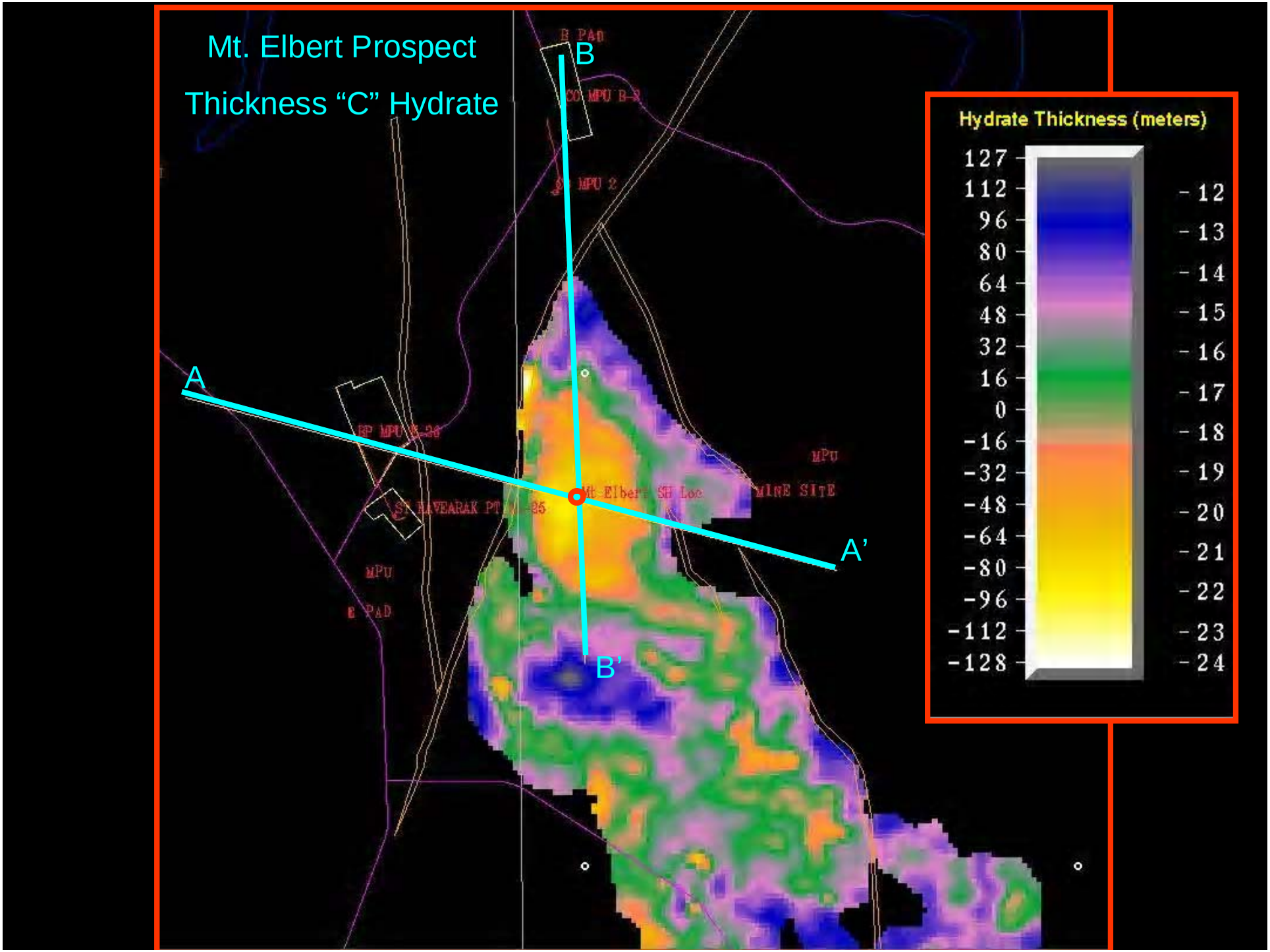
Gas Hydrate Prospect Mapping, MPU



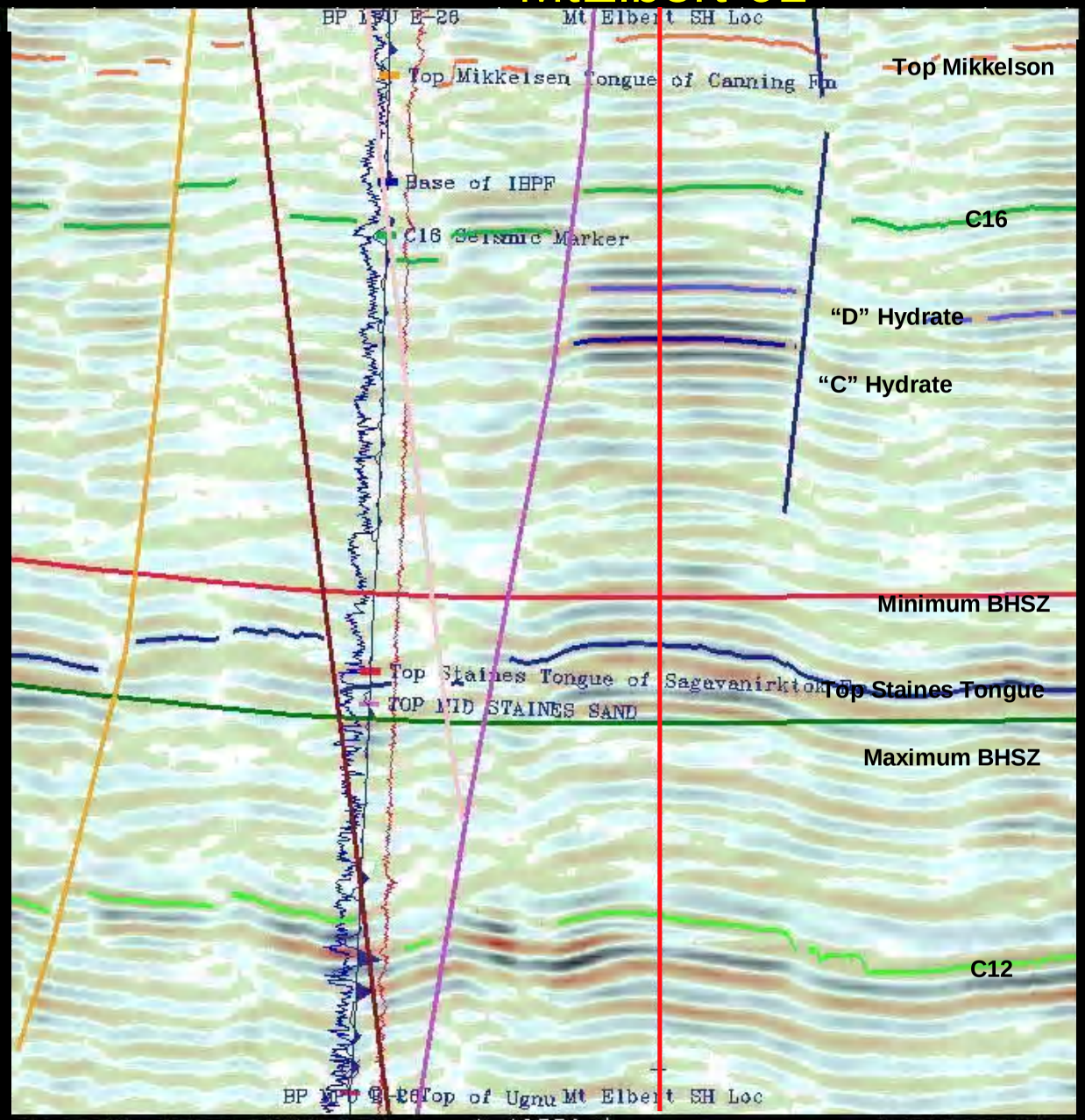
Mt. Elbert Prospect Seismic Amplitude

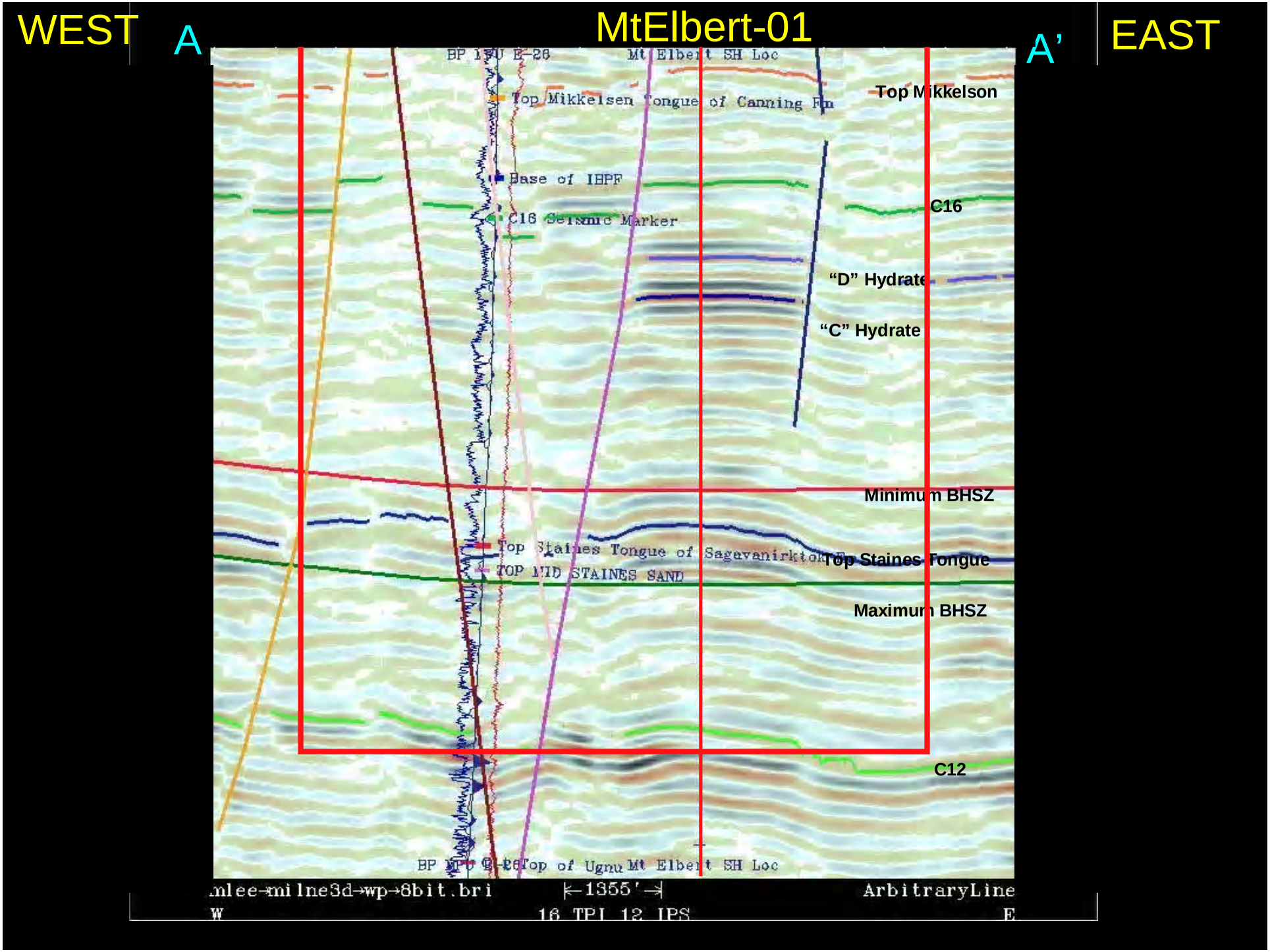
3-Way, Fault-Bounded
Closure within
Conventional Trap



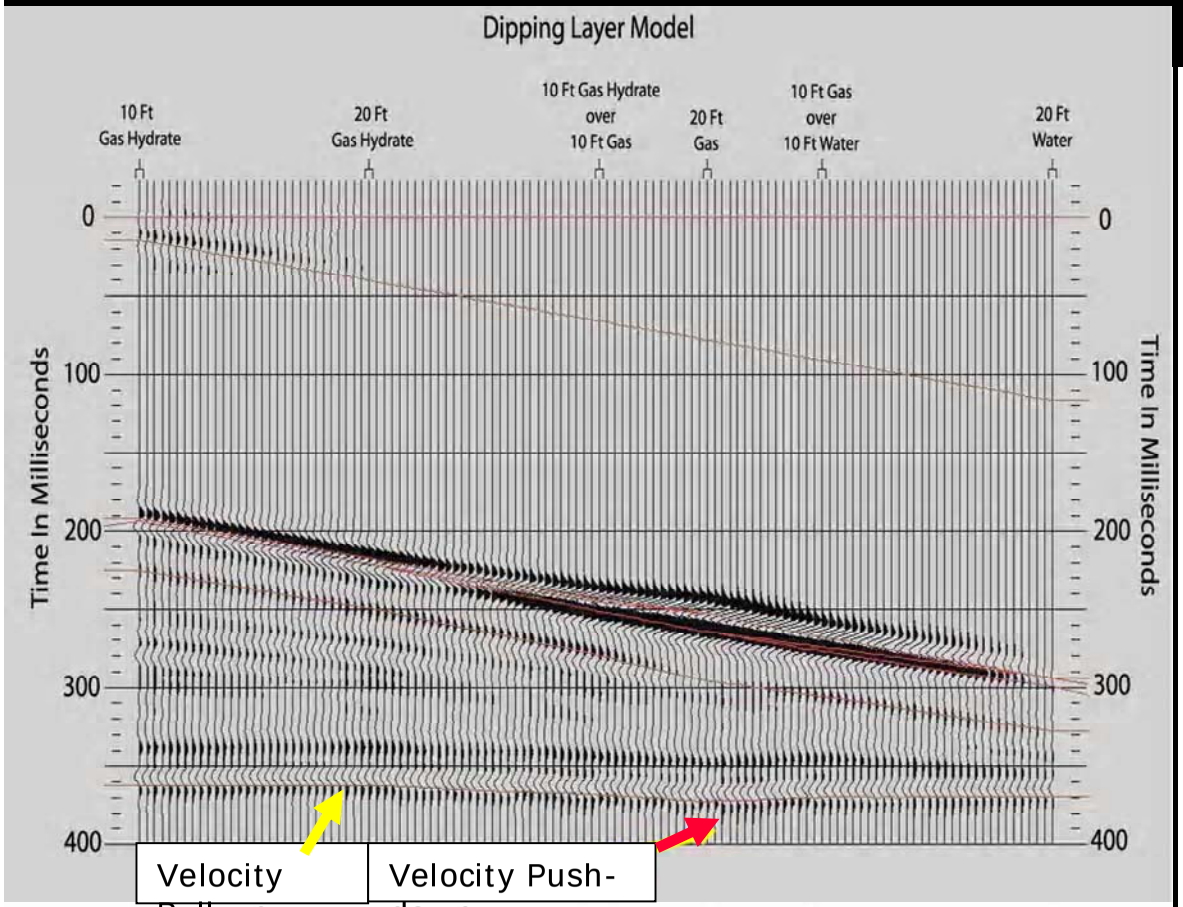

Mt. Elbert Prospect
Thickness “C” Hydrate
B
B’
A
A’
Hydrate Thickness (meters)
127
112
96
80
64
48
32
16
0
-16
-32
-48
-64
-80
-96
-112
-128
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
-23
-24

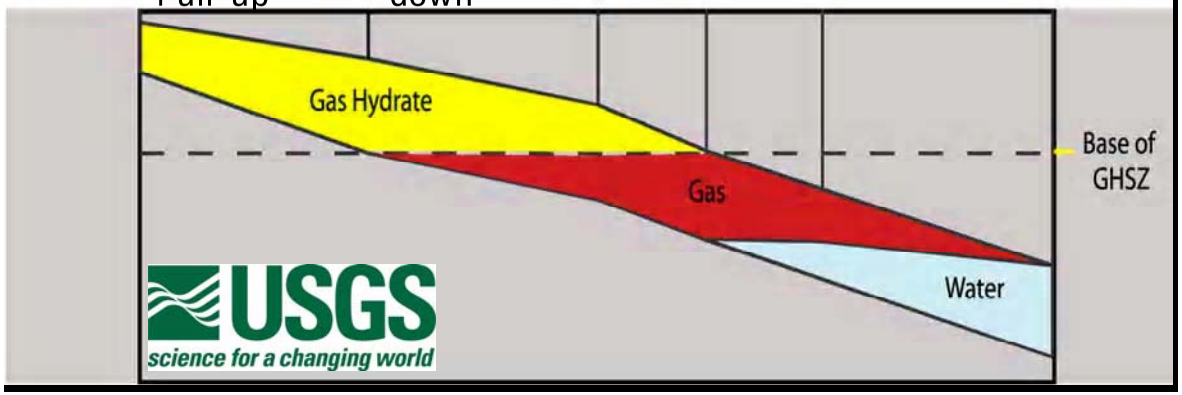
WEST A MtElbert-01 A' EAST



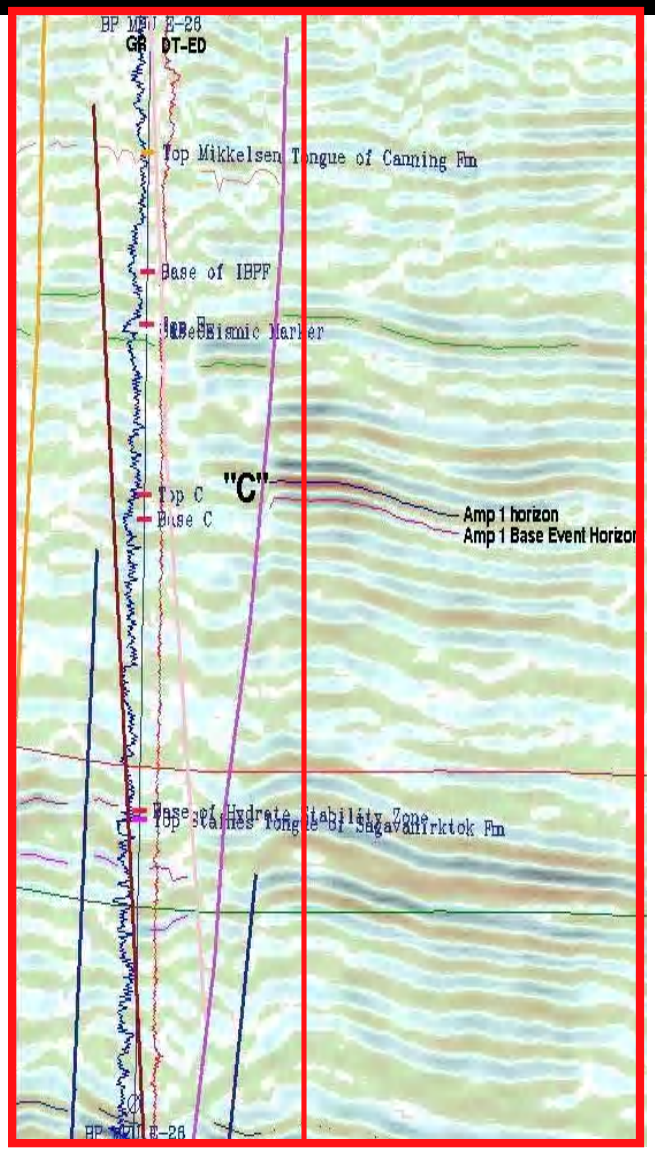

WEST
A
MtElbert-01
A'
EAST
Top Mikkelsen
C16
"D" Hydrate
"C" Hydrate
Minimum BHSZ
Top Staines Tongue
Maximum BHSZ
C12
Top Mikkelsen Tongue of Canning Fm
Base of IBPF
C16 Seismic Marker
TOP MID STAINES SAND
Top of Ugnu
Mt Elbert SH Loc
←1355'→
ArbitraryLine
16 TPI 12 IPS
W
E

Seismic Modeling and Velocities





MtElbert-01



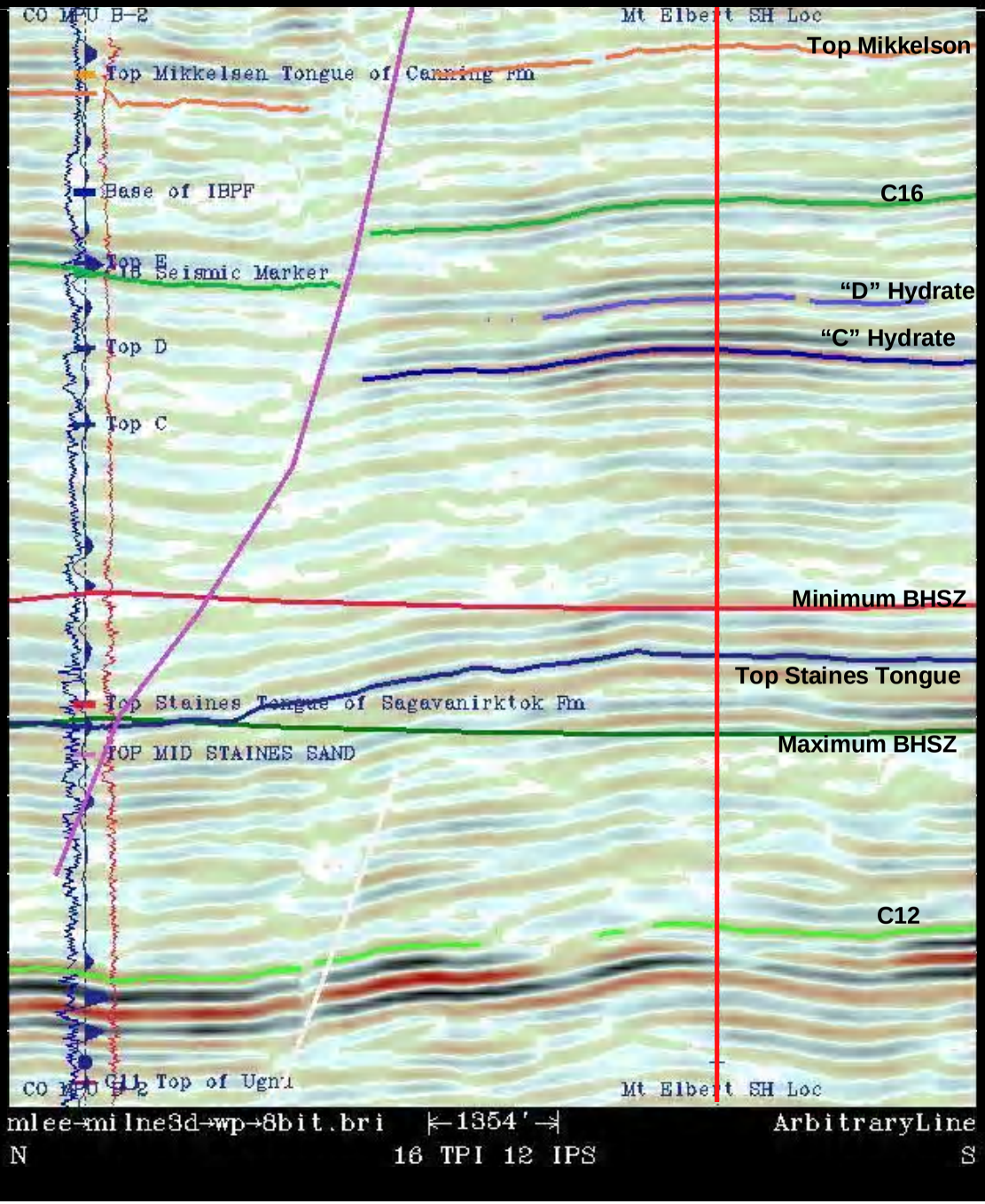
NORTH

B

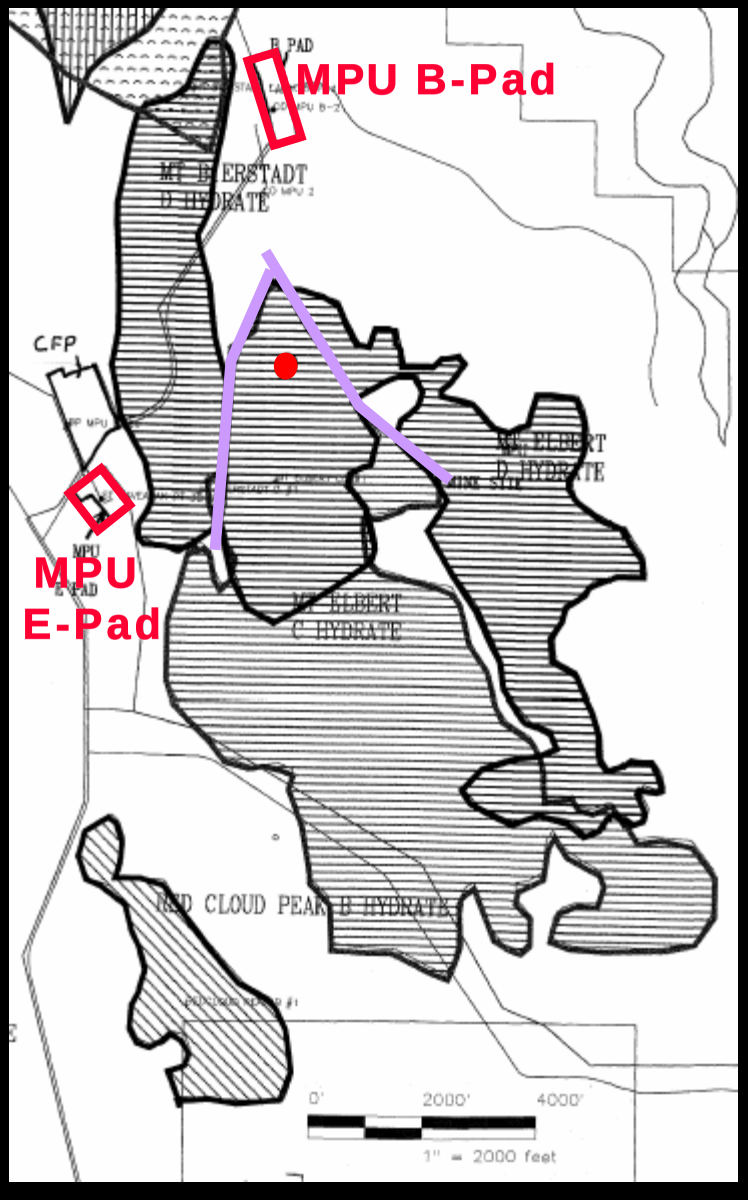
MtElbert-01

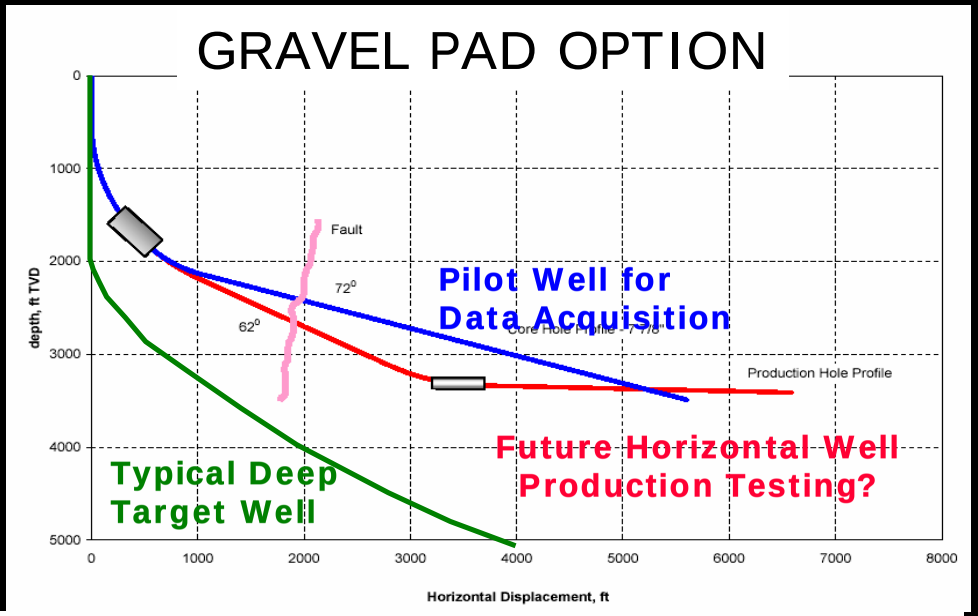
B’

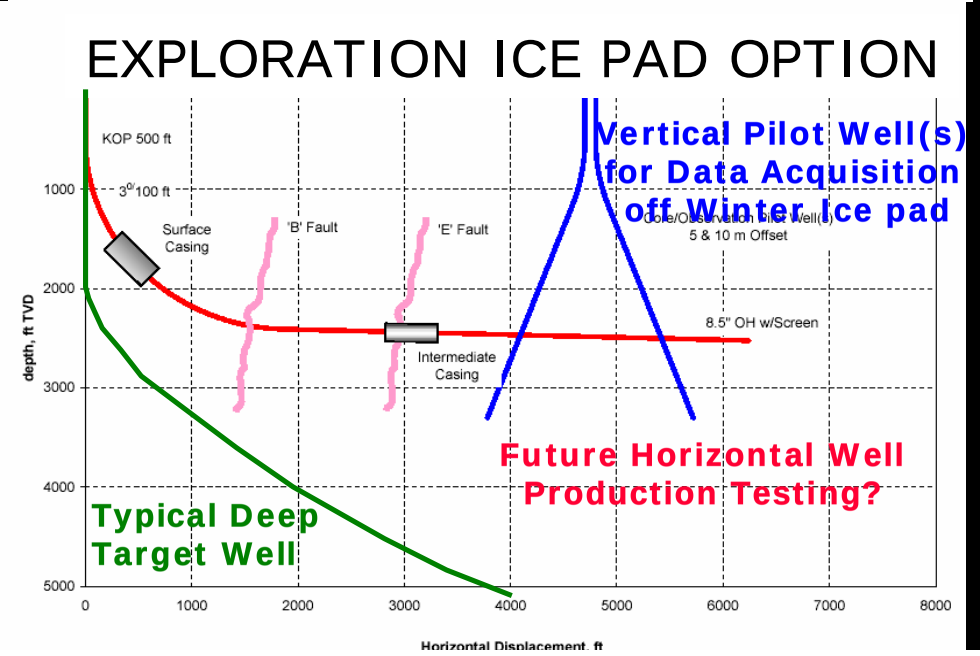
SOUTH

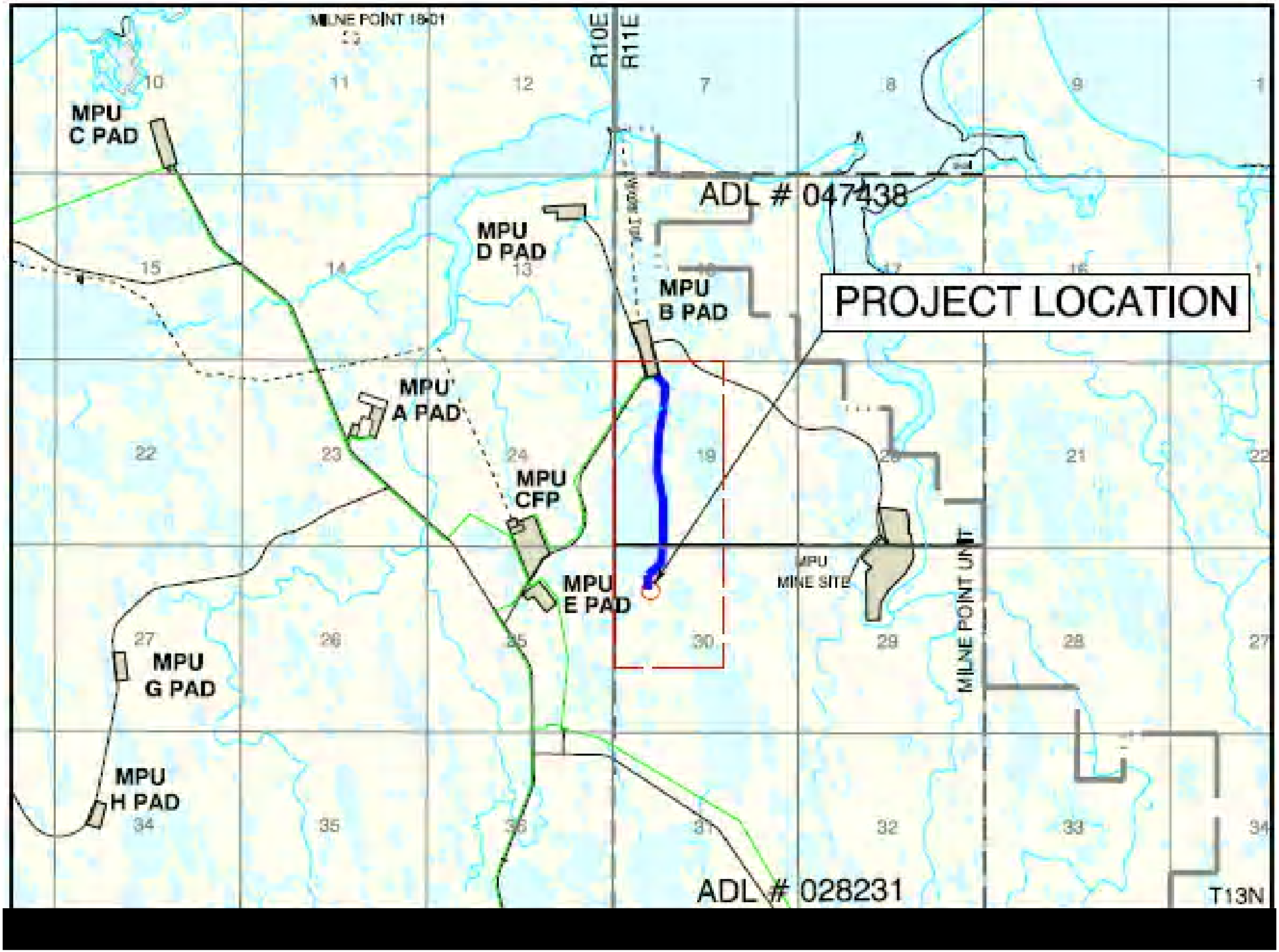


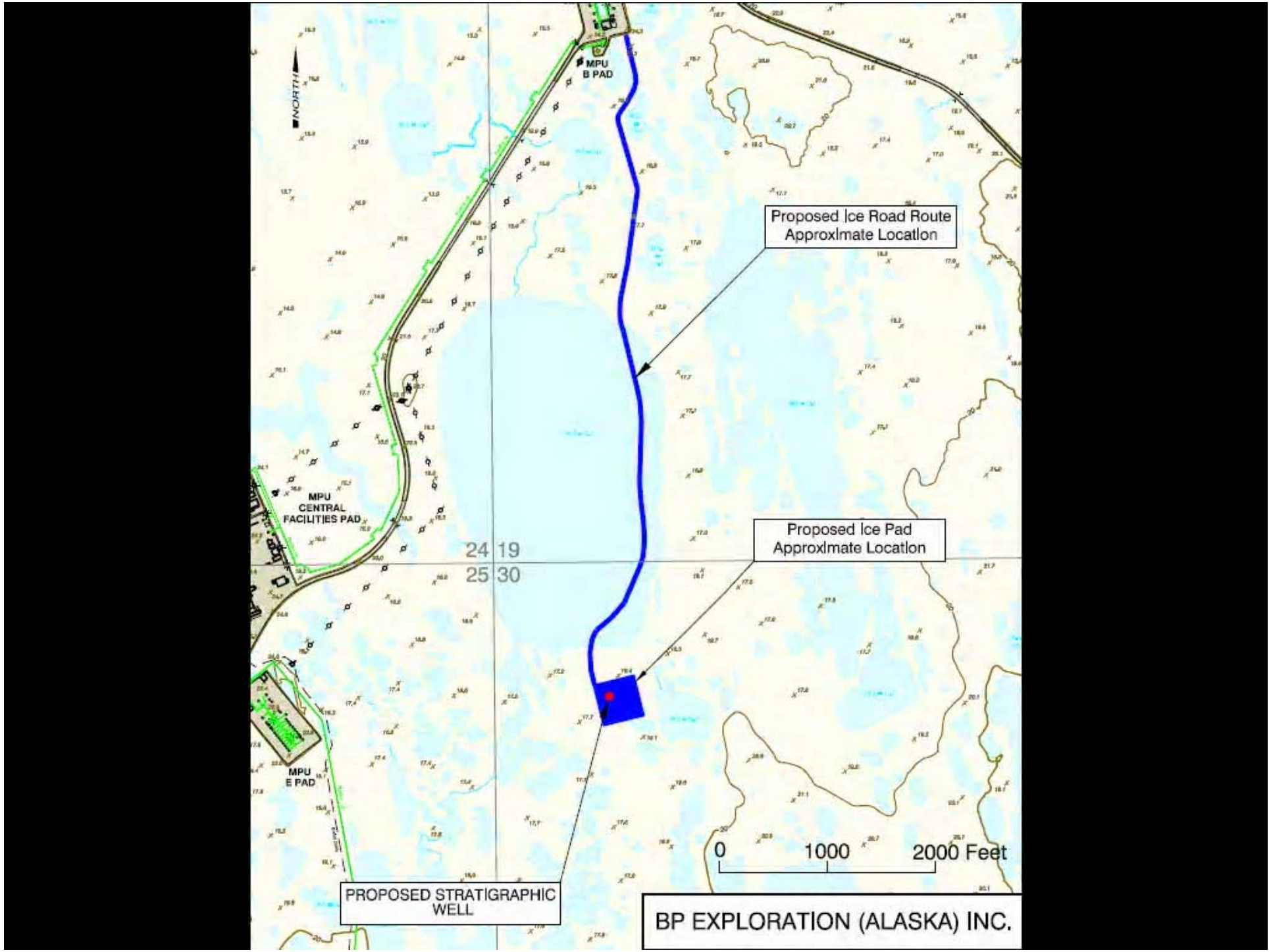
Phase 3a: Stratigraphic Test Plans








MILNE POINT 18401
R10E
R11E
MPU
C PAD
MPU
D PAD
MPU
B PAD
ADL # 047438
PROJECT LOCATION
MPU
A PAD
MPU
CFP
MPU
E PAD
MPU
MINE SITE
MILNE POINT UNIT
MPU
G PAD
MPU
H PAD
ADL # 028231
T13N


MPU
B PAD
Proposed Ice Road Route
Approximate Location
MPU
CENTRAL
FACILITIES PAD
24 19
25 30
Proposed Ice Pad
Approximate Location
MPU
E PAD
0
1000
2000 Feet
PROPOSED STRATIGRAPHIC
WELL
BP EXPLORATION (ALASKA) INC.

Doyon14 Rig

- BP-Contracted Rig
- BP MPU Ice Season
  - 1 Hydrate Well
  - 2 Non-hydrate Wells
- Gas Hydrate Well 1st

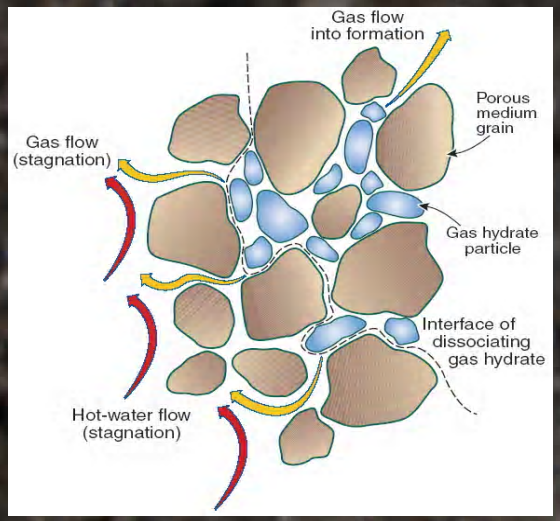
Mud-Chilling System

- Maintain Gas Hydrate and Borehole Stability
- Key Safety and Data Acquisition Component

Mud-Chilling Unit, Courtesy Mallik Research Project, 2002

Gas hydrate commonly exists as a pore filling phase in reservoir sands

3-inch wireline core from Mallik



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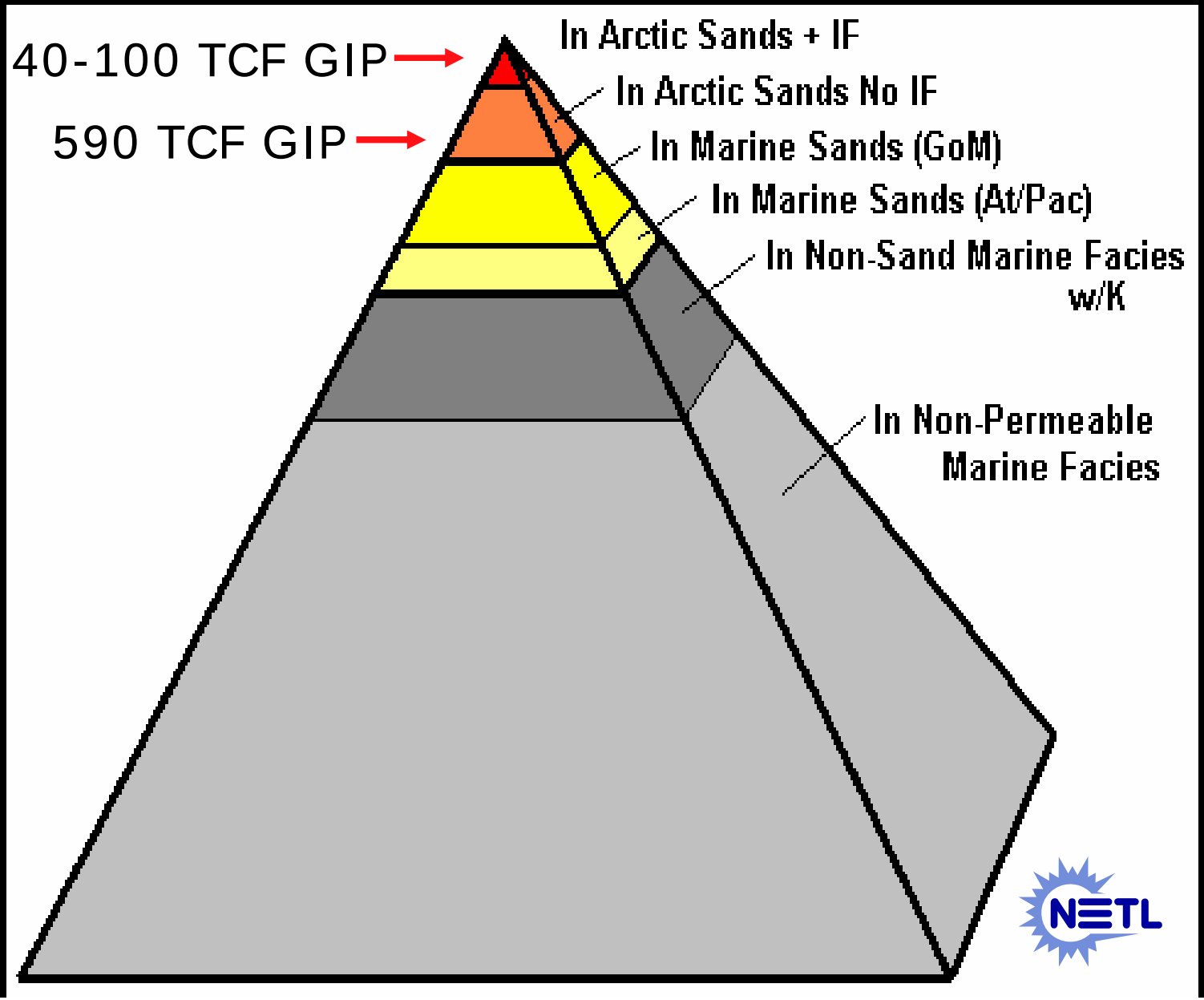
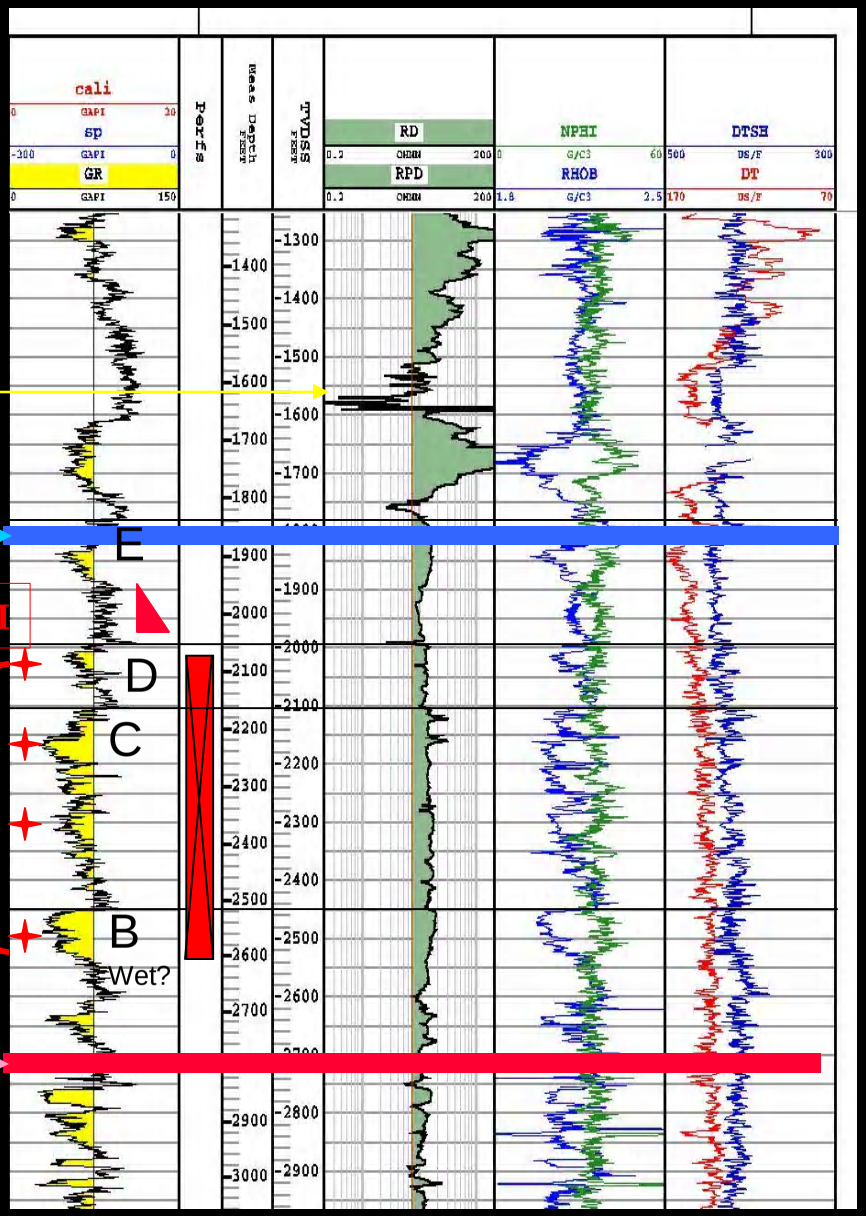
Resource Prize Pyramid



MtElbert-01 Type Log

Formations/Risk



Mid-Eocene Unconformity

~Base Permafrost

Mud-Chilling & OBM

Sagavanirktok Gas Hydrate-Bearing Zones E, D, C, B

~ Sagavanirktok Core Interval

~Base Hydrate Stability

Schematic OH MDT

Casing Program

12-1/4” hole
9-5/8” surf. csg.

7-5/8” hole
3” WL core
8-1/2” Ream
8-1/2” hole to TD
7” Cont. liner
if fail OH MDT

Preliminary Conclusions

- ANS – Gas Hydrate Petroleum System
  - Complex Shallow Structure & Stratigraphy
  - High-graded MPU Prospects
- Theoretical Modeling Results to Date
  - Potential Resource 33 TCF GIP Eileen Trend
  - Broad Potential Recoverable Range: 0-12 TCF
  - Uncalibrated Modeled Production Rates
    - 0-2 MMSCF/d/well
  - Production Character Long with Flat Declines
  - Takes Decades to Recover EUR
  - How to Sustain Gas Flow in Cold Regime
- Significant Uncertainties Remain