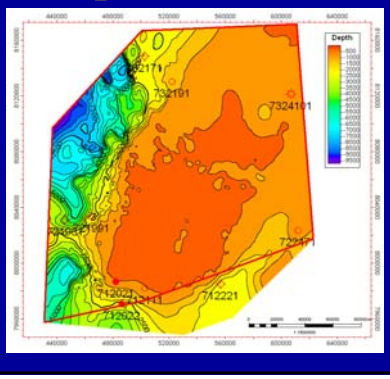
Prospect Evaluation



Exploration Strategy

1. Global Basin Analysis — Complete Basin Studies, Acquire New Exploration Licenses
2. Develop Play Concepts
3. Define Exploration Play Areas
4. Evaluate Prospects — Compile Full Lead & Prospect Inventory
5. Identify Drillable Prospects — Drillable Prospects/ Well proposals
6. Drill Exploration Wells — Identify new reserves?
7. Develop New Field

Definitions

- A Play: An exploration concept that includes a specific source, reservoir, and trap type
- A Lead: An possible trap, data is not sufficient to fully map it.
- A Prospect: A specific trap that has been identified and mapped but has not been drilled yet.
- Wildcat Well: A well far from previous drilling
- Reserves: Oil and gas that have been drilled and can be produced economically

CRITICAL DECISIONS?

- Which Play to Enter
- Which Prospects to Drill
- Play and Prospect Decisions Require Methodical Analysis
  - Technical Risk Evaluation
  - Economic Evaluation

Basin/Play Evaluation

1. Basin Scale Assessment
2. Estimation of undiscovered potential within each Play
3. Volumetric Calculations (Reserve estimates)
4. Assessment of Prospect-Specific Risk
5. Economic Analysis
   - Infrastructure
   - Market
   - Price
   - Taxes and Royalties
   - Political Risks

Probability of Success

Example ↓

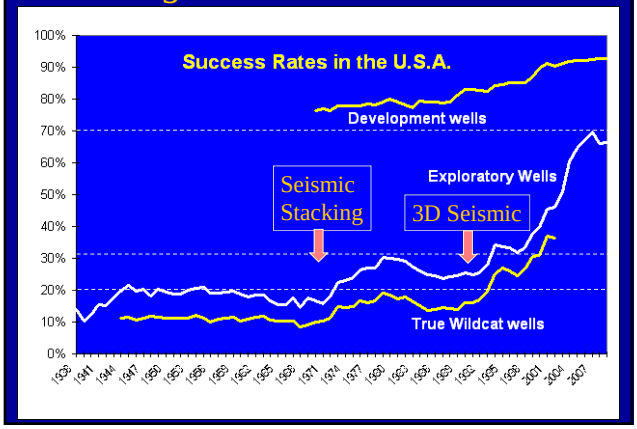
Risk Factor		Risk (0-1.0)
◆ Probability hydrocarbon charge		0.80
◆ Probability of good reservoir		0.80
◆ Probability of a trap		0.70
(Multiply all the factors)	Chance of Success	0.44

To drill or not to drill?

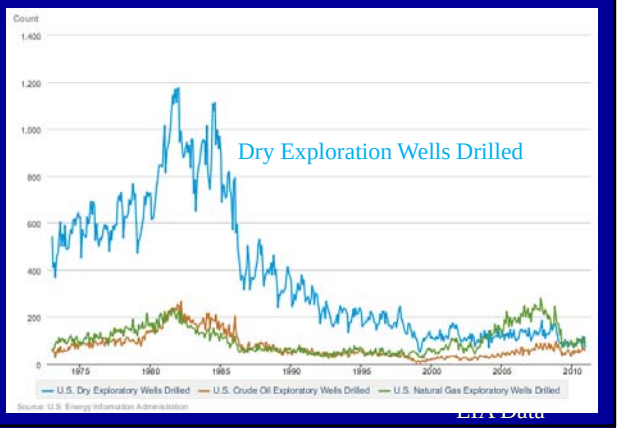
- Basin-scale Conventional Play Assessment:

1) Identify areas of a basin where there are: source rocks, reservoirs and traps
2) Identify prospects in those areas
3) Rank the prospects by risk
4) Drill the best one, then re-evaluate the others

Drilling Success Rates



Drilling of Exploration Wells in US

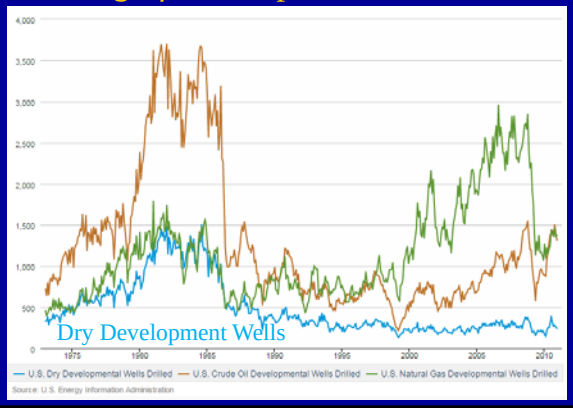


EIA Data

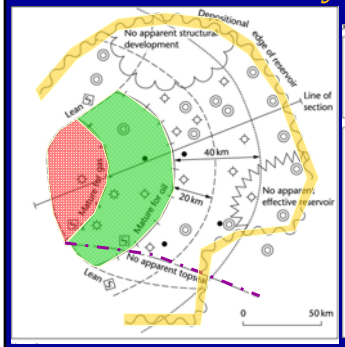
More Detailed Risk Factors

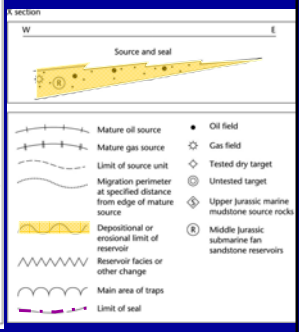
- Hydrocarbon charge
  - Source Rock Quality (TOC, Kerogen type)
  - Maturity of Source Rock
  - Migration Pathways
- Reservoir
  - Porosity
  - Permeability
- Trap
  - Closure (Trap volume)
  - Top Seal, Fault Seal (Trapping efficiency)
  - Timing

Drilling of Development Wells in US

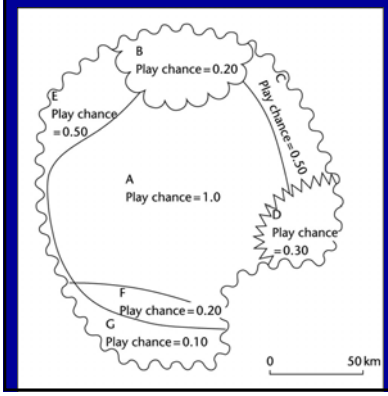


Basin-wide Play Map



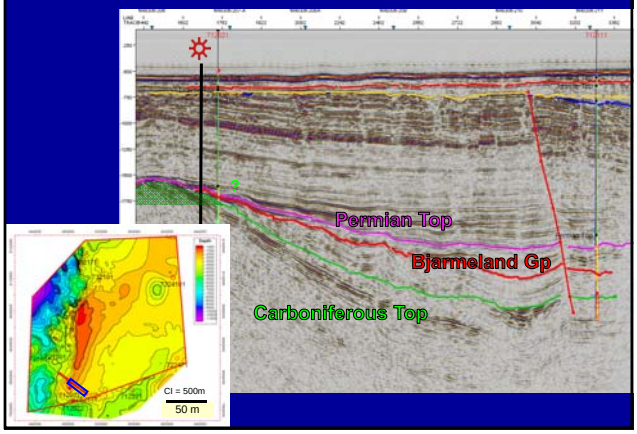


Probability of Play Success



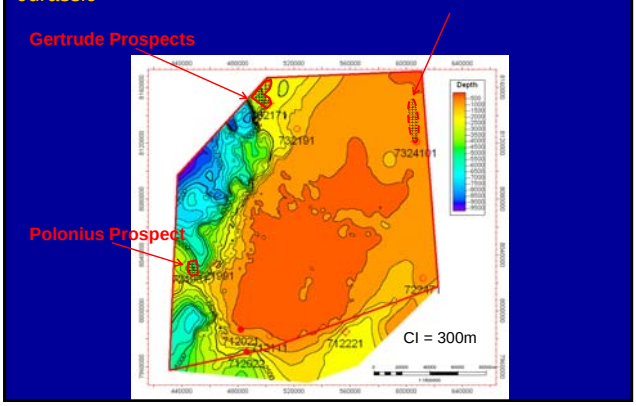
A. Everything is cool (100%)
B. No structural traps (20%)
C. Long migration required (50%)
D. Long migration and bad reservoir (30%)
E. Poor source (50%)

HAMLET Prospect

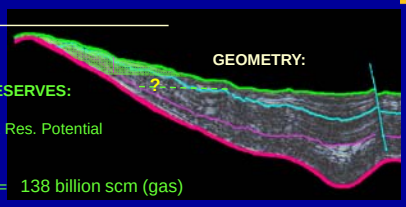


Prospects Evaluation, Barents Sea

Jurassic



Hamlet



ESTIMATED RESERVES:

Risk Elements x Res. Potential

P_{50} = 138 billion scm (gas)

RISK ELEMENTS:	.34
Source Presence =	1
Source Maturity =	1
Reservoir Quality* =	.6
Trap Quality =	.8
Migration/Trap Timing =	.7

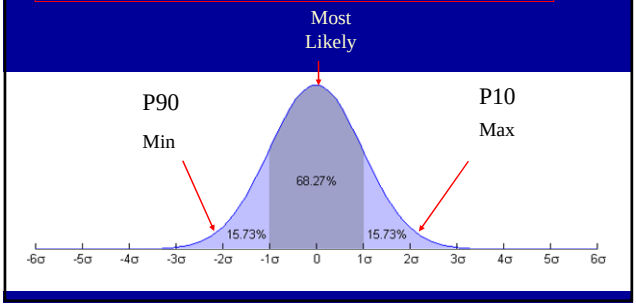
RESERVOIR POTENTIAL:	P_{90}	P_{10}
Pay Aerial Extent =	200km²	340km²
Pay Thickness = * (Multizone)	750m	1050m
Porosity =	7 %	15 %
Saturation =	40 %	60 %

411 Billion scm

Probability Distribution

Every risk element of a prospect is imperfectly known before drilling.

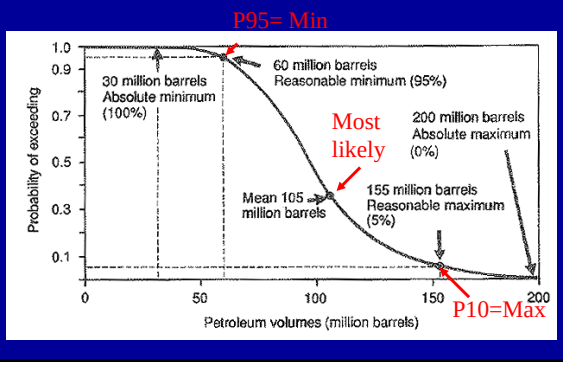
P90 = “I am 90% sure that it will be bigger than this”



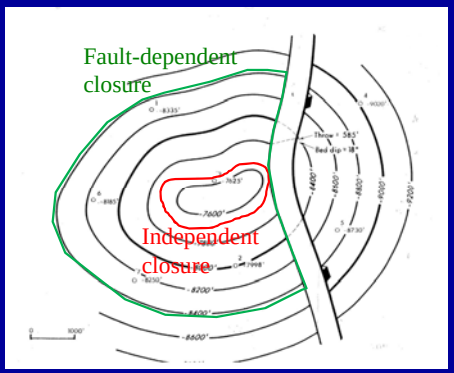
Volumetric calculation

- Reserves=
  - Area of trap x
  - Net reservoir thickness x
  - Porosity x
  - Hydrocarbon saturation x
  - Recovery factor x
  - Formation volume factor

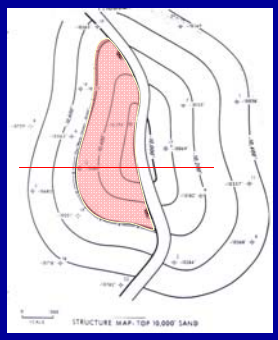
Cumulative Probability

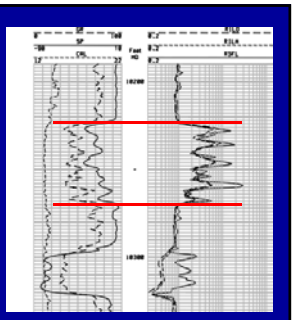


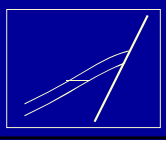
Area Risk



Volumetric Example





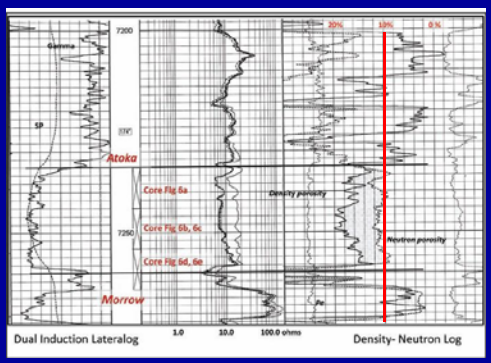


Thickness: 48 ft
Net/Gross: 0.40
Net Thickness = 19 ft

Recovery Factor

- Oil in place vs. Reserves
- Most of the oil stays stuck in the reservoir
- Reserves “can be produced economically”
- Varies widely depending on permeability, oil viscosity, reservoir pressure, etc.
- 30% average?

Net Reservoir – Set Porosity Cut off

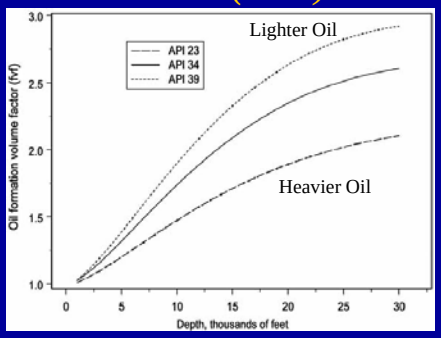


Only include the high porosity reservoir

Formation Volume Factor

- Change in volume from reservoir to surface conditions
- Depends on Reservoir Temp, Pressure and gas-oil ratio
- 1 to 3.0
- High shrinkage oil B_{oi}= 1.4
- Low Shrinkage oil B_{oi} = 1.2

Alaska North Slope Formation Volume Factor (FVF)

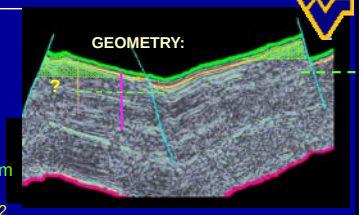


Gertrude

ESTIMATED RESERVES:

Risk Elements x Res. Potential

P_{50} = 0.80 billion scm

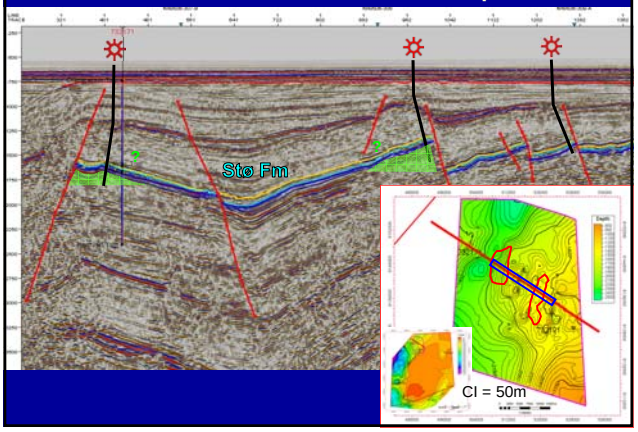


RISK ELEMENTS:	
Source Presence =	.8
Source Maturity =	.6
Reservoir Quality =	.7
Trap Quality =	.7
Migration/Trap Timing =	.5
	.12

RESERVOIR POTENTIAL:	P_{90}	P_{10}
Pay Aerial Extent =	25km²	27km²
Pay Thickness =	140m	150m
Porosity =	9 %	11 %
Saturation$_c$ =	70 %	80 %

6.84 Billion scm

GERTRUDE Prospect



How to compare two prospects?

- Small size, Low Risk
- Reserves= 6.8 billion
- Chance of success= 30%
- Risked volume= 6.8 * 0.30= 2 billion scm

- Big size, High Risk,
- Reserves= 14 billion
- Chance of success= 12%
- Risked volume= 14* 0.12= 1.68 billion scm

"Risked Reserves"

North Slope Basin Scale Assessment

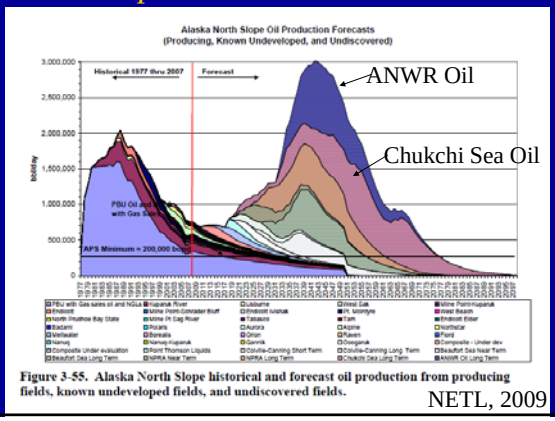


Figure 3-55. Alaska North Slope historical and forecast oil production from producing fields, known undeveloped fields, and undiscovered fields.

NETL, 2009

Take Home Ideas

- Exploration is about reducing risk by collecting the right data
- Risk comes from uncertainty (incomplete knowledge)
- Reserves calculations require quantitative evaluation of all components of the Petroleum System