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Subsurface Risk and Uncertainty in Petroleum Exploration-The Challenges

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Content of Talk

- The need
- Definition of Risk & Uncertainty
- Approaches to Risk and Uncertainty
- Bias
- Process



Who Does It?

- **Private Sector Petroleum E&P companies**
- **State Petroleum companies**
- **Government agencies and ministries**
- **Consultants**
- **Non Government Agencies**

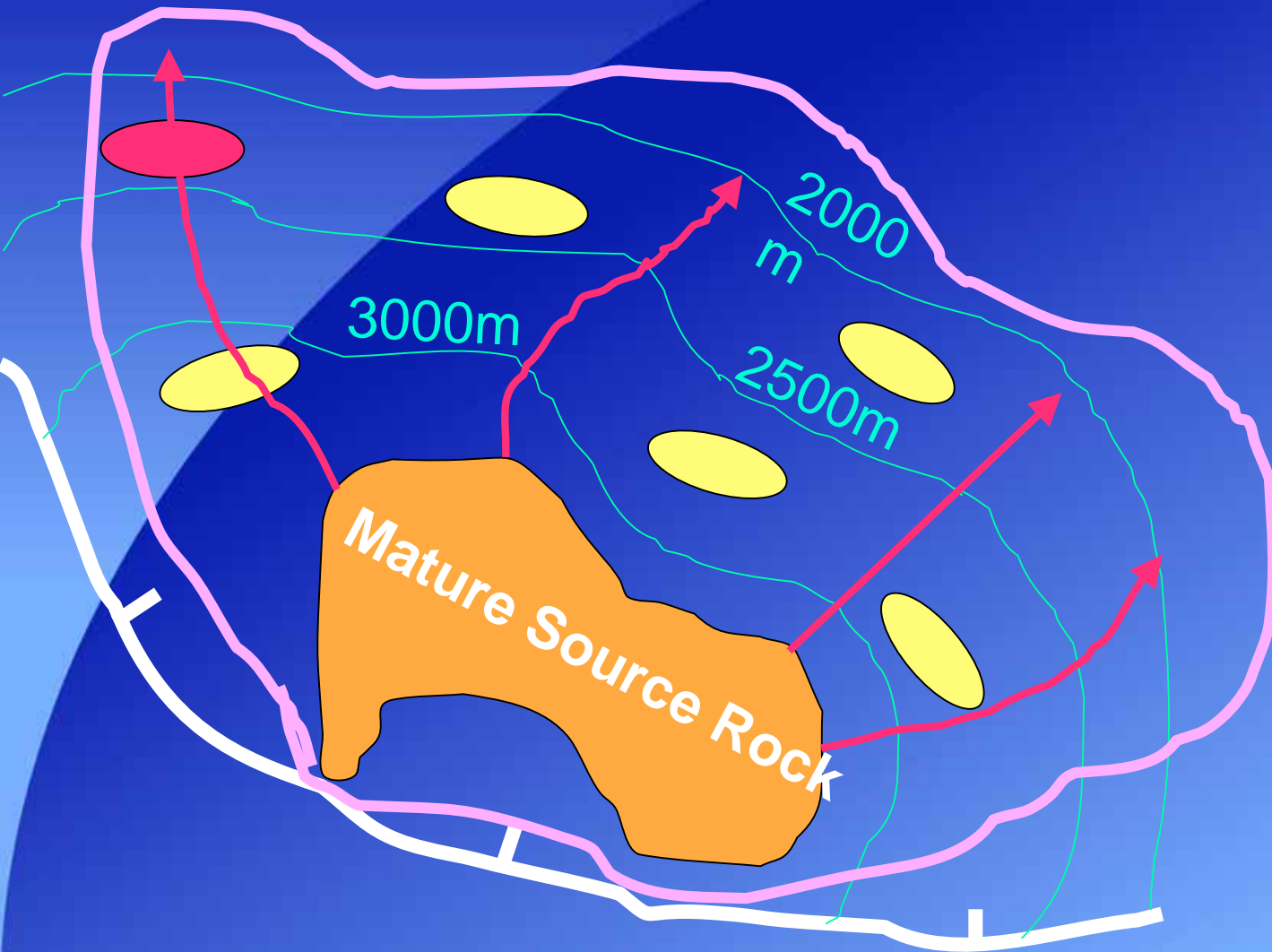


What Is It for?

- Estimating prospect volumes
- Estimating play, system, basin potential
- Estimating national potentials
- Estimating regional and global potential
- Bottom line is economic assessment but strategic assessments are also important



Petroleum System Potential



Global Potential

Depending on your source the remaining global potential is estimated (since 1950s) to be anywhere between 1 and 4 trillion barrels. Over the years many estimates have centred around 2 trillion barrels.



Definition of Risk

- To take a risk is to do something you are not sure you are able to do. You are only trying to do it
- Risk-taking means doing something whilst tacitly or explicitly estimating, on incomplete data, ones capacity to do it



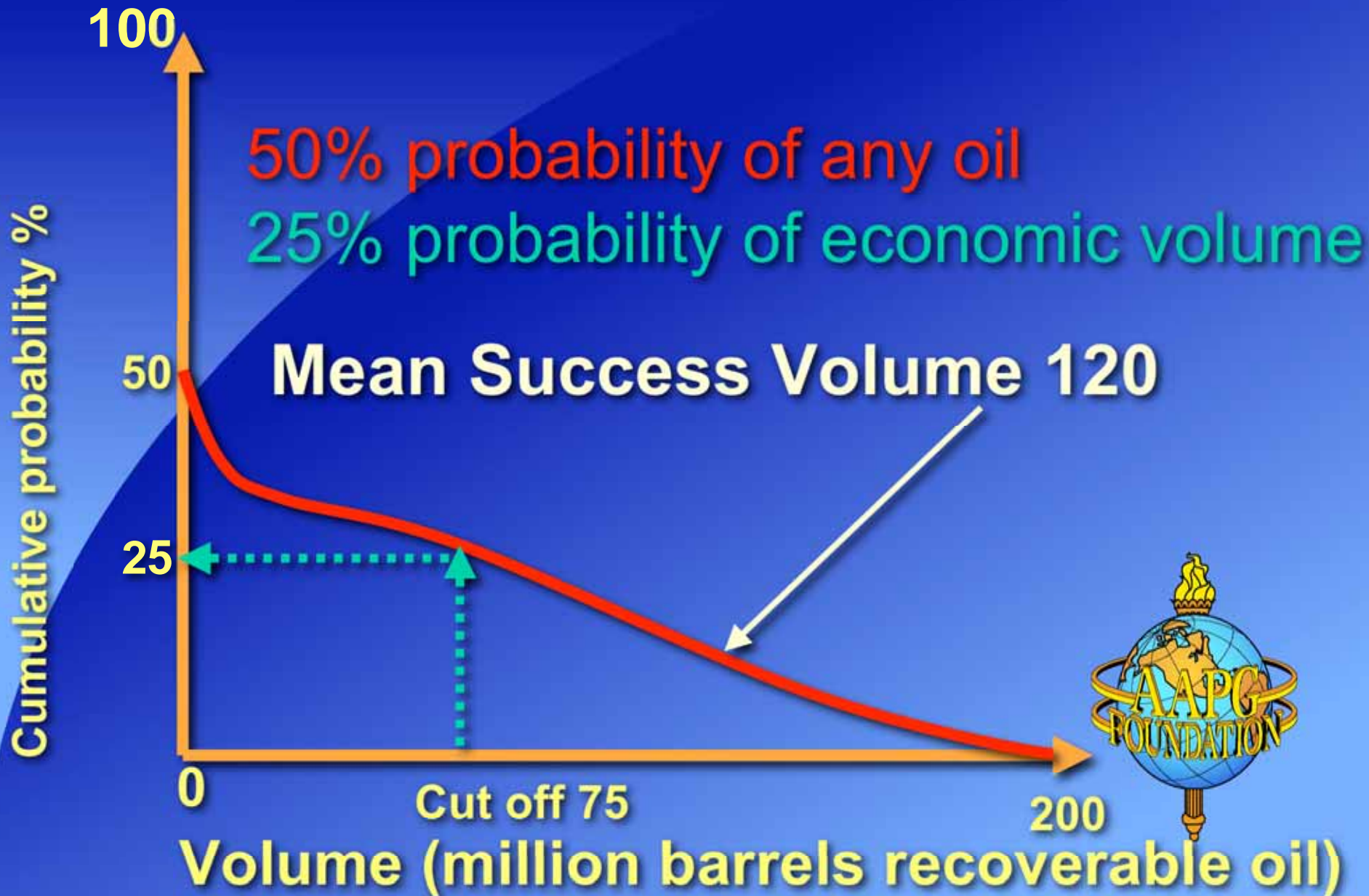
Adapted from Cohen & Hansel, 1956

Definition of Uncertainty

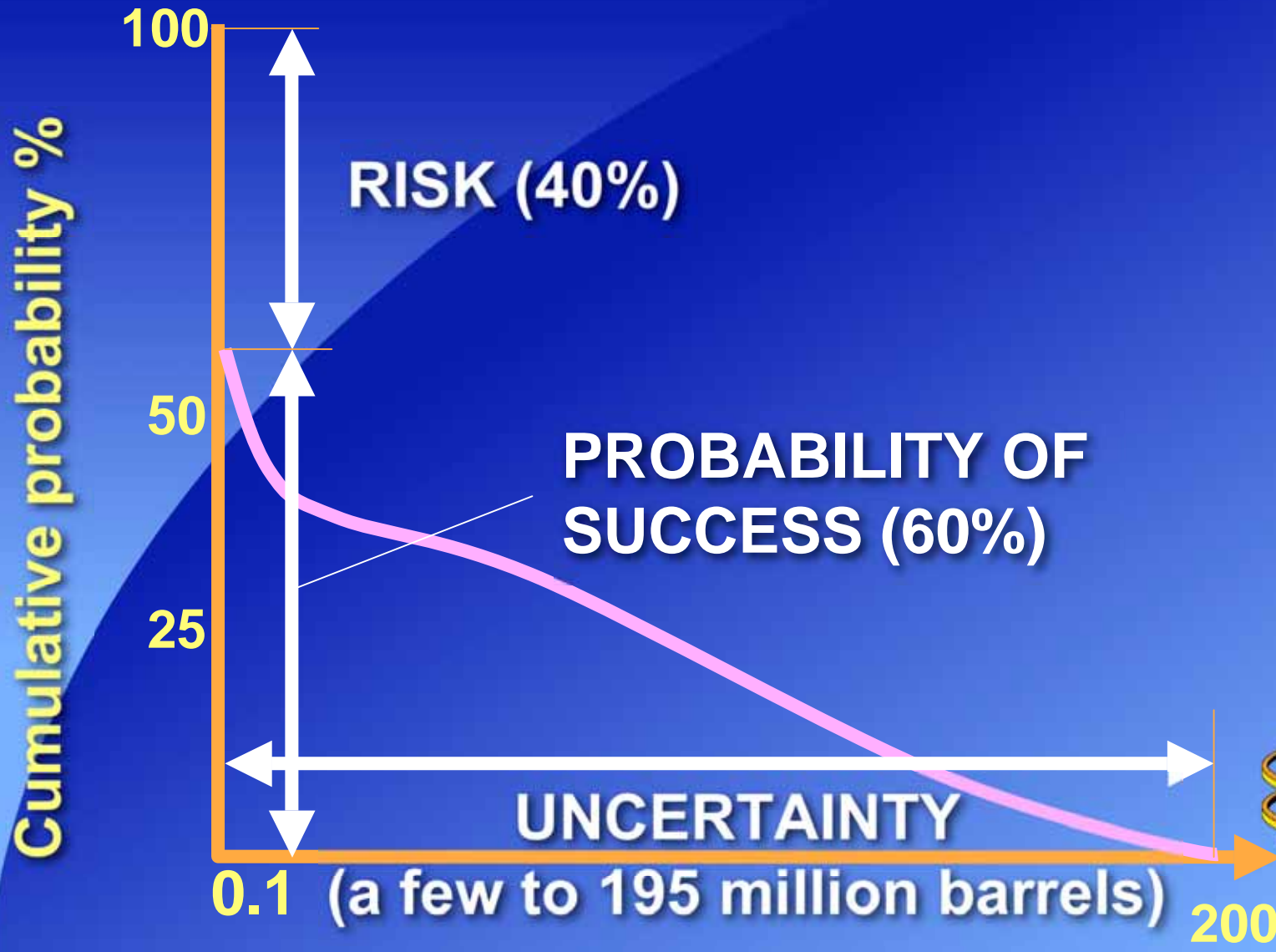
- Looking forward, uncertainty encompasses the range of possible outcomes, some of which involve success/gain and others involve failure/loss



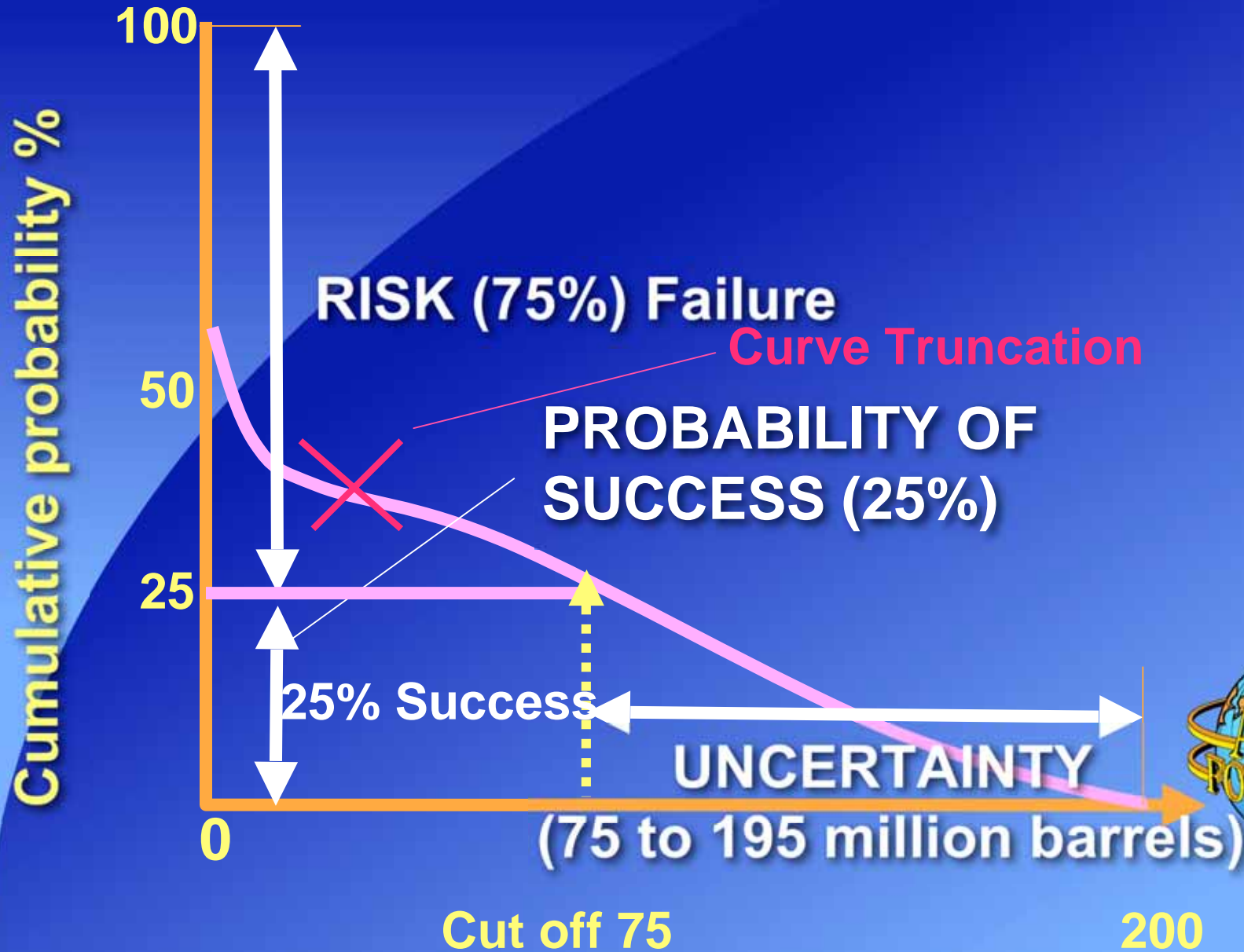
Expectation Curve



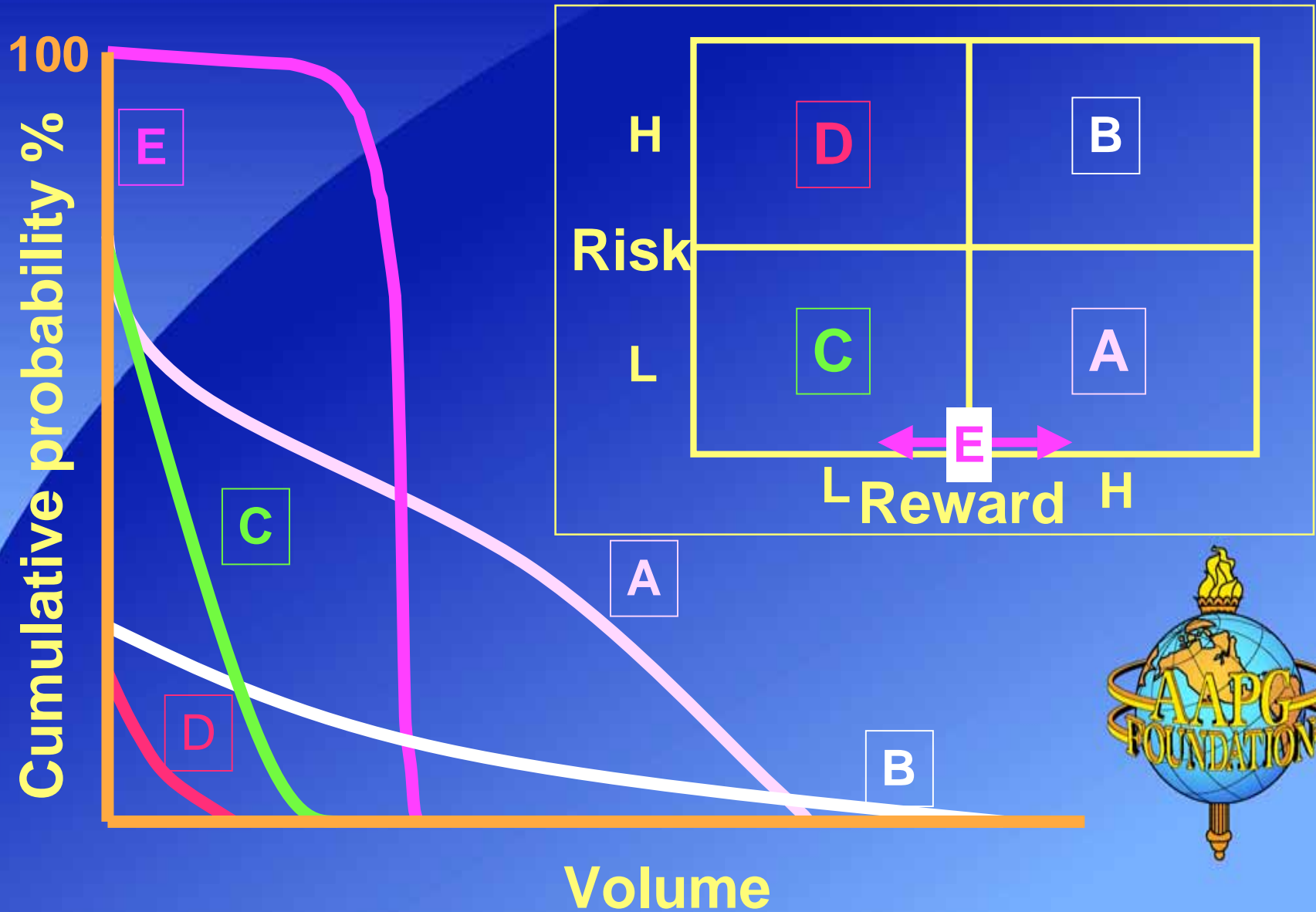
Geological Risk and Uncertainty



Economic Risk and Uncertainty



Risk & Uncertainty in Expectation Curves



Approaches

- **Experts**
- **Analogue comparison**
- **Historical performance**
- **Prospect, play, system, basin geological attributes**

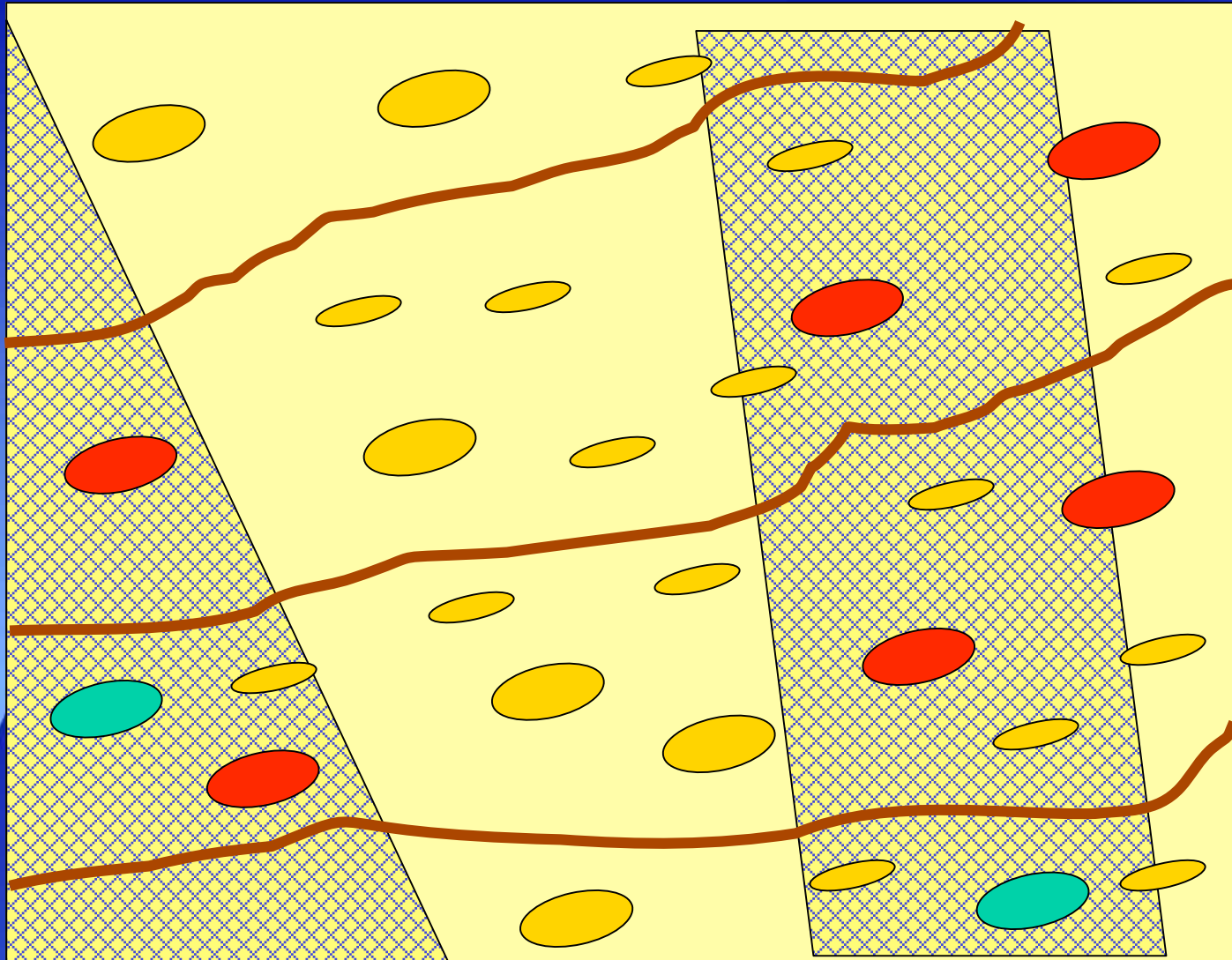


Analogue Methods

- Area of basin proportional to potential volume of petroleum
- Volume of sedimentary basin proportional to potential volume of petroleum
- Area of oilfield versus area of basin extrapolation
- Tectonostratigraphic basin comparisons
- New technology updates on adjacent acreage



Analogue Comparison



100km

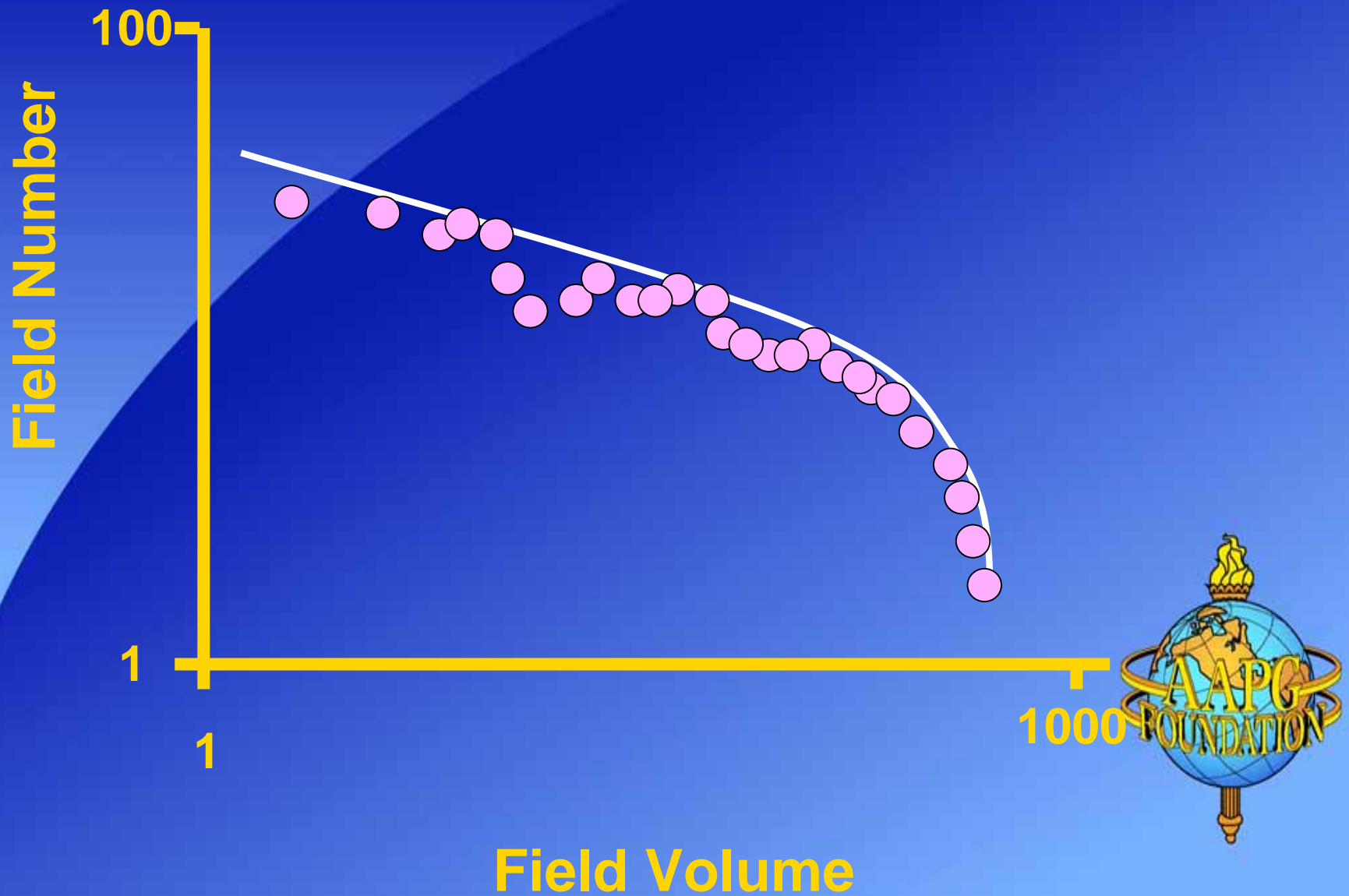


Forecasting From Historical Performance Methods

- Creaming curves
- Decline curves
- Power law plots
- Hubbert curves

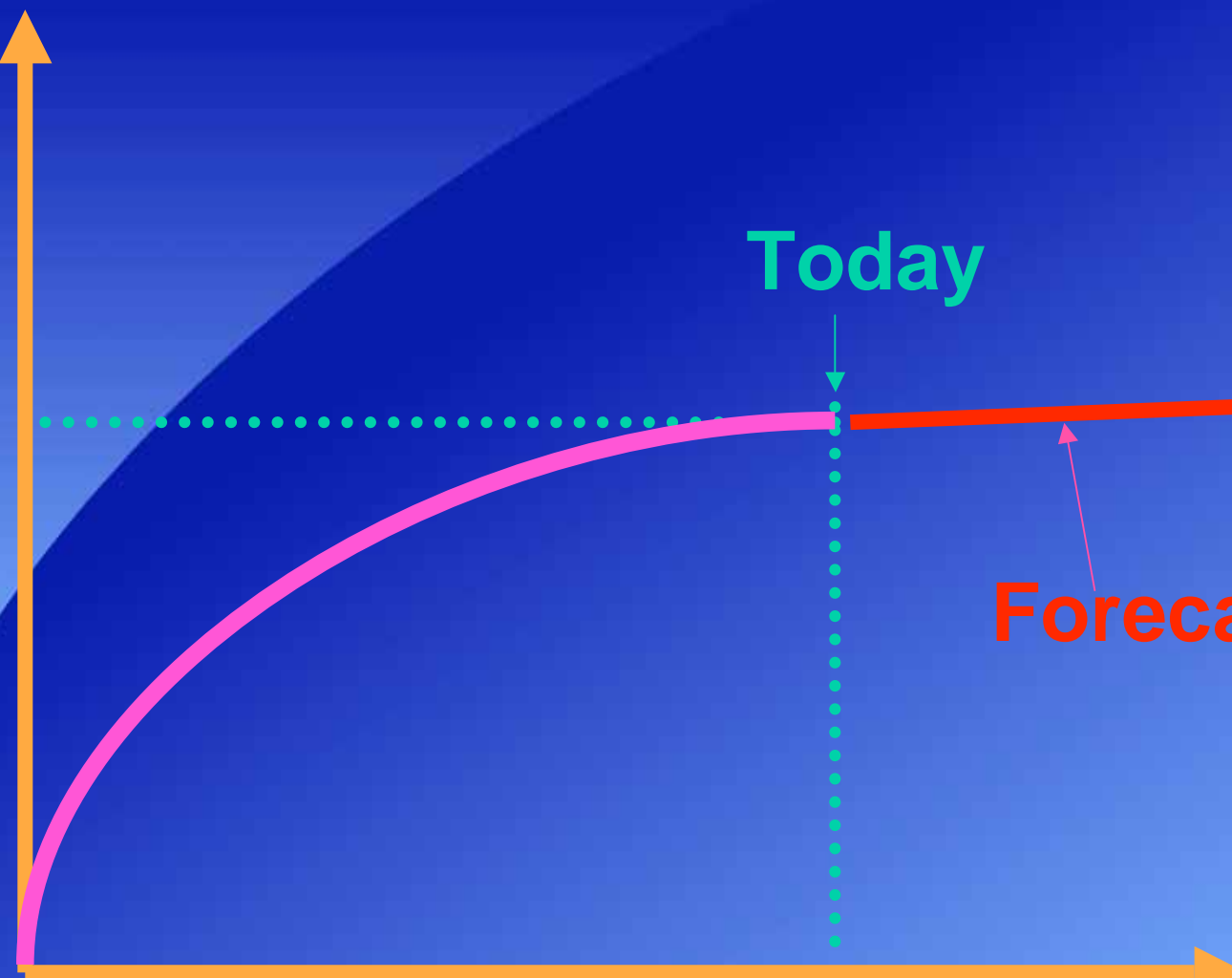


Fractal Distribution



Creaming Curve

Cumulative discovery



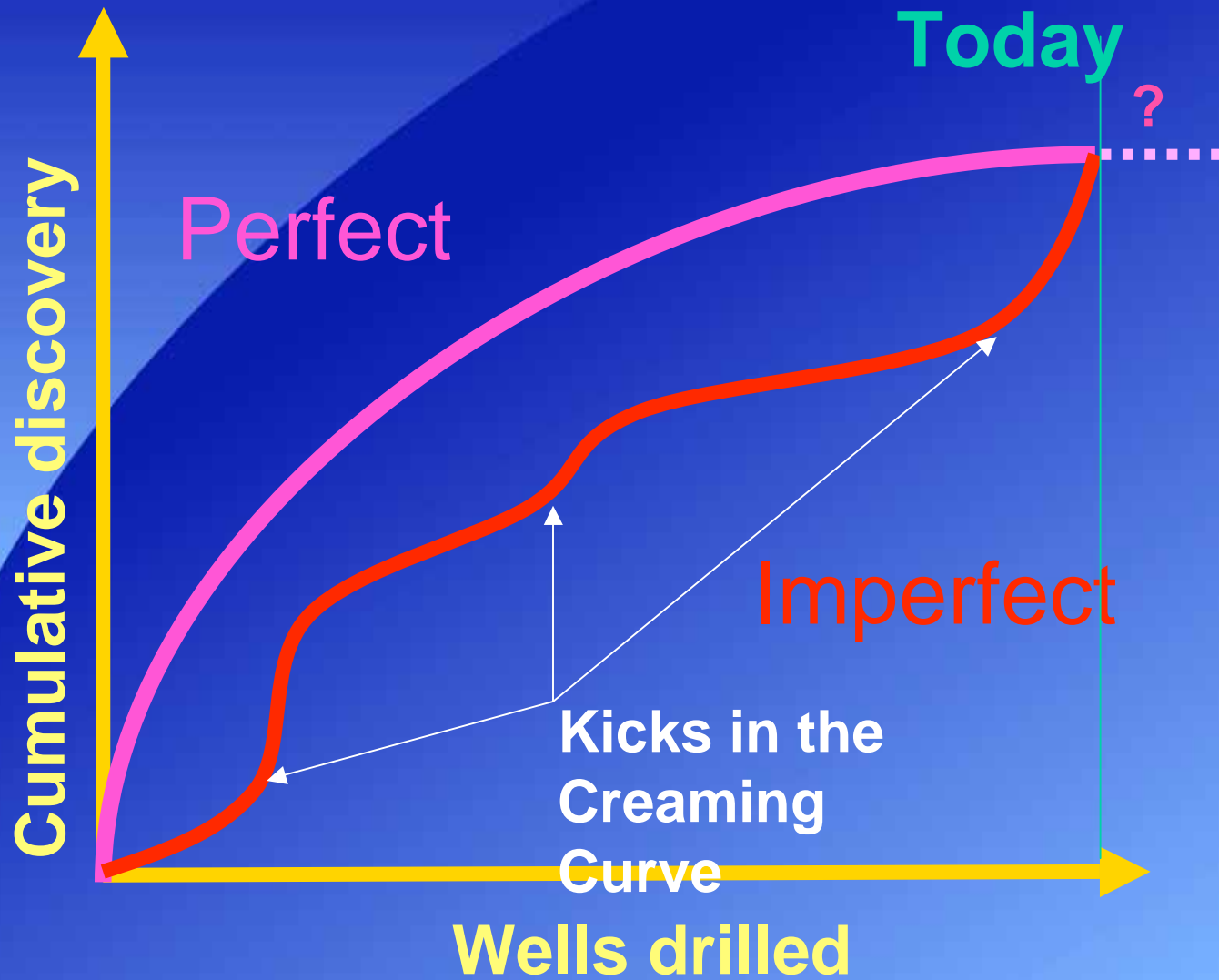
Today

Forecast trend

Wells drilled

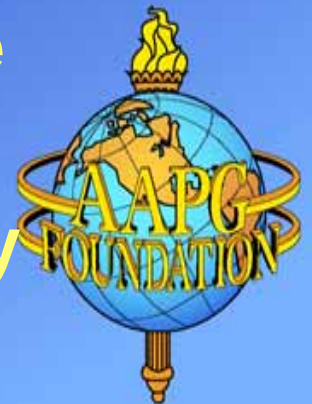


Perfect vs. Imperfect Creaming

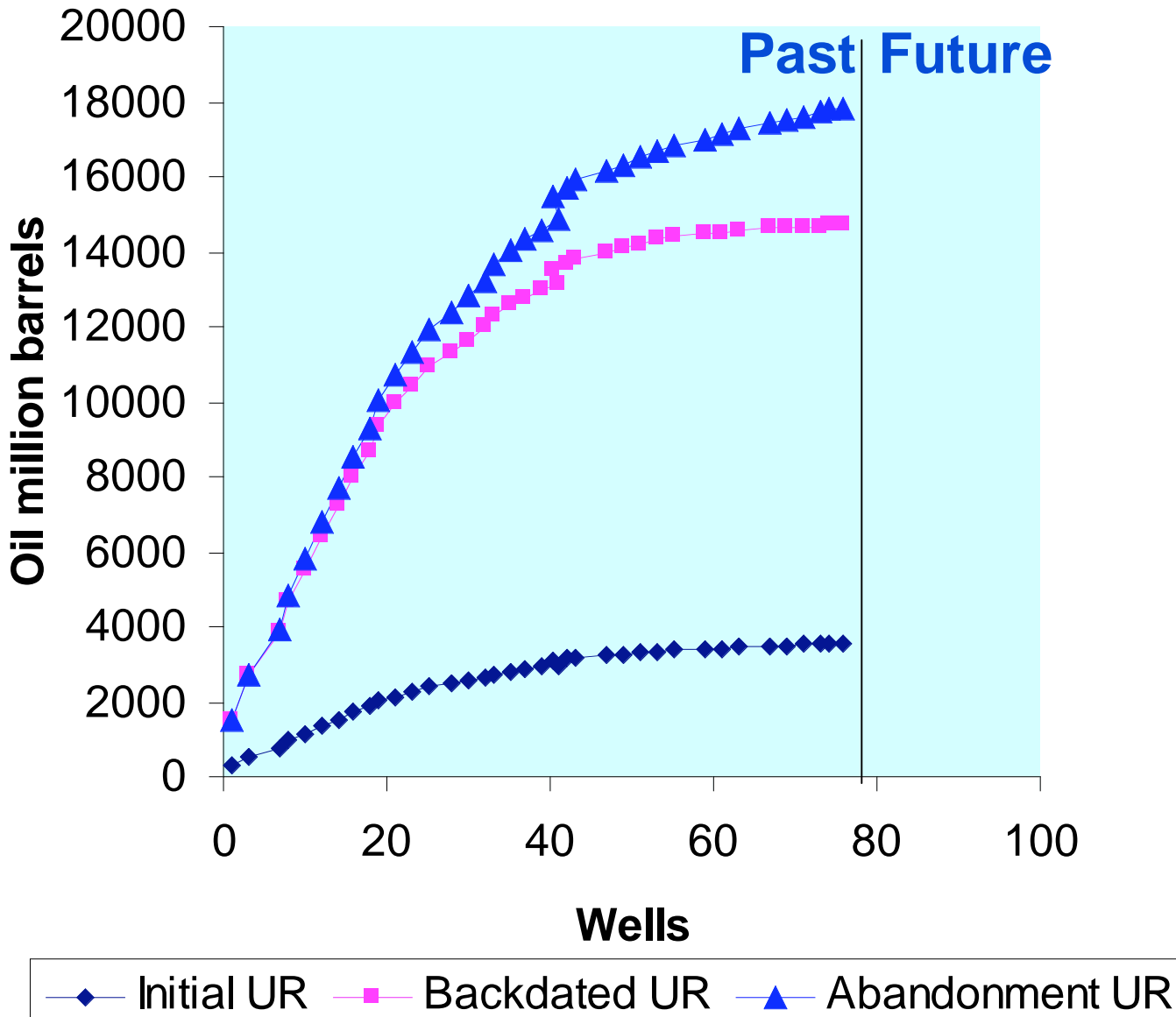


Dealing with source data

- In house data with numerous fields is more reliable. Scouting data is less so.
- What figure represents a field volume for extrapolating future exploration success?
- Field volumes are conservatively reported, but not always so.
- New discovery volumes relating to the P90 are usually reported.
- With appraisal, field volumes generally increase.



Creaming Curve Backdating



Questions

- What do the data represent?
- Is it primary or secondary data?
- What does an imperfect curve represent?
- Is the curve representative of the whole geology?
- Is technology on the horizon that will introduce a kick to the curve?
- Would new ideas produce a future kick in the curve?



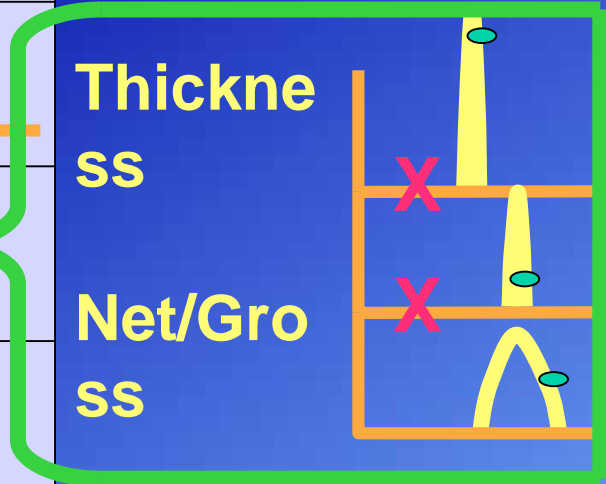
Prospect Play Approaches

- **Deterministic approaches**
- **One dimensional Probability Density Function (PDF)**
- **Geostatistics**
- **Body mapping**

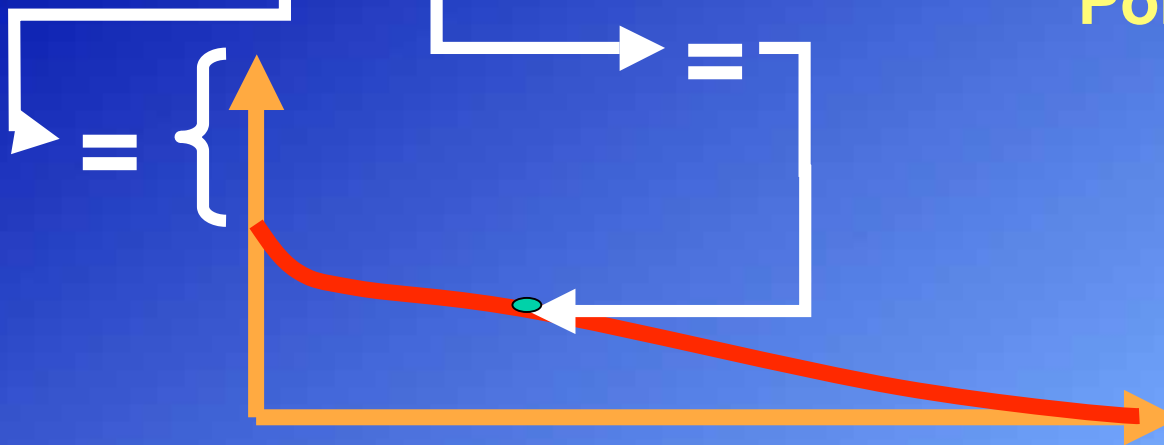


One Dimensional PDF

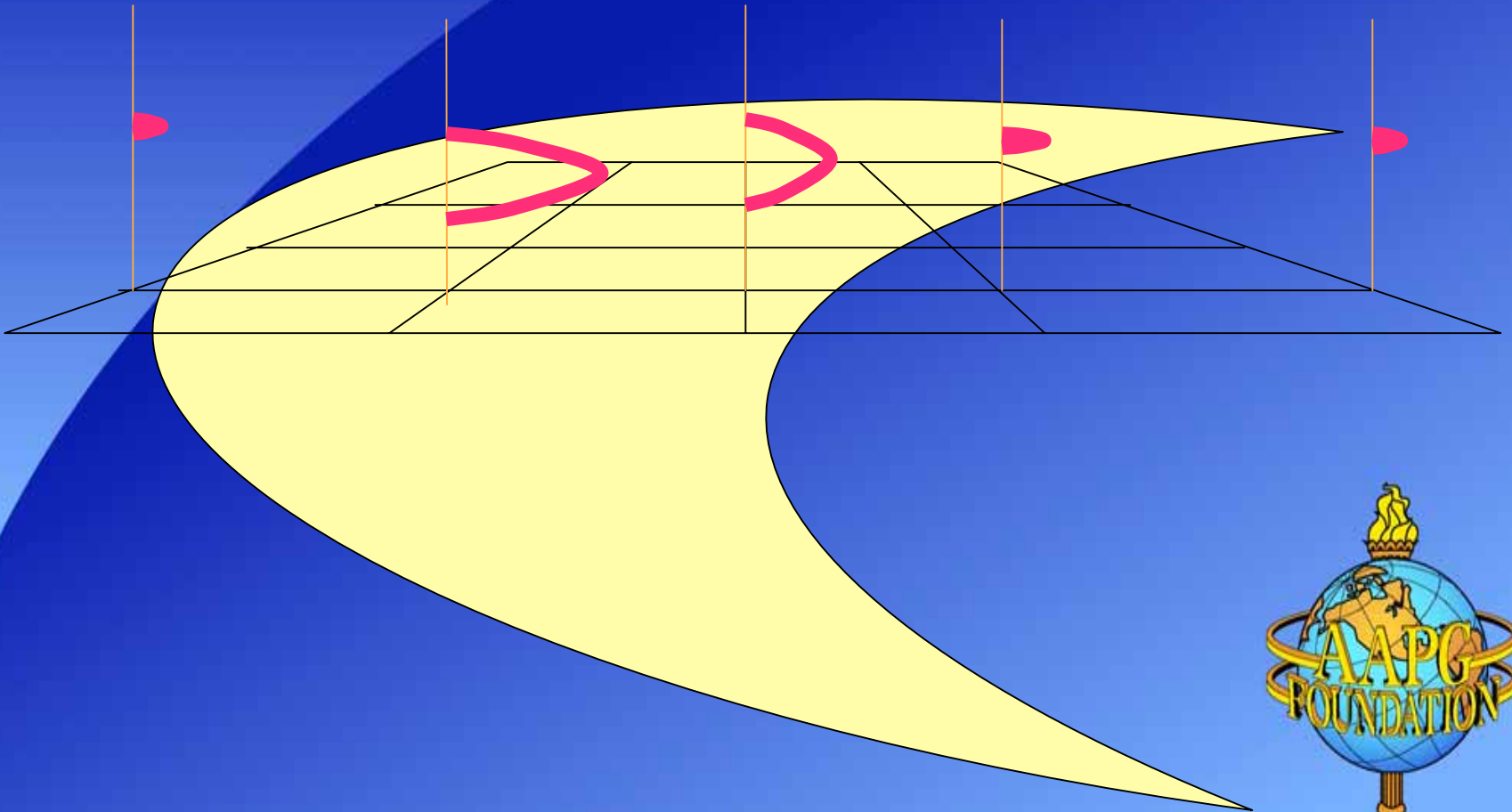
| | Risk Uncertainty | |
|-----------|------------------|---|
| Charge | X | X |
| Structure | X | X |
| Reservoir | X | X |
| Seal | X | X |



Porosity

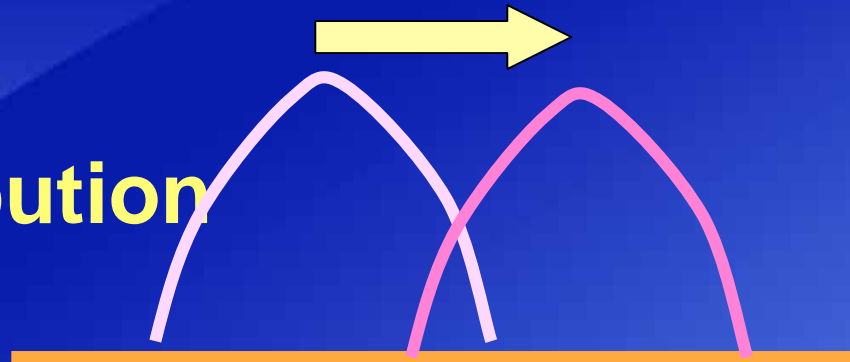


Geostatistical

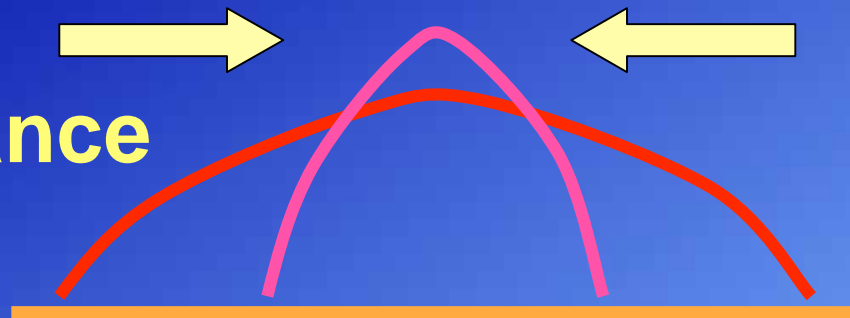


Consequences of Bias

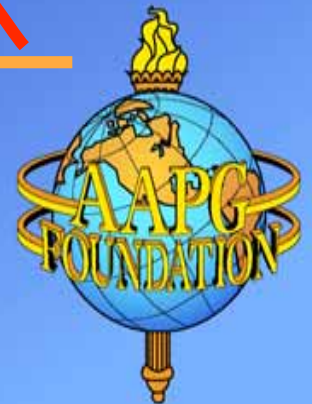
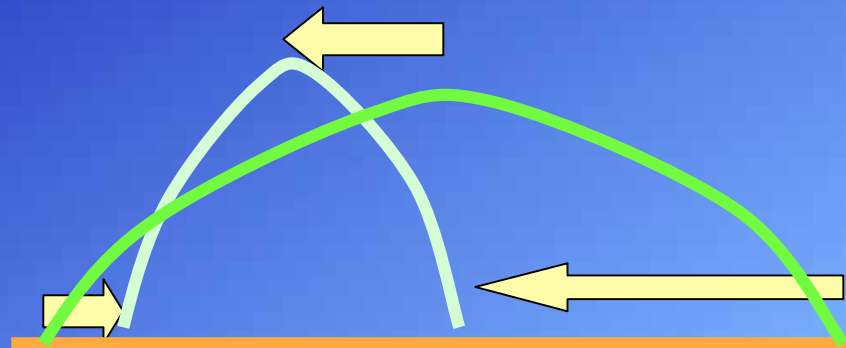
- Shift in distribution



- Different variance

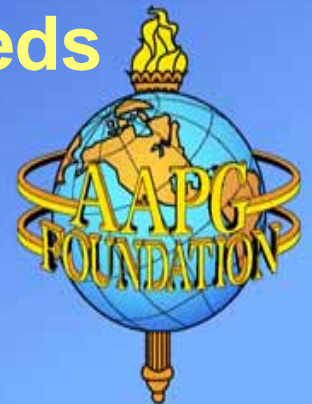


- Both



Fertile Ground for Bias?

- Our data/knowledge are limited compared to natural complexity
- Inappropriate standards/quality
- Complex problems give humans difficulty
- Humans are prone to reasoning errors
- Humans find great difficulty in overcoming subjectivity
- We are sensitive to management needs
- Business environment



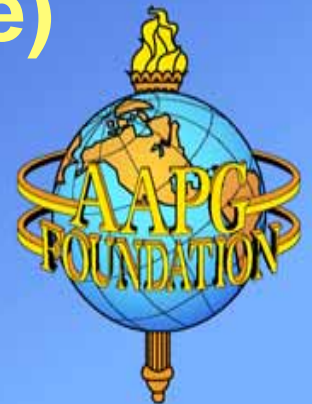
Types of Bias

- **Perceptual**
- **Motivational**
- **Reasoning**
- **Environmental**



Motivational Bias

- Need to influence decisions
- Career pressure/performance targets
- Ego, not admitting what does not know
- Partisanship
- Group dynamics (Peer pressure)



Reasoning Bias

- **Overvaluation-Geological model given more weight than it merits**
- **Accessibility/Neglect-Recent or spectacular data only utilised and other data ignored. Neglect of prior data**
- **Fixity-Being fixed on a starting model. Average map! Being unable to consider other models**
- **Exclusion-Success/Failure cases are left out. Not allowing for significant upsides/downsides**



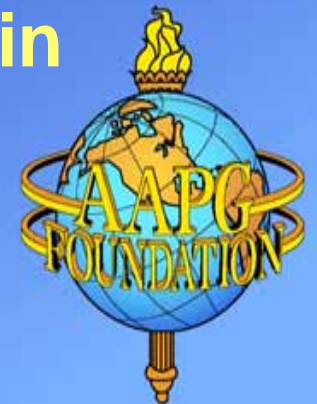
Business Environment Bias

- Risk averse/amenable
- Context dependency
- Management preoccupation
- Good money after bad
- Flying high/low



Multiple Assessment Approach

- There is no correct answer nor can bias be eliminated
- In any basin, play, prospect there are various methodologies available utilising a variety of tools
- Assessments using more than one methodology allow a calibration and cross-checking
- Where multiple assessments arrive in the same ball park there is a higher degree of confidence in the results



Requirements

- **Open process**
- **Shared set of methods, and more than one**
- **Dedicated team**
- **Champion- who can meet with other champions**
- **Access to all expertise**



Critical Elements for Exploration

- Well defined goal(s) and strategy
- With determined or target portfolio requirements
- Backed up by Petroleum Systems Approach
- Intimately linked to Risk & Uncertainty methodologies , more than one!
- Expert people, in a learning organisation which can enhance performance by learning from successes and failures

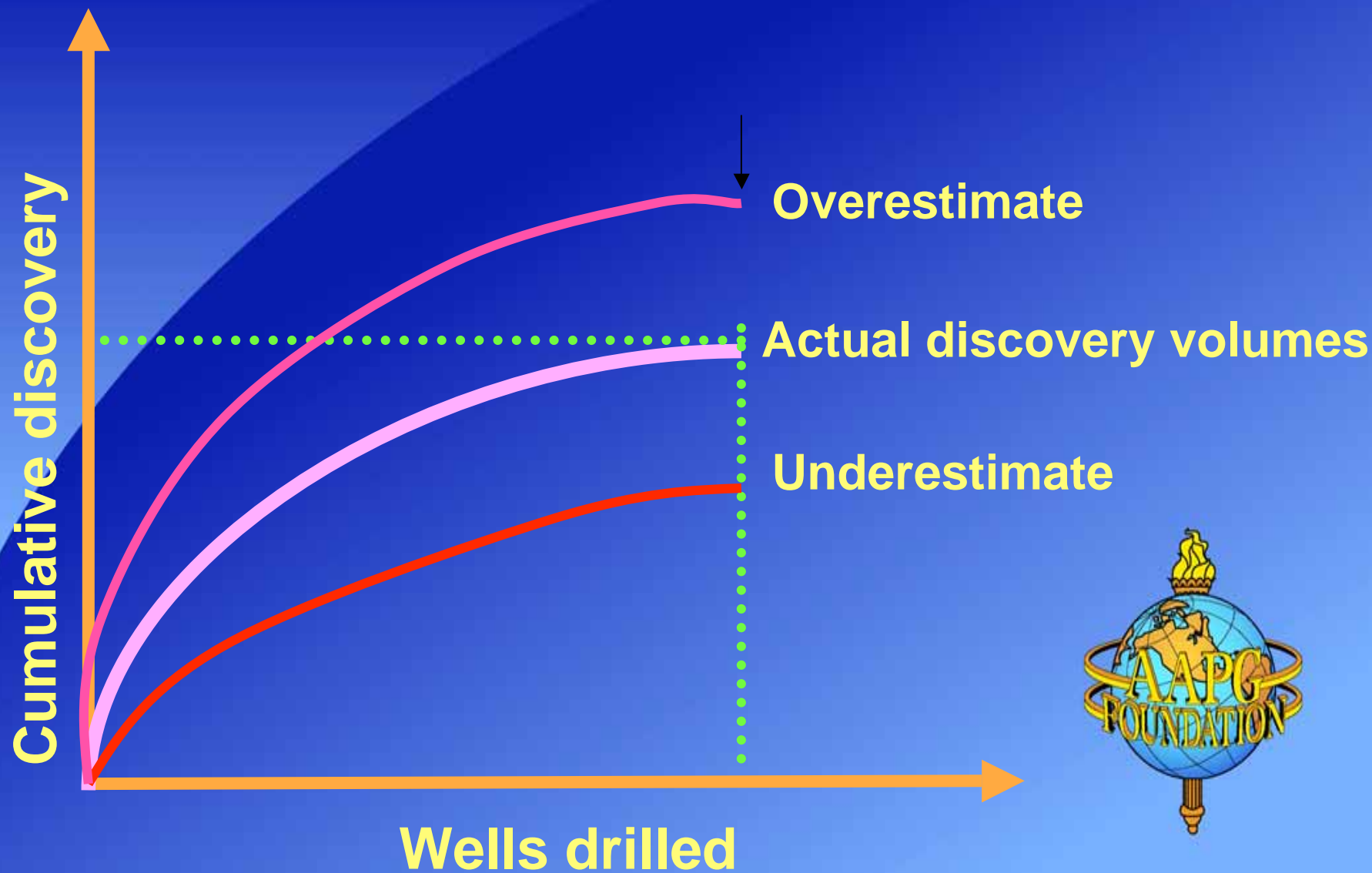


Exploration Performance Criteria

- Finding costs
- Hydrocarbons discovered
- Success Ratio
- Expectation versus discovery volumes
- Trap or reservoir parameters vs. predicted
- Value adding through basins>>petroleum plays; leads>>prospects>>discoveries within a petroleum systems context
- Reducing risk and uncertainty and increasing economic value



Expectation Forecast vs. Actual



Acknowledgement of Risk

- Clearly state the main risks/uncertainties
- Explain exactly what has been done (pre-drilling to minimize the risks)
- Explain what will clearly merit a success and what is failure
- Recognise that totally unforeseen geology may consign success/failure criteria to the bin



Summing up

- No individual estimate is correct
- Variety of methods should be used
- Many pitfalls, biases are many
- Primary versus secondary data considerations
- Performance tracking is vital
- Systematic process/methodology required organisation wide



Good Luck

