The value of using relative amplitude changes

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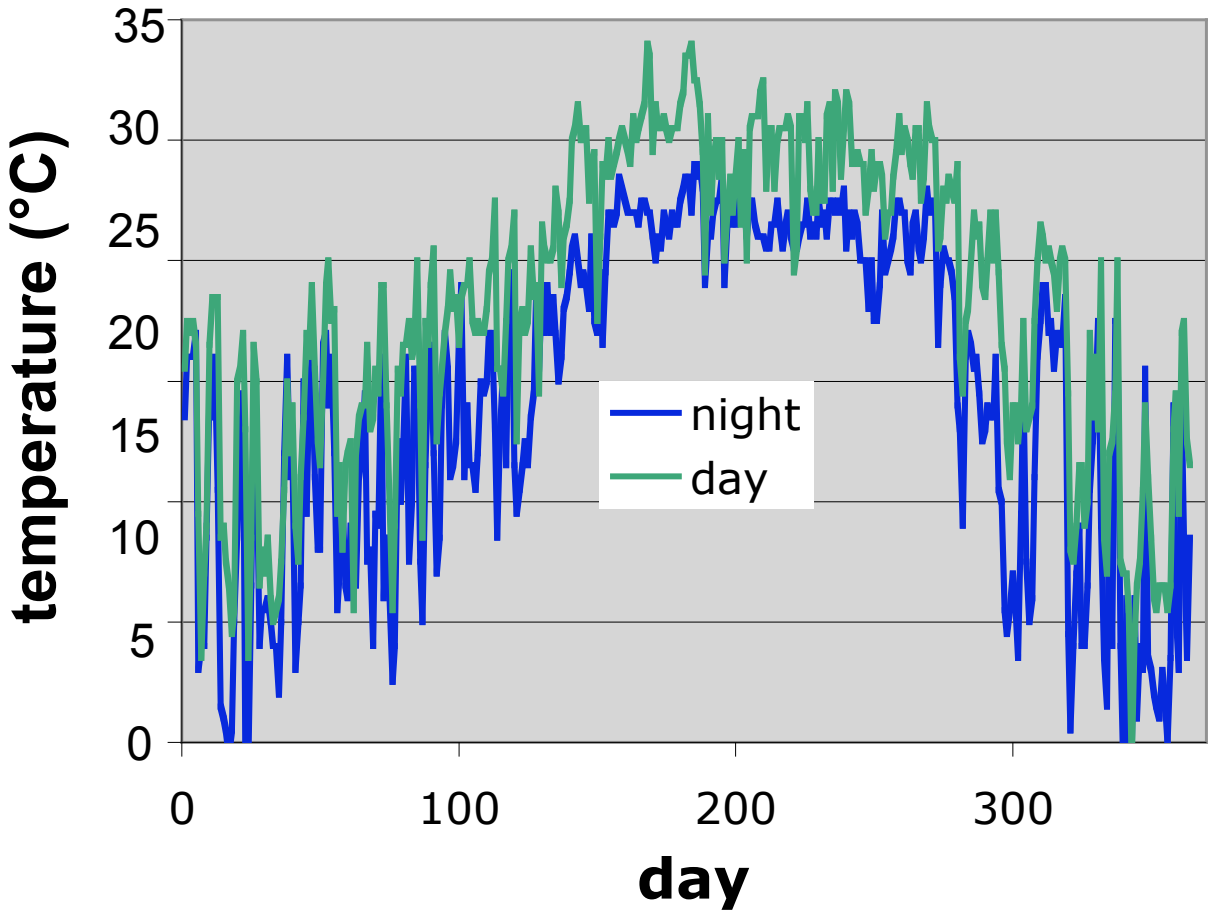
Outline

- Introduction and background
- Measurement error to risk & uncertainty
- Uncovering the importance of relative seismic amplitude
  - Approach
  - Results
    - Simple risking
    - More realistic example which includes volumetric (value) uncertainty
  - Value of information
    - Option value of obtaining information after bidding
    - Value of obtaining information before bidding against a competitor with inferior information, “winner’s curse”

Differential measurements

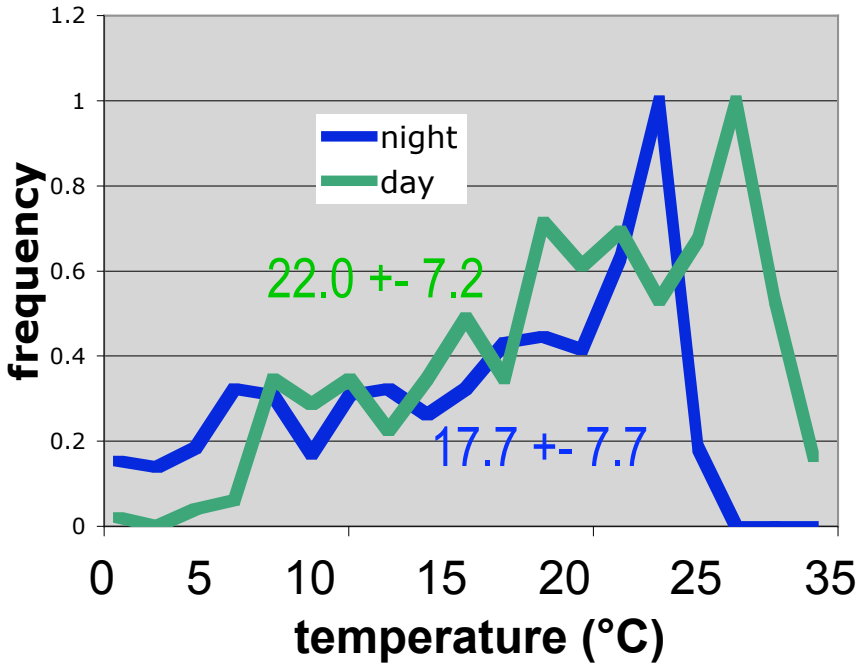
- Reduce risk in the presence of correlated signals
- Used in many disciplines:
  - Medical testing (.e.g., T/E testosterone drug testing)
  - Electronics
    - Low voltage differential signaling, LVDS (I.e., gigabit ethernet)
    - PCI Express and USB communication protocols
    - High voltage differential signaling in SCSI-1 equipment
- Earth science example
  - Telling day from night using temperature

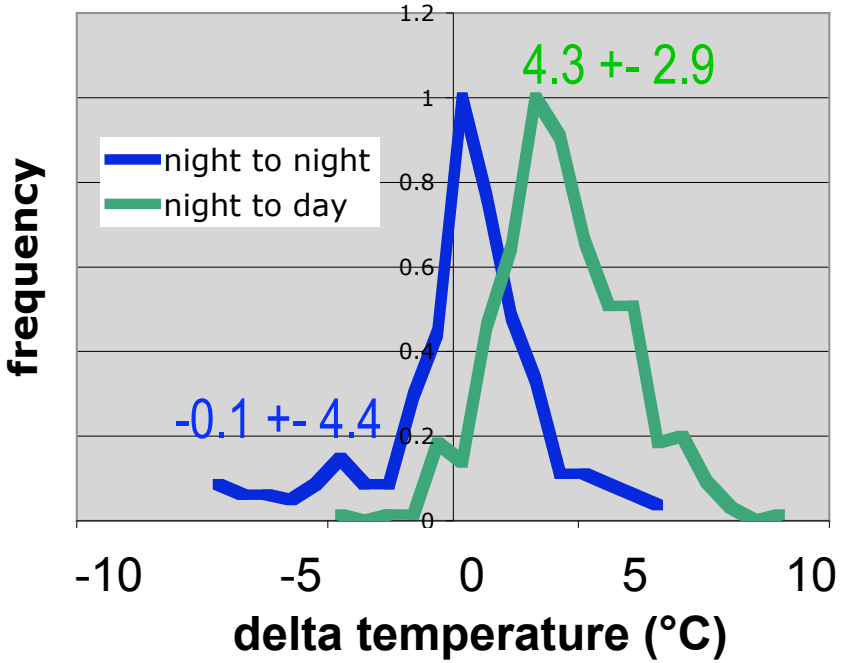
Can you tell the difference between day and night using temperature alone?

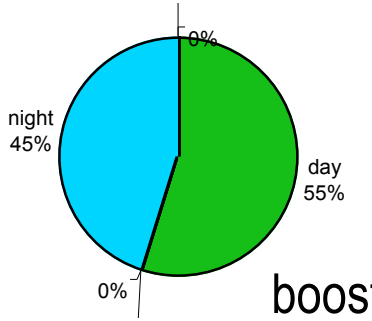


Note: temperature at 4 PM (day) and 4 AM (night) local time in Livermore, CA (2005), source NOAA

Differential temperature measurement allows better discrimination







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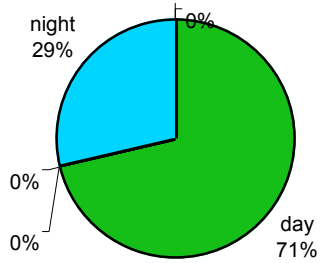


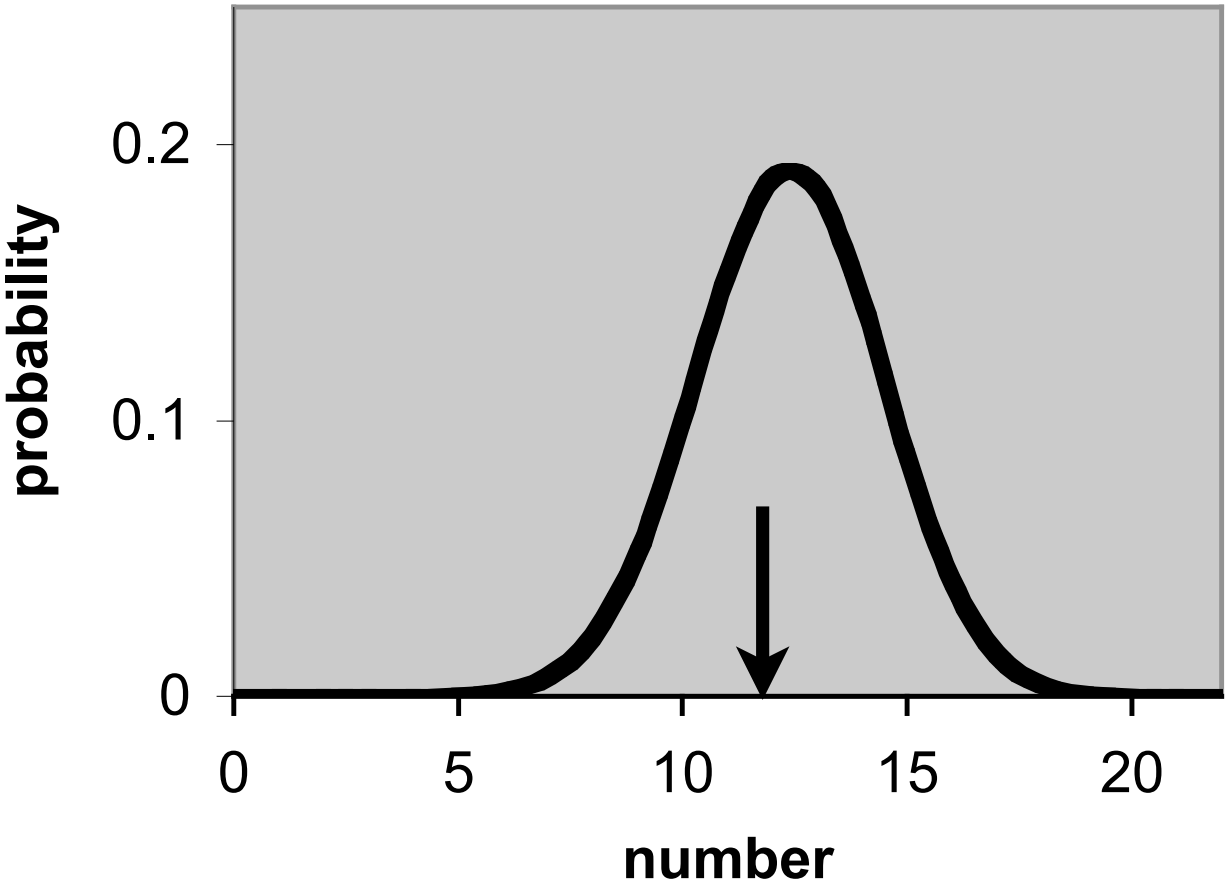
boost = 1.42

Note: prior probabilties 50% each

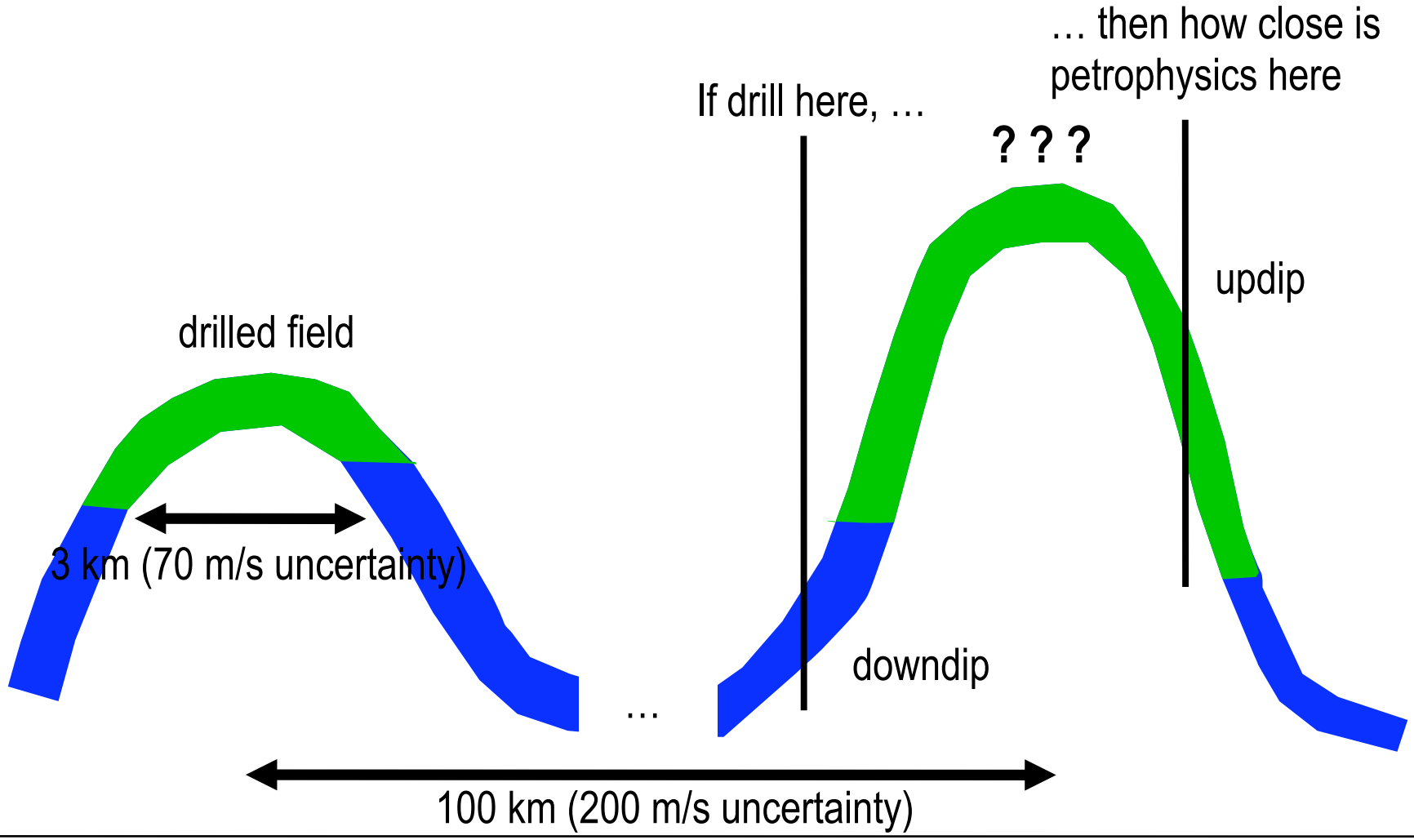
Amplitude risking

- Classes (shale, brine, oil, low sat gas, gas)
- Prior probabilities from standard geologic risking
- Bayesian update based on amplitude expectation
- Seismic confidence (discount)
  - Quality of seismic data & processing
  - Quality and relevance of petrophysical data
- Gravity (fit to structure, additional Bayesian update)
- Calibrated by lookback study

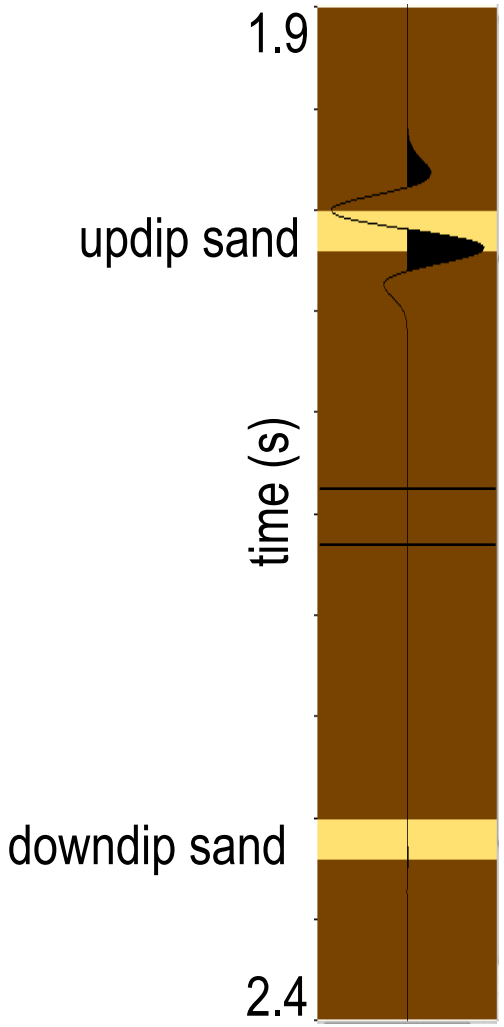
Lookback study calibration (2000-2005)

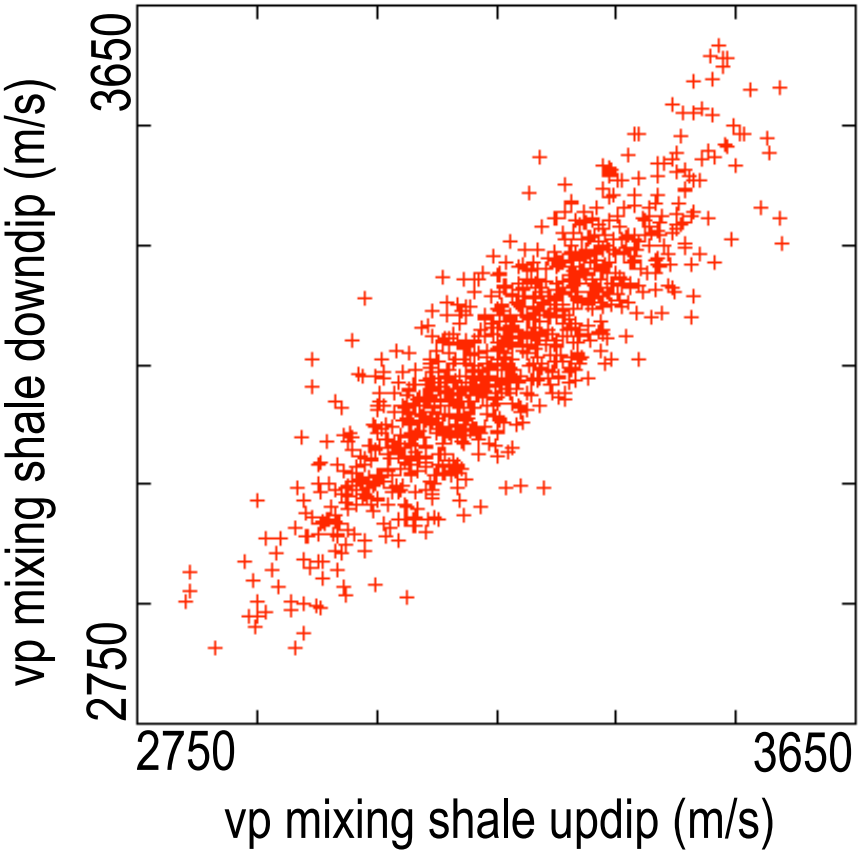


The concept of correlation in petrophysics



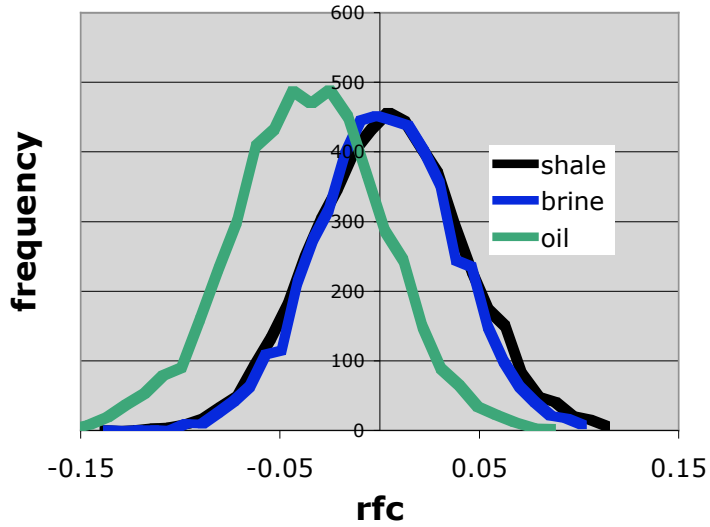
Model with correlation from downdip to updip properties

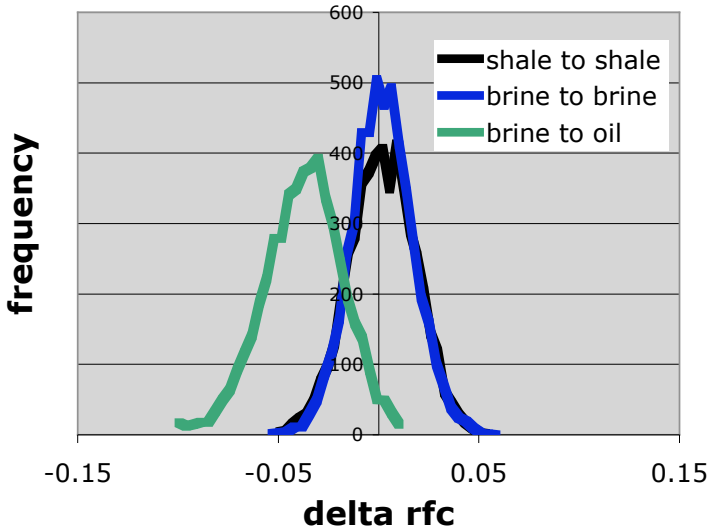


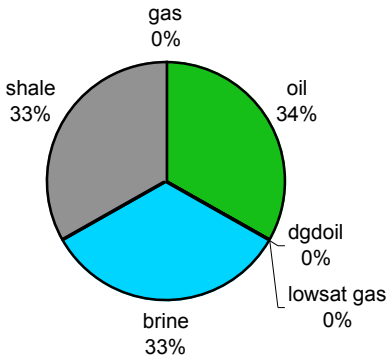


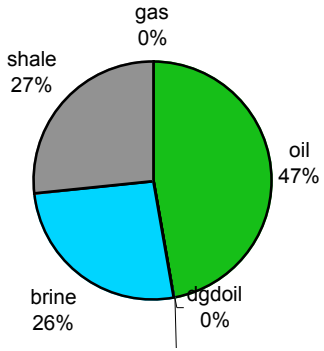
So = 70%, thickness = 32.6 m, porosity = 18.2%

Updip-downdip amplitude change leads to less risk than absolute amplitude









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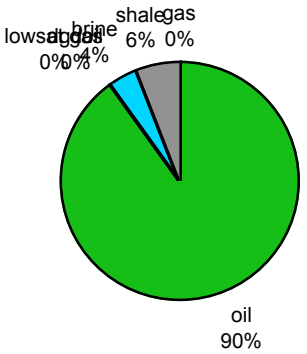


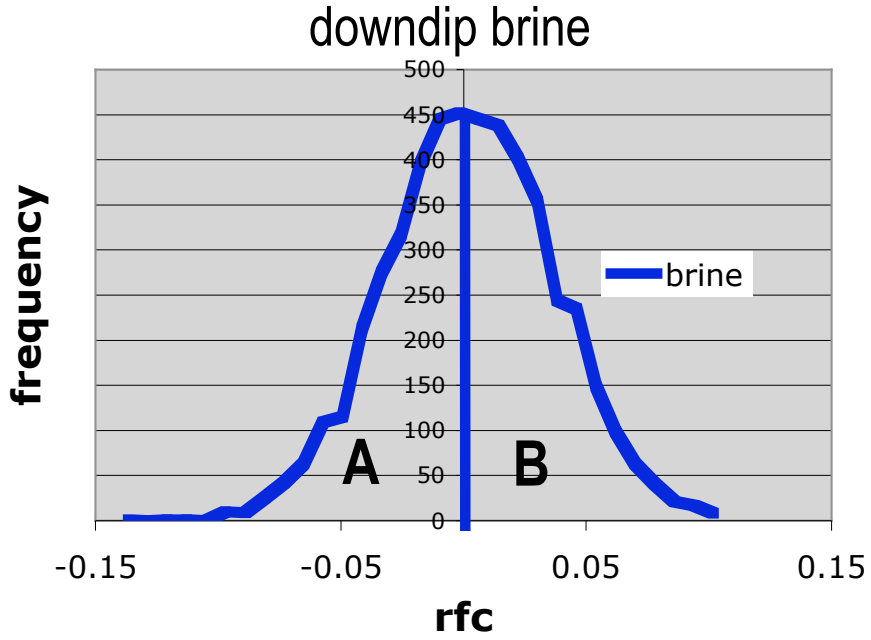
boost = 2.70

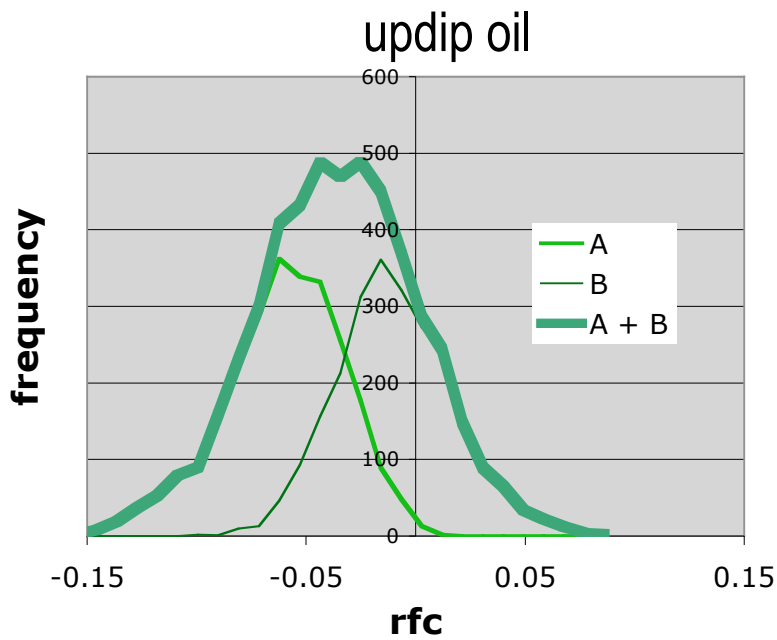
The value of using relative amplitude changes

20 October 2006

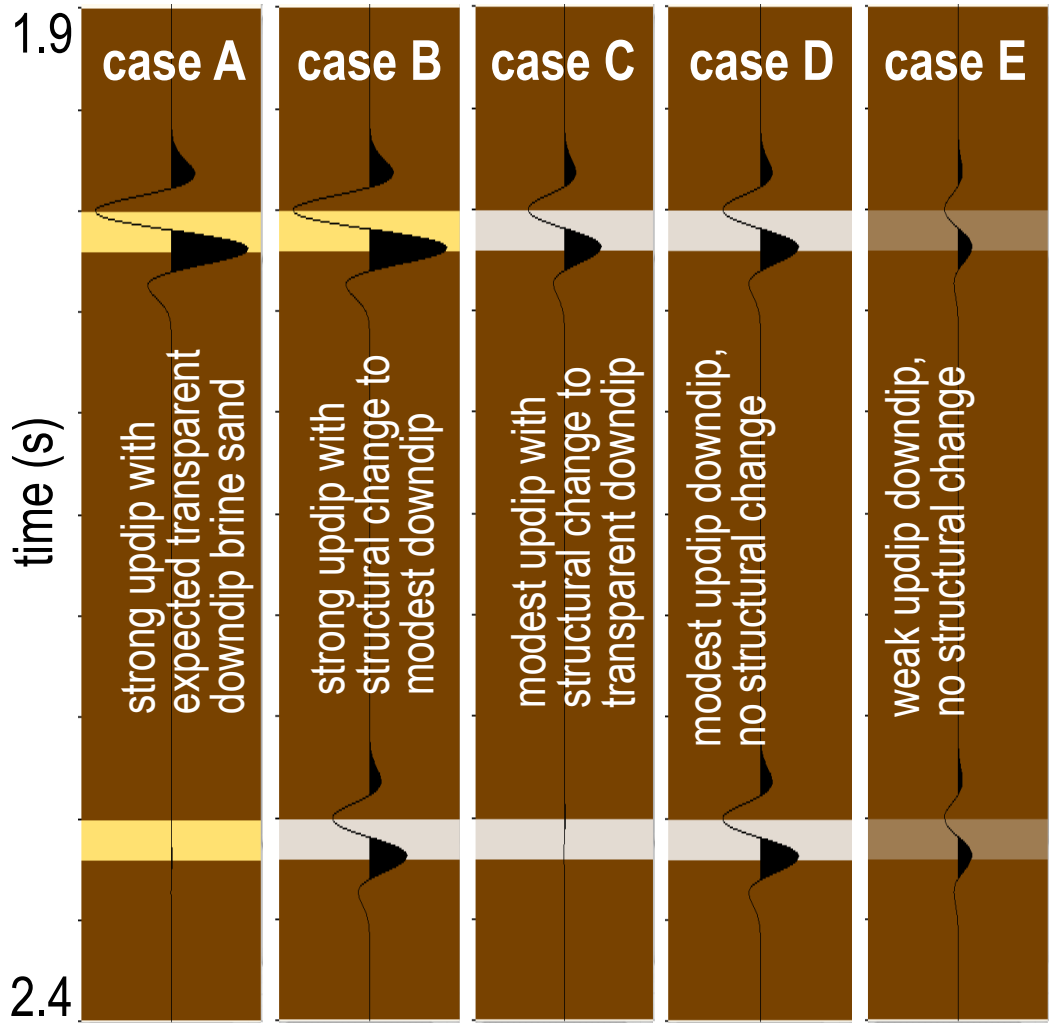
Note: N/G=80%+-15/7.5%, fixed thickness, 100% seismic confidence

Updip-downdip property correlation

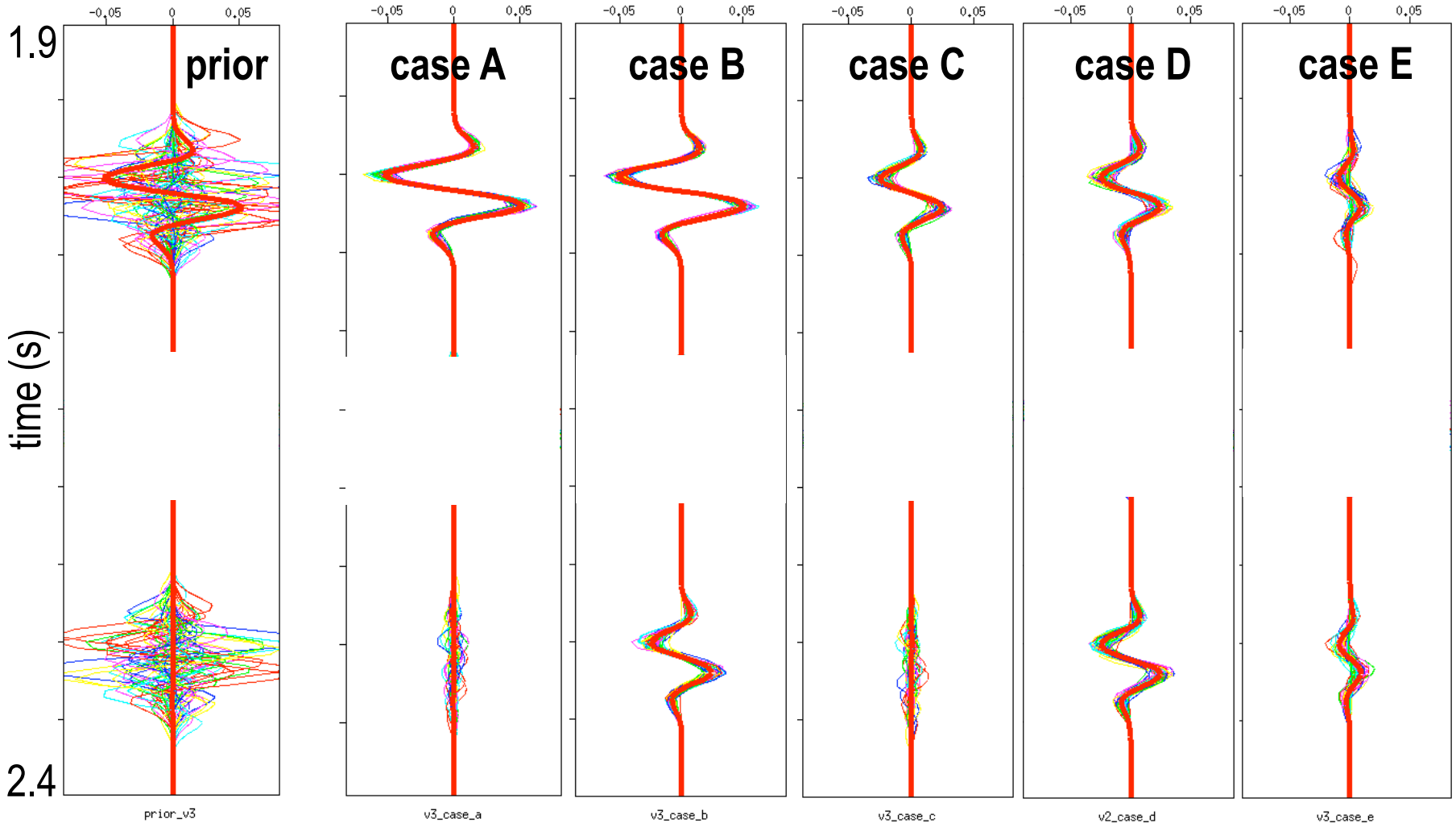




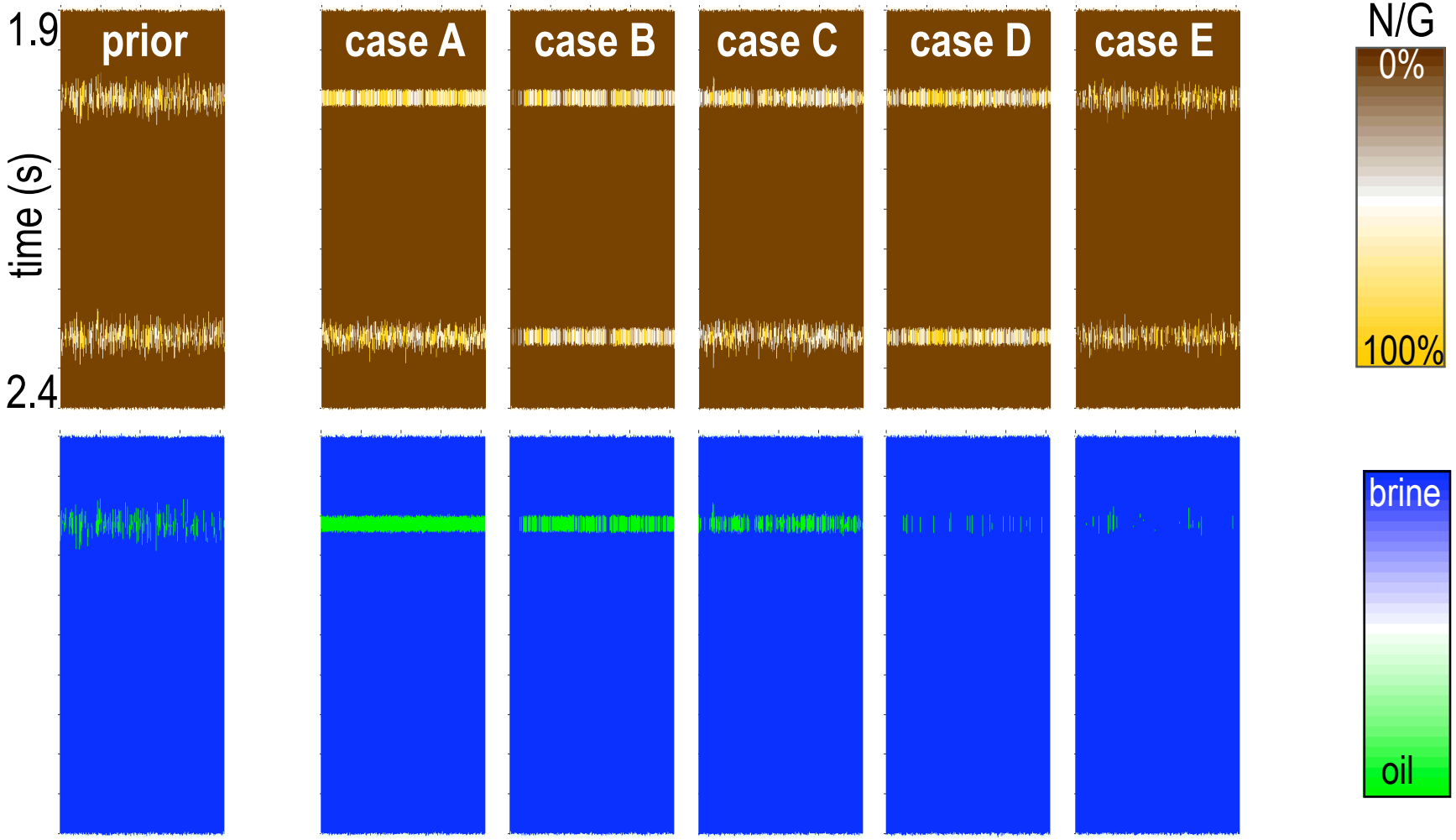
Seismic data that could be observed



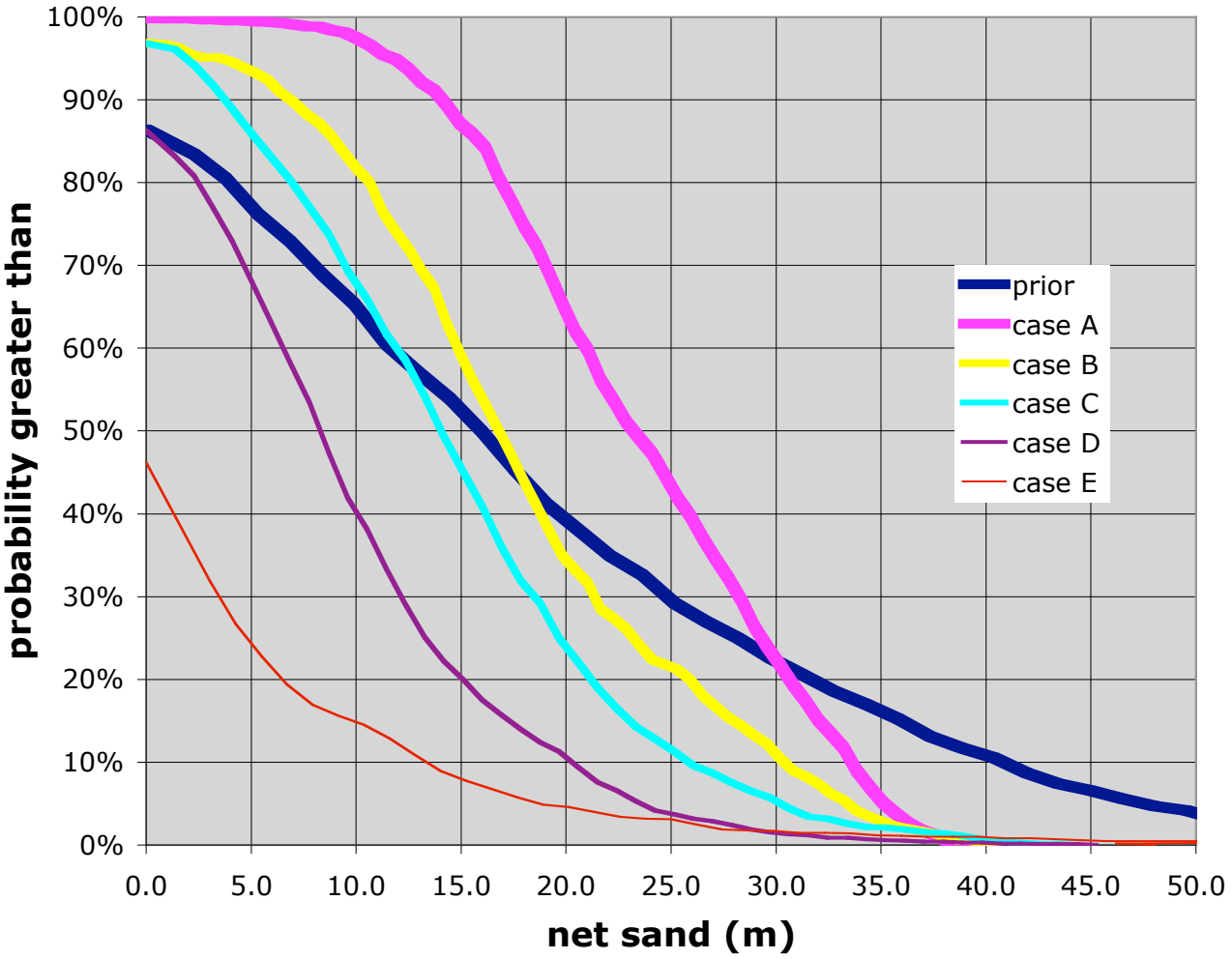
Models match data to within data measurement error



What the models could look like



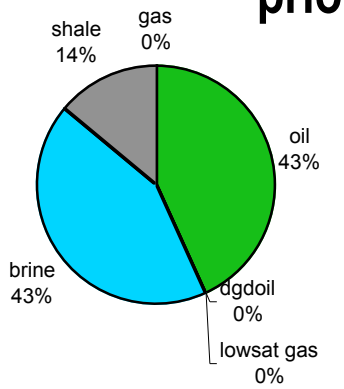
How much oil (value) could there be?



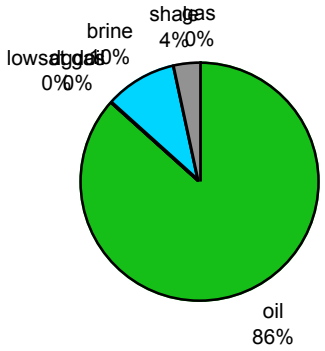
What is the risk?

bhpbilliton

prior

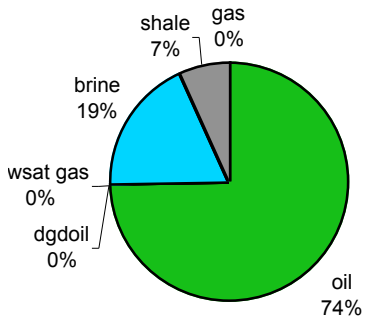


case A



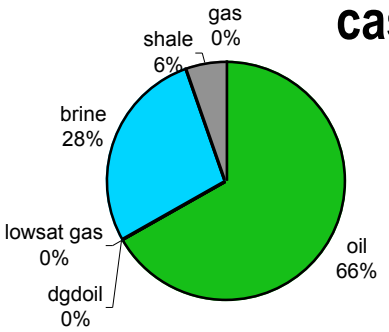
boost = 2.01

case B



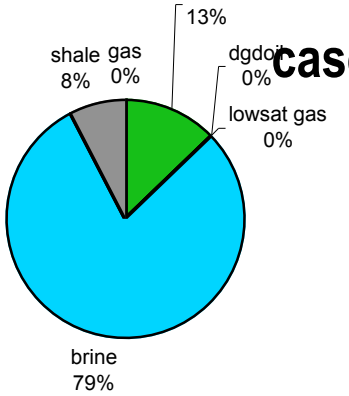
boost = 1.73

case C



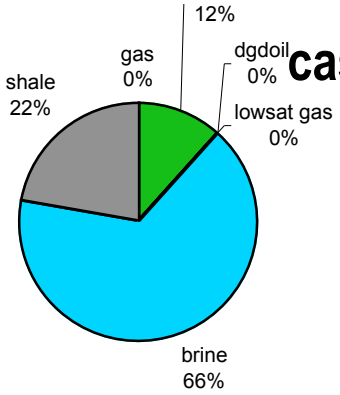
boost = 1.55

case D



boost = 0.29

case E



boost = 0.27

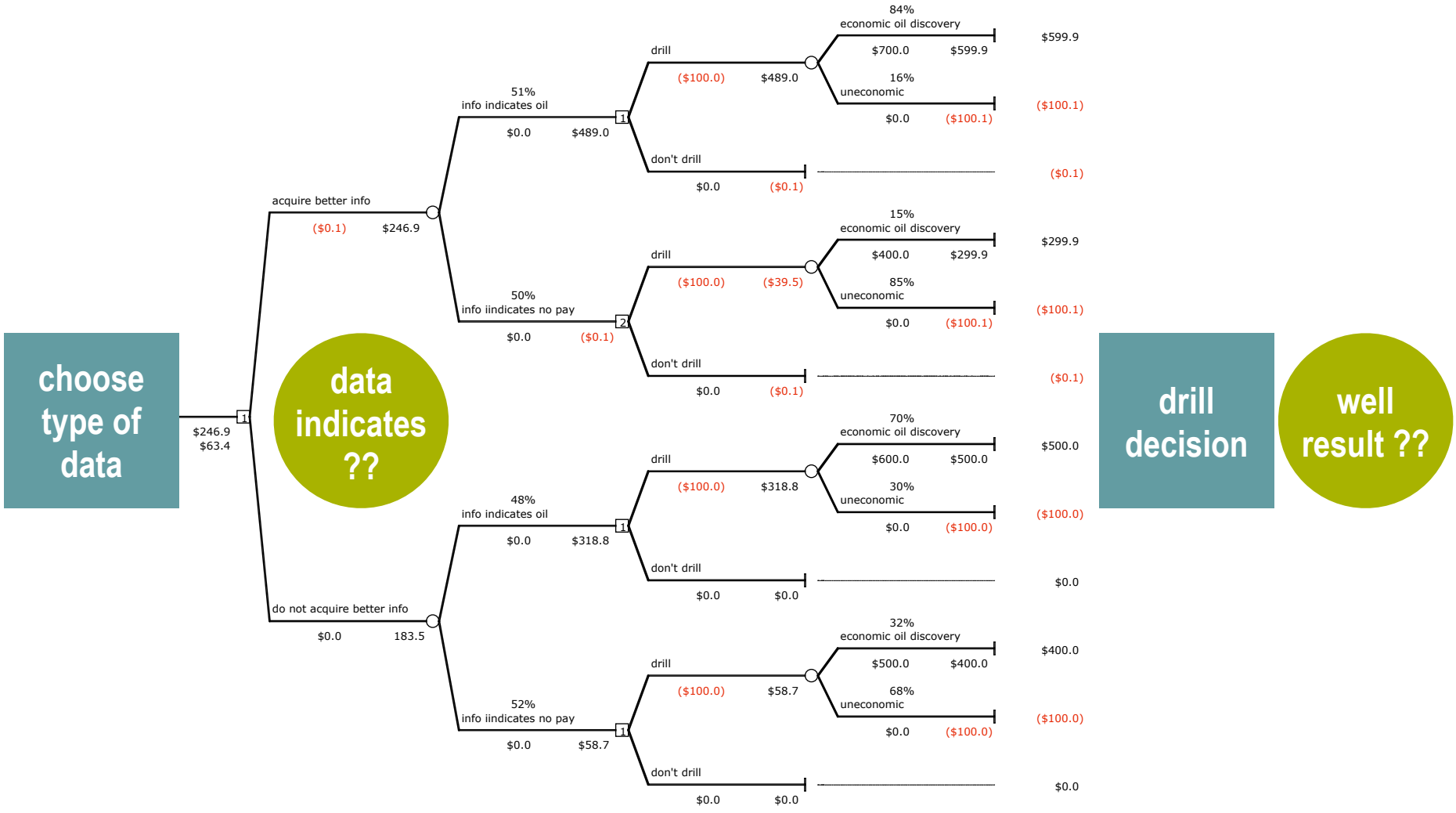
Value of differential information

- Value of obtaining information
  - With good 3D seismic, standard amplitude risking vs. relative amplitude risking
- Value of having better information in a competitive bidding situation vs. a single competitor with inferior information

Inputs for value of information

cost of better info =	0.1	MM$
well cost =	100.0	MM$
good info good outcome NPV =	700.0	MM$
good info poor outcome NPV =	400.0	MM$
poor info good outcome NPV =	600.0	MM$
poor info poor outcome NPV =	500.0	MM$
P(economic discovery) =	50%	
Z(good info, good outcome) =	85%	
Z(good info, poor outcome) =	16%	
Z(poor info, good outcome) =	67%	
Z(poor info, poor outcome) =	29%	
correlation of good/bad info =	50%	

VOI decision tree



Value of obtaining the information

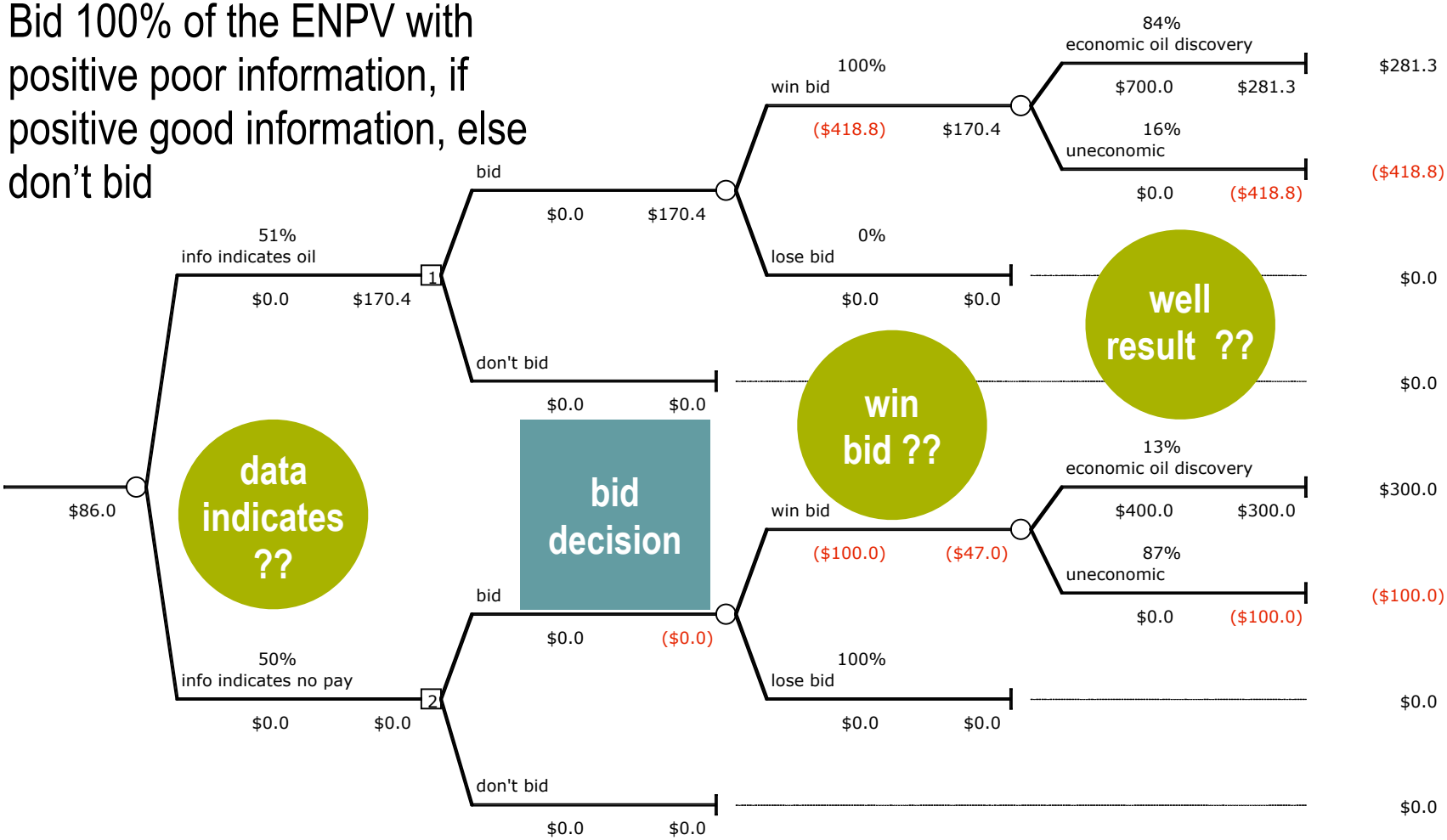
should better data be aquired =	yes	
value with better info =	$246.9	MM$
value with poor info =	$183.5	MM$
value of better info =	$63.4	MM$

Value of information in a competitive bid

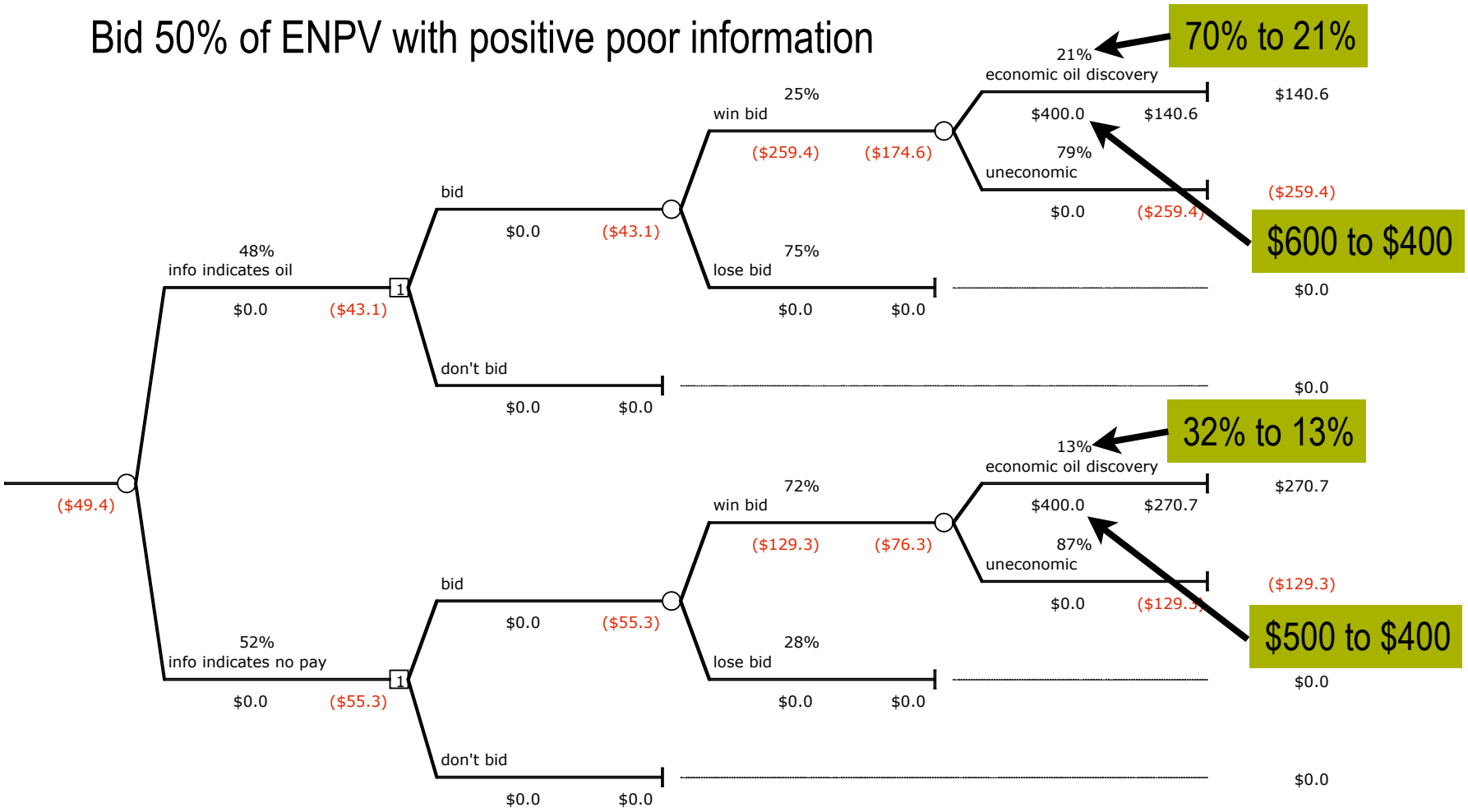
- Two parties bidding
- First party has poor information and does not know it
  - Bids 50% of ENPV given the poor information
- Second party has good information and knows that other party does not
  - Bids 100% of ENPV given the poor information, if the good information is positive
  - Does not bid if the good information is negative, would not win if bid

Value tree for bidder with good information

Bid 100% of the ENPV with positive poor information, if positive good information, else don't bid



Value tree for bidder with poor information who does not know it



Results of bidding (Winner's Curse)

will poor data bid against good =	yes	
max bid of poor data =	$159.4	MM$
value of opportunity =	($49.4)	MM$
bid of good data =	$318.8	MM$
value of opportunity =	$86.0	MM$

could have a more aggresive bid strategy for party with good information, bid 50% of ENPV with good information ($245 MM), increasing value $37 MM to $123 MM

Is the asymmetry of information good or bad from the governments perspective?

- expected value with only good information is:
  - 51% x $318MM = $162MM
- expected value with good and poor information is:
  - + 48% x 25% x $160MM + 52% x 72% x $29MM = +$30MM

Conclusions

- Use of relative change in amplitudes from the downdip to the updip area significantly mitigates risk
- Not only is there increased risk, when there is no downdip to updip amplitude change, there is also an expectation of less sand in the success case
- Significant business value in this analysis
  - Value of relative amplitude information for a characteristic new venture evaluation is $60 million USD
  - In a competitive bidding situation it is the difference between making $90 million USD and losing $50 million USD