[AV]Threshold Effects on Prospect Risking*

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Search and Discovery Article #110120 (2010)
Posted June 28, 2010

*Adapted from oral presentation at Session, Geophysical Integration: A Road Map to Exploration Success, at AAPG Annual Convention and Exhibition, New Orleans, April 11-14, 2010

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Abstract

Most companies exploring for oil and gas continuously try to develop and improve their risk analysis process to consistently and properly risk prospects. One of the most significant impacts on prospect risking is the presence of seismic amplitude anomalies that are Direct Hydrocarbon Indicators (DHI's). The technology and methods to identify and risk seismic amplitude anomalies have improved considerably through the years, especially with the use of AVO (Amplitude versus Offset), modern seismic acquisition and processing techniques, and advanced interpretation systems and workflows. To properly evaluate DHI prospects, a systematic risk analysis process is required so that companies can make better decisions related to their exploration portfolio.

For the past eight years, a consortium of oil companies in the US and Europe has developed a work process to interpret and risk seismic amplitude anomalies on exploration and development prospects. Approximately 150 prospects have been reviewed and documented in a database where the geological risk factors, seismic and rock physics data quality, and amplitude anomaly characteristics (as many as 37) have been analyzed to calculate the probability of geological success (Pg - flowable hydrocarbons). The drilling results for each prospect were compared to the calculated Final Pg, a function of the Initial Pg (geology) and DHI Index (impact of the anomaly characteristics modified by data quality).

The Final Pg and DHI Index compared to drilling result trends indicate a DHI Threshold Effect on prospects at the high end of the risk spectrum and a low Pg Threshold Effect at the low end of the spectrum. In other words, on the upper end of the spectrum there is a point at which a significant amount of the risks have been reduced to dramatically increase the Final Pg and DHI Index. On the lower end of the spectrum there is a threshold below which essentially all the wells are dry holes. Using these database trends, Pg can be calibrated to a wide range of 5% to 95% Final Pg. Therefore in DHI prospects, geoscientists should be more optimistic in analyzing the prospect risk if Final Pg and DHI Index are above certain threshold levels. Conversely, the low end of the risk profile prospects in the portfolio should probably be farmed out or not drilled with an overall goal of upgrading the exploration portfolio.

References

Alexander, J. A. and J.R. Lohr, 1998, Risk Analysis: Lessons Learned: SPE 49030-MS, SPE Annual Technical Conference and Exhibition, New Orleans, Louisiana, Sept.27-30, 1998, (Web accessed 17 June 2010)
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Threshold Effects on Prospect Risking

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Traditionally, most companies risk prospects considering these Geologic Chance Factors

GEOLOGIC CHANCE FACTORS

Source Rock

- fetch area and thickness
- richness
- thermal maturity
- type

Migration and Timing

- closure forms before/during migration
- migration distance and pathways

Reservoir Rock

- facies and extent
- minimal thickness
- reservoir quality

Closure

- confidence of depth/shape of closure
- structural and stratigraphic traps
- confidence in mapping

Containment

- sealing capacity/top and bottom
- preservation

But how does the presence of seismic amplitude anomalies (DHI's) impact these chance factors?

Direct Hydrocarbon Indicator (DHI), Hydrocarbon Indicator (HCI):
A type of seismic amplitude anomaly, seismic event, or characteristic of seismic data that can occur in a hydrocarbon-bearing reservoir.

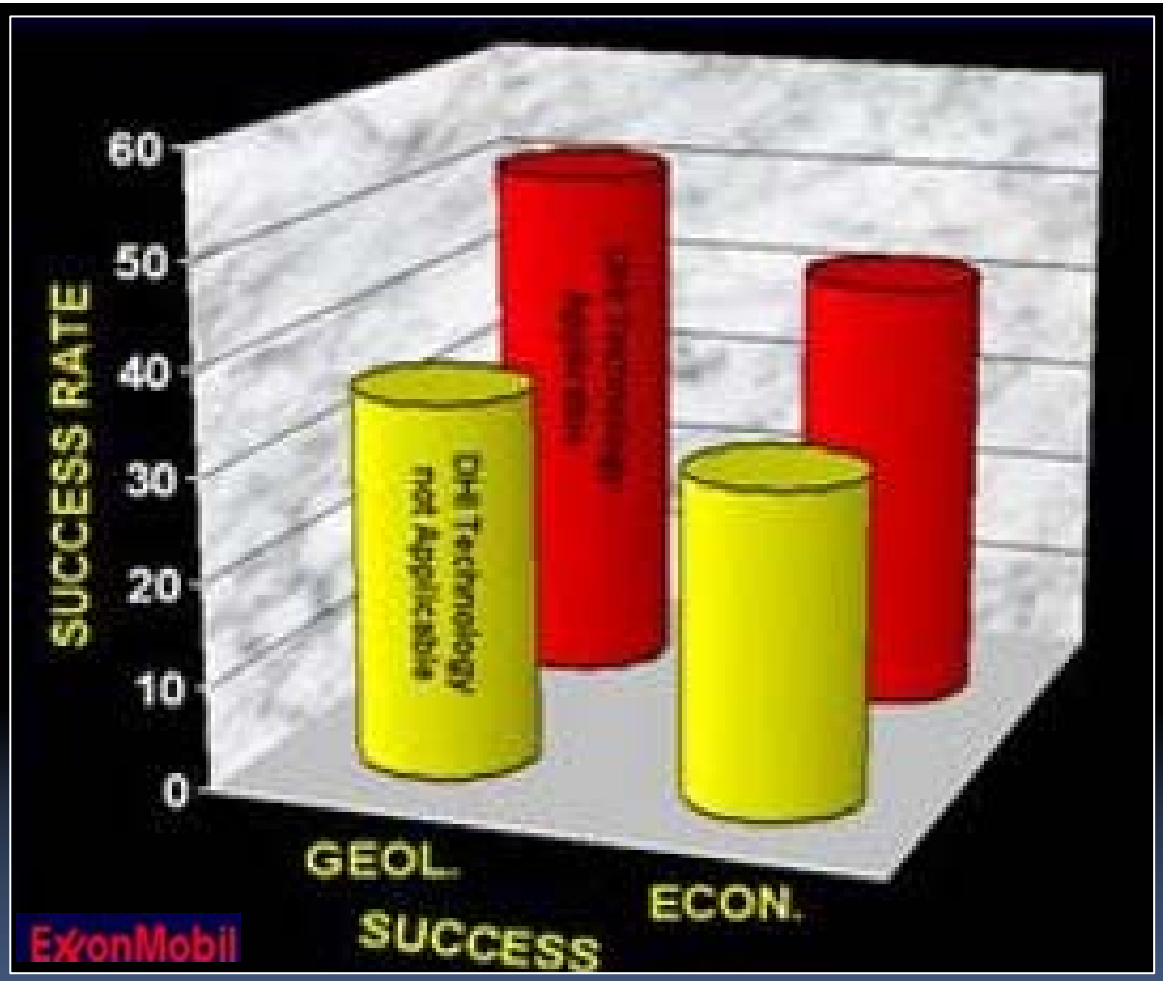
Typical DHIs:

bright spot
flat spot
dim spot
shadow zone
amplitude conformance to structure
polarity reversal
velocity sag
gas chimney
downdip phase change
appropriate AVO response

NOTE: Many of these characteristics can also be generated by factors other than the presence of hydrocarbons.

ExxonMobil DHI Best Practices (1994-2004)

~20% increase in success rate with DHI Technology



DHI Technology applied

DHI Technology not applied

Fahmy, 2006, SEG/AAPG Distinguished Lecturer

Need a Systematic and Consistent Work Process
to
Interpret and Risk Seismic Amplitude Anomalies

A DHI Interpretation and Risk Analysis Consortium was formed in Houston in January, 2001, through Rose & Associates specifically to address risking seismic amplitude anomalies

Over the last 9 years, these consortium members have contributed to developing the most comprehensive independent DHI database and evaluation methodology in the Industry…

Anadarko
Apache
BHP
Burlington
Centrica
Conoco/Phillips
Devon
Dominion
Dong
EEX
ENI
Enterprise
Hunt Petroleum/XTO
JNOC
Kerr McGee
Maersk
Marathon
Newfield
Nexen
Noble
Ocean
Oxy
Pioneer
Repsol
Samson
Santos
Shell
Spinnaker
Statoil/Hydro
Stone
Talisman
Tullow
Unocal
Westport

Goals of our DHI Risk Analysis Work Process

1. Specifically address seismic amplitudes
   - impact on prospect risking

2. Objectively characterize observations with documented occurrences of recoverable hydrocarbons in the subsurface via prospect reviews and risk analysis discussion.

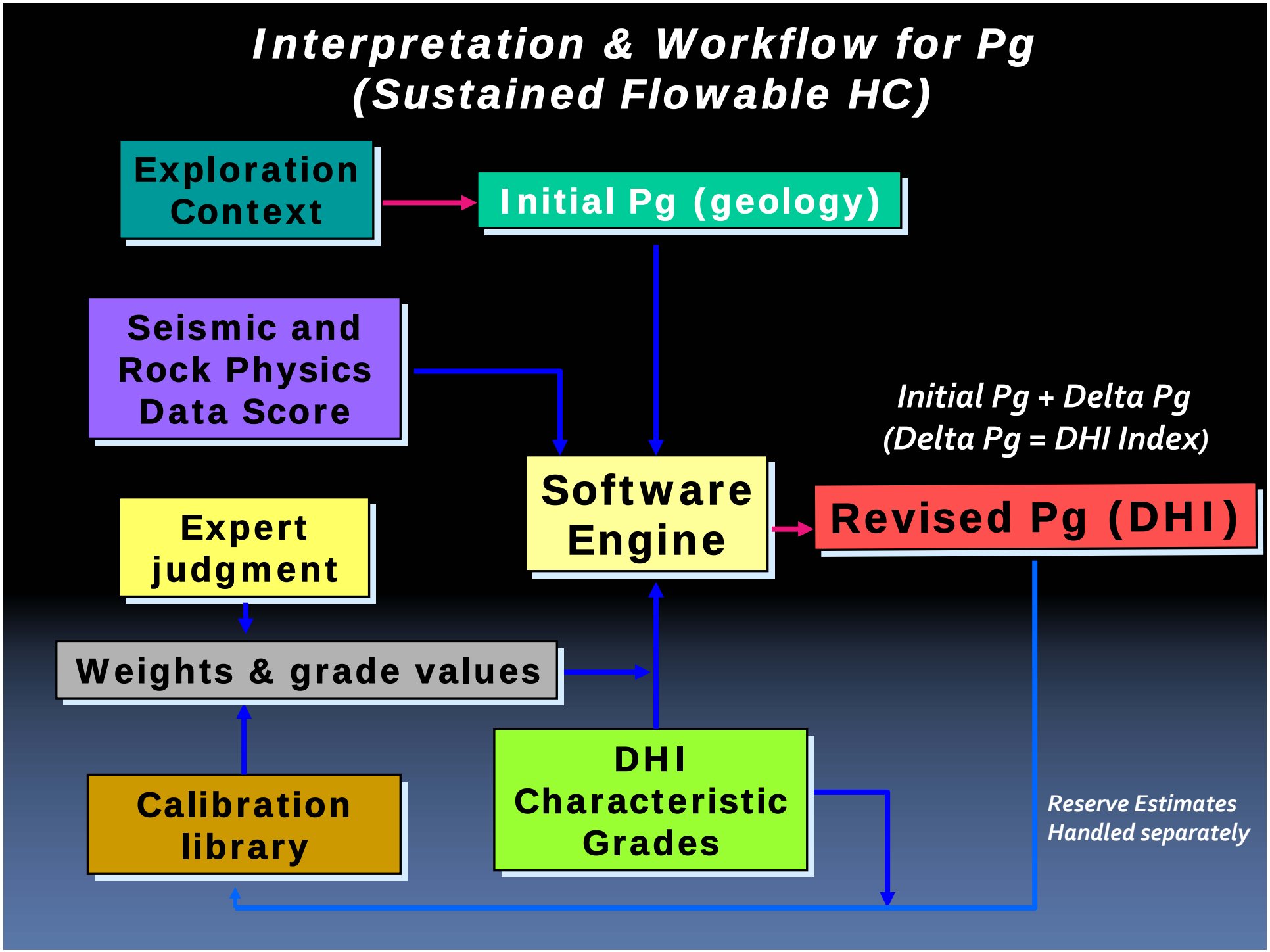
3. Archive amplitude prospects:
   Build a statistically significant library of drilled prospect results for all four AVO Class anomalies, ultimately by geologic province

Goals of DHI Risk Analysis Work Process

4. Use prospect database to improve predictability of:
   - Likelihood of recoverable oil and/or gas occurrence = *Pg*
   - The range of uncertainty with reservoir hydrocarbon volumes

5. Improve the DHI interpretation work process (SAAM software)
   - help risk seismic amplitudes,
   - provide an educational tool for interpreters

6. Discussion/Review of technologies pertinent for amplitude interpretation


Interpretation & Workflow for Pg
(Sustained Flowable HC)
Exploration Context
Initial Pg (geology)
Seismic and Rock Physics Data Score
Initial Pg + Delta Pg
(Delta Pg = DHI Index)
Software Engine
Revised Pg (DHI)
Expert judgment
Weights & grade values
Calibration library
DHI Characteristic Grades
Reserve Estimates Handled separately

Rose & Associates DHI Consortium

Initial Pg – Probability of geological success independent of the seismic amplitude information as a DHI indicator.

DHI Index (Delta Pg) – The component of the Final Pg that is due to the presence of DHI characteristics weighted by the data quality.

In other words:

The interpreter's confidence level that the seismic anomaly is truly a DHI

Final or Revised Pg = **Initial Pg + DHI Index**

DHI Risk Analysis Consortium

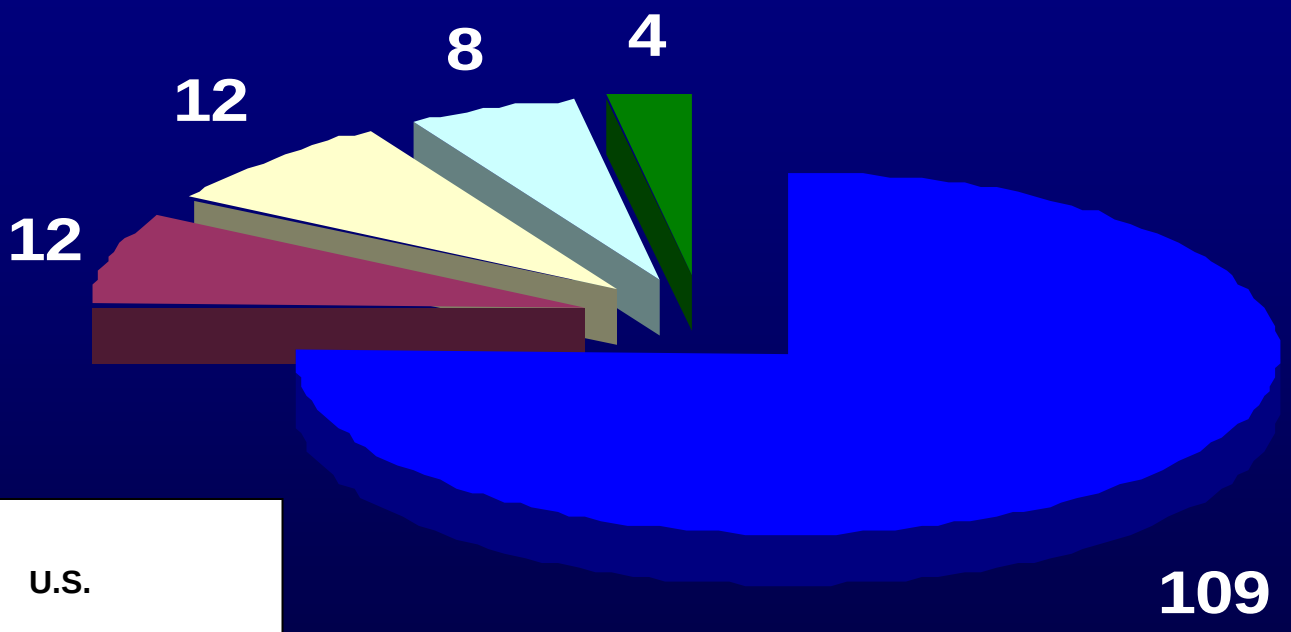
Progress as of (March 2007-Phase 4)

145 Drilled Prospects (at end Phase 4) have been analyzed to determine the prevalent factors and trends and calibrate our work process (SAAM) scores and weighting factors.

Prospect reviews are essential for learning and determining the best possible Pg.

DHI Consortium Location of Wells

145 total wells (78 successful, 67 dry)



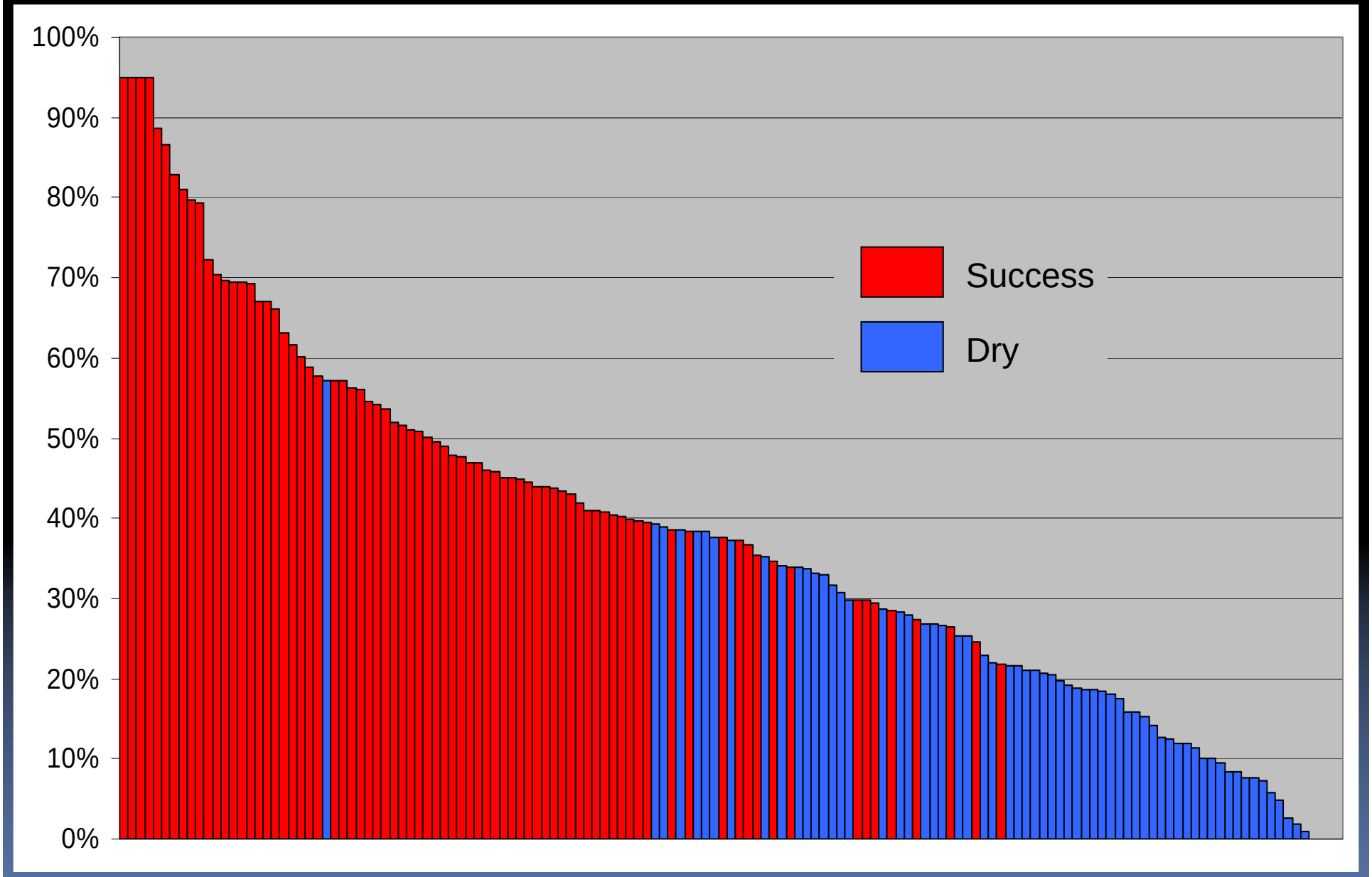
Rose & Associates DHI Consortium

70% rank wildcats in known trends

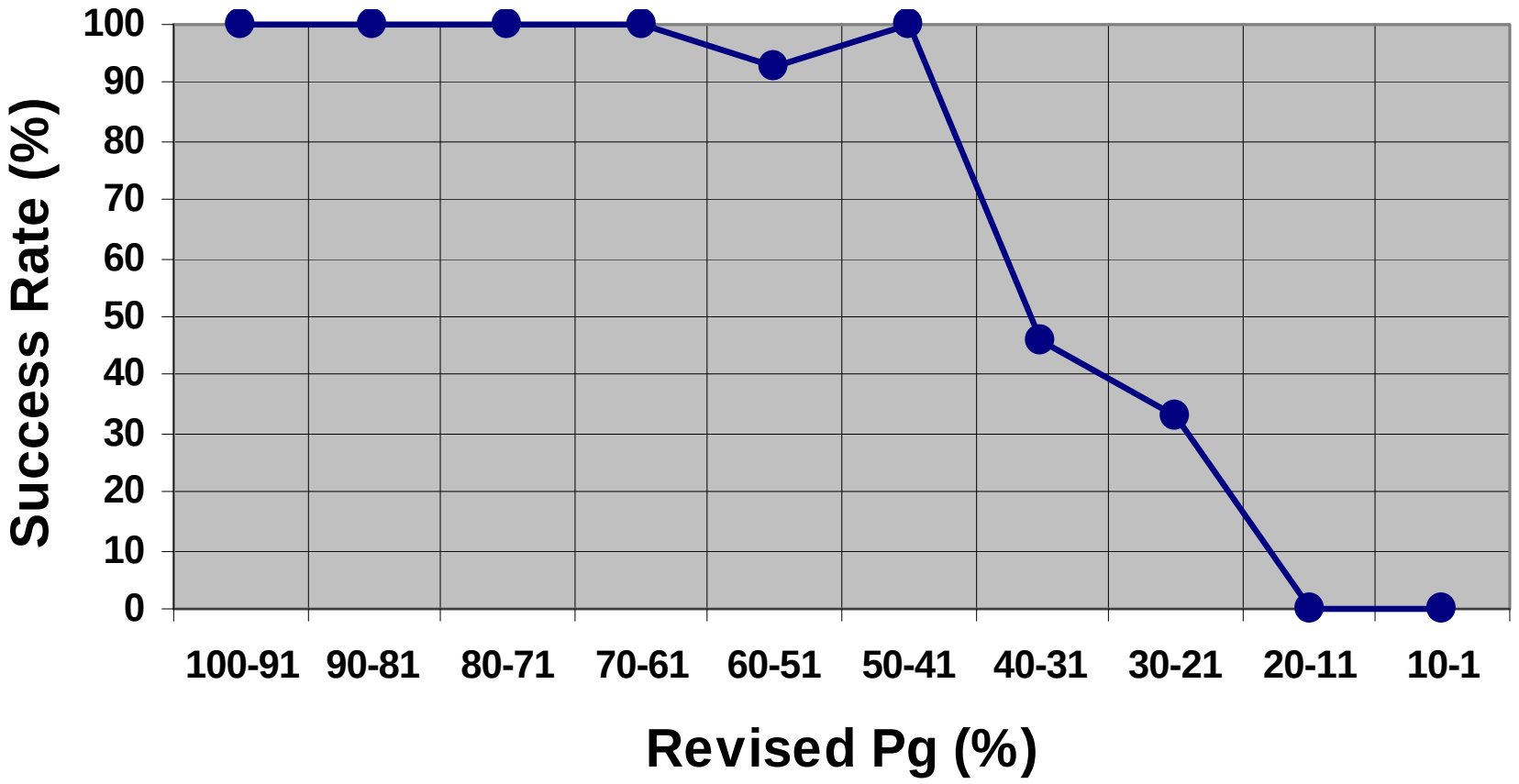
10% new play/basin wildcats and deeper pool wildcats

20% extensions to known reservoirs and development wells

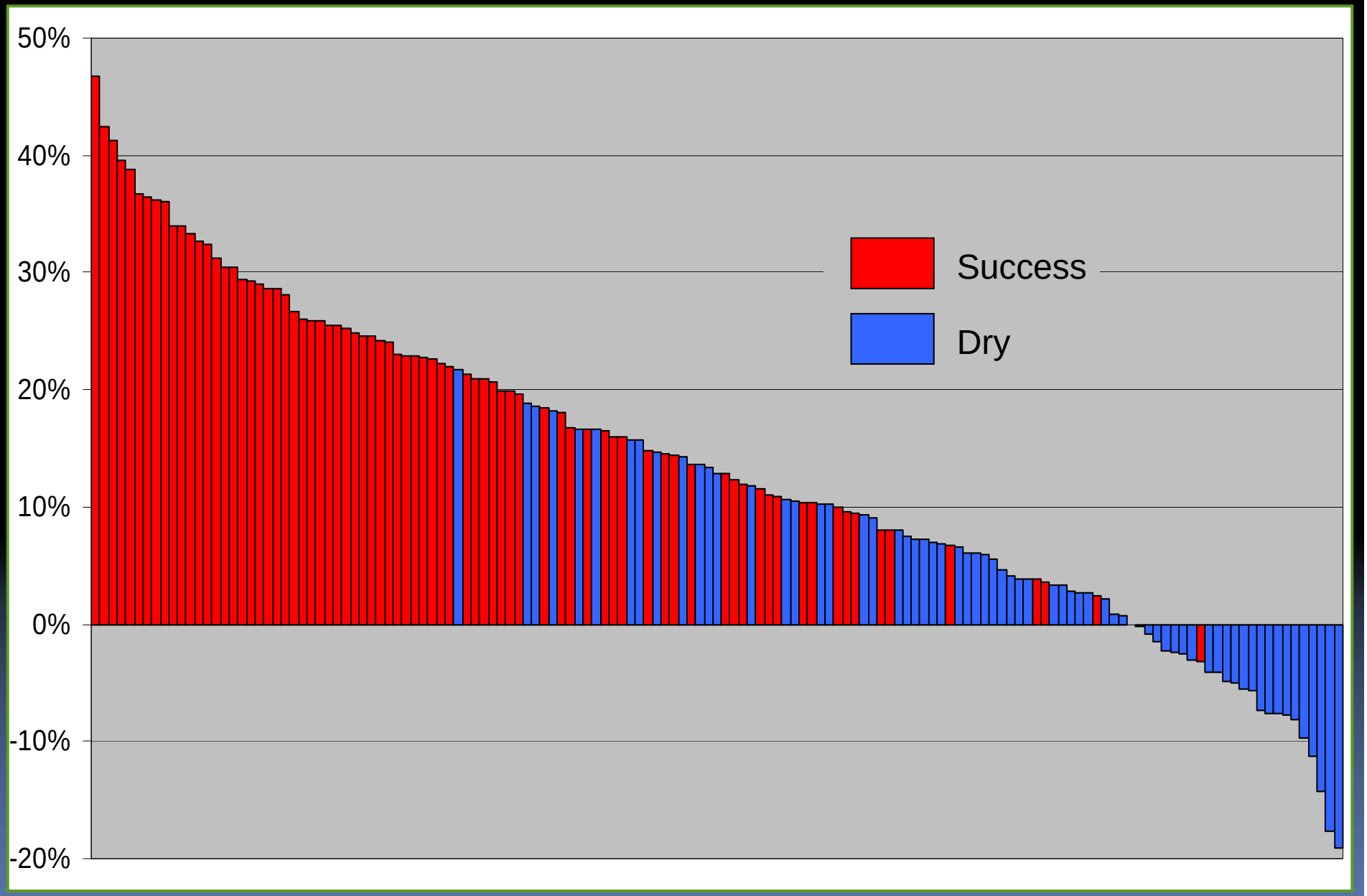
Revised Pg versus Well Outcome



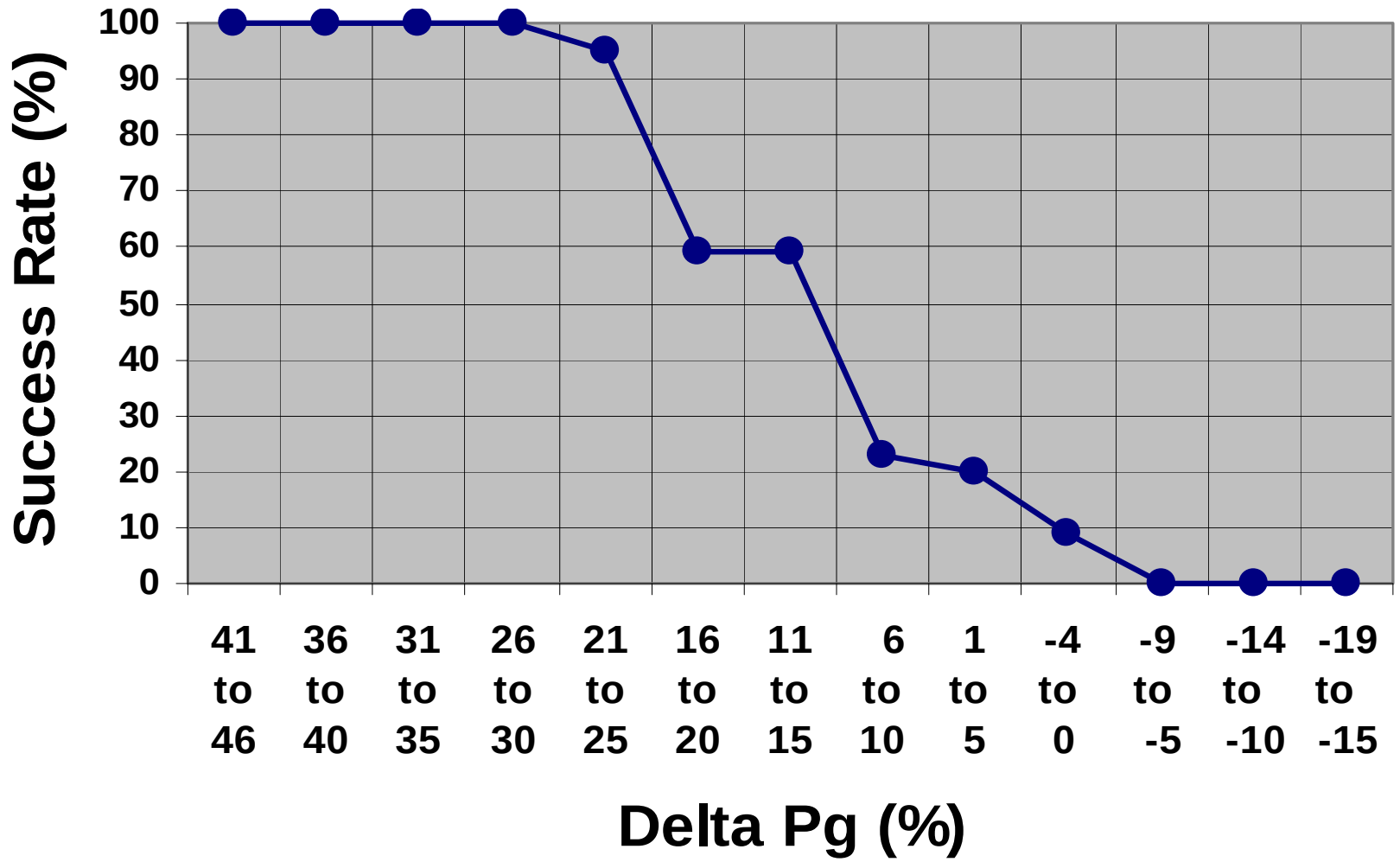
Revised Pg vs Well Outcome
Phase 4



DHI Index (Delta Pg) versus Well Outcome



Delta Pg (5% Groupings) vs Well Outcome
Phase 4



Rose & Associates DHI Consortium

Conclusions:

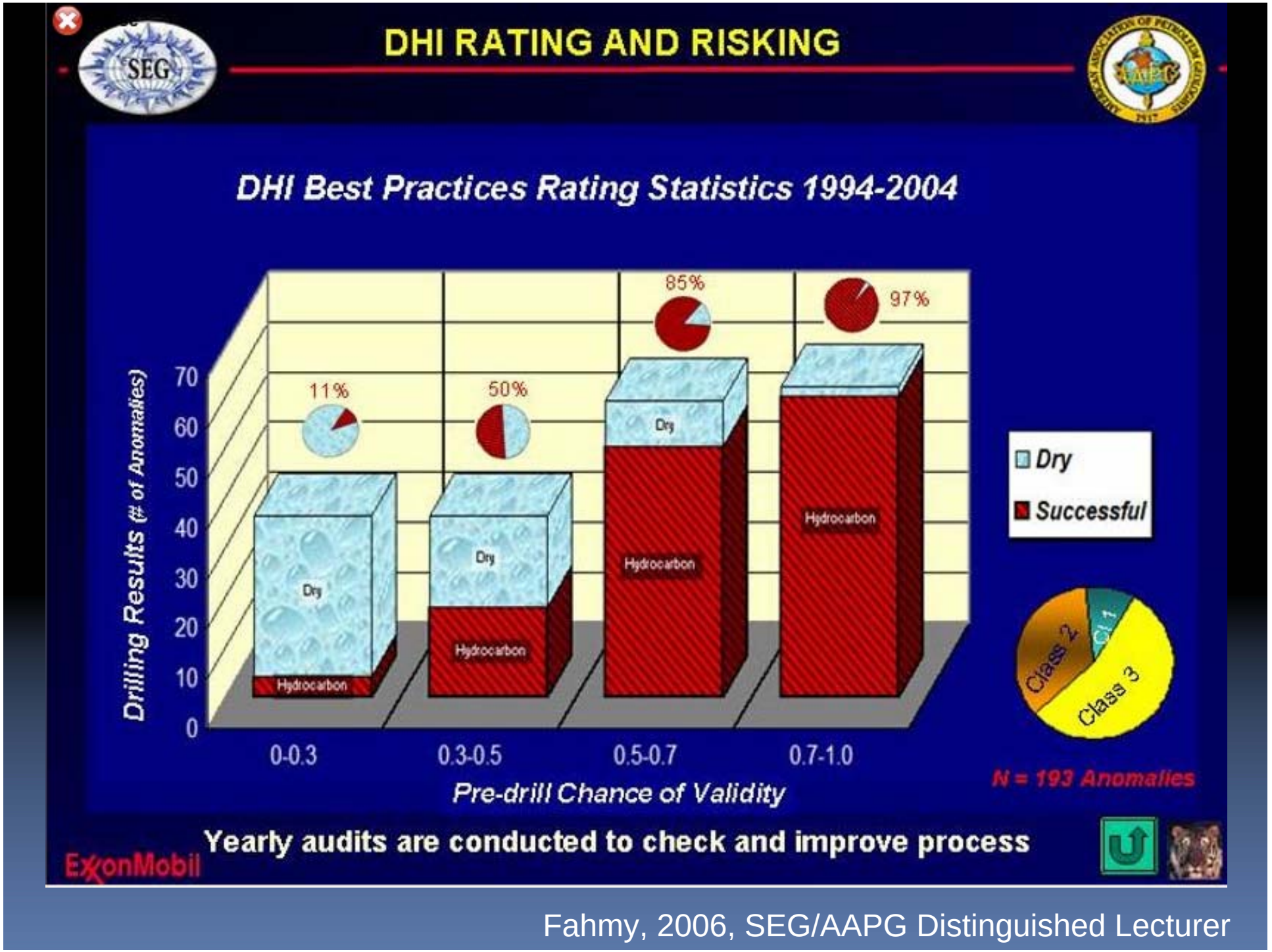
When the Revised or Final Pg was > 40% essentially all the wells were successful.

When the DHI Index or Delta Pg was > 20% essentially all the wells were successful.

DHI Threshold Effect

When the Revised or Final Pg was < 20% essentially all the wells were failures.

Low Pg Threshold Effect



Fahmy, 2006, SEG/AAPG Distinguished Lecturer

Possible causes of DHI Threshold Effect in any company DHI prospect database:

- *Prospects in database not representative of entire population of amplitude related prospects*
- *Management will not accept very high Pg values for exploration wells*
- *Databases are not large enough to identify trends*
- *Human nature drives explorationists to be conservative for high Pg prospects*
- *Interpretation bias*

Possible causes of Low Pg Threshold Effect in any company DHI prospect database:

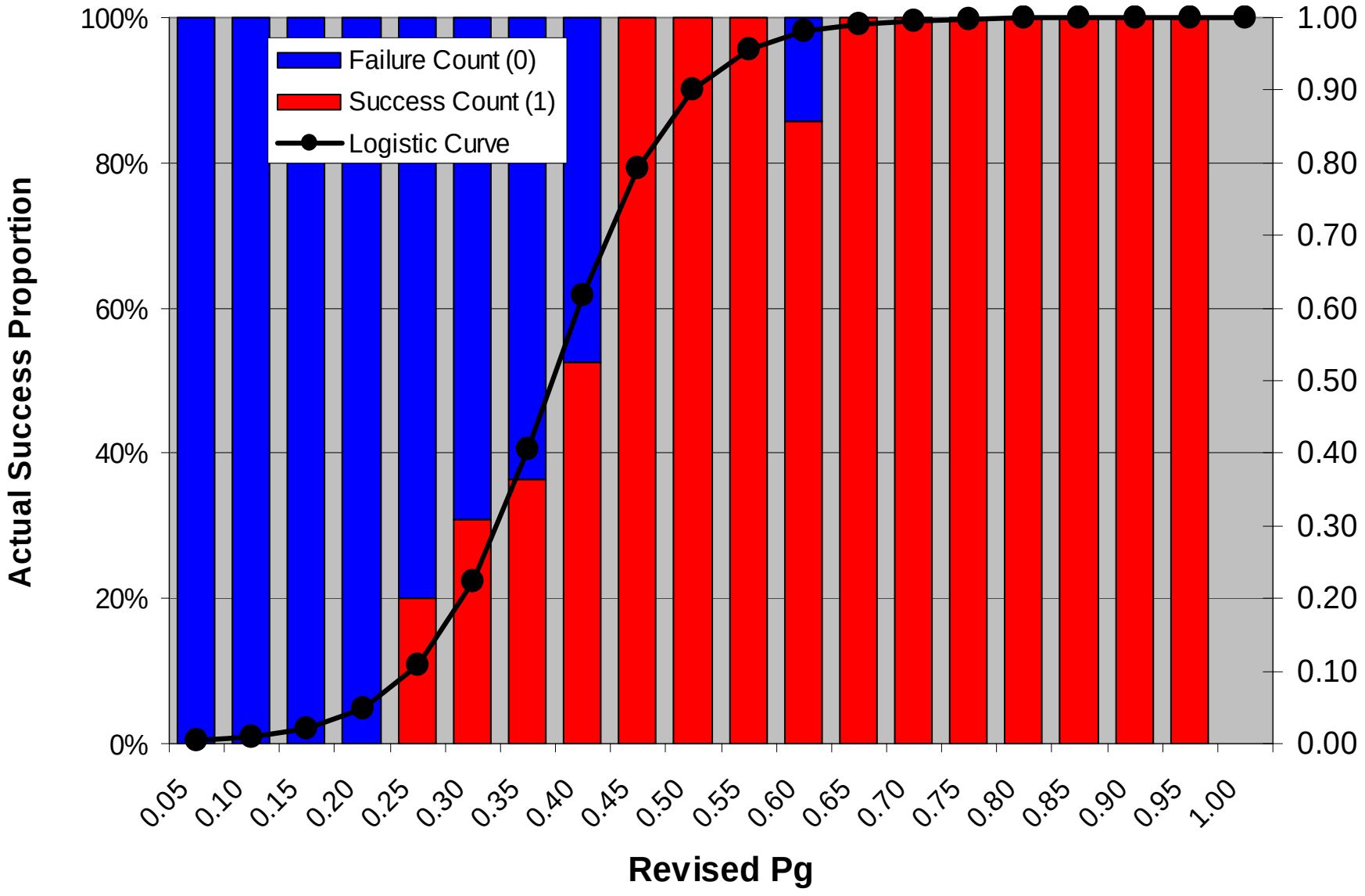
- *Data quality or lack of data becomes critical*
- *These prospects typically have few or no DHI characteristics*
- *Databases are not large enough to identify trends*
- *Geologic chance factors are so unknown that accuracy in determining high risk prospects is very poor*
- *Interpretation bias*

Alexander and Lohr, 1998, “Risk Analysis: Lessons Learned”

Surprisingly, explorationists tend to be conservative when estimating chance of success for “midrange” projects – 25% to 60% chance of success.
Such projects are successful 35% to 75% of the time.

However, for “high-risk” projects – less than 20% chance of success - explorationists have historically proven overly optimistic. Taken as a whole, such ventures have found oil less than 5% of the time.

Rose & Associates DHI Consortium



Calibration of Revised Pg Results by Curve Fitting

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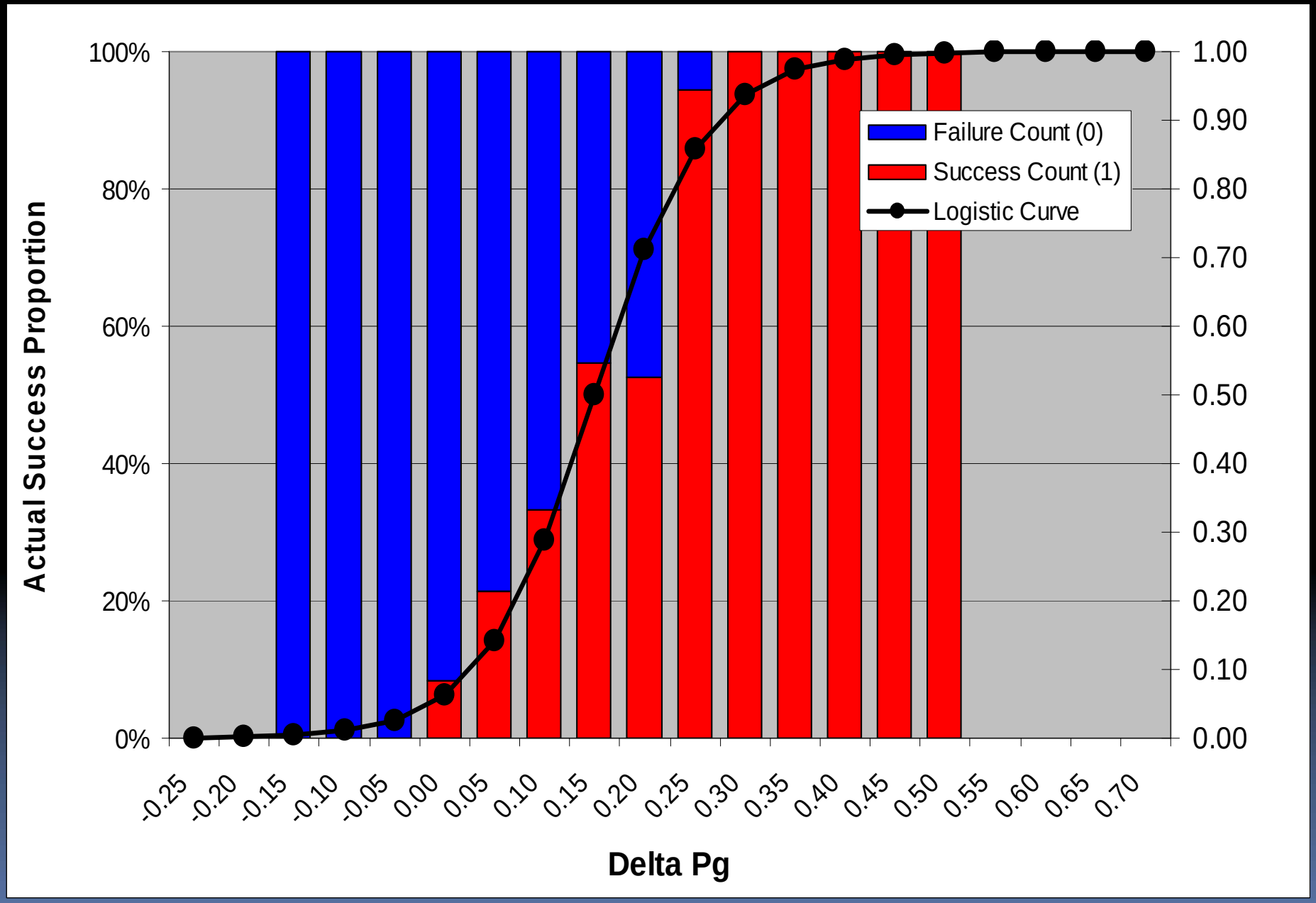

Calibration of Delta Pg Results by Curve Fitting

Conclusions

1. The Final Pg compared to drilling result trends indicate a DHI Threshold Effect for high Pg prospects and a Low Pg Threshold Effect for low Pg prospects.

2. At the upper end of the risk spectrum there is a point (DHI Threshold) at which a significant amount of geologic risks have been reduced to dramatically increase the Final Pg.

3. At the lower end of the risk spectrum there is a Low Pg Threshold below which essentially most wells are failures.

4. With a consistent and systematic process to evaluate amplitude related prospects, calibration methods can be developed to a wide range of Final Pg values (5%-95%).

5. For DHI prospects, in general geoscientists should be more optimistic in analyzing prospect risk above certain threshold levels.

6. Conversely, low risk prospects below a certain threshold should probably be farmed out or not drilled to upgrade the exploration portfolio.