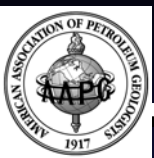


DHI / AVO Analysis Best Practices: **A Worldwide Analysis**

Kurt W. Rudolph
ExxonMobil *Exploration Company*
Houston, Texas, U.S.A.

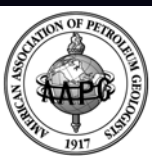
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INTRODUCTION

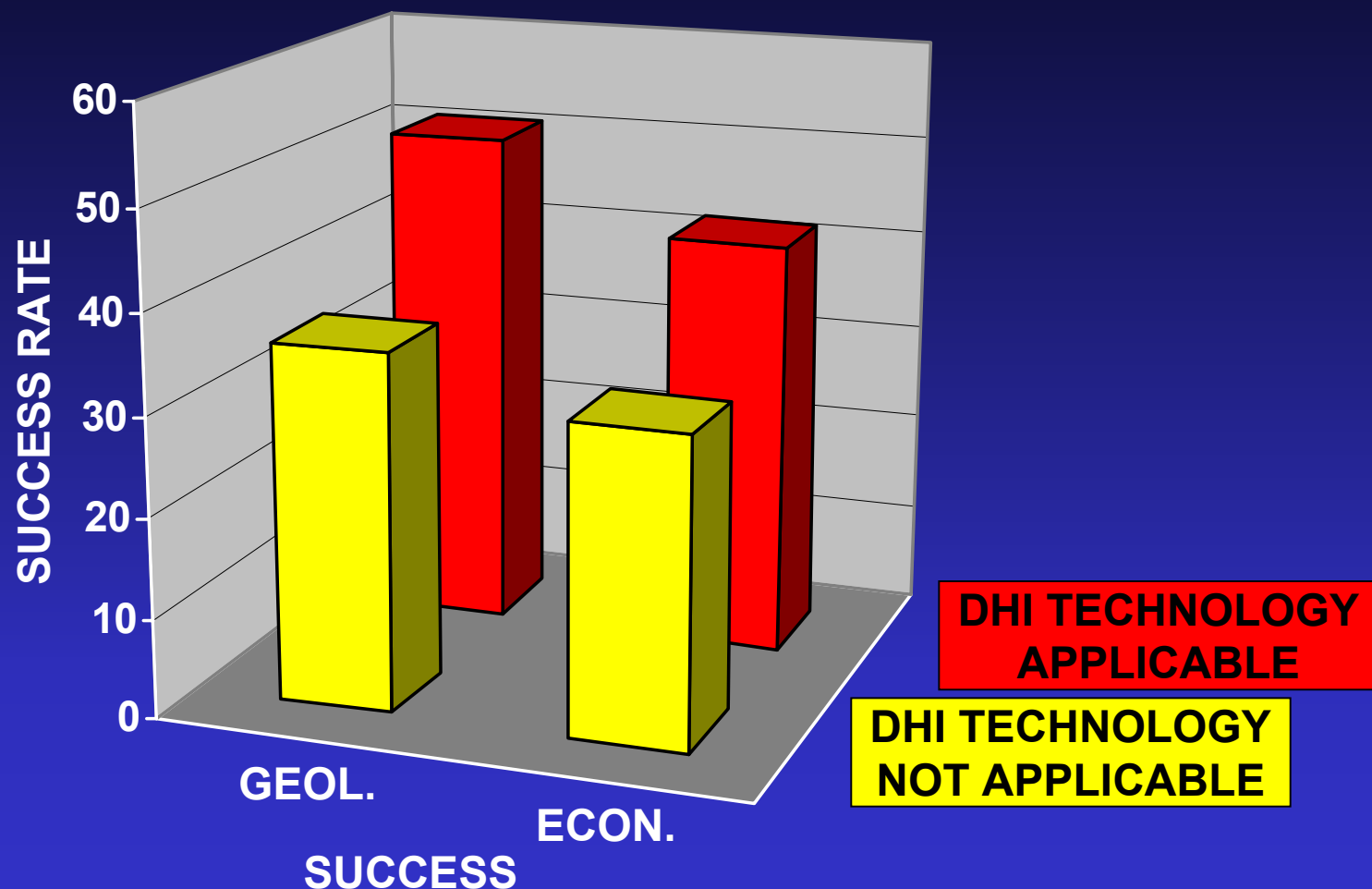


- **DHI TECHNOLOGY PROVIDES CLEAR TECHNICAL AND COMMERCIAL BENEFITS, AS EVIDENCED BY A HIGHER SUCCESS RATE (+20%) IN DHI PLAYS**
- **DHI TECHNOLOGY IS AN INCREASINGLY IMPORTANT ELEMENT OF PETROLEUM GEOSCIENCE ANALYSIS, IN PART DUE TO:**
 - + **IMPROVEMENTS IN TECHNOLOGY, ESPECIALLY SEISMIC DATA QUALITY**
 - + **EXPLORATION PORTFOLIO WEIGHTED TOWARDS DHI PLAYS (TERTIARY OFFSHORE)**
- **A “BEST PRACTICES” APPROACH TO DHI ANALYSIS HAS BEEN DEVELOPED TO ENSURE OPTIMAL APPLICATION OF THIS CRITICAL TECHNOLOGY:**
 - + **GUIDELINES FOR DHI ANALYSIS**
 - + **SPECIFICATIONS OF OPTIMAL PROCESSING STREAM**
 - + **DHI RISKING SYSTEM**

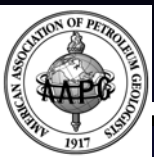


WILDCAT SUCCESS RATE

APPLICATION OF DHI TECHNOLOGY vs. GEOLOGIC and ECONOMIC SUCCESS



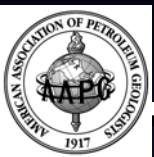
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OUTLINE OF PRESENTATION



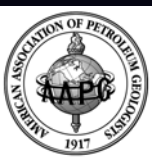
- DESCRIPTION OF WORLDWIDE HISTORICAL RESULTS OVER LAST FOUR YEARS ⇒ **STATISTICAL AUDIT OF PREDICTIONS USING BEST PRACTICES**
- LEARNINGS FROM KEY DHI TECHNOLOGY APPLICATIONS ⇒ **EXAMPLES OF IMPROVED TECHNOLOGIES AND IDENTIFIED PITFALLS IN:**
 - SEISMIC PROCESSING
 - AVO ANALYSIS
 - GAS vs. OIL PREDICTION
 - EMERGING TECHNOLOGIES
- CONCLUSIONS ⇒ **WHAT HAVE WE LEARNED, WHERE WE ARE GOING**



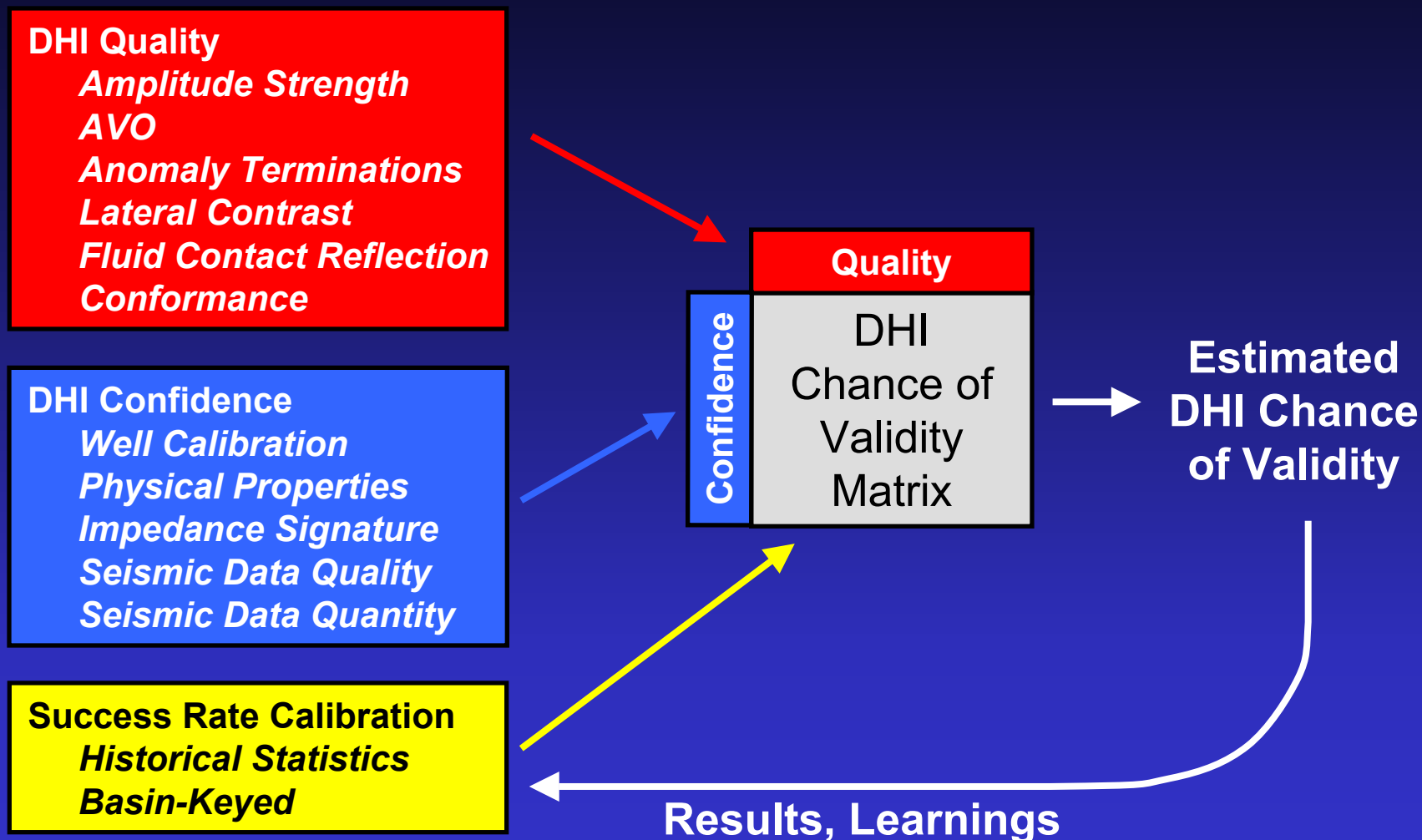
DHI RATING AND RISKING PROCEDURE

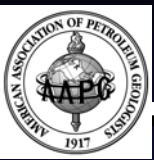


- **DHI QUALITY FACTORS** ⇒ *HOW GOOD DOES ANOMALY LOOK BASED ON ALL RELEVANT CHARACTERISTICS?*
- **DHI CONFIDENCE FACTORS** ⇒ *HOW CONFIDENT AM I OF THE DATA SUPPORTING THE ANOMALY?*
- **THESE FACTORS COMBINED INTO A RISK MATRIX TO ESTIMATE THE CHANCE OF VALIDITY** ⇒ *WHAT IS THE PROBABILITY THAT THE ANOMALY IS A VALID HYDROCARBON EFFECT?*
- **RISK MATRIX CALIBRATED BASED ON HISTORICAL STATISTICS** ⇒ *WHAT ARE THE RESULTS OF SIMILAR ANOMALIES THAT HAVE BEEN DRILLED IN THE AREA?*



DHI RATING AND RISKING PROCEDURE

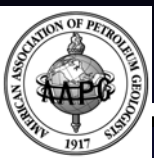




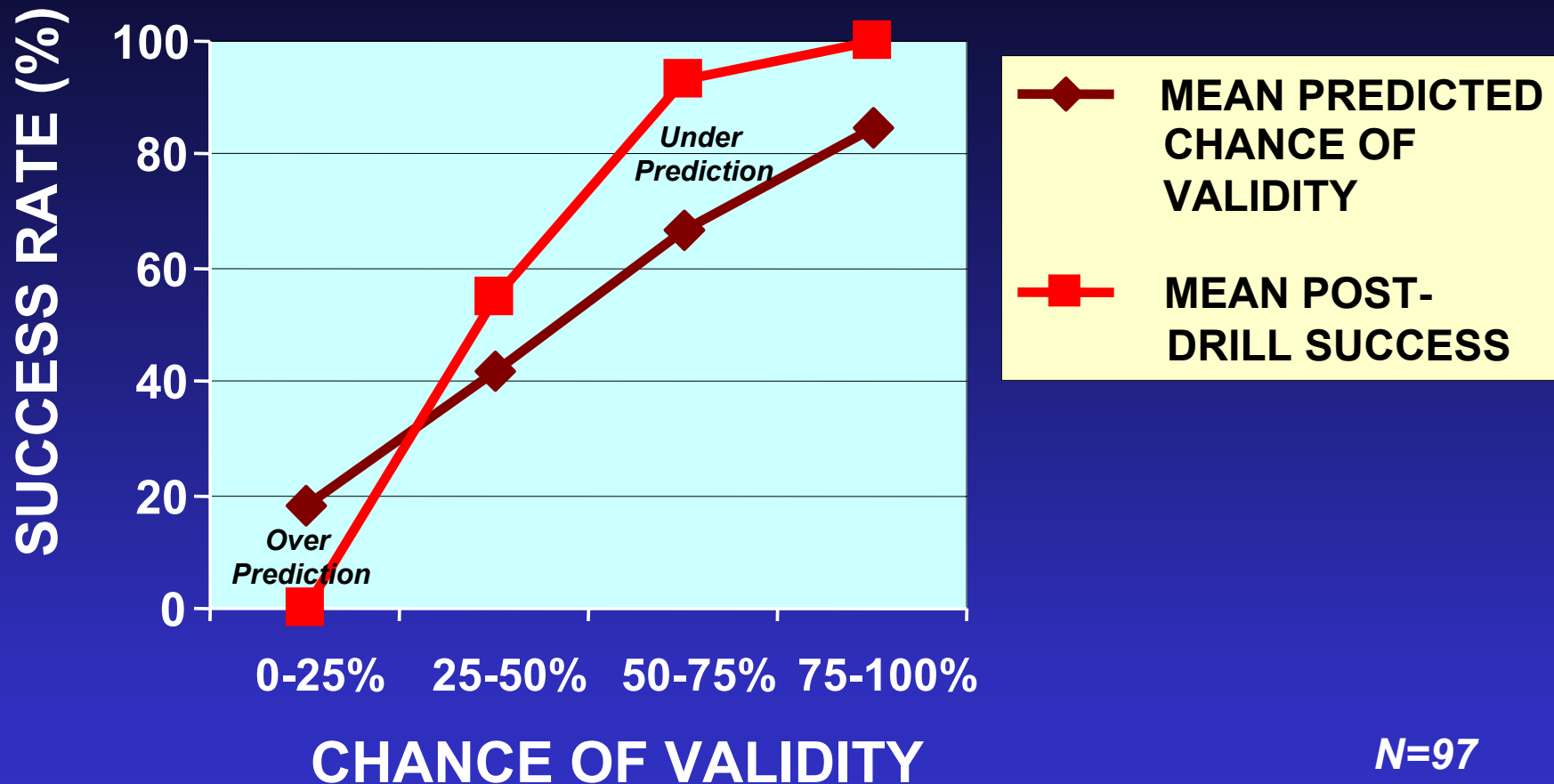
PREDICTED vs. ACTUAL DHI TECHNICAL SUCCESS

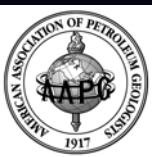
(CHANCE OF VALIDITY)

- **WELL RESULTS HAVE BEEN USED TO AUDIT THE DHI CHANCE OF VALIDITY**
- **STRONG CORRELATION BETWEEN TECHNICAL SUCCESS AND HIGH PREDRILL CHANCE OF VALIDITY**
- **SOME UNDER-PREDICTION OF SUCCESS FOR BEST ANOMALIES ⇒ *E.G. ALL (24 OF 24) OF 75-100% CHANCE OF VALIDITY ANOMALIES WERE TECHNICAL SUCCESSES***
- **UNDERPREDICTION INFLUENCED BY HIGH TECHNICAL SUCCESS RATE IN WEST AFRICA ⇒ *HAS BEEN ADDRESSED BY ADJUSTING RISK MATRIX FOR THIS AREA***



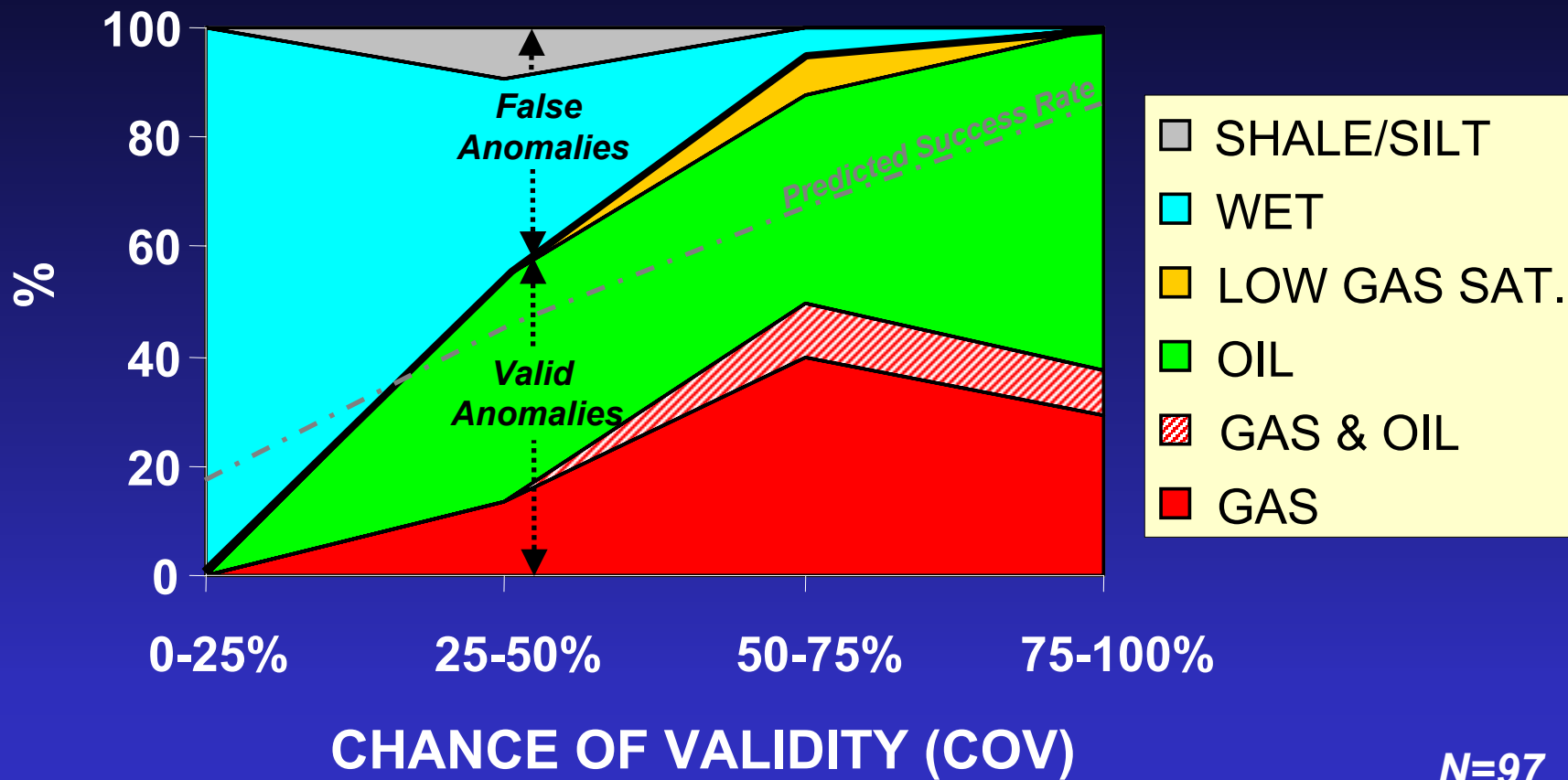
PREDICTED vs ACTUAL DHI TECHNICAL SUCCESS SORTED BY RISK TIERS

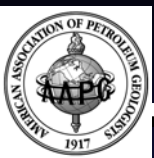




DRILLED ANOMALY RESULTS

SORTED BY RISK TIERS





DHI QUALITY FACTORS

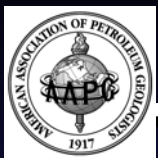


- ALL INDIVIDUAL QUALITY FACTORS DISPLAY A SMALL POSITIVE CORRELATION WITH SUCCESS ⇒

HIGHER SCORE FOR VALID ANOMALIES

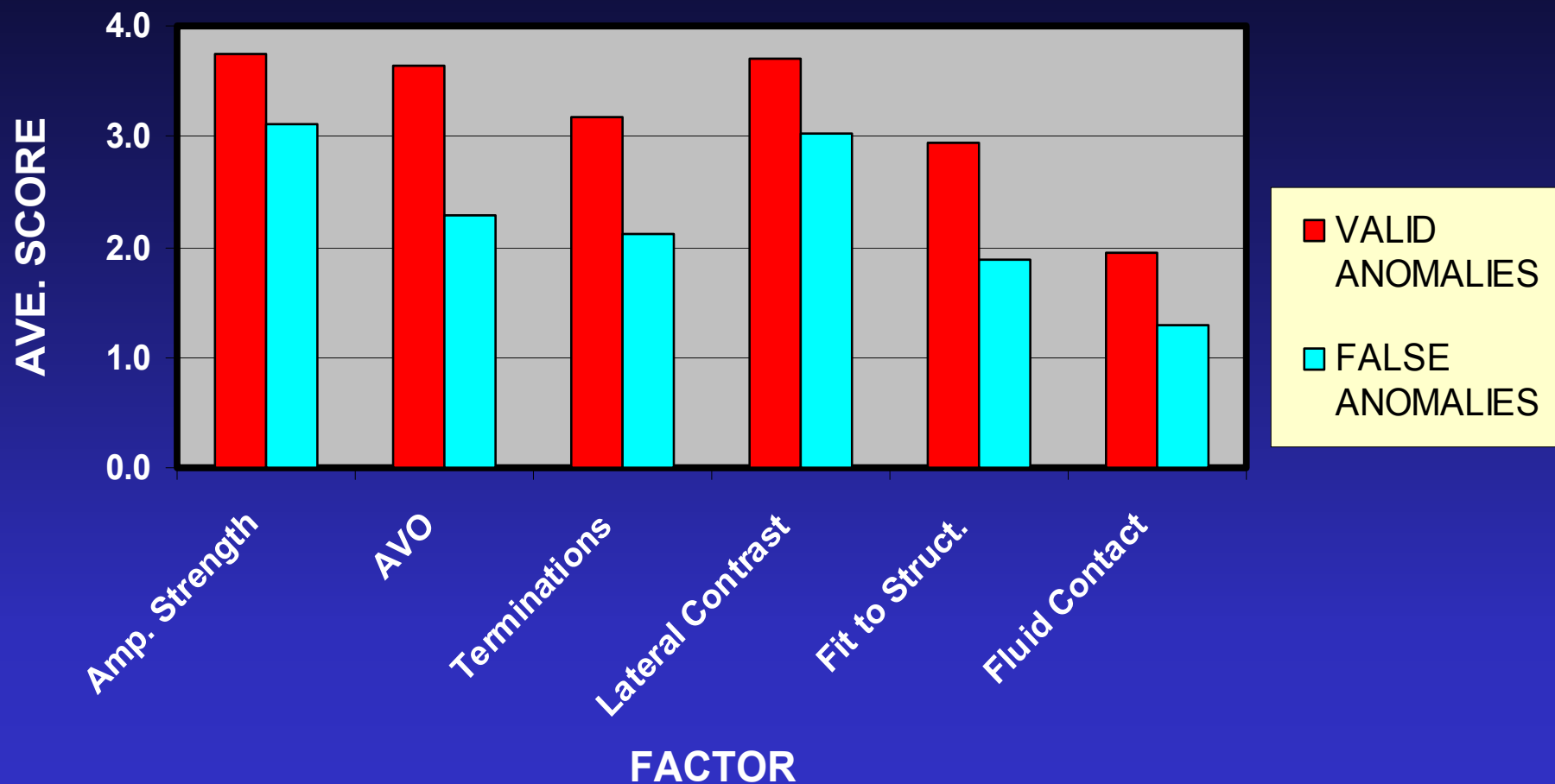
- NO SINGLE CHARACTERISTIC OR TECHNOLOGY IS A PANACEA - ALL ARE IMPORTANT FOR OPTIMAL PREDICTIVE CAPABILITIES ⇒

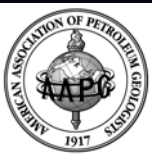
EXAMPLE FLUID CONTACT REFLECTIONS



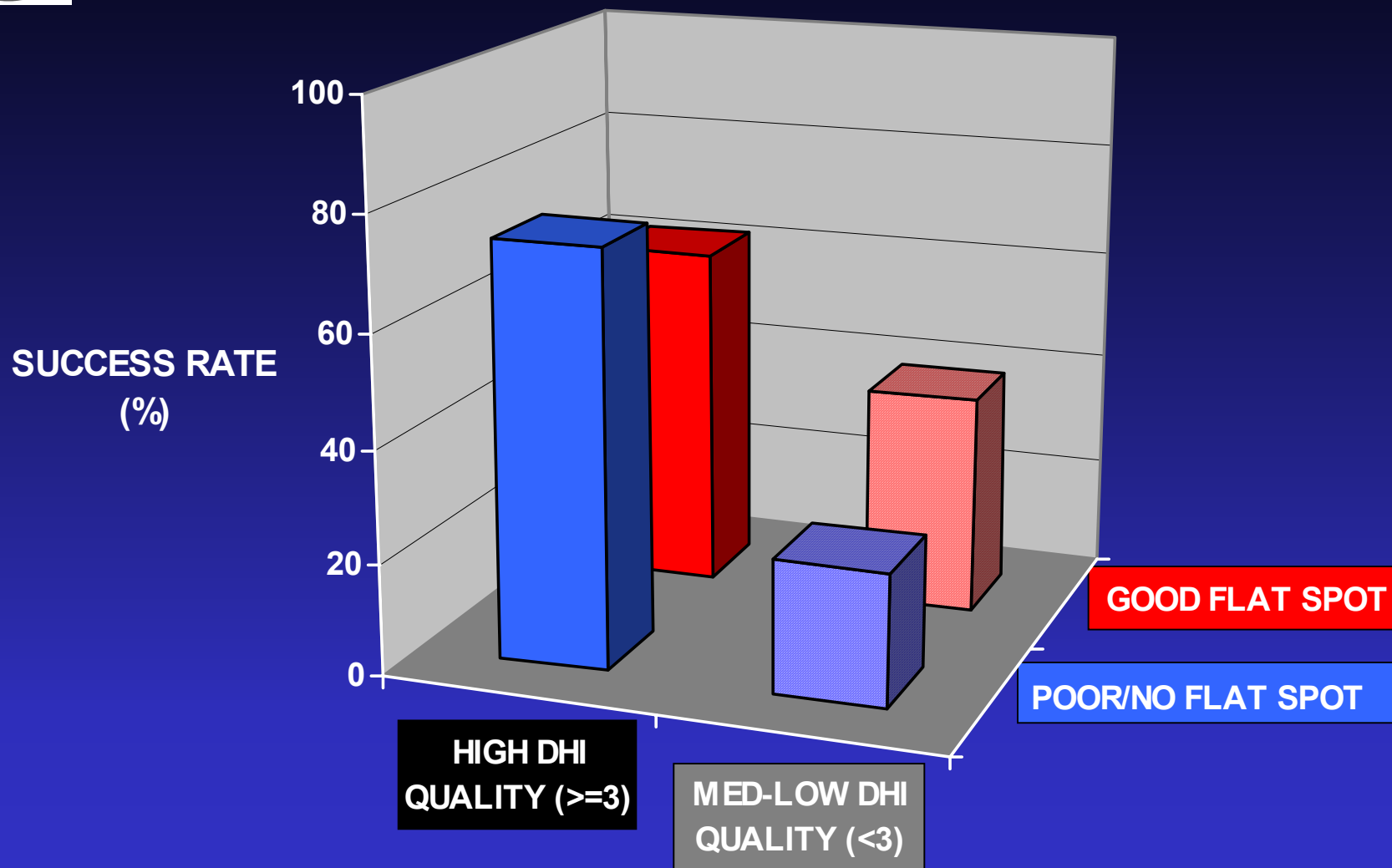
DHI QUALITY FACTORS

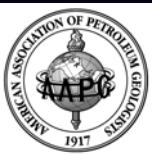
VALID vs. FALSE ANOMALIES



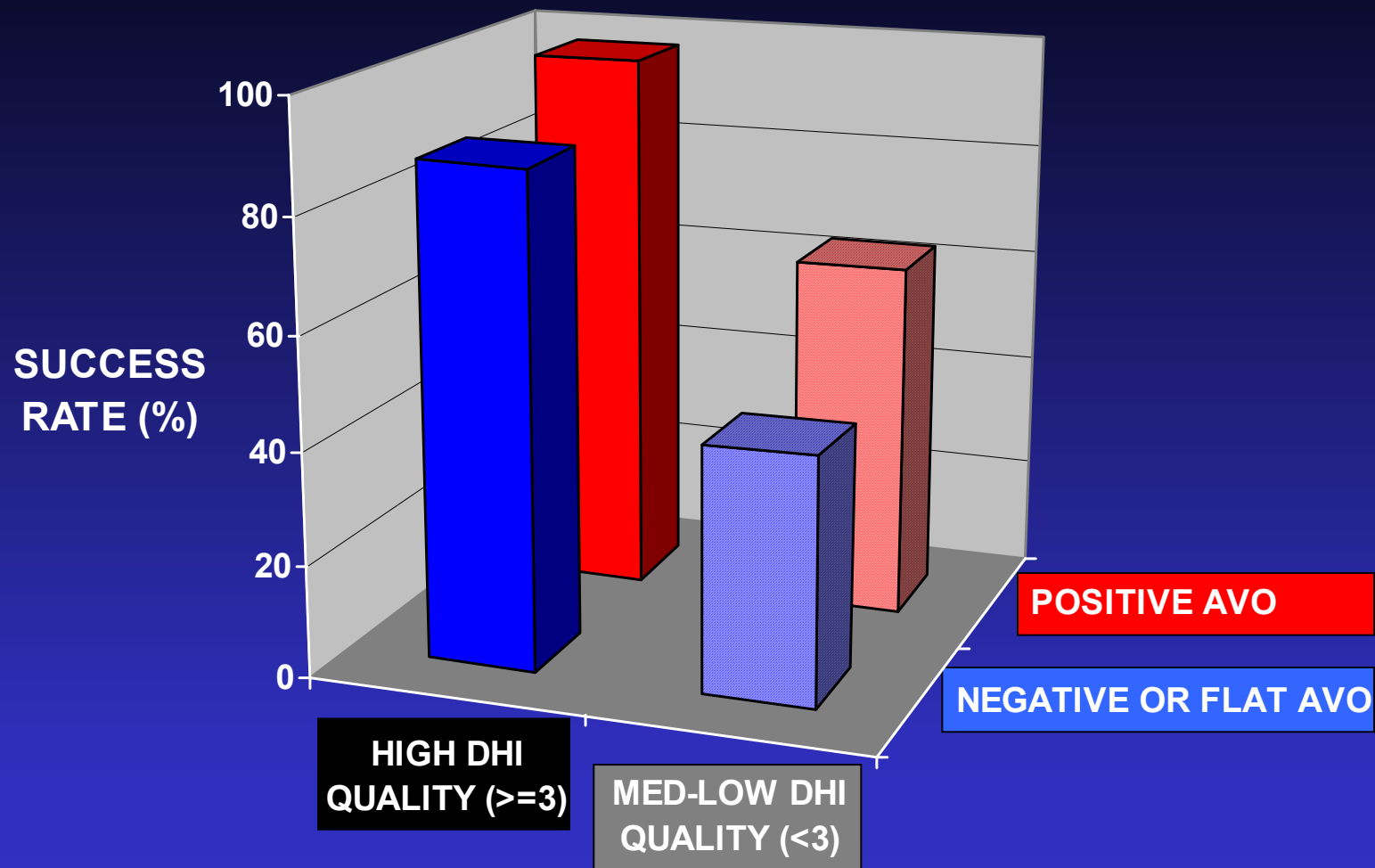


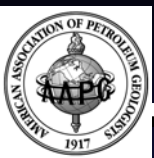
FLAT SPOTS vs. SUCCESS





AVO vs. SUCCESS

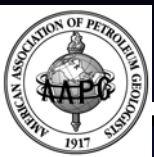




SEISMIC DATA QUALITY OVERVIEW



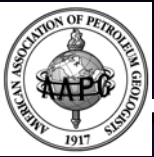
- **SEISMIC DATA QUALITY IS ABSOLUTELY CRITICAL TO DHI ANALYSIS:**
 - + **INTEGRITY OF AMPLITUDE AND PHASE ON FULL AND PARTIAL STACKED SECTIONS**
 - + **INTEGRITY OF IMAGE GATHERS (AMPLITUDE, PHASE, POSITIONING)**
 - + **WELL TIE VALIDATION**
- **POOR SEISMIC DATA QUALITY MOST IMPORTANT CAUSE OF “FALSE ANOMALIES”**



AVO ANALYSIS OVERVIEW



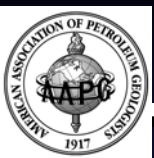
- INTEGRITY OF SEISMIC DATA CRITICAL \Rightarrow *AMPLITUDE/PHASE, SEISMIC VELOCITIES, POSITIONING, MULTIPLES, ACQUISITION, ETC.*
- VALIDATED POSITIVE AVO IS NOT ALWAYS ASSOCIATED WITH HYDROCARBONS \Rightarrow *OTHER DHI CHARACTERISTICS REMAIN CRITICAL; CAREFUL SELECTION OF MUTE PATTERN ALSO IMPORTANT*
- 3D AVO IS AN INDISPENSABLE TOOL FOR FLUID AND STRATIGRAPHIC INTERPRETATION \Rightarrow *INCLUDING ANOMALY RECONNAISSANCE, SUBTLE CLASS 2 ANOMALIES, HIGH RESOLUTION STRATIGRAPHIC INTERPRETATION*
- AVO DISPLAYS (ENVELOPE, FLUID FACTOR, ETC.) CAN BE MISLEADING WHEN USED ALONE \Rightarrow *AUDIT WITH GATHERS AND ANGLE STACKS NECESSARY*



GAS vs. OIL PREDICTION OVERVIEW



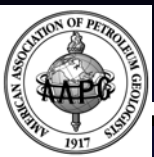
- **GENERALLY INCREASED OCCURRENCE OF GAS WITH HIGHER CHANCE OF DHI VALIDITY CONSISTENT WITH EXPECTATION THAT GAS DHIs, ON AVERAGE, ARE MORE OBVIOUS**
- **ON AN INDIVIDUAL ANOMALY BASIS, SEISMIC PREDICTION OF OIL vs. GAS REMAINS A DIFFICULT ISSUE**
- **HOWEVER, WHEN BOTH PHASES ARE PRESENT IN A SINGLE RESERVOIR, BETTER OPPORTUNITY FOR PREDRILL PREDICTION**



EMERGING TOOLS OVERVIEW



- MORE WIDESPREAD APPLICATION OF PRESTACK ATTRIBUTES FOR FLUID AND RESERVOIR PREDICTION \Rightarrow ***VERY SENSITIVE TO DATA QUALITY***
- NEW VISUALIZATION TOOLS FOR SEMI-AUTOMATED RECOGNITION AND MAPPING OF ANOMALIES \Rightarrow ***SCREENING TOOLS AT PRESENT, NOT A TOTAL REPLACEMENT FOR CONVENTIONAL ANALYSIS***
- 3D ELASTIC INVERSION BECOMING MORE WIDELY USED \Rightarrow ***MORE DIRECT TIE OF SEISMIC TO GEOLOGIC MODELS***

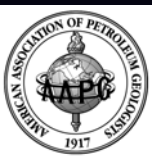


CONCLUSIONS



KEYS TO SUCCESSFUL DHI ANALYSIS

- **SEISMIC DATA QUALITY IS PARAMOUNT:**
 - + **AMPLITUDE/PHASE PRESERVATION OF BOTH STACKED AND GATHER DATA**
 - + **INTEGRITY OF PRESTACK DATA FOR AVO ANALYSIS (EG POSITIONING, MULTIPLES, RESIDUAL MOVEOUT, MUTE)**
- **3D AVO IS A VERY USEFUL TOOL FOR RECOGNITION OF SUBTLE (CLASS 2) ANOMALIES**
- **NON-UNIQUENESS OF SEISMIC RESPONSE (PHYSICAL PROPERTIES, INTERFERENCE) MAKES PREDRILL DISTINCTION OF OIL vs. GAS DIFFICULT**
- **NO SINGLE TOOL IS A UNIVERSAL REMEDY - BEST RESULTS OBTAINED BY HONORING THE FUNDAMENTALS, INTEGRATING ALL ASPECTS, AND CONTINUOUS LEARNING.**



CURRENT & FUTURE TRENDS FOR DHI ANALYSIS



- **IMPROVED DHI/AVO PROCESSING**
 - + **MORE WIDESPREAD AND IMPROVED APPLICATION OF PRESTACK MIGRATION, NONHYPERBOLIC MOVEOUT ANALYSIS, Q-COMPENSATION, ETC.**
 - + **WILL FACILITATE IDENTIFICATION OF SUBTLE AVO ANOMALIES AND ALLOW USE OF LONGER OFFSETS**
- **FURTHER APPLICATION AND DEVELOPMENT OF PRE-STACK ATTRIBUTES, INCLUDING ADVANCED USE OF MULTIPLE CUBES**
 - + **QUANTITATIVE AVO**
 - + **USE OF VISUALIZATION TECHNOLOGY FOR N-DIMENSIONAL ANALYSIS**
- **INCREASING DHI/AVO APPLICATIONS IN EXPLOITATION**
 - + **IMPROVED QUANTITATIVE RESERVOIR PREDICTIONS**
 - + **4D/TIME-LAPSE APPLICATIONS**