BETTER RESERVOIR MANAGEMENT THROUGH INTEGRATION OF AVAILABLE DATA

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AGENDA

- Reservoir Management - Objectives, Principles
- Reservoir Performance Evaluation Methods
- Capturing and Validation of data
- Data Interpretation
- Data Analysis and Preparation
- Data Integration - Considerations
- Geo-cellular Model
- Upgridding
- Field Development
- Advances in Reservoir Management technologies
- Top - Down Modeling
- Future areas of Advances in technologies

RESERVOIR MANAGEMENT

- Controlling operations and maximising economic recovery :
  - Application of available technology and knowledge
  - To a Reservoir System
  - Within a given management environment

- It is a daunting task because it requires dealing with many uncertain parameters

- Reservoir simulation together with history matching, decline curve analysis and material balance calculations are currently practiced for forecasting the future behaviour of a reservoir

RESERVOIR MANAGEMENT: OBJECTIVES

1. Decrease Risk
2. Increase Oil and Gas Production
3. Increase Oil & Gas reserves
4. Minimize Capital Expenditure
5. Minimize Operating Costs

FIVE PRINCIPLES OF RESERVOIR MANAGEMENT

1. Conservation of Reservoir energy
2. Early application of simple strategies
3. Sustained and systematic data collection campaign
4. Implementation of improved technologies
5. Multi-disciplinary team

RESERVOIR PERFORMANCE EVALUATION METHODS

VOLUMETRIC

- Simple (static) – minimum data
- Recovery as a function of lowest FTHP
- Reserves = GIP Volume * Recovery Factor

ANALOGUE

- Similarity –base reservoir performance
- Valid for comparable properties ranges
- Suitable for data mining and AI

MATERIAL BALANCE (GAS & WATER)

- Gas properties as function of P & T
- Needs some dynamic data (production)
- Very sensitive to initial data
- P/z = - (Pi/Zi*G) Gp + Pi/Zi

MATERIAL BALANCE (OIL, WATER & GAS)

- Fluids and Pressure as function of time
- Reservoir mechanism identification
- Multiple reservoirs, fluids, wells.
- Compartments & fluids transfer

DECLINE CURVE ANALYSIS

- Production data versus time or cumulative
- Data driven (exponential, hyperbolic, etc.)
- Limited link to reservoir and operations

PRODUCTION ANALYSIS (RTA OR INVERSE RATE)

- Production data versus time or cumulative
- Integrates transient & steady state
- Links to reservoir and operating conditions
- Useful in unconventional

RESERVOIR SIMULATION

- Physics first principle model
- Geology and geophysics detail
- Multiple reservoirs, fluids, wells.
- Compartments & fluids transfer
- Gravity, capillary, chemistry, scale, etc.
- Numerical – computational intensive

CAPTURING AND VALIDATION OF DATA

- Begins with the ability to capture operational data, equipments and facilities.
- Facilities decide when, why and what type of measurements can be incorporated.
- Critical phase impacts the timeliness, accuracy and comprehensive nature of the measurements.
- Multitude of sources include SCADA system, hand-held data entry, manual data entry or involvement of third parties.
- Data collected-Well-head pressures, choke settings, downtime, separator temp. and pressure, compressor throughput pressures and production data flow rates of liquids and gas and tank inventories.
- Comparisons to prior data can highlight errors & discrepancies to confirm the accuracy of the data

DATA INTERPRETATION

- Use widely varying scales and resolutions –reveal different aspects of the formation and the reservoir behavior

- Geophysical data models for example reveals acoustic impedance contrasts ,pressure transient data at different scales primarily identify mobility and storability contrasts

- Desires cooperation across the asset team

DATA ANALYSIS

- Turning this data into useful, relevant information that will help make business-critical decision is one of the main challenges the industry faces today

- To gain the best benefits from analytics the underlying data from multiple sources need to be connected

- Analytic tools provide the ability to alert decision makers when specific conditions are met ,which changes the dynamics for a reactive self service pull of data to a proactive push of critical information to users

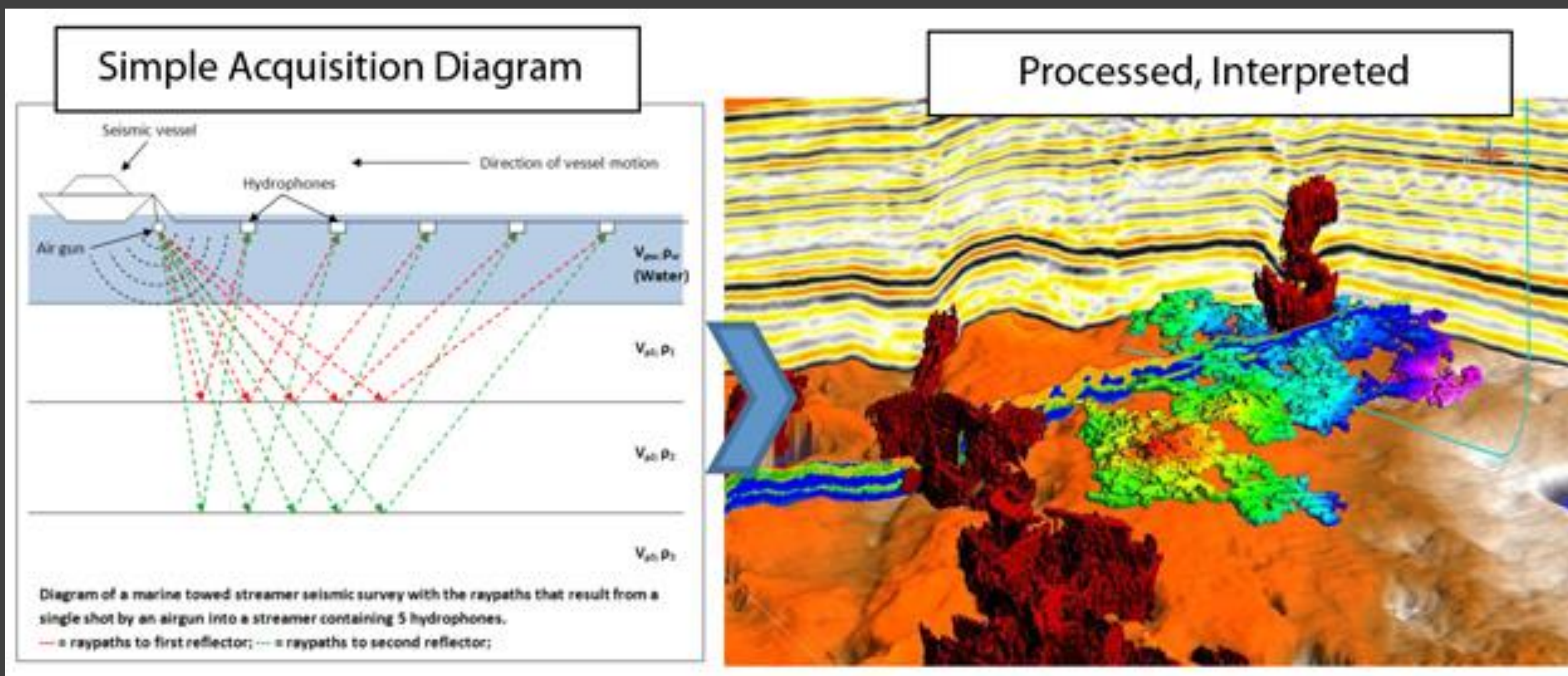
- Complex production problems — such as sanding which adversely affect production — require an understanding of the issues and the tools to critically analyze data and determine historical patterns

- Variety of pre-built analytics ,data and visualization tools are available, so that the system provides value out-of-box

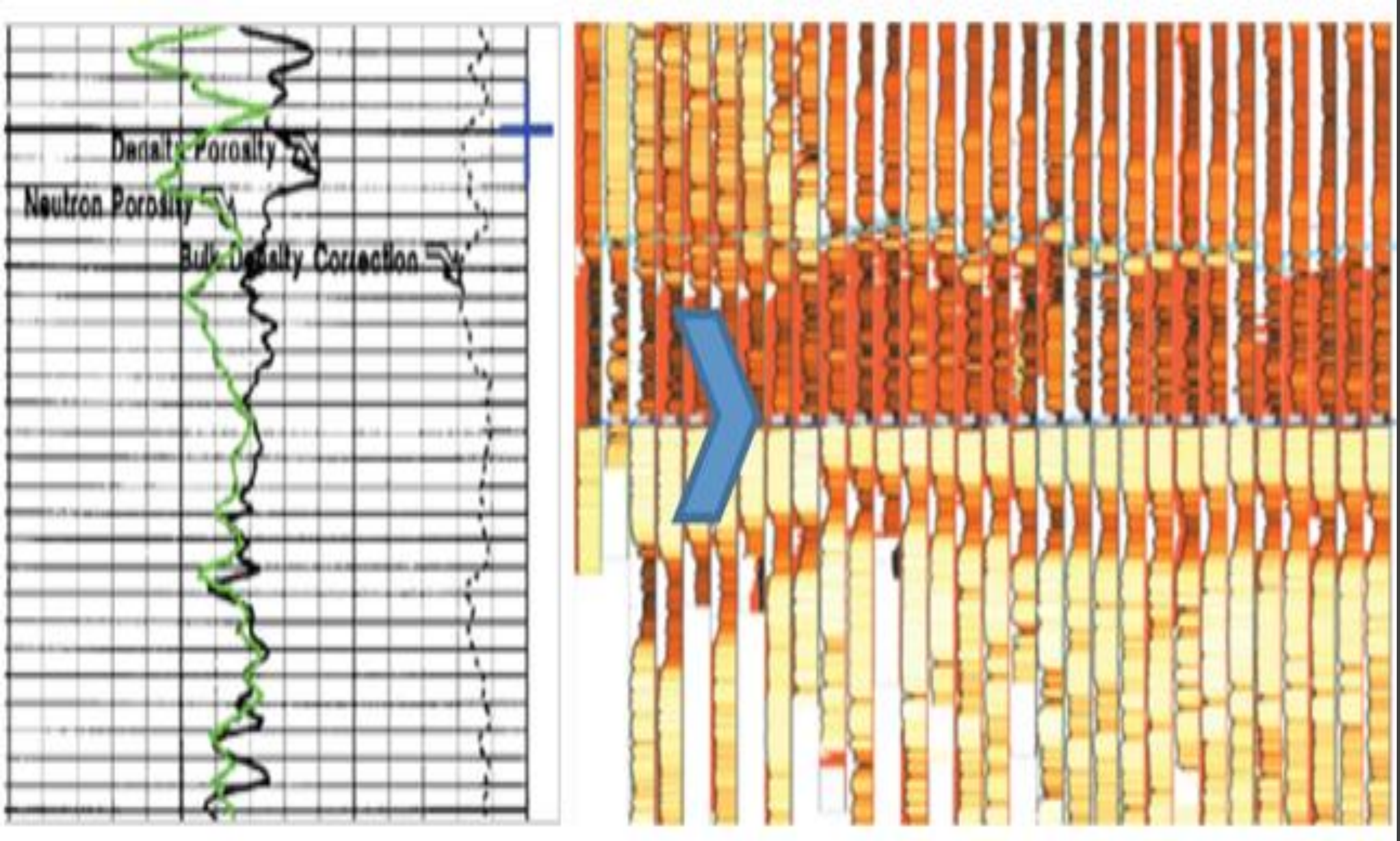
DATA PREPARATION

- Review and analyze the geological, seismic, and engineering data
- Depth structure maps constructed on the top of Pay sands illustrates the structural configuration of the field at these reservoir levels
- The maps, mainly based on well information and dip-meter logs, are broadly guided by the seismic interpretation as well as by other available maps deemed reliable
- The review includes open-hole log, PVT, pressure, and production data
- Identifying pay zones and determining petro-physical properties, porosity and initial water saturation

SIMPLE SEISMIC ACQUISITION DIAGRAM (LEFT) AND A PROCESSED, INTERPRETED 3D SEISMIC EARTH MODEL (RIGHT)



RAW WELL-LOG (LEFT) AND PROCESSED WELL LOG IMAGES SHOWING THE ROCK TYPE (RIGHT)



DATA INTEGRATION

- Combination of technical and business processes used to combine data from disparate sources into meaningful and valuable information

- A complete data integration solution encompasses discovery, cleansing, monitoring, transforming and delivery of data from a variety of sources

- Data integration ranges from the traditional - tracking and mapping time horizons to identify potential structural or stratigraphic traps - to the state-of-the-art in identifying the reservoir and the hydrocarbon accumulations themselves

- Integration with existing internal and external systems, such as workflow and finance, provides an enterprise wide view of data that dramatically affects long-term strategic planning and performance

WHY DATA INTEGRATION ?

- Encourage a standardized approach to discovering IT assets and establishing a common business language
- Analyze, cleanse, monitor and manage data, enabling better business decisions and improve business process execution
- Integrating data across multiple sources and targets, can satisfy the most complex requirements with the most scalable runtime available
- Increase efficiencies by leveraging a single point entry for master data files for wells, field equipments etc, saving duplicate entry and costly interfaces
- The process of integrating data is dynamic, not static; each data type is subject to change
- The reservoir system is never known completely, but the knowledge becomes more complete as the reservoir matures

KEY CONSIDERATIONS FOR INTEGRATION

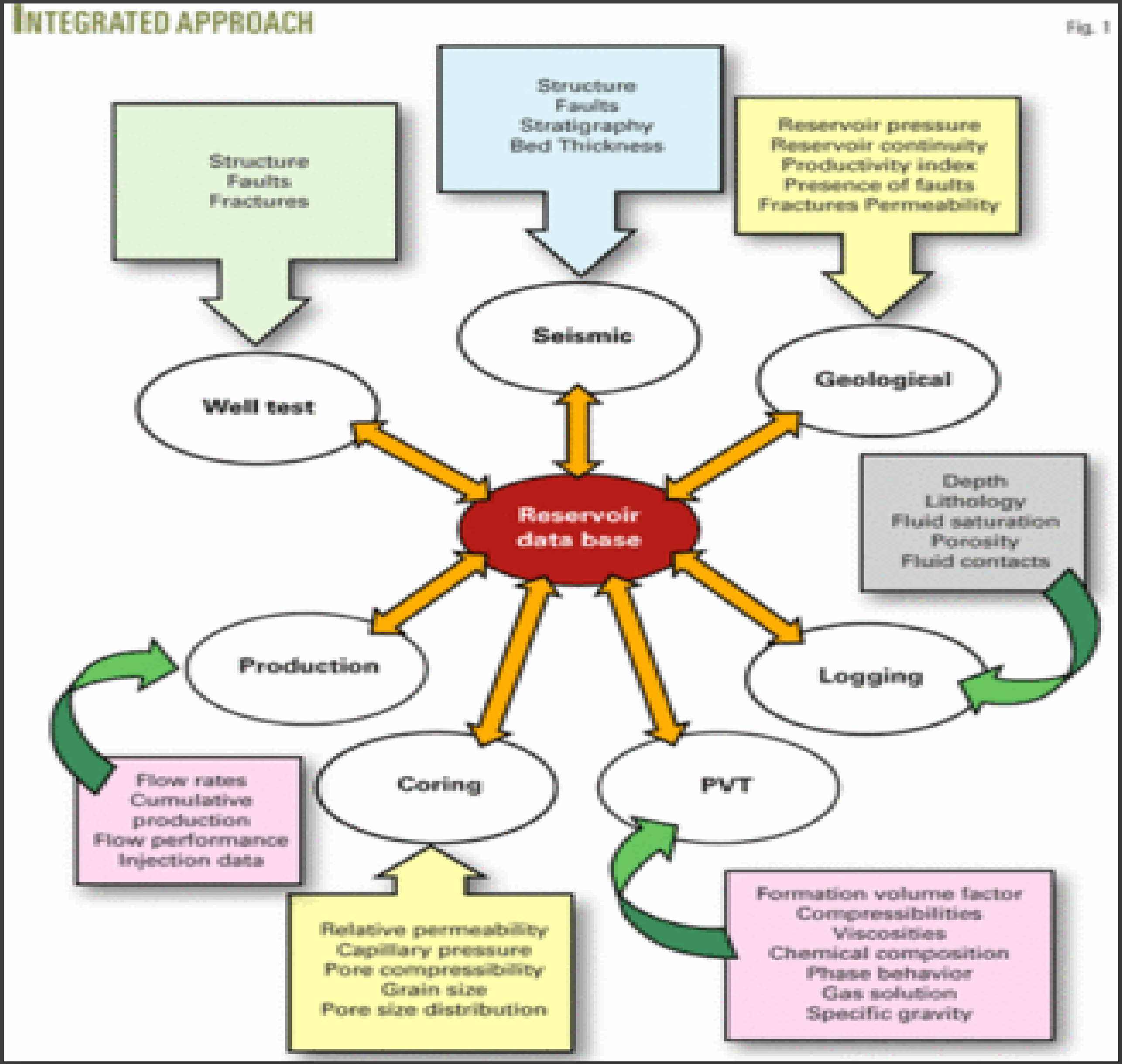
Forrester Research Inc. analyst Michele Goetz cited the following questions:

1. How does the data you're collecting need to be used? Is it for operational purposes or analytics applications—or both?
2. What's the nature of the data, and where is it located? Is the information structured, unstructured or semi-structured? And what systems, internal or external, is it being stored in?
3. How long do you need to retain the data and the integration links you develop? Will the integrations be persistent or one-off connections to meet short-term requirements?

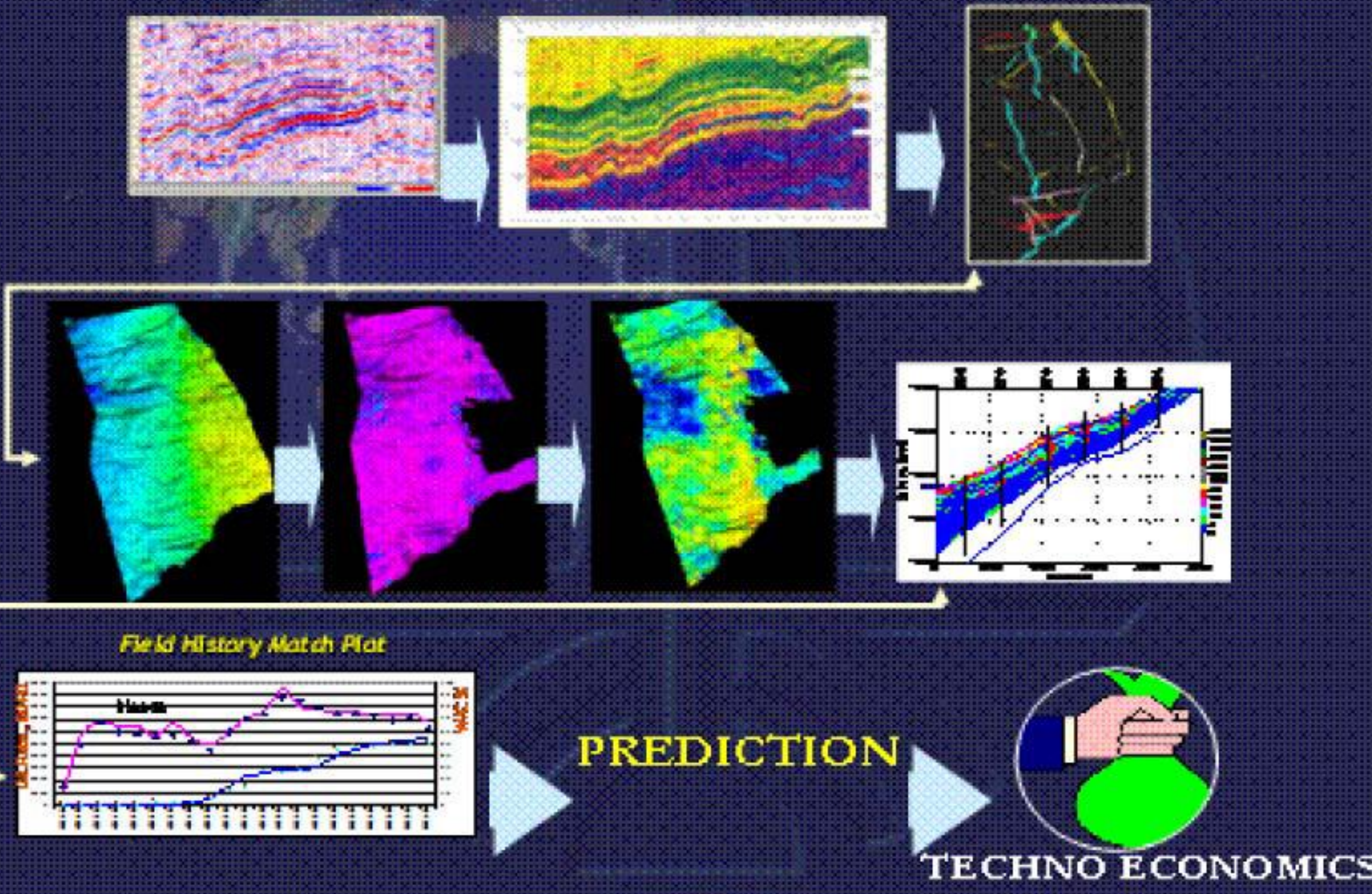
The challenges are to know when to integrate and at what level the integration should take place?

Unless the integration can better identify the reservoir properties for more accurate reservoir performance predictions of optimal hydrocarbon recovery, the integration may not be meaningful

INTEGRATED APPROACH



Reservoir Simulation Study



GEO-CELLULAR MODEL

- Direct and interpreted and data using deterministic and stochastic methods

- Stochastic models provide multiple equiprobable 3D realizations of the reservoir model to explore and perhaps even quantify the effects of the uncertainty about various aspects of the reservoir characterization

- Deterministic techniques more appropriate for fields with high data density ,lots of wells and years of production information

GEO-CELLULAR MODEL-BENEFITS

- Allows a heterogeneous reservoir to be given a chopped up rough looking character between the wells

- Display various reservoir surfaces,faults and wells in 3-D graphics

- Display any item of data on the screen by 3-D modelling software including isochores, facies and rock property grids

- Well correlation can be brought up along with variety of horizon tops

- Statistical applications provide for the analysis of rock properties and applying arithmetical or logical operations on the data

UPGRIDDING

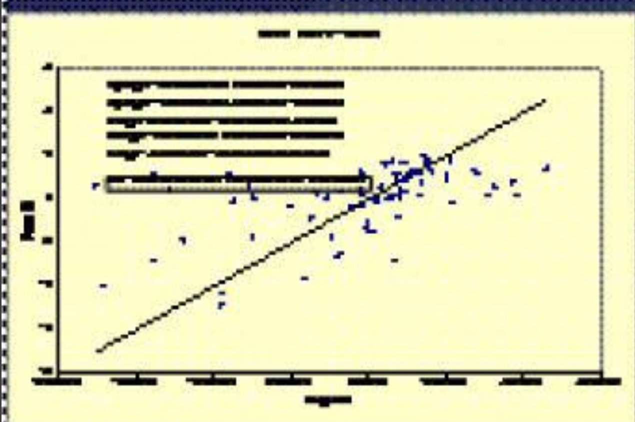
- Geo-cellular Model to Simulation Model

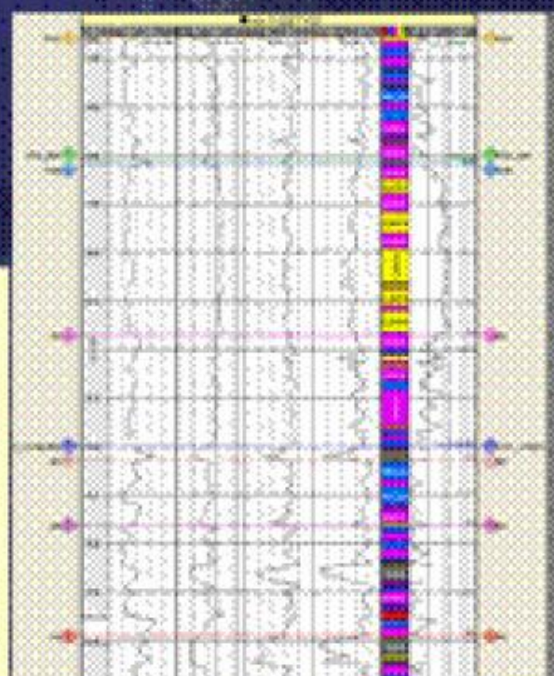
- Different methods for upscaling
  - Static Methods
  - Log data analysis
  - Variance based methods
  - Proportional layering
  - Dynamic Methods
  - Streamline Simulation
  - FMM

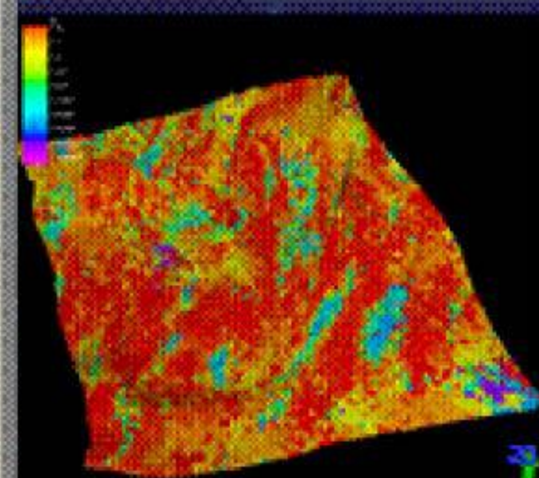
Reservoir Characterization

- Efforts made to derive a correlation for permeability by correlating multiple well logs with core permeability and scale up with build-up permeability

$$\log k = A\,(\Phi \log)^{l} + B\,(Sw)^{m} + C\,(GR)^{n} + D\,(\text{Density})^{o} \ldots.$$







FIELD DEVELOPMENT

- A successful reservoir development plan depends on analyzing and integrating the available data from geology, geophysics, and reservoir engineering

- Putting together the plan is both an art and skill as well as a science

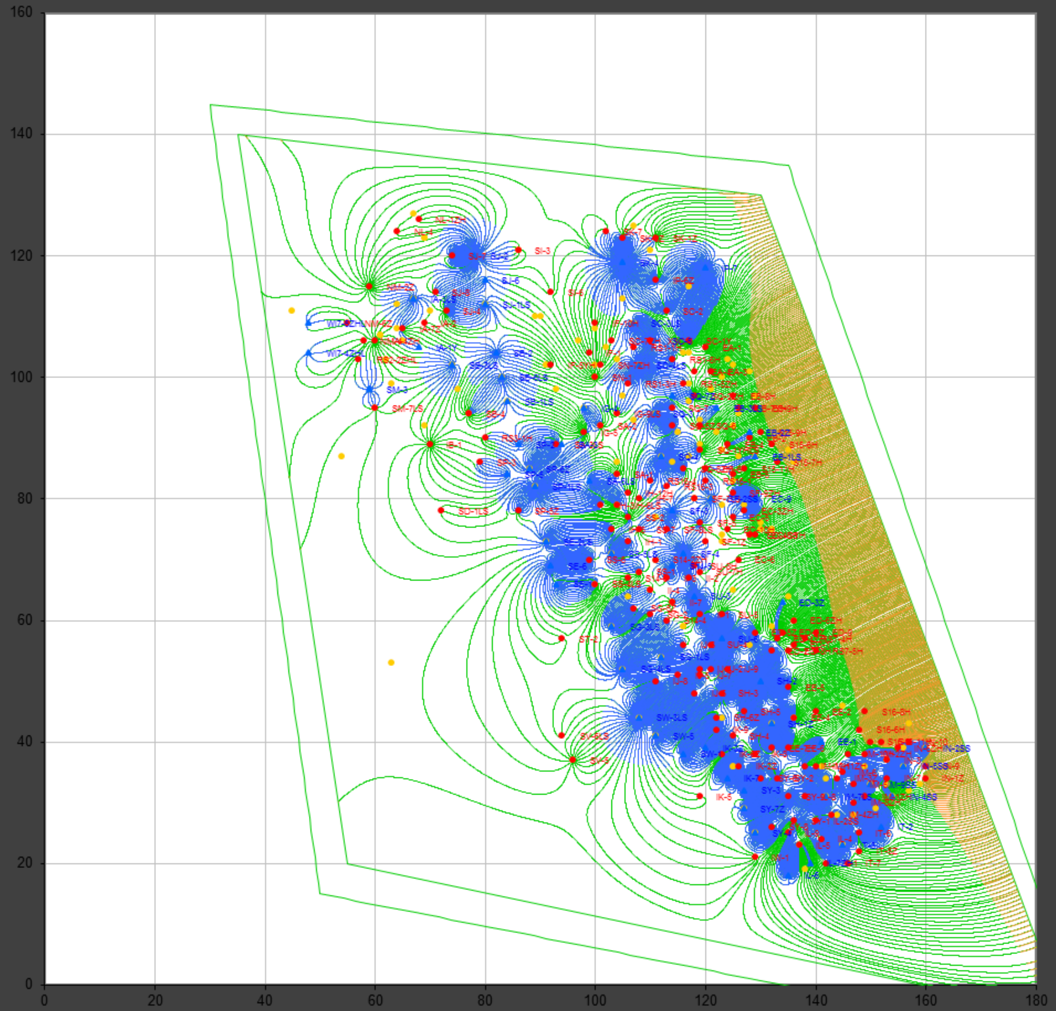
- No short cuts or easy numerical solutions exist that adequately substitute for skill, experience, and vision

- Development and depletion strategies depend on the life-cycle of a reservoir

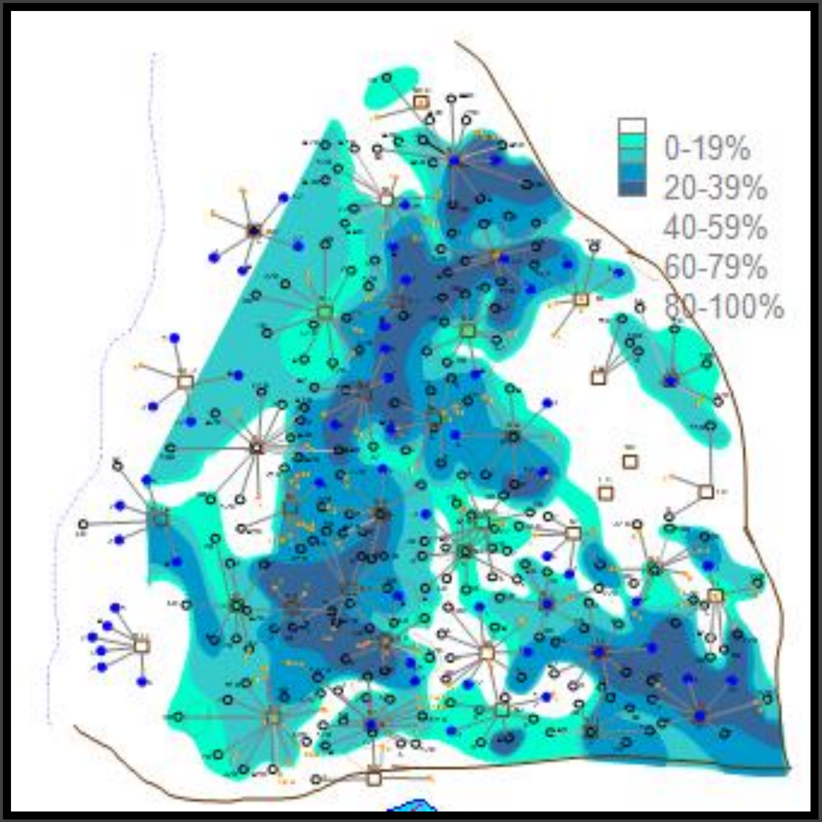
- In a new discovery, the plan needs to address how best to develop the field, including well spacing, well configuration, and recovery scheme

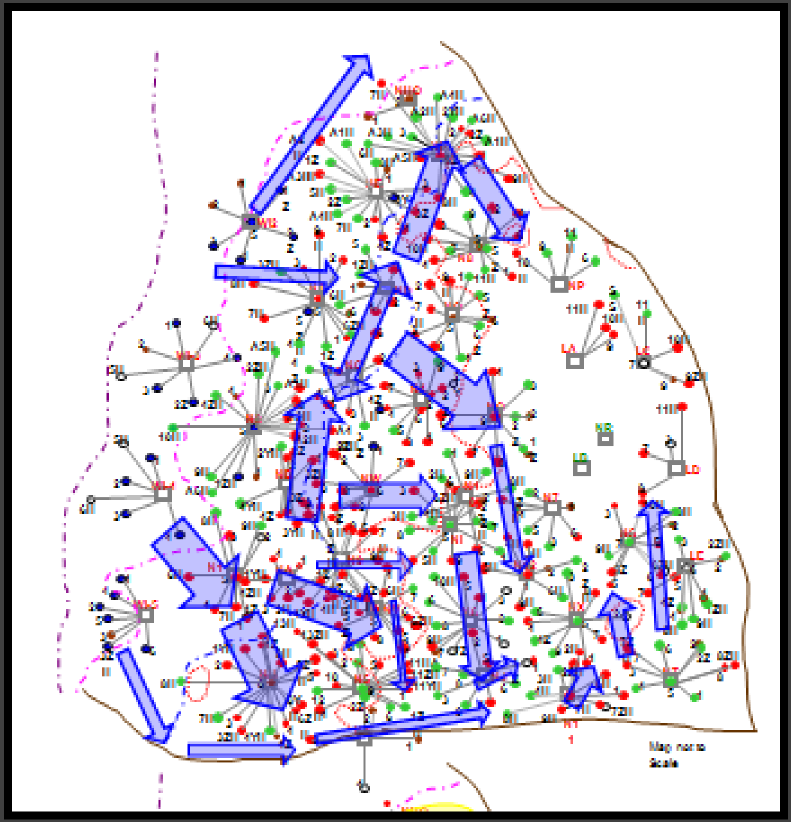
- If the reservoir has been depleted by primary means, the plan needs to investigate secondary and tertiary recovery schemes

RESERVOIR DESCRIPTION THROUGH MONITORING FLUID MOVEMENTS



FLUID MIGRATION PATH





DRILLING AND WELL PLACEMENT

- Time lapse seismic, facies modelling , and the dynamic model for the field is extensively used for accurate placement of the wells

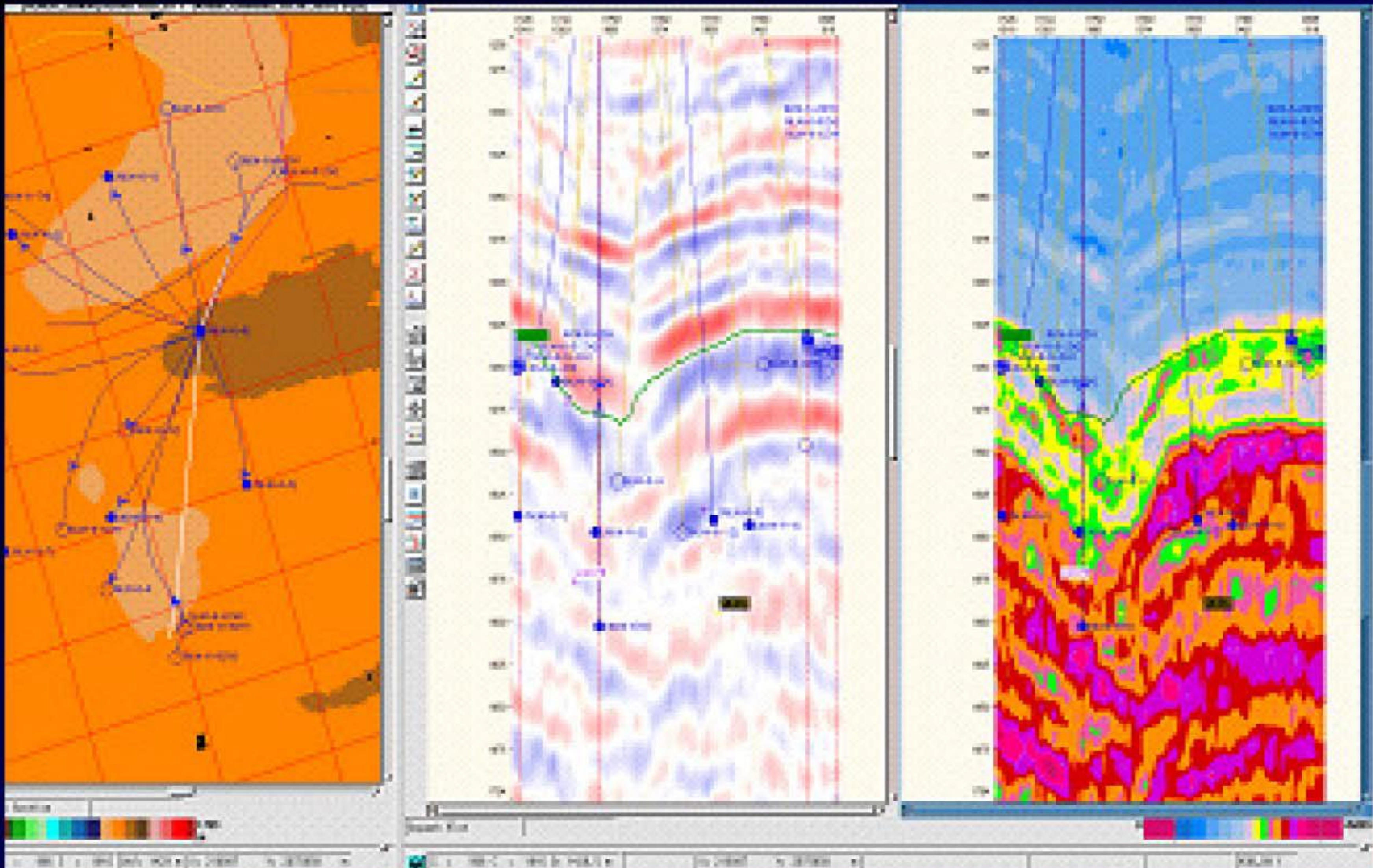
- The close grid 3D seismic has brought out finer structural details for placing wells in the most favourable areas

- The disposition of minor faults could be defined more accurately and the spatial distribution of digenetic effects could be understood more accurately

- Optimum drain hole placement, can be done by Down Hole Fluid Analysis (DFA) and permeability profiling along with conventional Wire line Formation Tester (WFT) pressure survey

- DFA is used to determine the present location of contacts, and based on samples, the drain hole can be placed successfully

Well placement with AI control – An example from Neelam field



ENHANCED OIL RECOVERY

- Enhancing oil recovery from existing wells is a key objective for oil and gas companies

- Generated data could help reservoir engineers map changes in the reservoir over time and provide decision support to production engineers for making changes in lifting methods

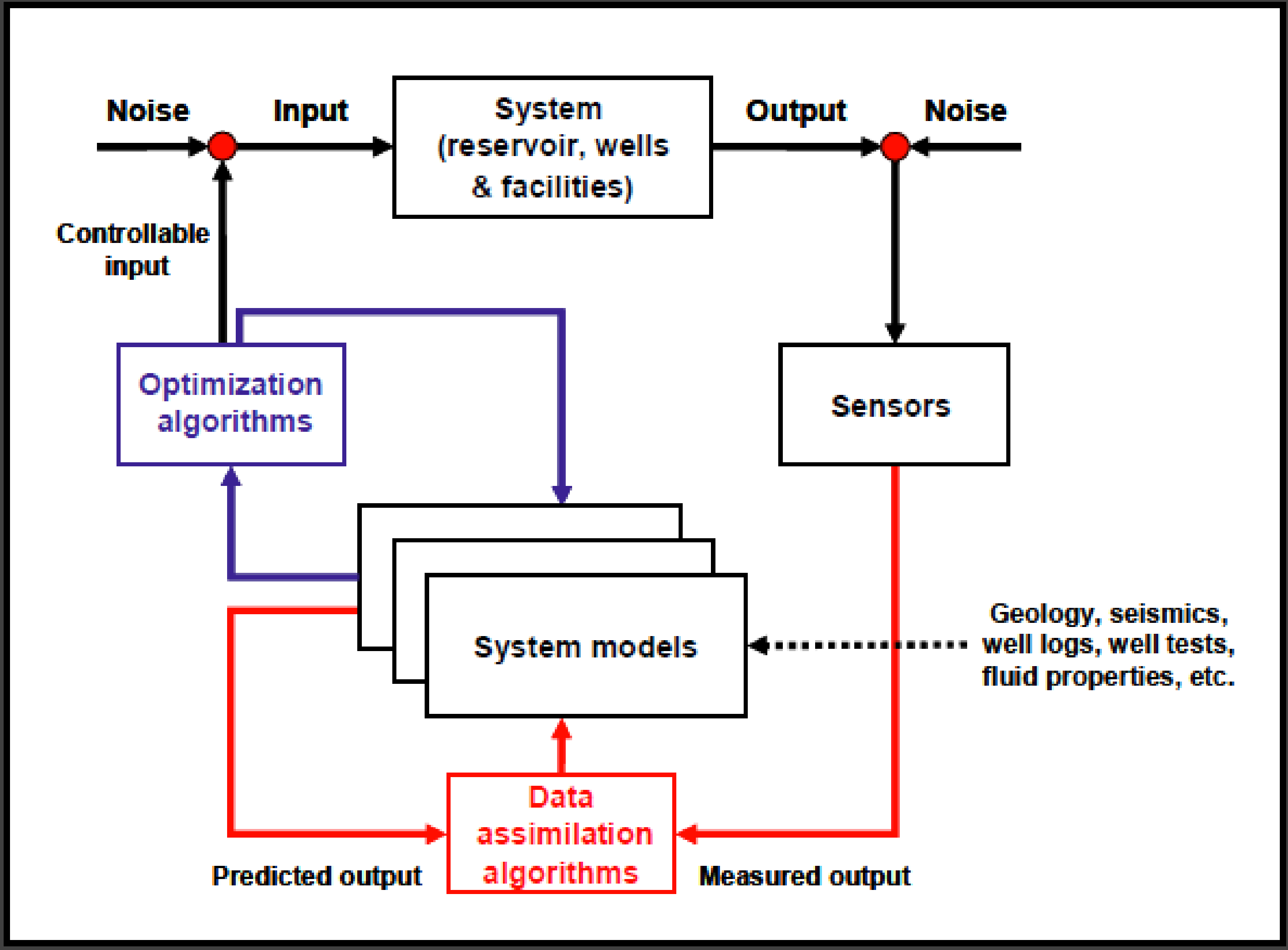
- This type of approach could also be used to predict production behaviour of wells under different EOR methods

ADVANCES IN RESERVOIR MANAGEMENT TECHNOLOGIES

Five major areas of technological advances:

1. Down-hole Sensors
2. Down-hole control Devices
3. Well Architecture
4. Field-wide Monitoring
5. Data acquisition, Transmission and Utilization

CLOSED-LOOP RESERVOIR MANAGEMENT PROCESS



CHALLENGES FOR RESERVOIR SIMULATION

- Significant investment –time and money
- History Matching-Experienced modelers and Geoscientists
- Expensive and time consuming endeavor
- Suitable for prolific assets

TOP DOWN MODELING

- Opposite angle by attempting to build a realization of the reservoir starting with well production behavior
- Alternate or a complement to traditional reservoir simulation
- Elegant integration of traditional reservoir engineering methods with pattern recognition capabilities of artificial intelligence and data mining
- Developing comprehensive spatio-temporal data base
- Discrete modeling techniques to generate production related prediction modeling of well behavior

ADVANTAGES OF TOP DOWN MODELING

- Flexible data requirement
- Short development time
- Ease of development and Analysis

SHORTCOMINGS

- Applicable to brown fields where reasonable amount of data is accessible.

FUTURE AREAS OF ADVANCES IN TECHNOLOGY

- Intelligent Fields-Adjustment of down-hole conditions
- Electromagnetic Imaging
- Gravity measurements
- Nano technology

SUMMARY

- Accurately and efficiently measuring, allocating and analyzing production data leads to optimized operations

- Precise and accurate information about facilities results in better adjustment of equipments for optimization of production

- Integration of available information facilitates better reservoir management

THANK YOU FOR YOUR ATTENTION

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