CROSS-DISCIPLINE DATA INTEGRATION IN RESERVOIR MODELLING: OPTIMIZING FLUID FLOW SIMULATION AND RESERVOIR MANAGEMENT

Hesham Al Qassab, J.C. Fitzmaurice, Z. Al Ali, M. Al Khalifa & P.W.J. Glover

University of Aberdeen & Saudi Aramco

Structure

- Minimising Impact of Hydrocarbon Extraction
- Data Integration Techniques
- Improved Reservoir Modelling
- Application the Unayzah Formation
- Summary

Minimising Environmental Impact

- **Can take many forms**
  - **Remediation of current pollution**
  - **The limitation of spills at refineries**
  - **Improved methods of transporting oil**
  - **Improved rig decommissioning**
  - **The reduction and prevention of pollutant gas emission**
  - **Extending current field life using improved analysis techniques**
  - **Improvements to the design of drilling and production rigs**
  - **Improved seismic methods to reduce their impact upon the sea-life**

Start: The Test Field

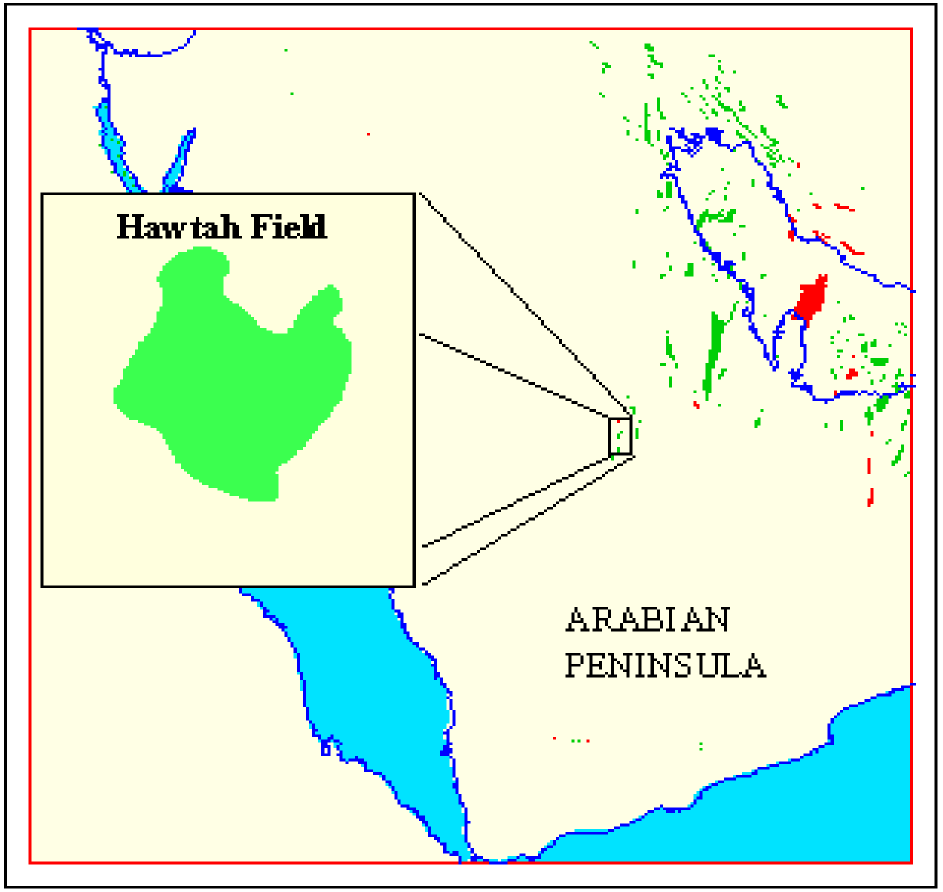
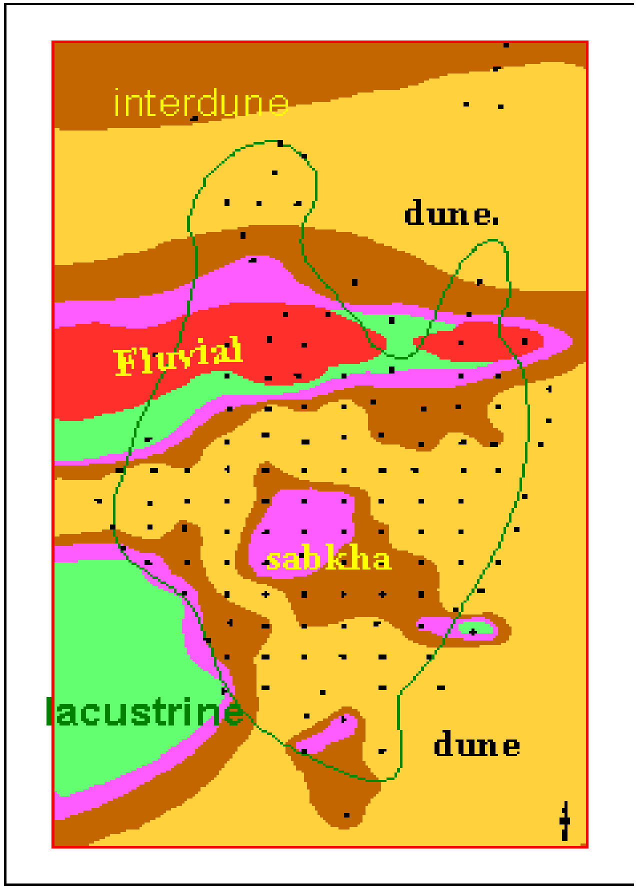
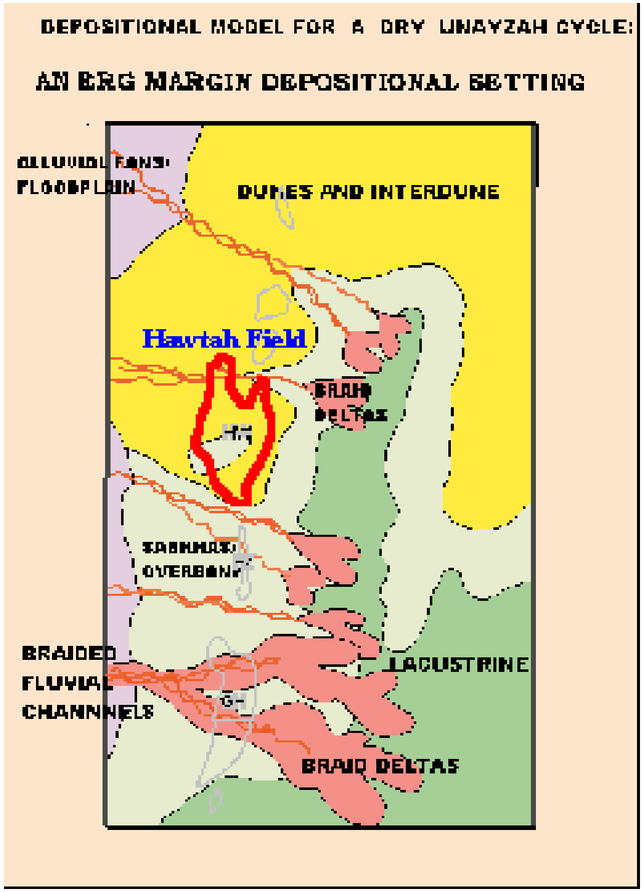


Fig1

- **Onshore Oil Reservoir in Saudi Arabia**

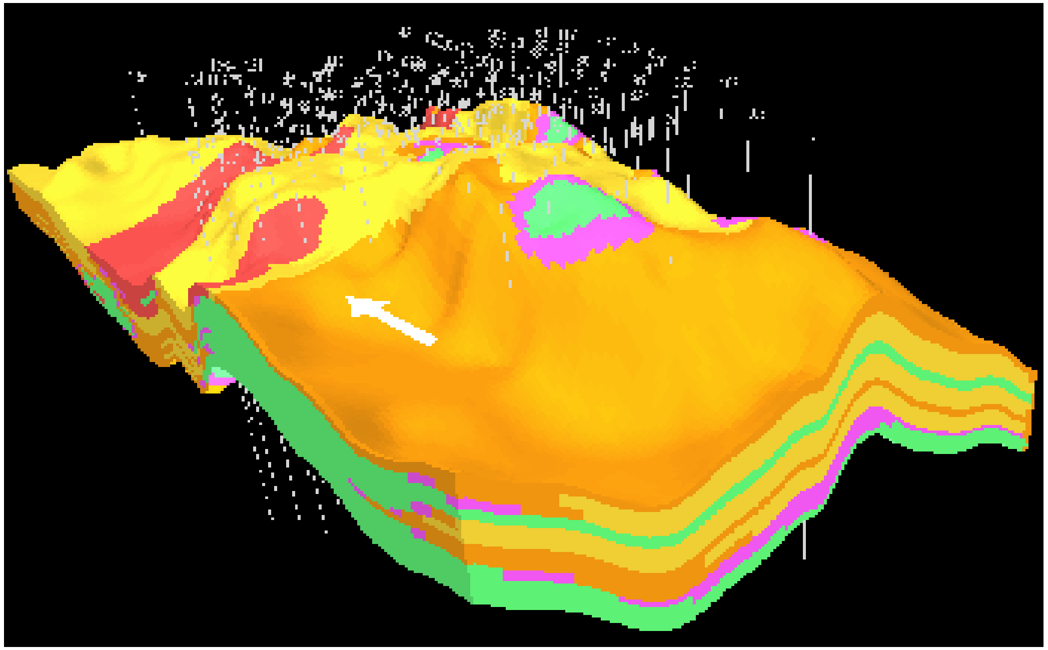
Step 1: Hand-drawn Facies Maps





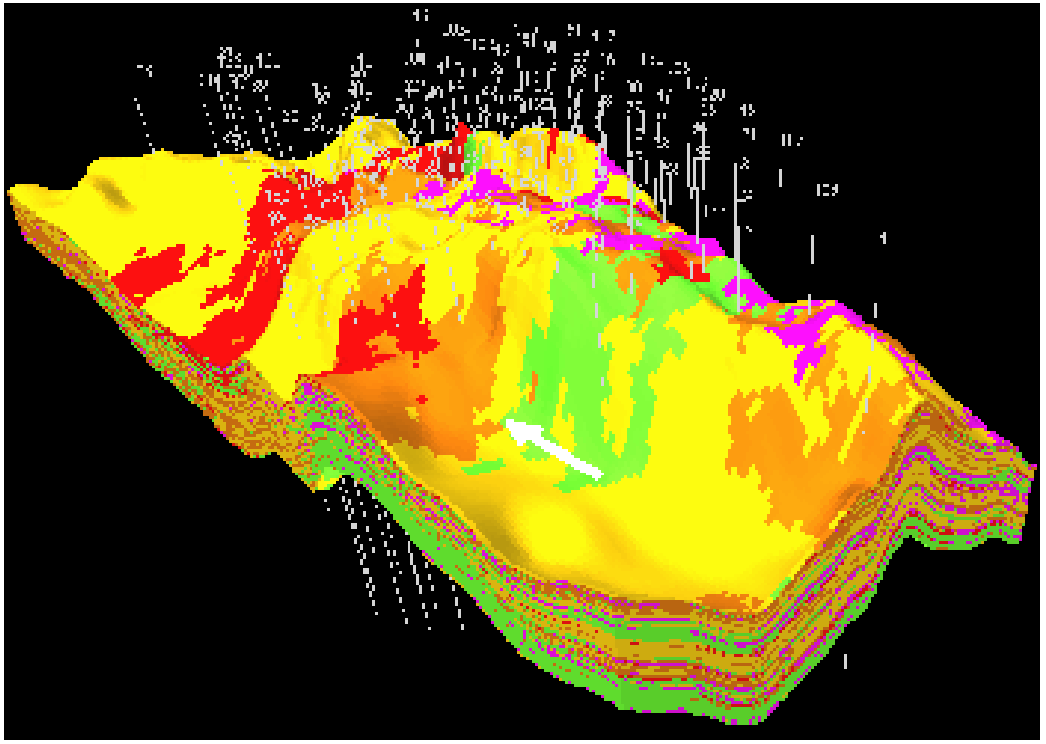
- Drawn by Geologists for the Unayzah A Formation from 13 zones in the reservoir at over 40 well locations

Step 2: Used to Build a 3D Model of Facies for the Reservoir



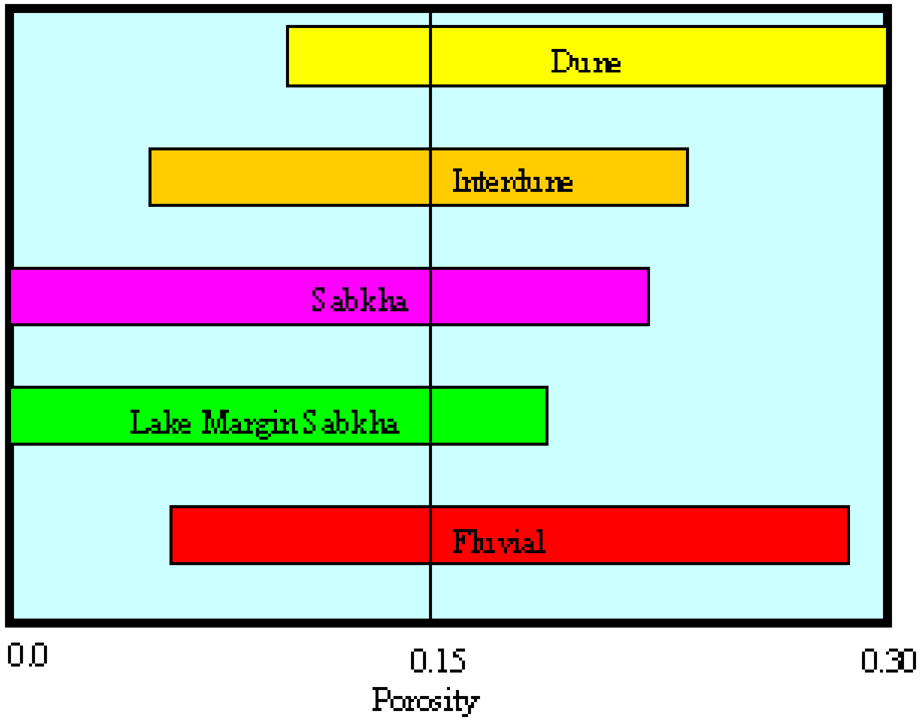
- Using all well data, no inter-well interpolation

Step 3: A 3D Facies Model Constructed Using Sequential Indicator Simulation



- **Works by distributing facies available at wells in the inter-well volume**

Step 4: Porosity (and Permeability) is Not Uniquely Defined by Facies



- **Facies alone cannot be used to predict reservoir porosity (or permeability)**

Step 5: However, Cross-referencing to Electrical Logs and Core Shows a Characteristic Distribution for Each Facies Type

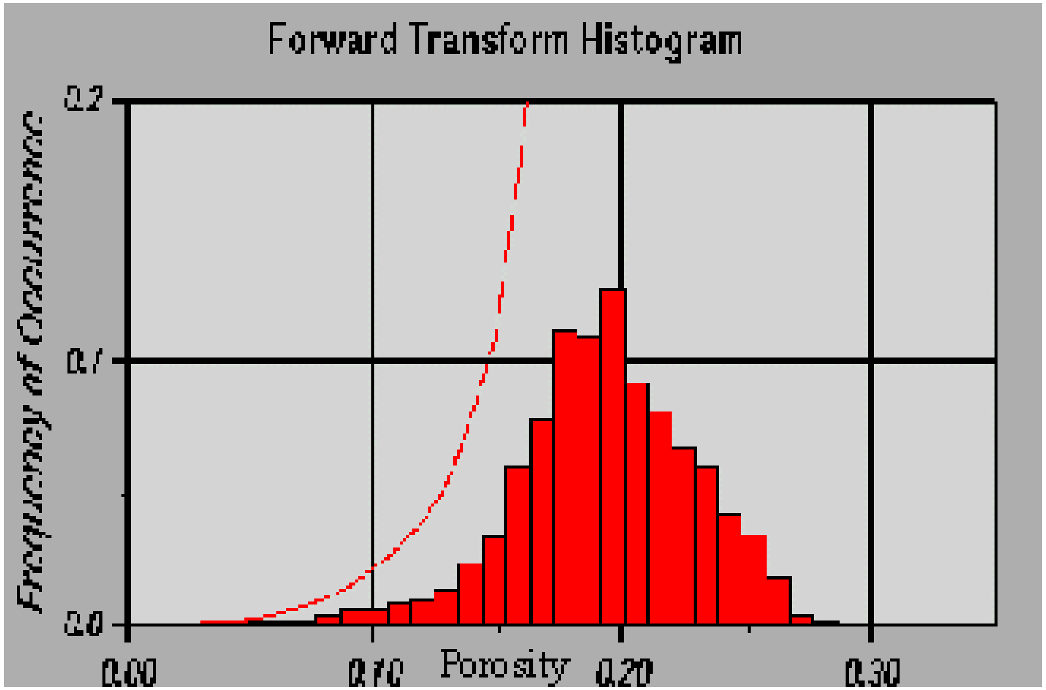
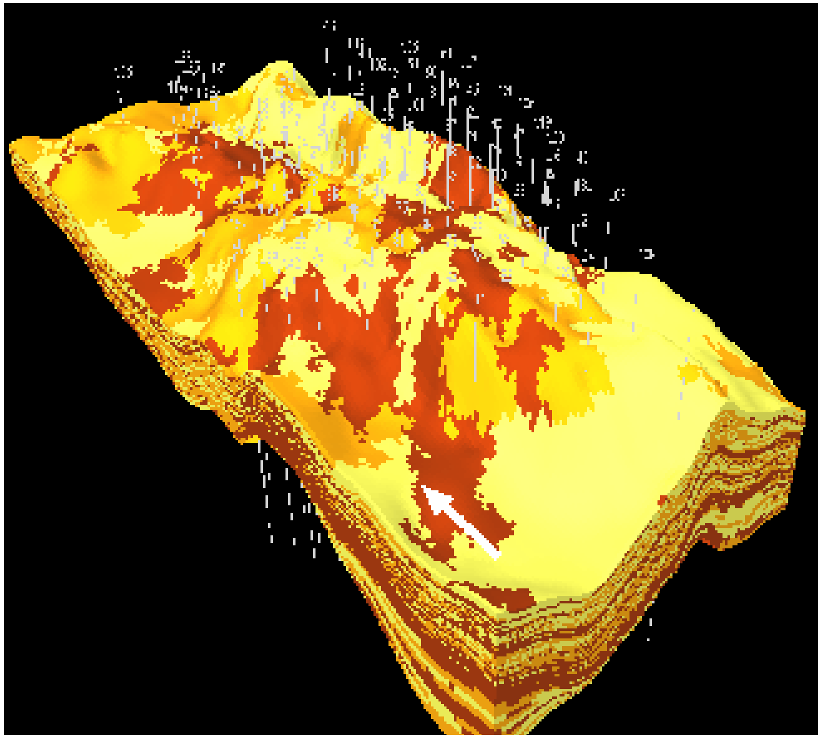


Fig6b

Step 6: Build 3D Porosity Model Using Cluster Analysis and the 3D Facies Model



- Input data includes well porosity (or permeability), facies type, core data

Step 7: 3D Impedance Model of the Reservoir from Seismic Data

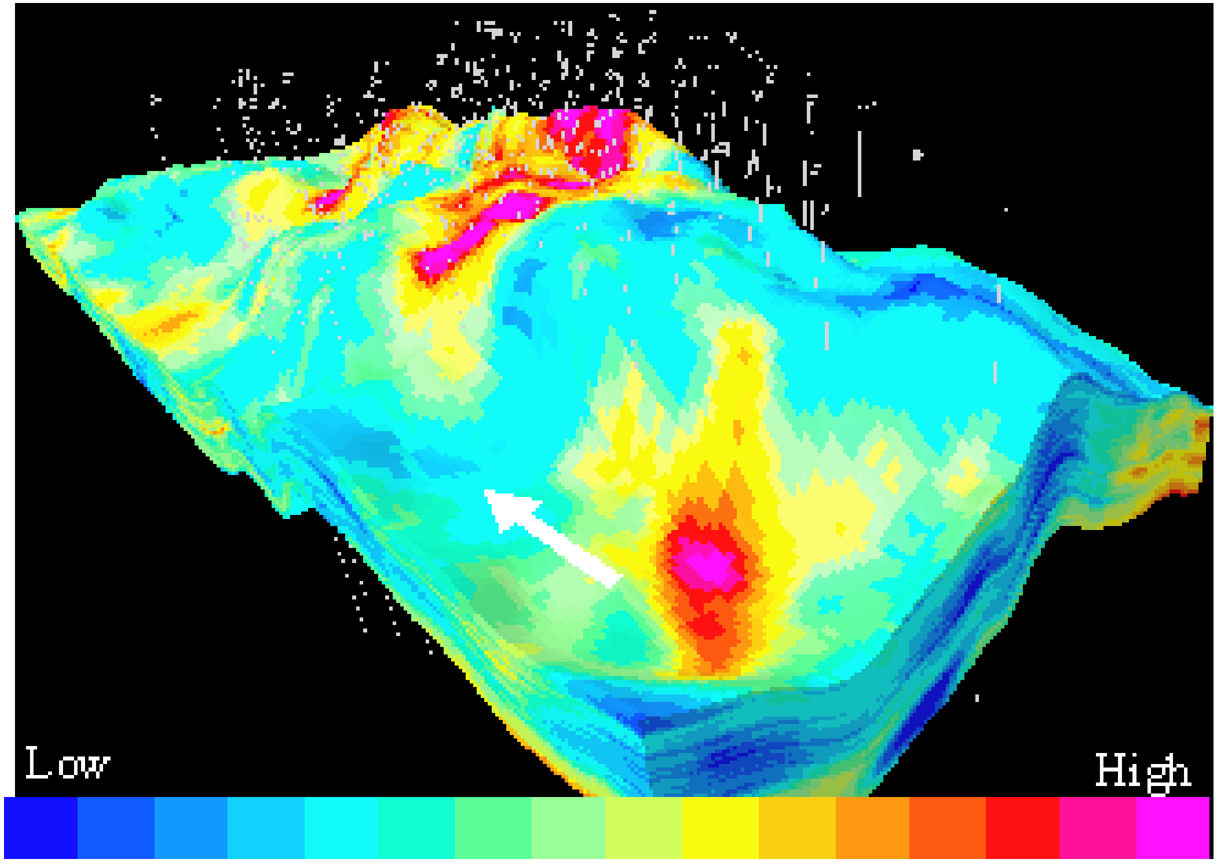


Fig9

Step 8: 3D Impedance Model in Time Domain Converted to Depth Domain

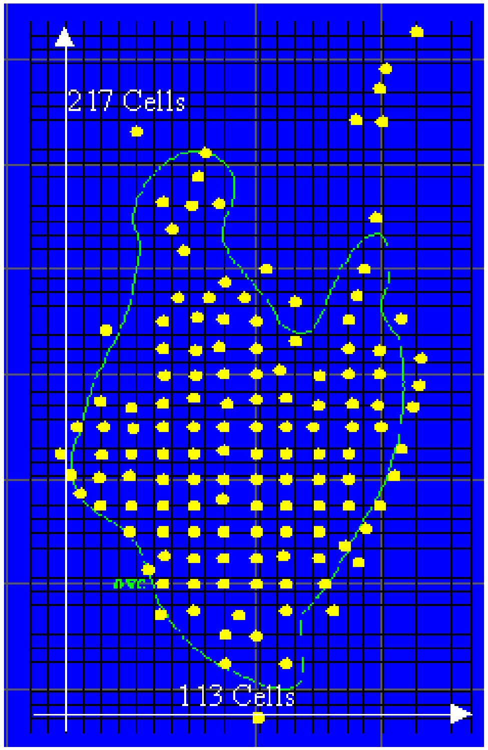
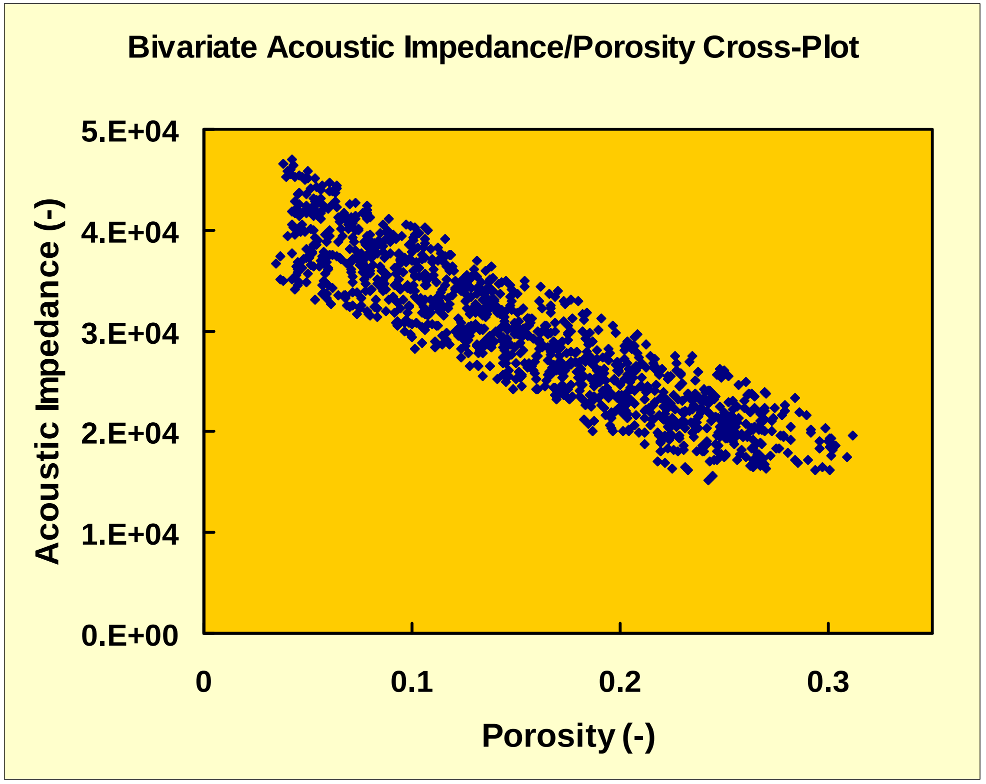


Fig10

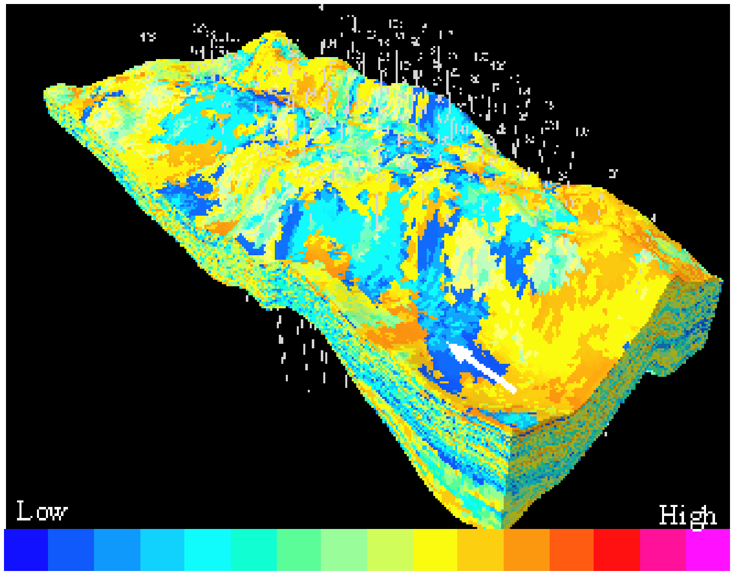
- Shows 1 layer of 15 in the reservoir, with wells (yellow) and sesimic lines (black)
- Total model size = 217 x 162 x 133 = 4.675 million cells

Step 9: Univariate and Bivariate Analysis of Acoustic Impedance and Porosity



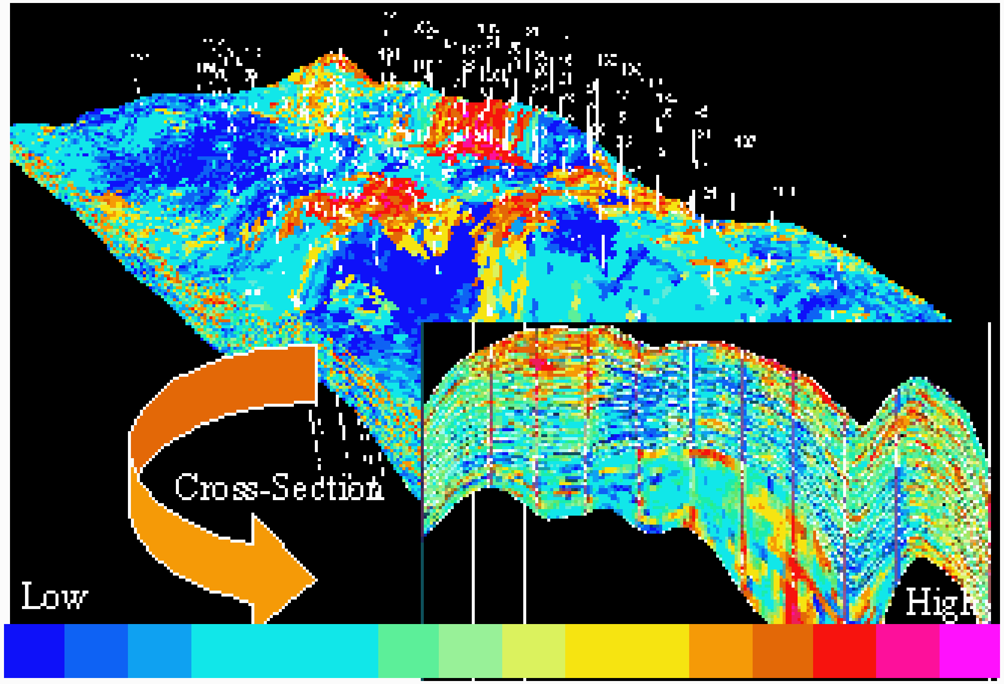
- **Cell-by-cell analysis**

Step 10: Build 3D Model of Porosity Distribution Using Sequential Gaussian Simulation and Co-Located Co-Kriging



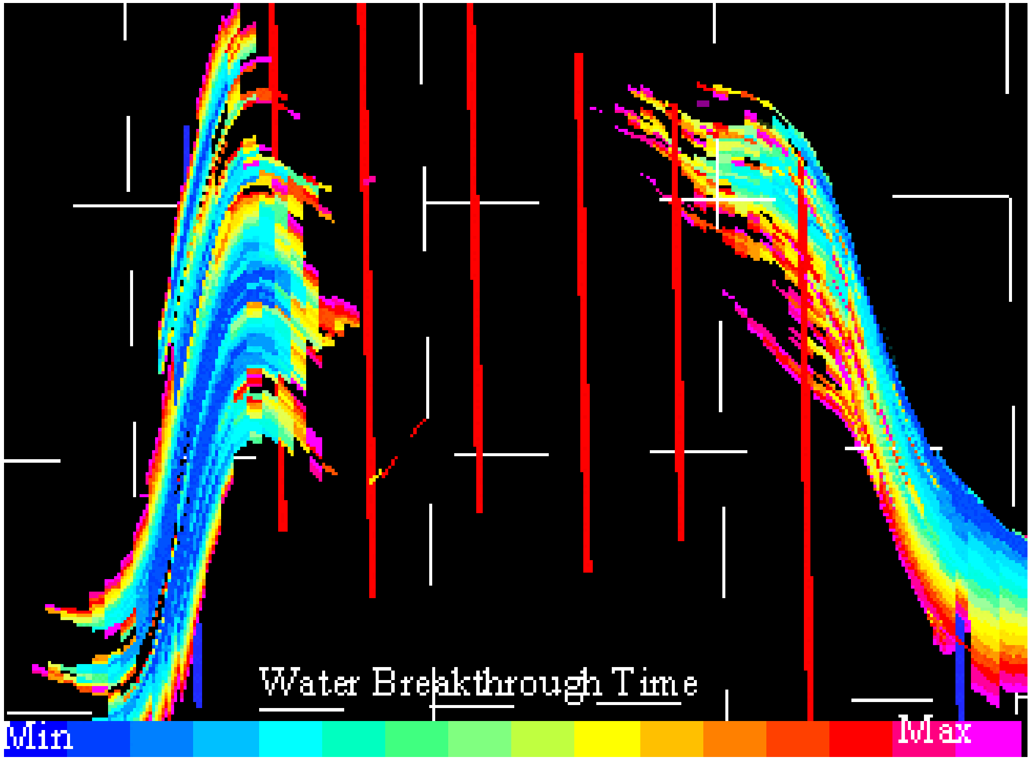
- **Uses bivariate AI/porosity and seismic data. The heterogeneity of the porosity is kept**

Step 11: Build 3D Model of Permeability Distribution Using Cloud Transforms



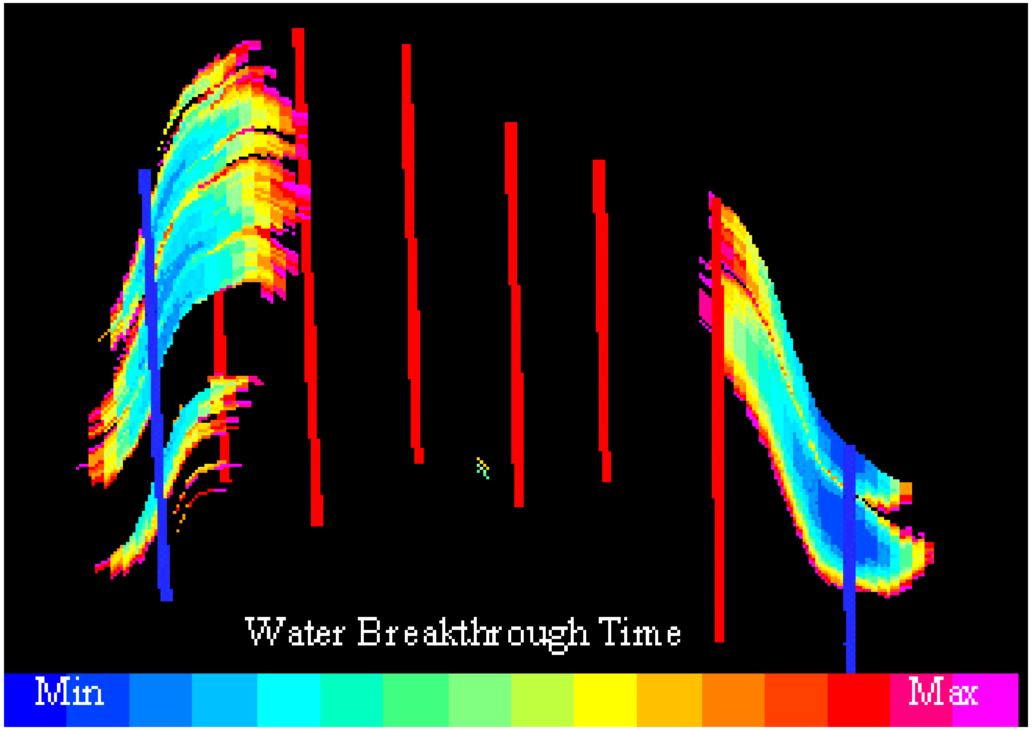
- Uses core porosity/permeability data and well flow test data. The heterogeneity of the permeability is kept

Step 12: Finally, Use 3D Permeability Model on a Streamline Flow Simulation



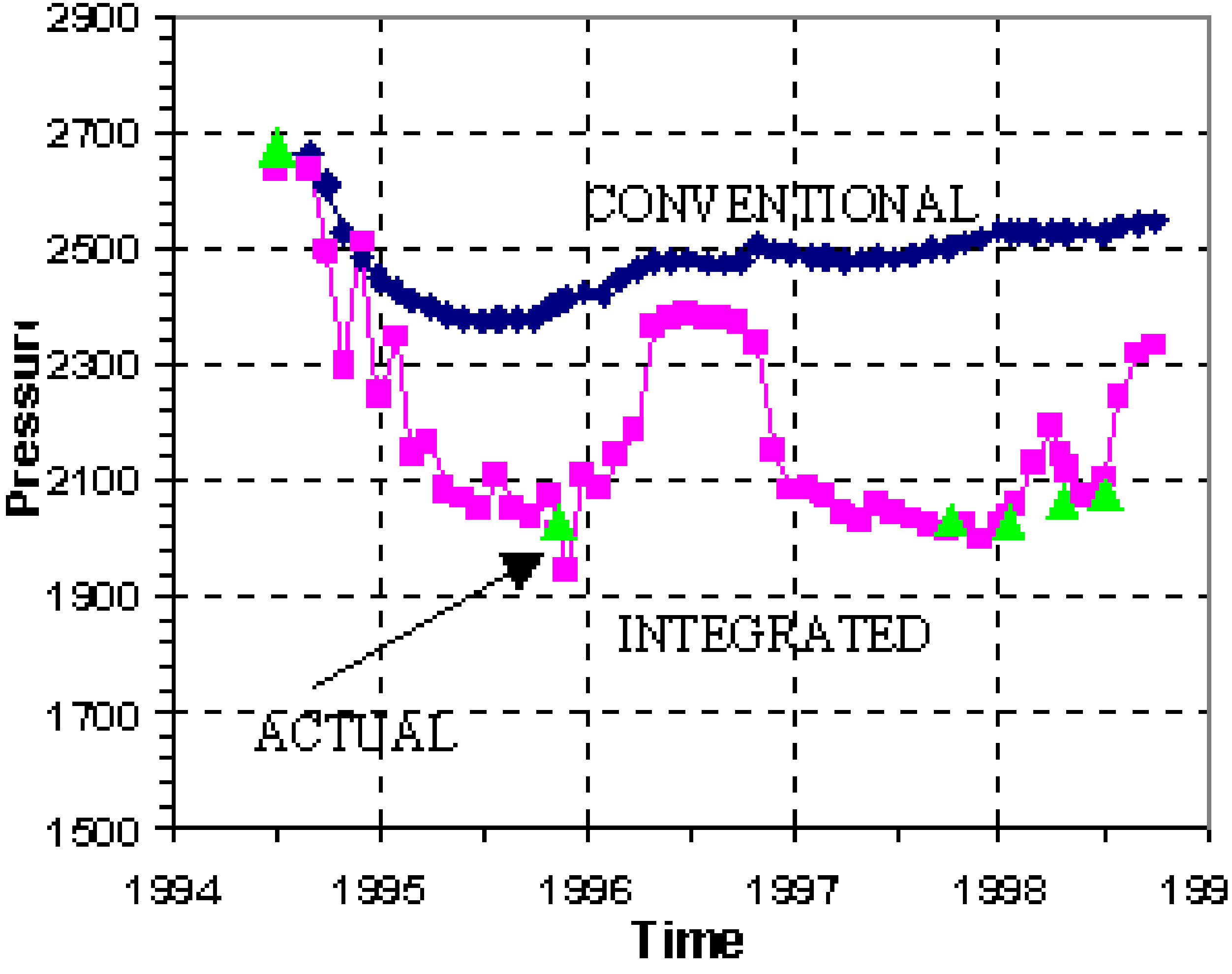
- **Final simulation is more accurate than conventional models**

Step 13: The Conventional Model Results



- **Final simulation is more accurate than conventional models**

Step 14: The New Model is a Much Better Fit to Real Production Pressure Data



Results

- Integrating existing data with new geostatistical techniques is successful
- Porosity, Permeability, AI, and Facies models are all more realistic - retaining their natural heterogeneity
- Fluid flow simulation with the new methods is faster (CPU time) and more accurate

Summary

- Existing data can be used to improve reservoir analysis
- Improved reservoir analysis allows the field to produce more oil for longer
- Environmental damage is reduced by obviating the need for new reservoirs
- Despite this, oil production volume is maintained and improved