Modern 3D Interpretation of a Mature, Structurally-Complex Oil Field: Whittier Field, Los Angeles Basin, California

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Focus of the Study

- **Create an Integrated 3D Model of a Very Mature, Complex Field.**
- **Understand:**
  - Structural Configuration.
  - Trapping Geometries.
  - Reservoir Distribution.
  - Fluid Distributions.
- **Quantify Optimal Targets for New Drilling.**
  - Design Multiple Infill Target Locations.

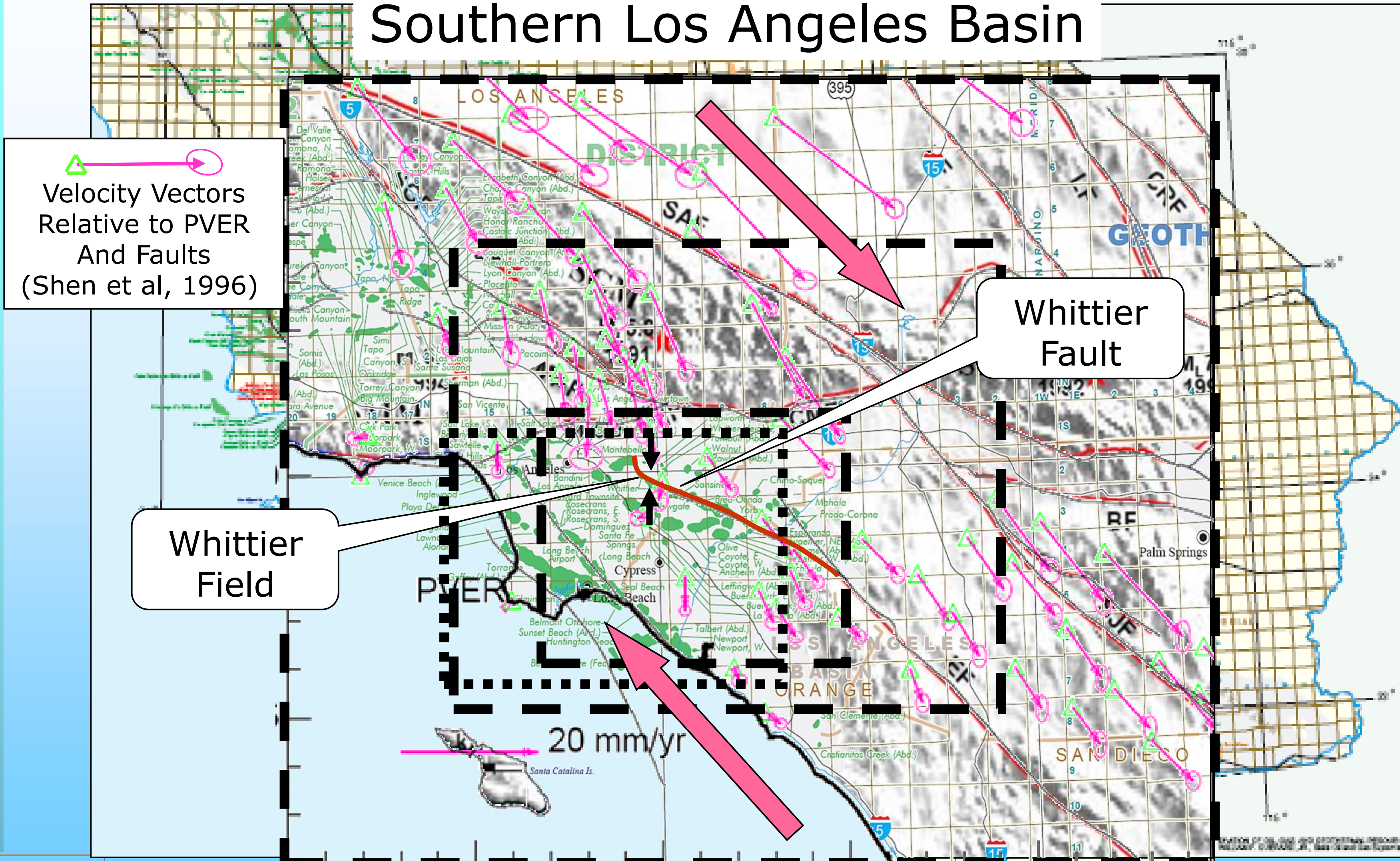
Why Use 3D-Modeling?

- **Ancient, Incomplete Legacy Mapping (2D)**
- **Complex Structure**
  - Near-Vertical and Overturned Beds.
  - Surface and Subsurface Dip and Contact Data.
- **Difficult Stratigraphic Correlations**
  - Channelized Fan Complex (Bathyl) Turbidites Make Character Correlation Difficult.
  - Correlation Is Improved 3D Viewing Along Bedding.
    - Eliminates Log-Stretch Caused by Oblique Pentration.
- **Geostatistical Modeling Can be Used**
  - As an Aid to Understanding the Reservoir Geometry.
- **This Technology Is Now Practical for Small Operators and Consultants**
  - Computing-Power, Low-Cost and Software Make Full-Featured 3D-Modeling Attractive to Small Operators.

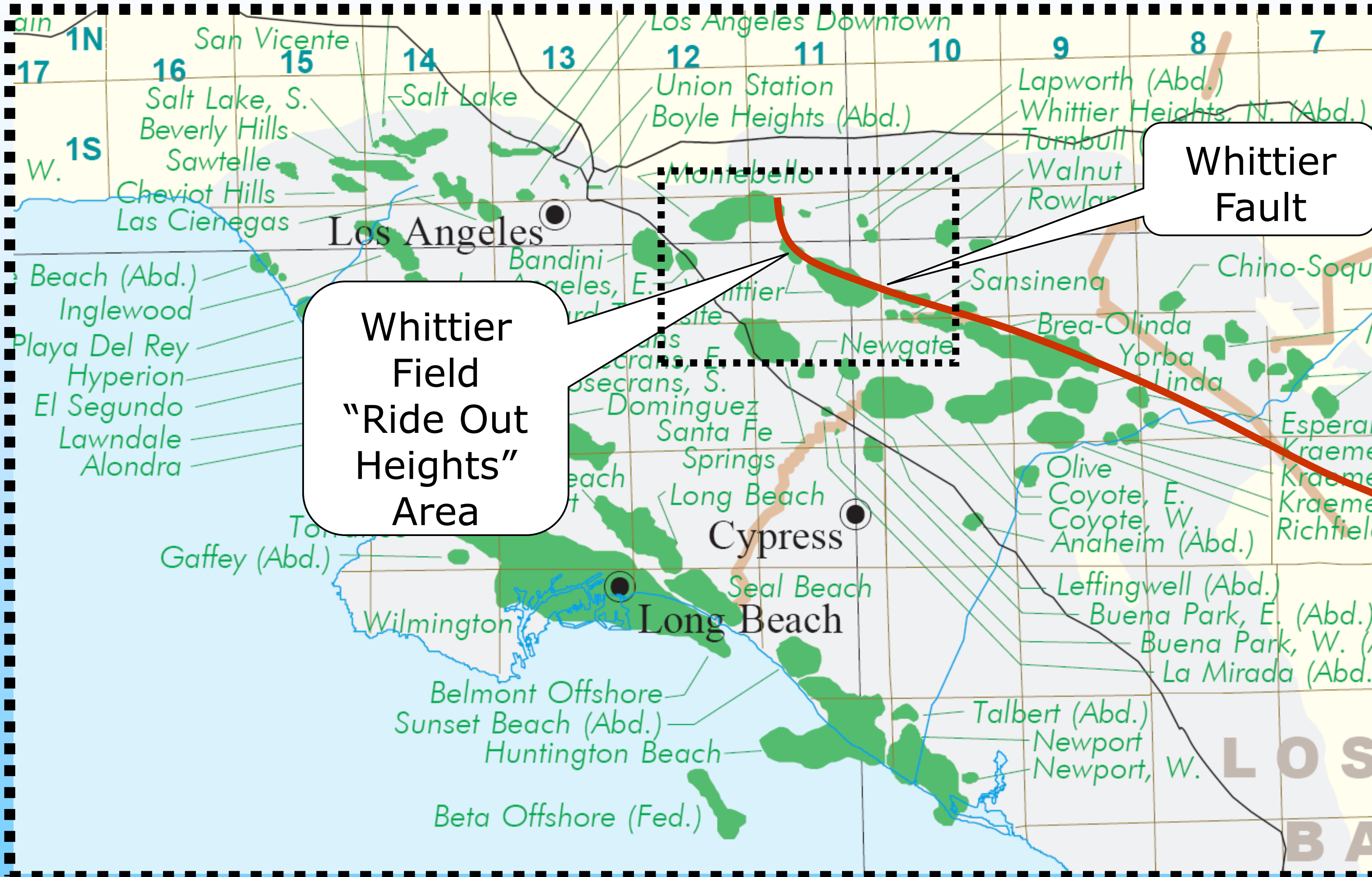
Study Resources

- **Available Data.**
  - Limited Proprietary Wireline Logs and Surveys:
    - SP, ILD, Gyro Surveys, and Dipmeters.
  - Public Data:
    - Thesis Surface Mapping (Strikes, Dips and Contacts).
    - Digital Elevation Data (USGS).
    - Air Photos (USGS).
    - Published Depositional Studies.
  - **No** Seismic Data.
  - **Incomplete** Modern Mapping and/or Reservoir Studies.
- **Available 3D Modeling Software (goCad).**
  - Adequate Experience with Modeling Techniques.
    - Structural and Geostatistical Methodologies

Physical and Tectonic Setting



Physical and Tectonic Setting



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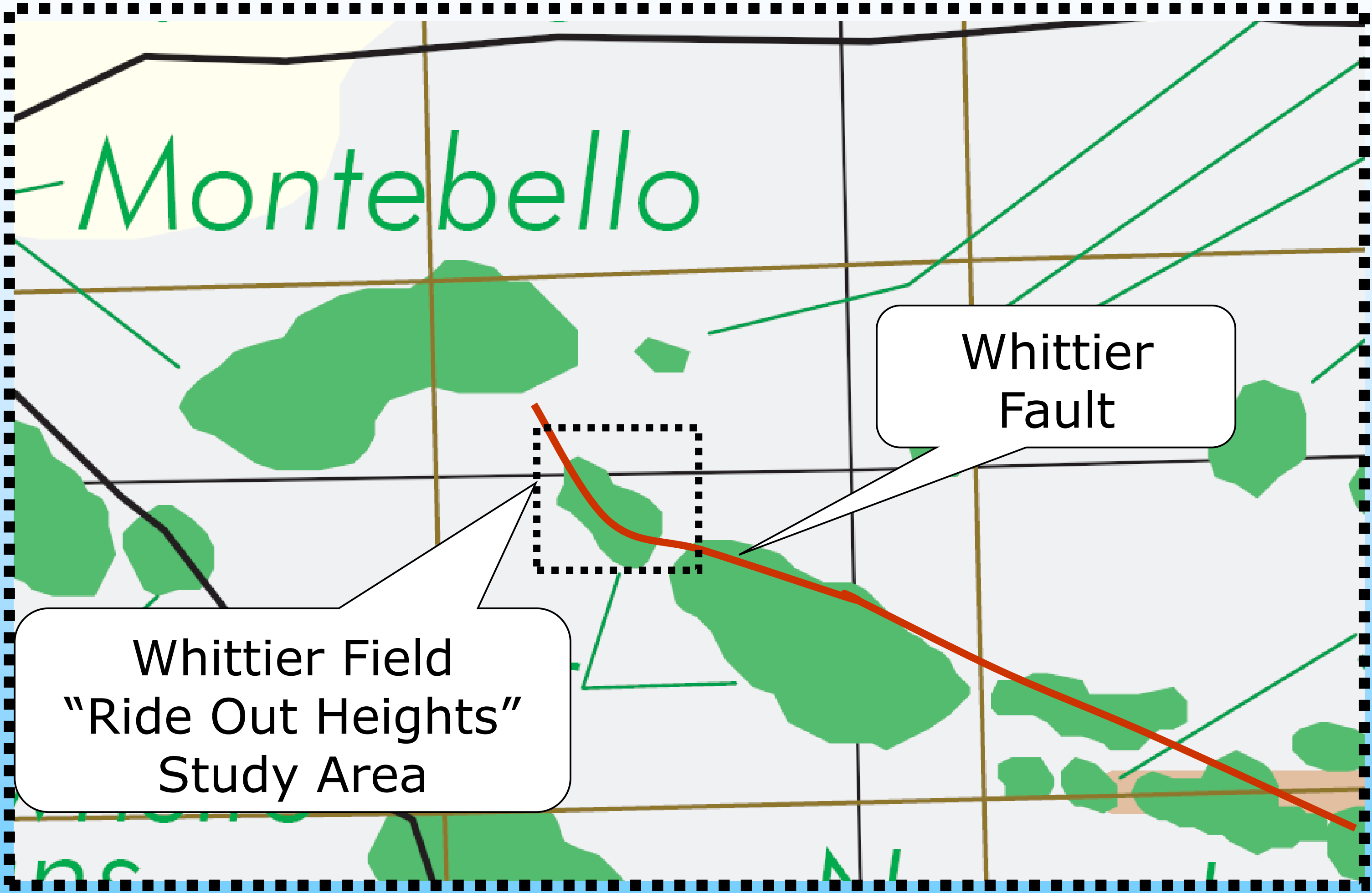
Physical and Tectonic Setting



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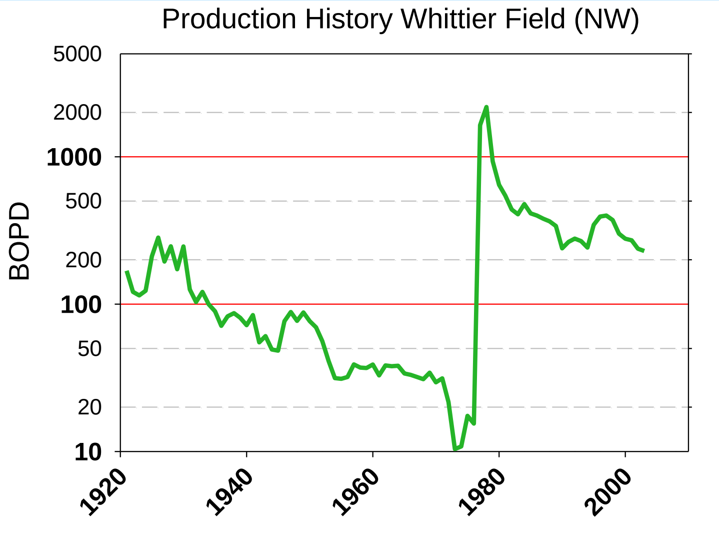
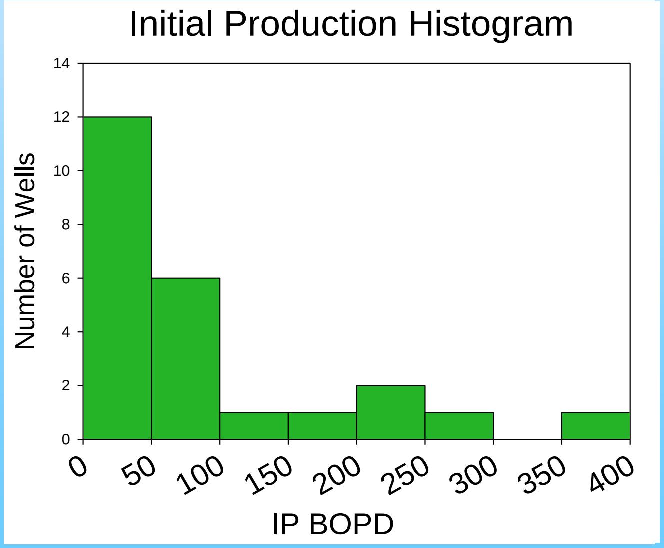
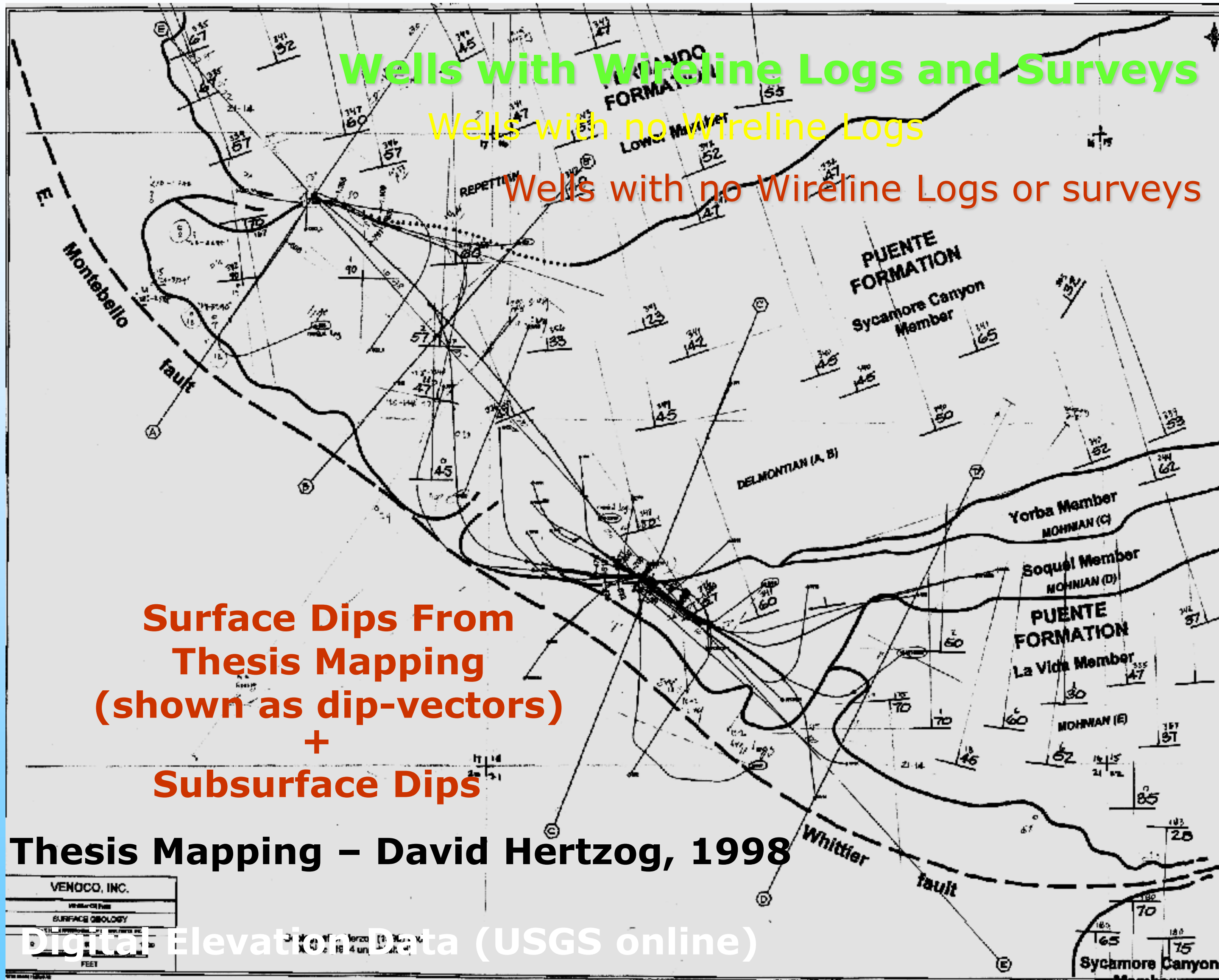
Field Background

- Whittier Field (Ride Out Heights Area)
  - First Producer in 1919 (Central Whittier 1896)
  - Multiple Operators (Current Operator: Matrix Oil)
  - Low Volume Wells (Miocene and Pliocene Turbidites)
    - 1919-1973 few wells (1 to 7)
    - Post-1973 many wells (22-27)
    - Average Well IP 90 BOPD
    - Average Well Cum. Production 110 MBO
    - Current Production ~230 BOPD
  - Long Life (88 years so far) Cum. Approx. 6.5 MMBO





Raw Data



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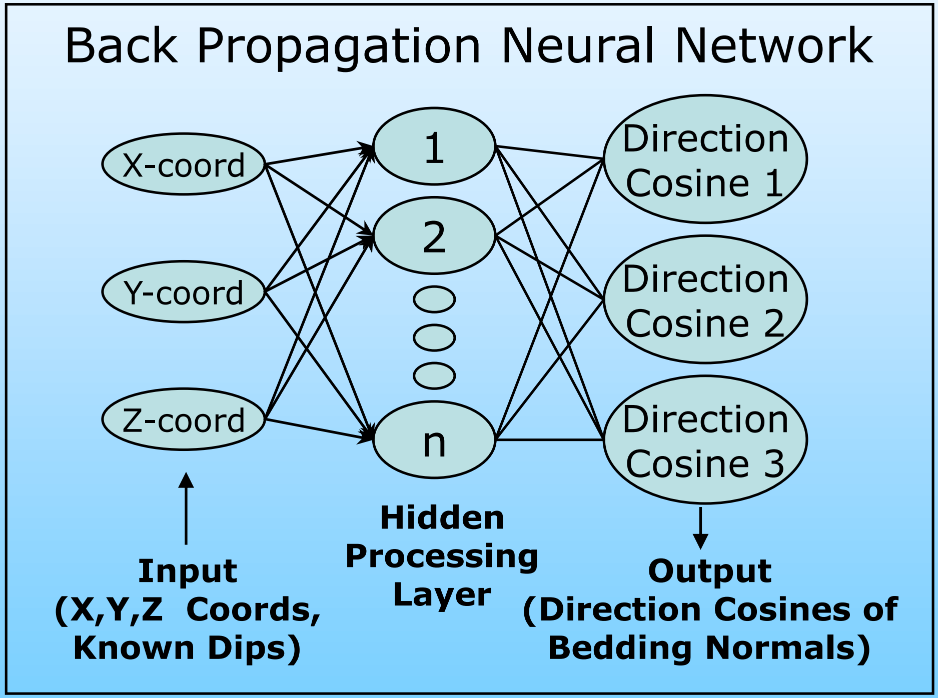
3D Dip Interpolation from Dipmeters

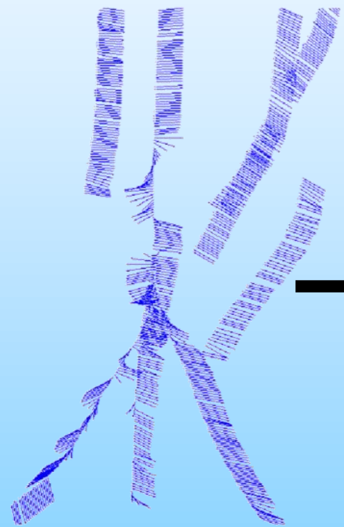
- *via* **Neural Network (NN) Parameterization**



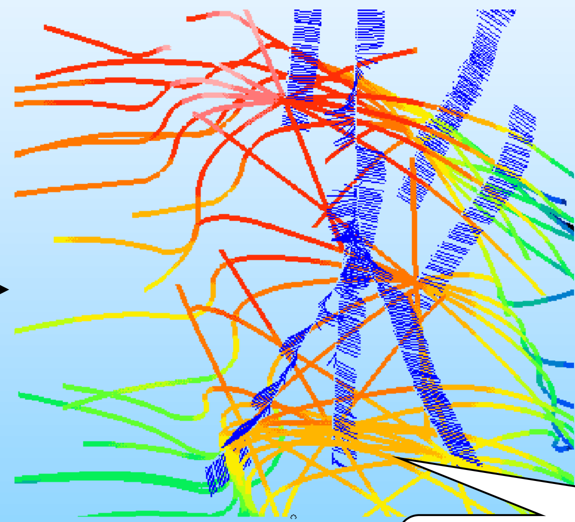
- NN is "trained" using dipmeter data from the wellbore measurements.
- After training, the NN can predict bedding dip/azimuth at any location in the study volume.

Structural Geometry Using Neural Network Dip Prediction

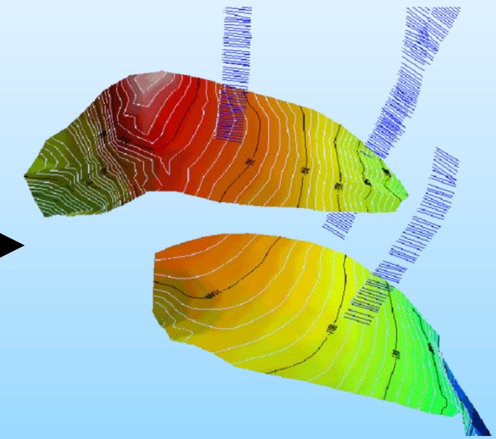
Input Well Dips in 3D



Layer-Geometry predictions



Detailed 3D Surfaces are made from "spiders"



"spider" lines radiate along all azimuths parallel to predicted bedding.

Before *NN Training* → ***After*** *NN Training (NN predictions)*

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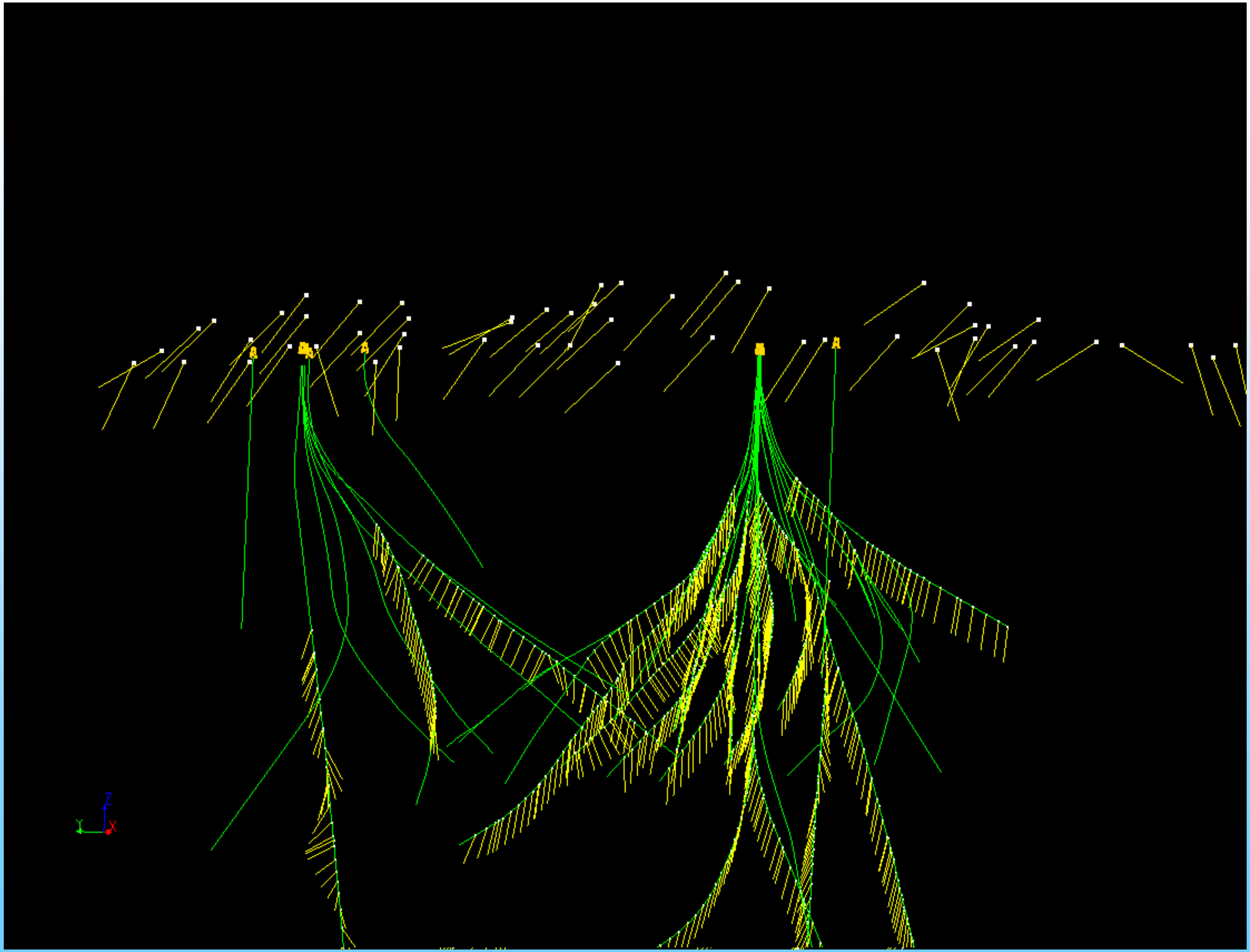
Surfaces From Dip Interpolation



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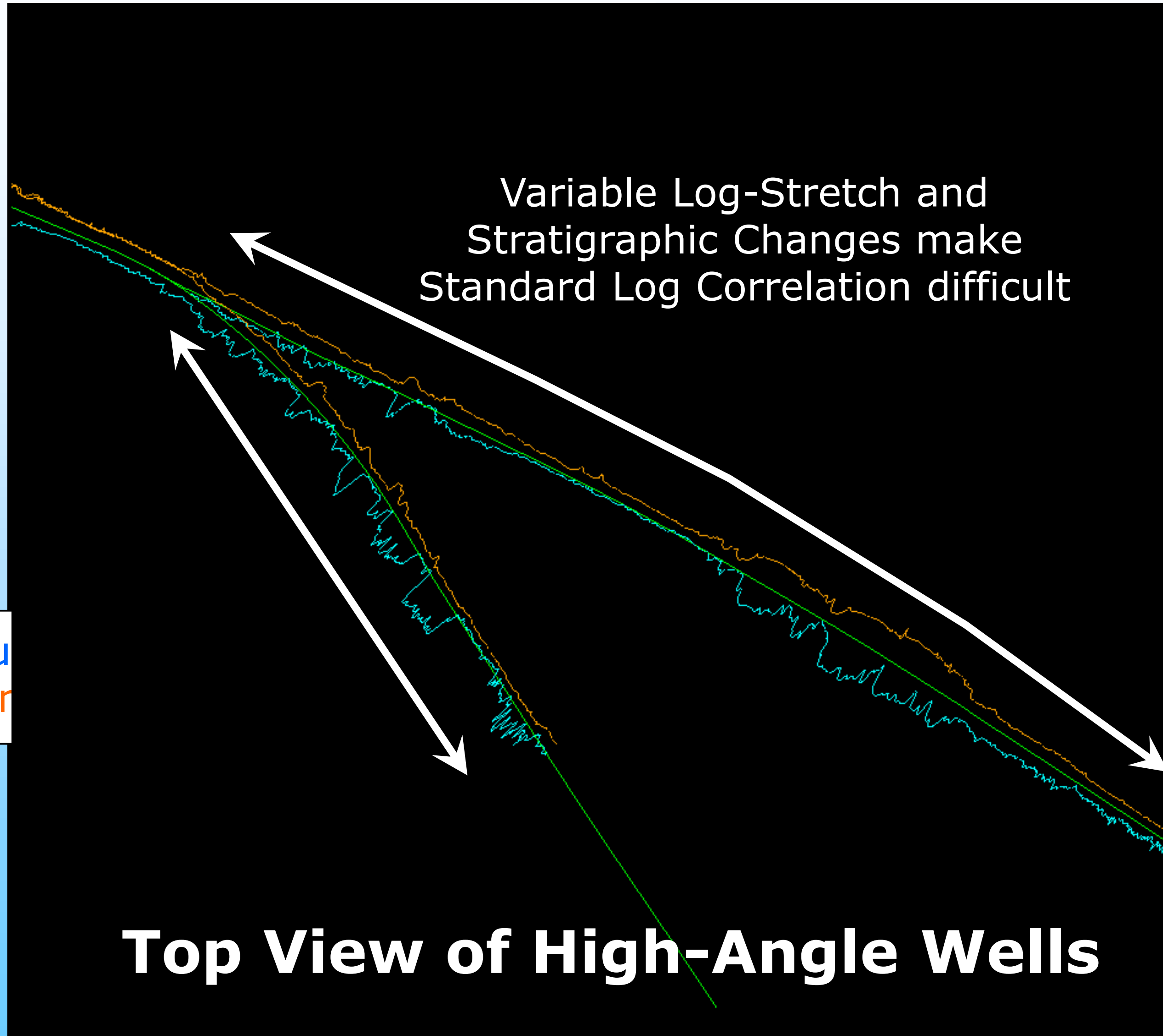
Marker Correlation
By Projecting Along Layering



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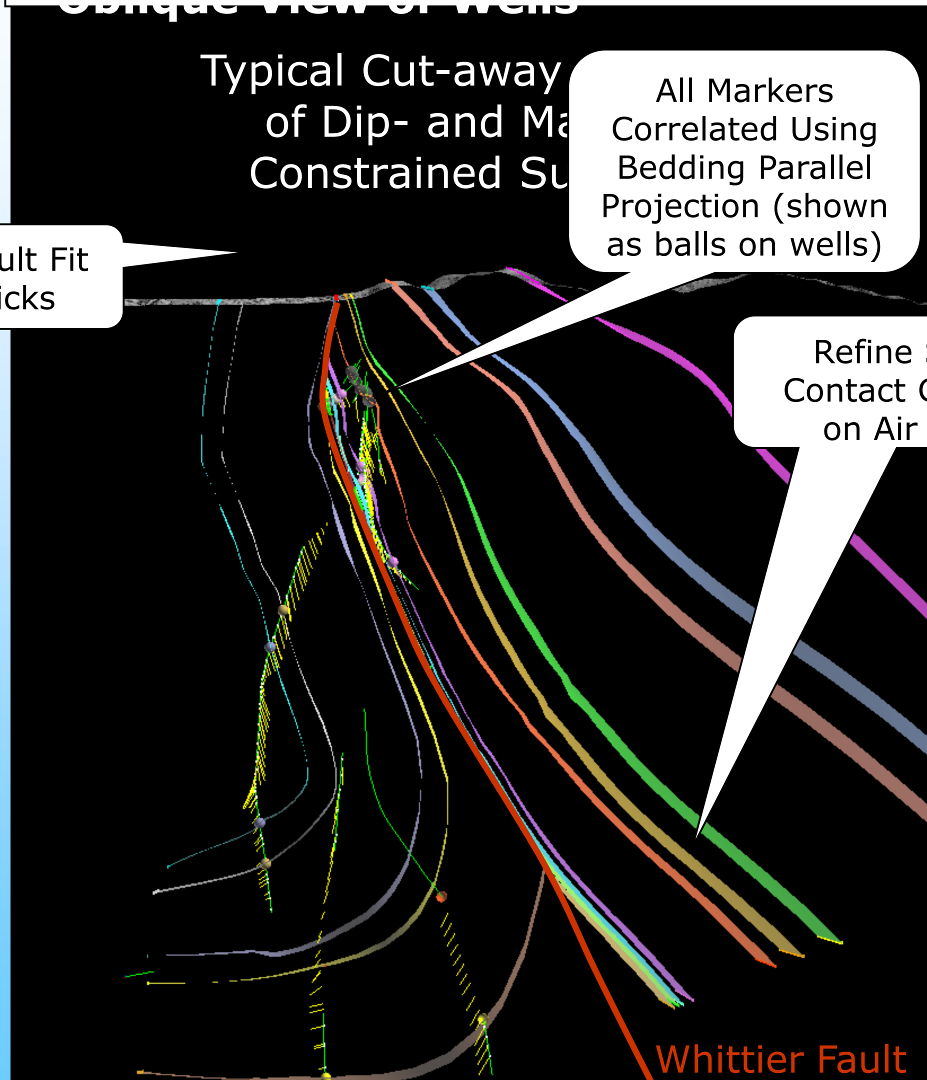
Surfaces Construction
Using Marker Picks and Dip Constraints

Fault, Footwall, and Hanging Wall Surfaces

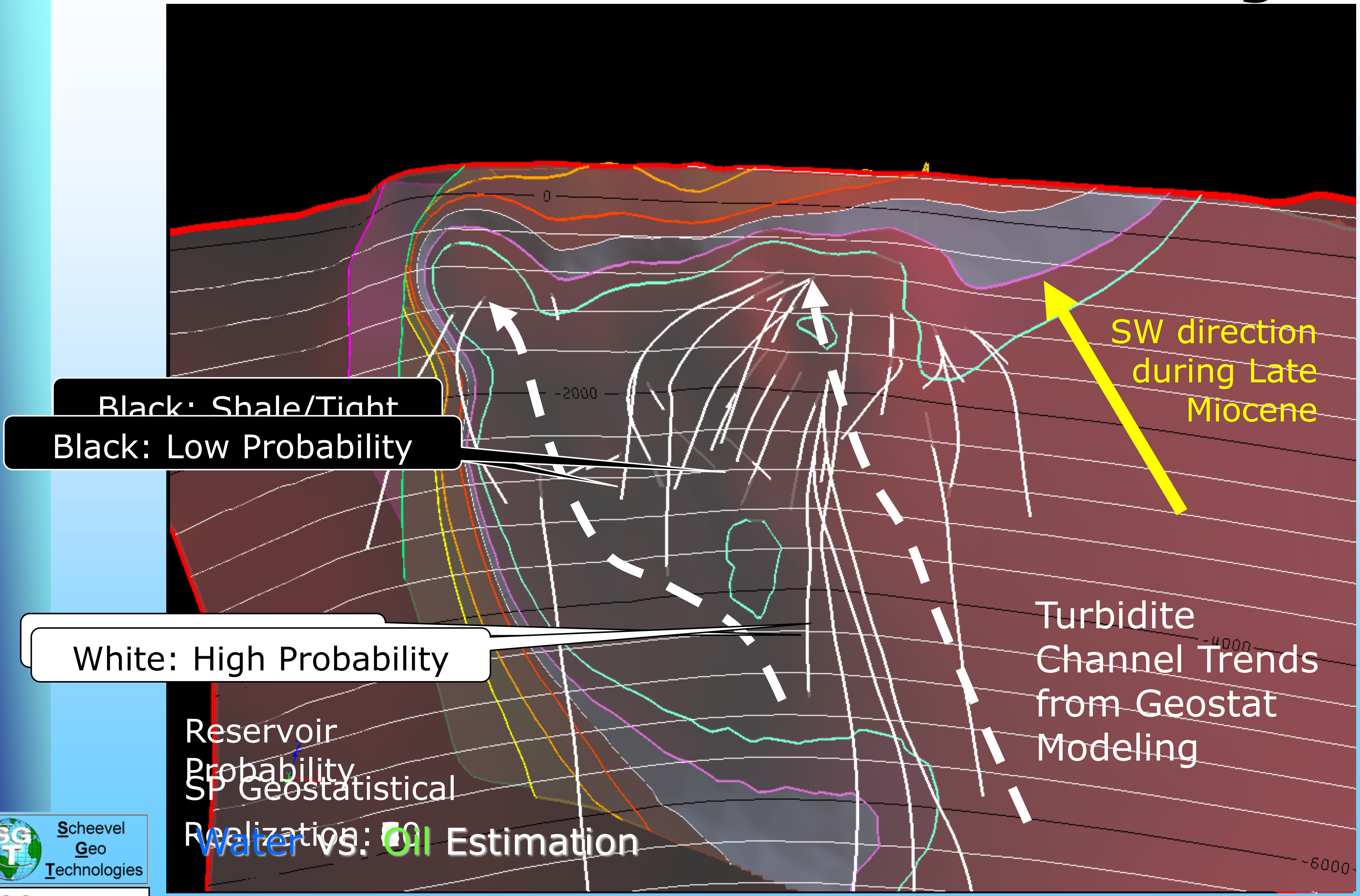


Whittier Fault Fit to Well Picks

All Markers Correlated Using Bedding Parallel Projection (shown as balls on wells)

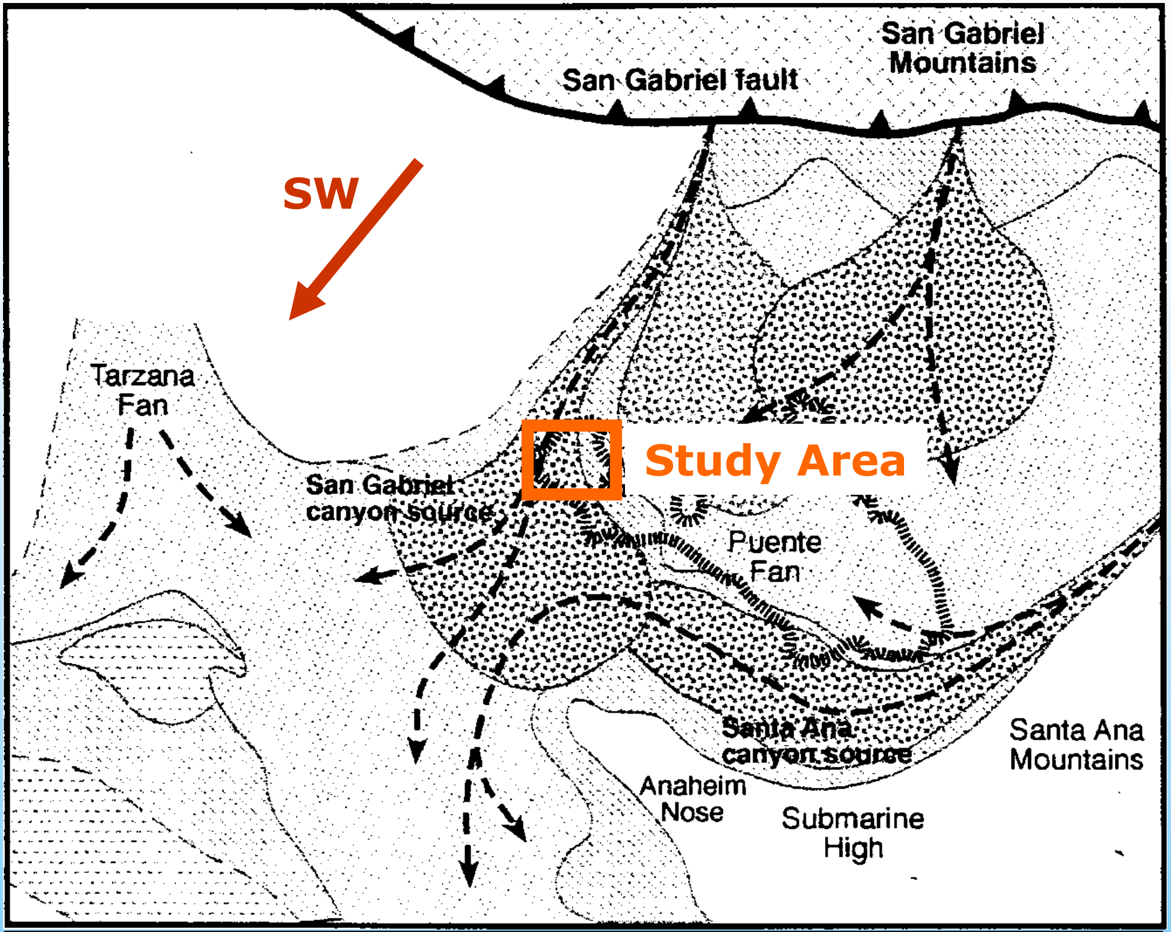
Refine Surface Contact Geometry on Air Photos

Stratigraphic Gridding and Geostatistical Reservoir Modeling



Paleo Depositional Trends Late Miocene

From Herzog,1990 after Redin, 1991 and Critelli et al., 1995



Mid to Upper Channelized Fan – SS and Congl.

Suprafan – Massive Sandstones, High Net to Gross.

Upper Fan, Shelf-slope, Overbank – Laminated Mudstones and Sandstones. Low Net to Gross.

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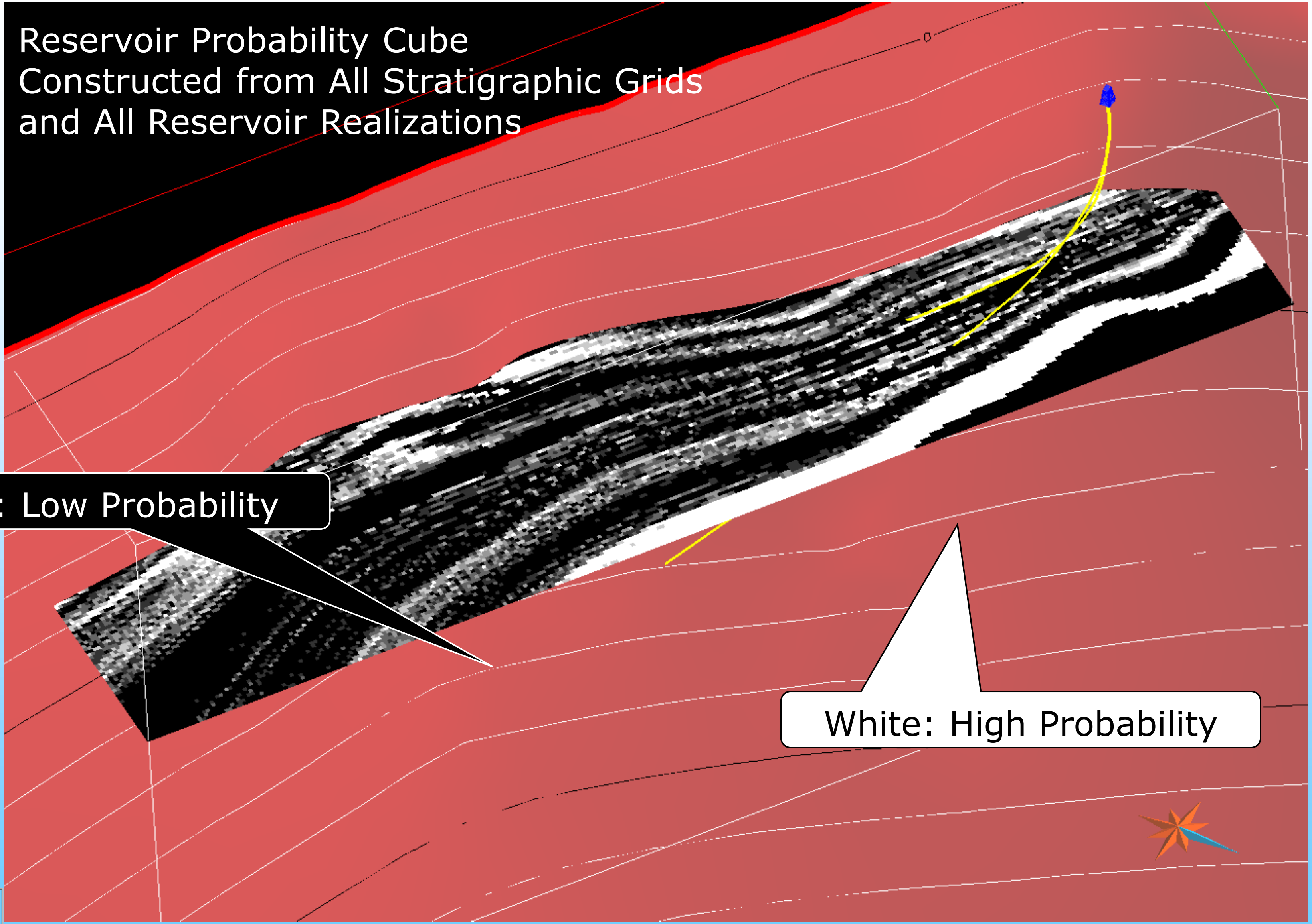
Well Planning from Model



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Results

- **3D Model Construction Reveals:**
  - Correlatable Stratigraphic Zones are Mappable.
  - Lateral Reservoir Limits Segregate the Field.
  - Traps are Sand Lobes Trapped by Fault Cutoffs Updip.
  - Undrilled Pay Can be Identified and Delineated.
- **4 Well Infill Program Designed from Model.**
  - Two Wells Drilled So Far (Early 2007).
    - Both Wells Encountered Pay as Modeled.
    - Both Wells Encountered Structure nearly as Modeled.
    - Virtually no Geosteering Required.
    - Preliminary Analysis Indicates Field Production will Double from These 2 Wells Alone.

Conclusions

- **Integrated 3D Modeling is a Practical Tool for Old Low Volume Fields.**
  - Value is Compounded in Fields with Little or no Modern Mapping and Structural Complexity.
  - May Provide High Value Even in Low Volume, Mature Fields.
  - Can be Used Effectively by Small Operators and Consultants.

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