Perceptive Interpreter Training: Integrating Structural Insights, Volumetric Tools and Spatial Thinking*

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Abstract

Completing accurate 3D structural interpretations can be challenging even for expert structural geologists with years of experience. General geologists, especially novice interpreters, are even more likely to struggle. Short project timelines, variable data quality, and difficult software all add pressure, often resulting in inadequately addressed (or incorrect) reservoir structure maps or 3D models.

Developing efficient interpretation skills has often relied on individual skills and direction. Classic training provides important structural concepts, analog examples, and software skills, but commonly does not address the integration of these with accurate perception of the structural geometry in 3D. Compared to other fields and industries, geology lags in deliberately selecting for and developing volumetric skills and applications.

At ConocoPhillips we have developed a new interpreter training program that targets the integration of concept, tools, and cognitive skills. By infusing structural geology concepts with 3D spatial thinking exercises, trainees appreciate and visualize ranges of admissible 3D deformation geometries for a given structure or concept. As individual concepts are introduced in training courses, the blending of theory and 3D form hones spatial cognizance skills that are needed to produce accurate subsurface structural interpretations. This style of on-the-fly 3D visualization of geologic forms in many ways captures the essence of geologic field mapping, wherein hiking to elevated vantage points empowers the field geologist to visualize, update, and re-interpret the geologic forms he/she is mapping (e.g., mapping intersecting folds in a mountainous thrust belt).

Perceptive Interpreter Training:

Integrating Structural Insights, Volumetric Tools, and Spatial Thinking

Thomas Neely and Robert Krantz
ConocoPhillips Subsurface Technology

AAPG Annual Meeting
April 12, 2010

3D, 4D Geoscience: today's reality

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- Poor and slow!
  - Why?
    - It's difficult!
    - Poor/limited data
    - Underdeveloped geoscience creativity
    - Short project timelines
    - Inefficiency
    - Hindering software
- The result: insufficient/incomplete trap maps/models

Why is 3D structural geometry important?

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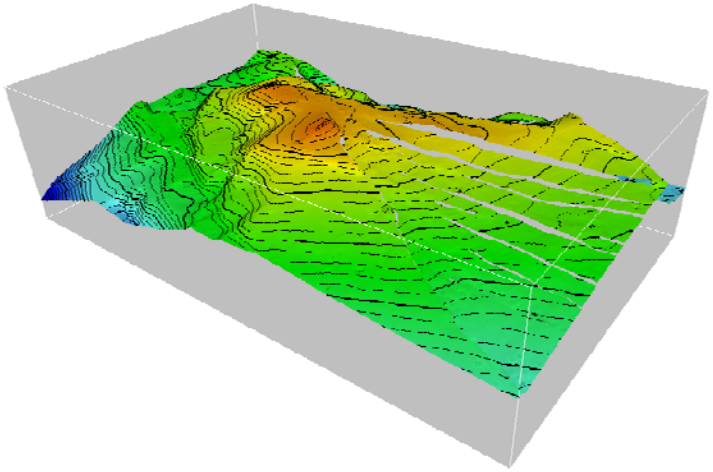
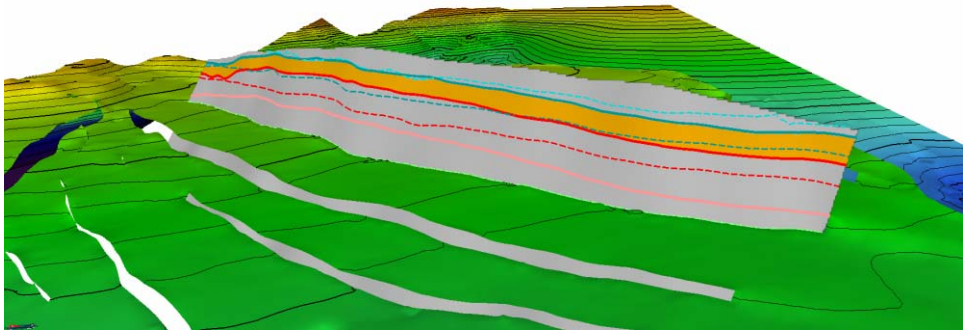
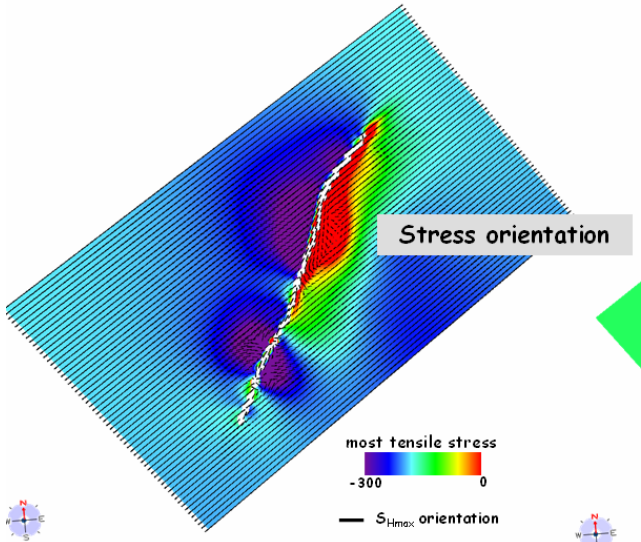
- Defines trap volumetrics

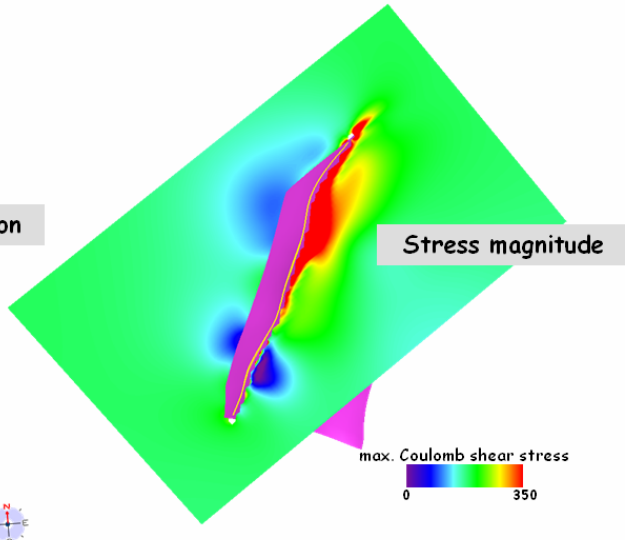


- Fault displacement geometry defines reservoir communication



- primary control on fracture development





The gold standard in interpretation

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- It does exist!
- What is it?

  A "complete geologic thought" that combines:

  1) An understanding of relevant geoscience concept/theory
  2) A structurally admissible & volumetrically-derived 3D description
  3) A 4D understanding of underlying geologic/mechanical processes

- Benefits:
  - More accurate initial perception
  - More rapid completion of interpretation
  - Mental model context -> efficiency & QC of progress/results

Traditional training: out of focus

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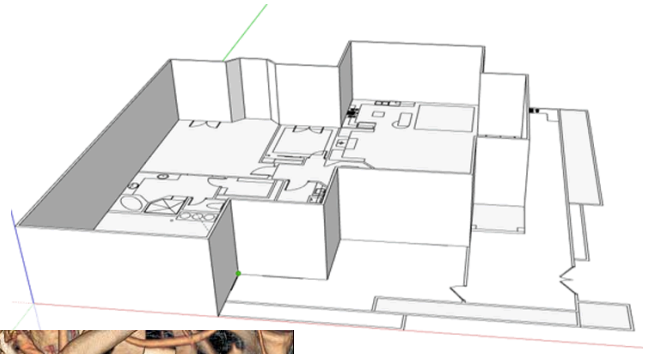
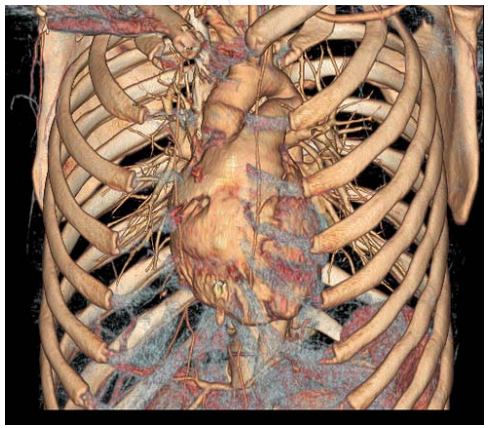
- Structural concepts + workstation workflows ≠ Gold Standard



- Comparison with other professions:

  Architecture:

  - immersive rendering & updating



  Radiology:

  - 3D imaging/exploration

  Military combat:

  - immersive battlefield simulation
  - focus on combat spatial awareness

- Yes, 3D spatial perception can be taught!

Achieving the gold standard

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- "Perceptive Interpreter Training"

- Continuous infusion of traditional training branches (concepts, workflows) with spatial thinking training (non-geologic, geologic)

- Permanently imbues 2 critical links:

    1) Link between 2D geology, 3D geology, 4D geology

    2) link between interpretation toolkit, 3D & 4D thinking

The 2D/3D/4D link

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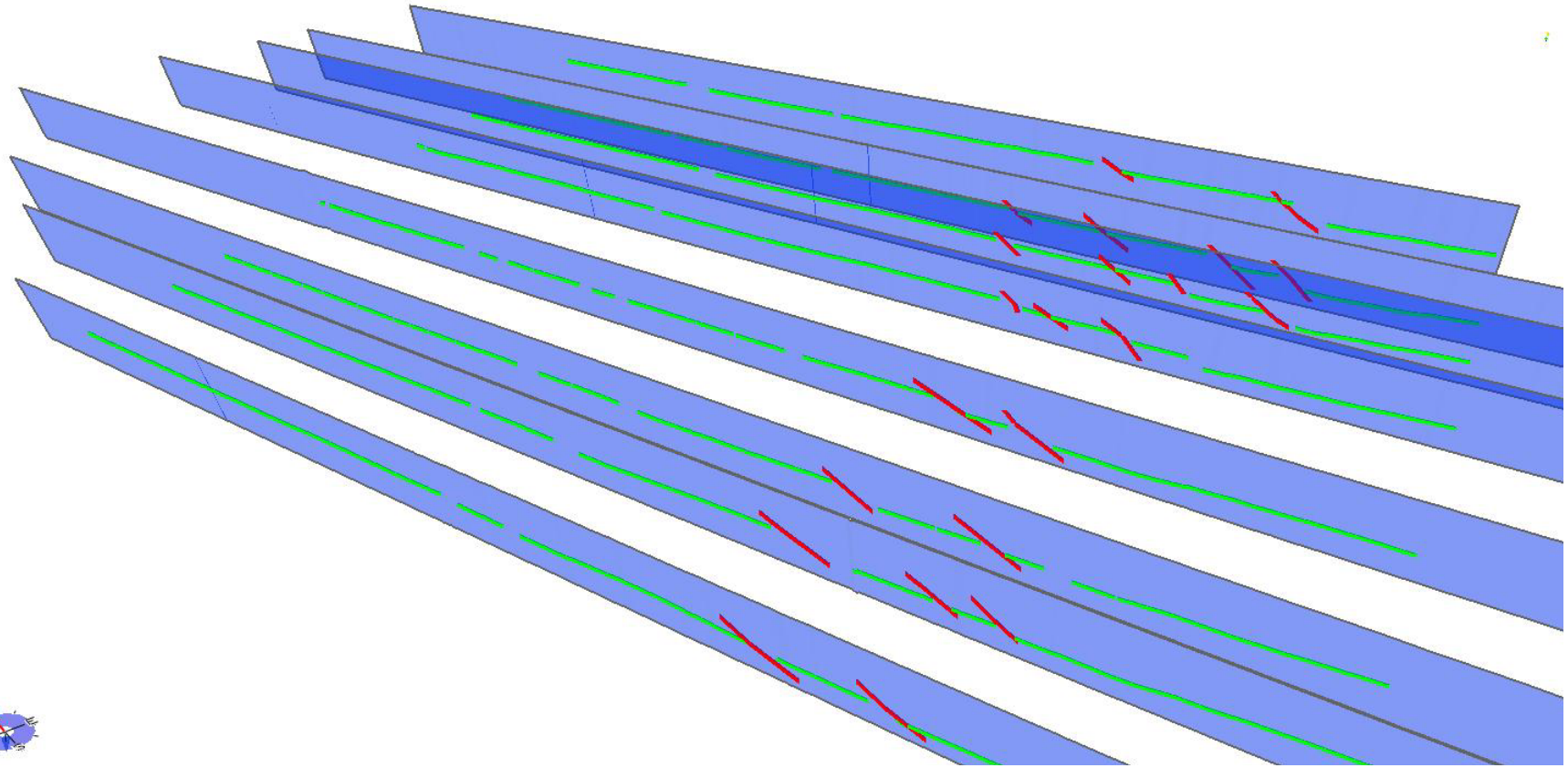
A) Theory + 3D form

- content introduced jointly
- "discovery-based" examples
- How do we begin to describe complex 3D structure?

→ mental 3D exploration.



The 2D/3D/4D link

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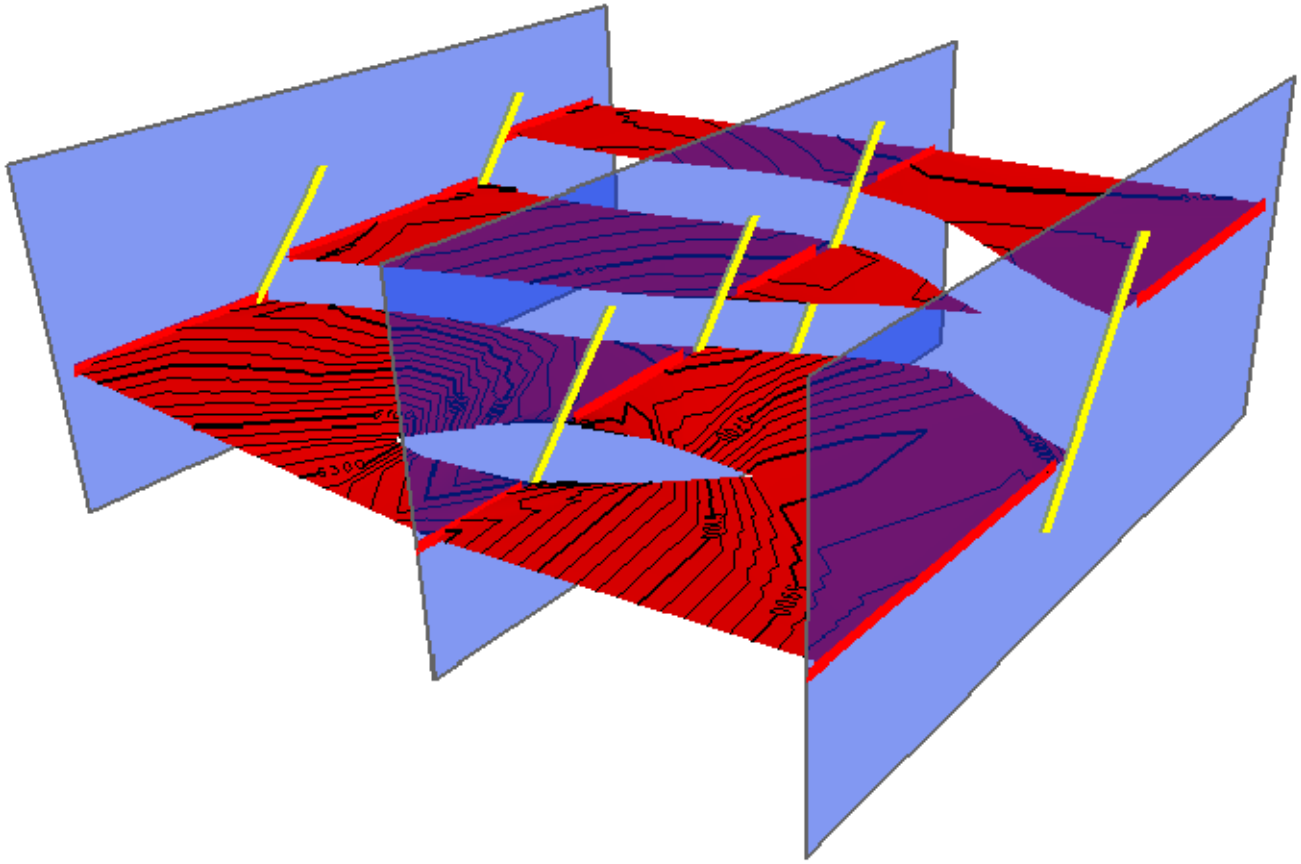
A) Theory + 3D form

B) admissible ranges of 3D form

- "typical" 3D geometry for a "typical" 2D cross-section?
- If you can't visualize it, it wont be an option



The 2D/3D/4D link

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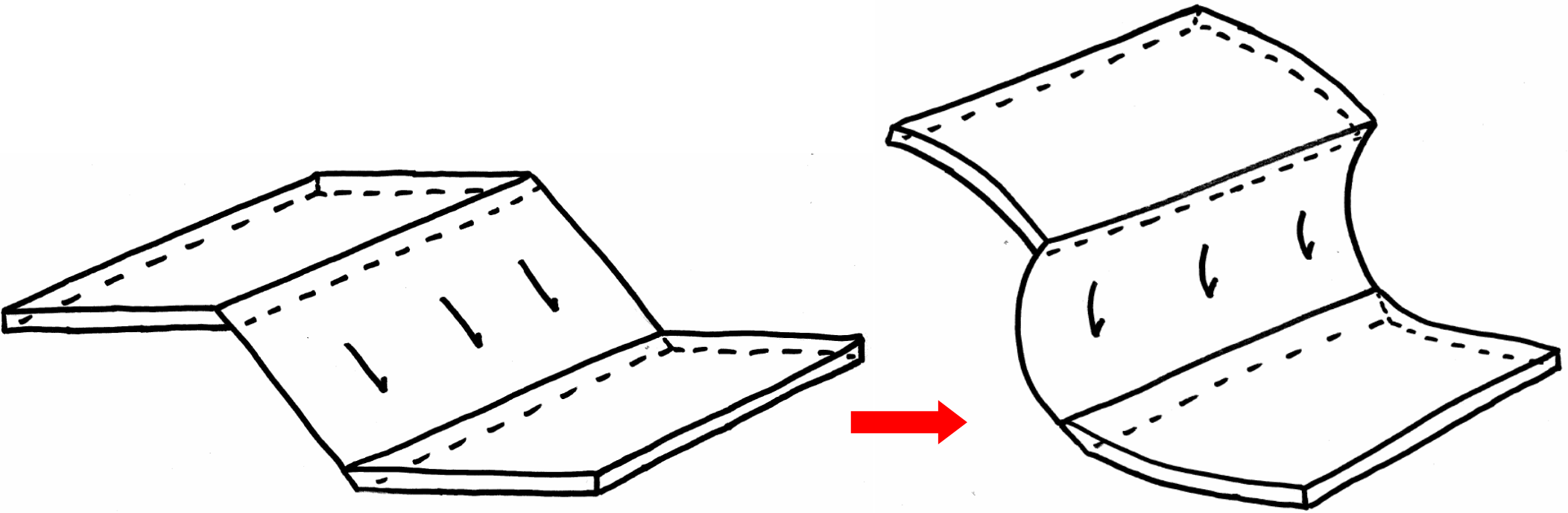
A) Theory + 3D form

B) admissible ranges of 3D form

C) 3D appreciation: a prerequisite for 4D component

- Spatial perception challenge: visualizing change in 3D form through time



The 2D/3D/4D link

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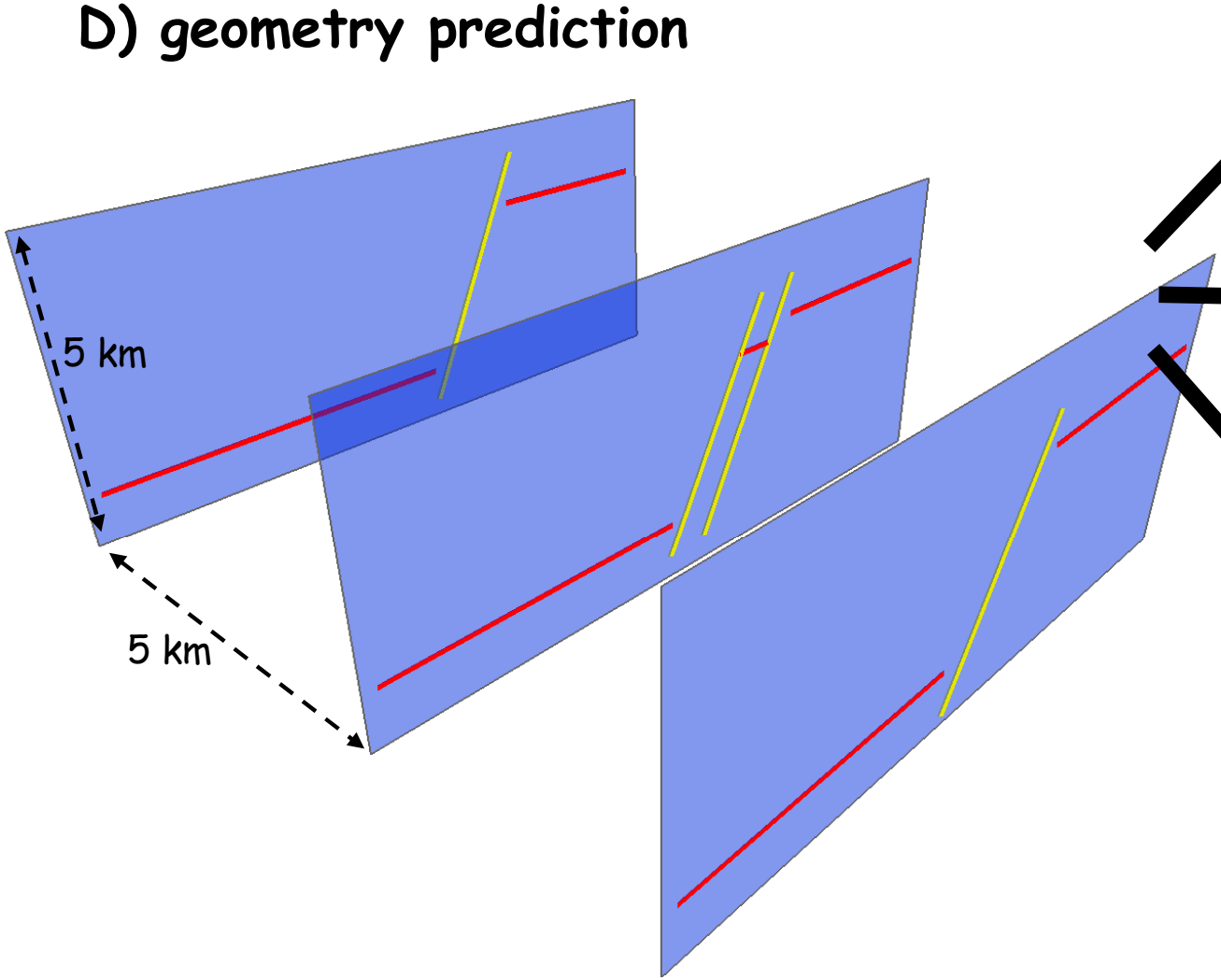
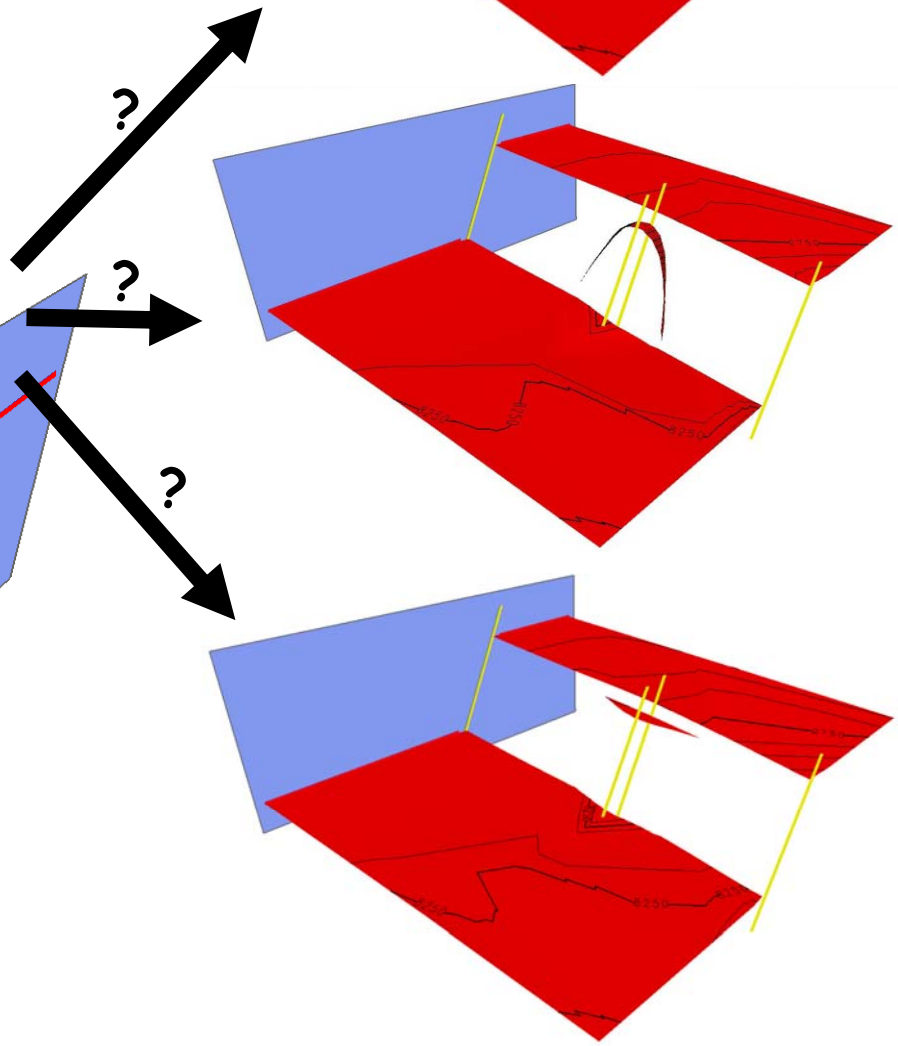
A) Theory + 3D form

B) admissible ranges of 3D form

C) 3D appreciation: a prerequisite for 4D comp

D) geometry prediction





The toolkit/3D-thinking link

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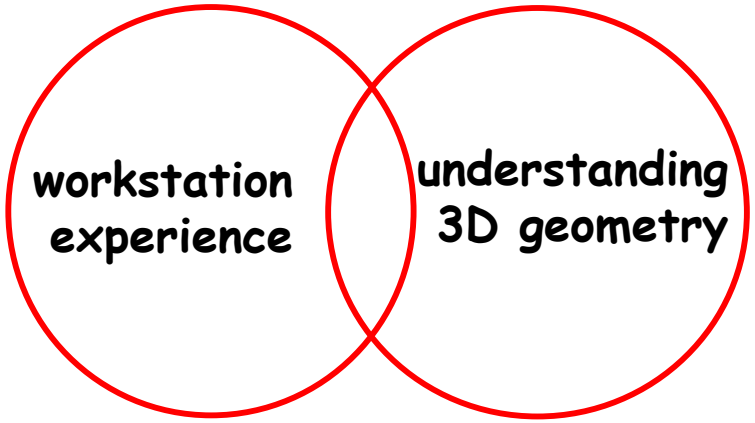
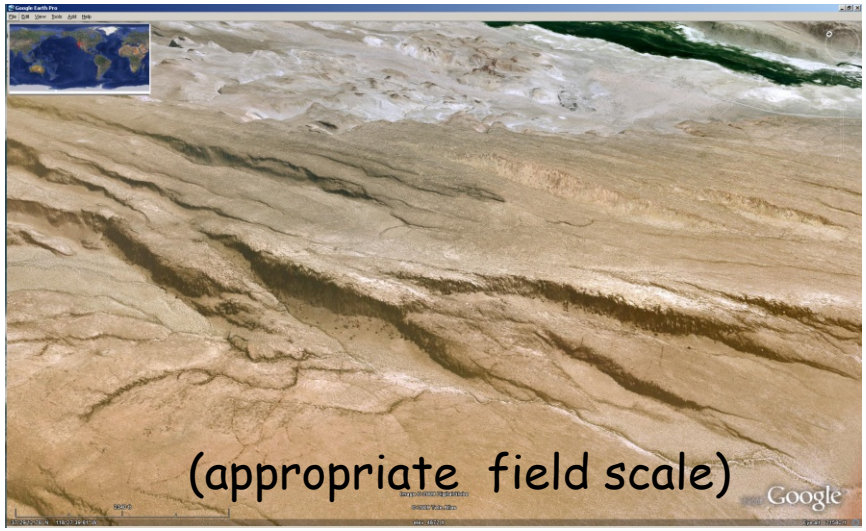
- Immersive interpretation volumes:



- Appropriate immersive "field volumes":

  a) <u>can</u> simulate subsurface 3D geometry: scale, complexity



The toolkit/3D-thinking link

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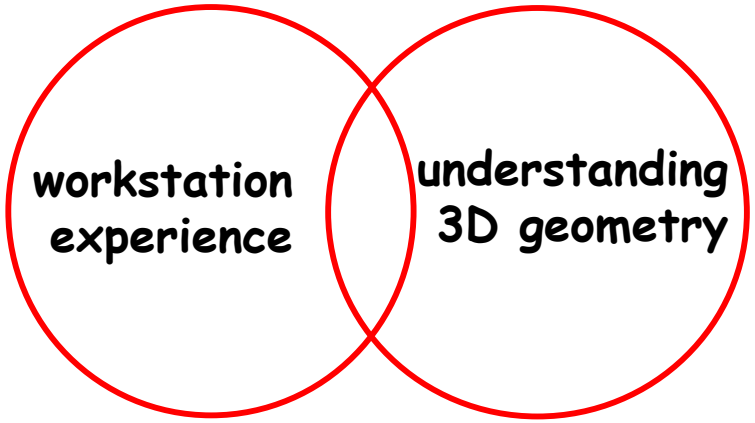
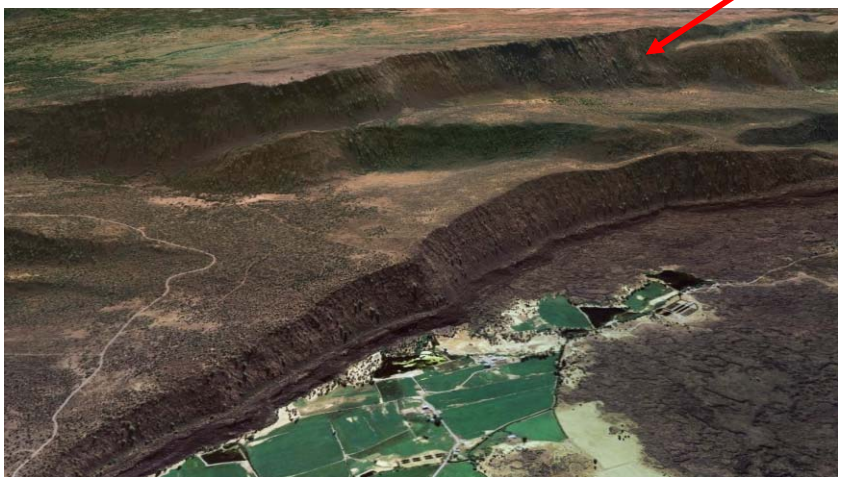
- Immersive interpretation volumes:

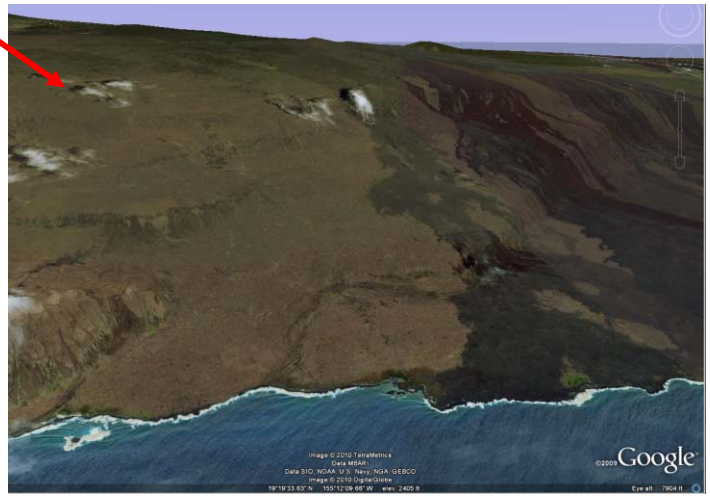


- Appropriate immersive "field volumes":

  a) can simulate subsurface 3D geometry: scale, complexity

  b) familiar workstation objects & products: lava flows, pavements





Proof's in the pudding…

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Field volume visualization

Mental 3D/4D model

Gold standard 3D model