Onshore San Joaquin Basin and Temblor Range, California: New Insights into the Structural Framework and Exploration Potential of a Complex and Mature Fold and Thrust Belt*

Matteo Molinaro[1], Thomas Hauge[2], Sean O'Connor[3], Anthony Salem[4], Olga V. Kostenko[4], and Steve Naruk[4]

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[1]Shell International E&P, Houston, Texas, United States (matteo.molinaro@shell.com)
[2]Consultant, Seattle, Washington, United States
[3]Aera Energy, Bakersfield, California, United States
[4]Shell International E&P, Houston, Texas, United States

Abstract

Aera (Shell/Exxon JV) is currently executing a conventional exploration campaign for remaining prospectivity in the Temblor fold and thrust belt at the western edge of the San Joaquin Basin, central California. This basin is an extremely mature hydrocarbon province, producing for more than a century from thousands of wells. Extensive new 3D seismic acquisition and processing efforts by Aera have resulted in significant uplift in the imaging of the fold-thrust belt. In spite of these advances, imaging of the deep structure of the fold and thrust belt remains challenging. In this talk, we will present a new and comprehensive structural framework that has been developed in support of the exploration campaign. Abundant well data, detailed surface geological maps, and seismic data have been integrated into a series of kinematically constrained cross-sections through the areas of interest. These sections allow us to describe the complex structural geometries and evolution of the basin, which involved an initial phase of normal faulting, followed and completely overprinted by a presently ongoing contractional phase of deformation. The latter is well expressed in the seismic data by folding at multiple scales, ranging from east-directed passive roof basement wedging to thrusting and folding above multiple shallower detachments identified throughout the stratigraphic section. The former is recorded in well data as abrupt thickness changes between areas of gentle thickness gradients and little folding, which is interpreted to reflect syndepositional extensional deformation.

Reference Cited

Sherkati, S., M. Molinaro, D.F. de Lamotte, and J. Letouzey, 2005, Detachment Folding in the Central and Eastern Zagros Folded-Belt (Iran): Salt Mobility, Multiple Detachments and Late Basement Control: Journal of Structural Geology, v. 27, p. 1680-1696.

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AAPG Houston
April 3rd, 2017

Matteo Molinaro, Anthony Salem, Olga Kostenko, Steve Naruk, (Shell International E&P)

Thomas Hauge (Consultant)

Sean O'Connor (Aera Energy)

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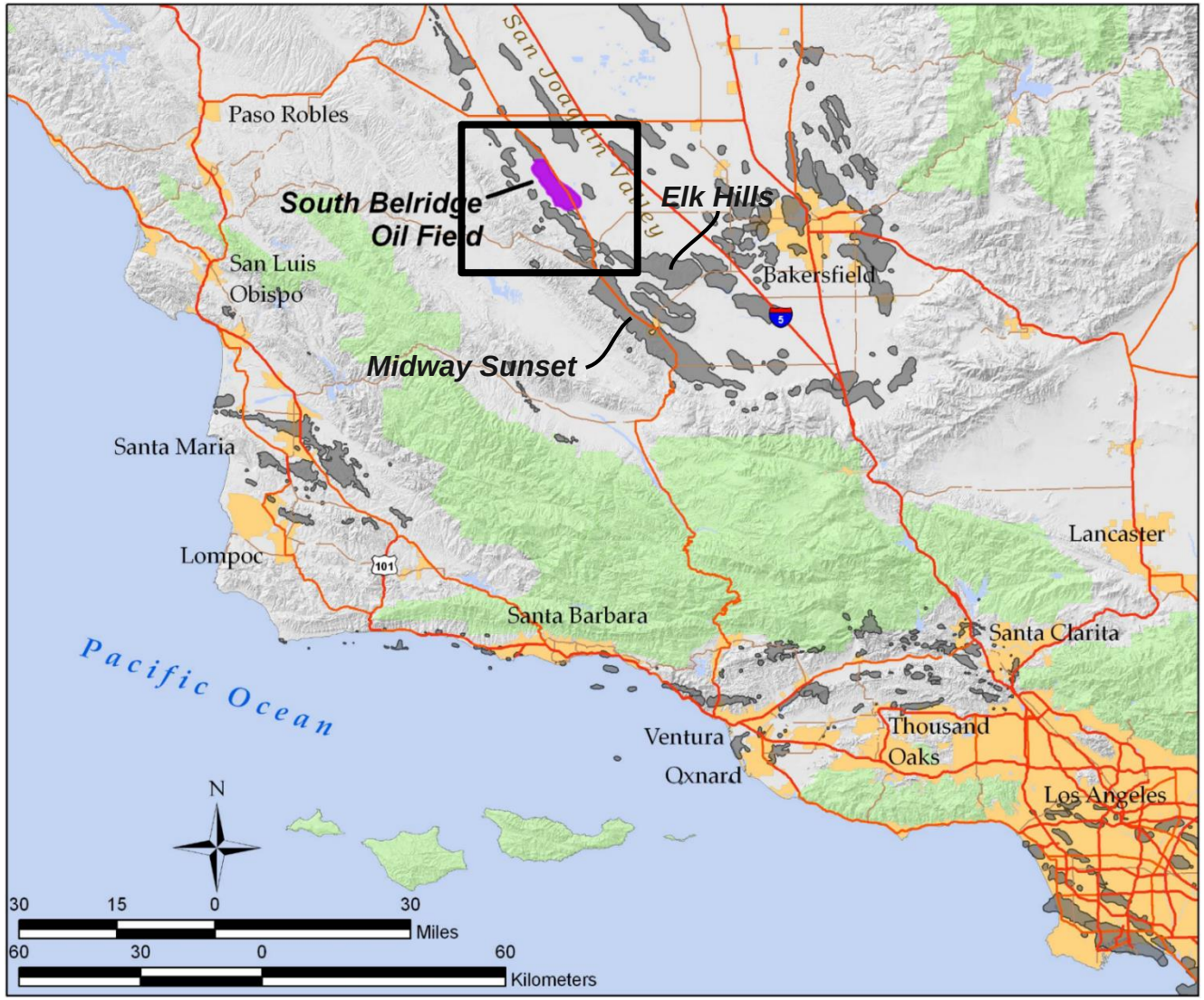
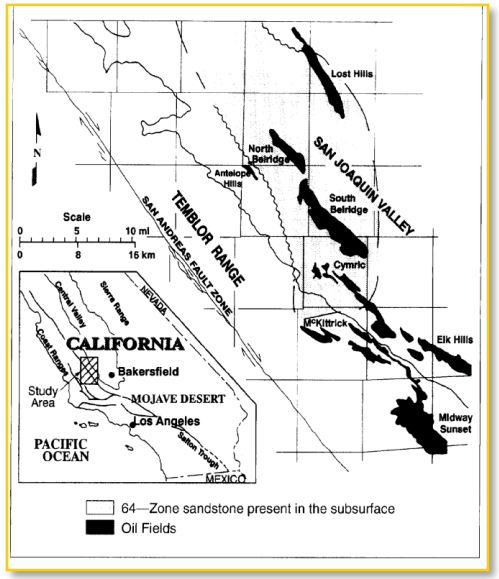
Outline of this Talk

- Geological setting of Aera Energy's exploration acreage in California
- The challenges of seismic imaging in the San Joaquin Basin and Temblor Range
- New structural interpretations
- Implications for exploration
- Conclusions

San Joaquin Basin, Southern Central California

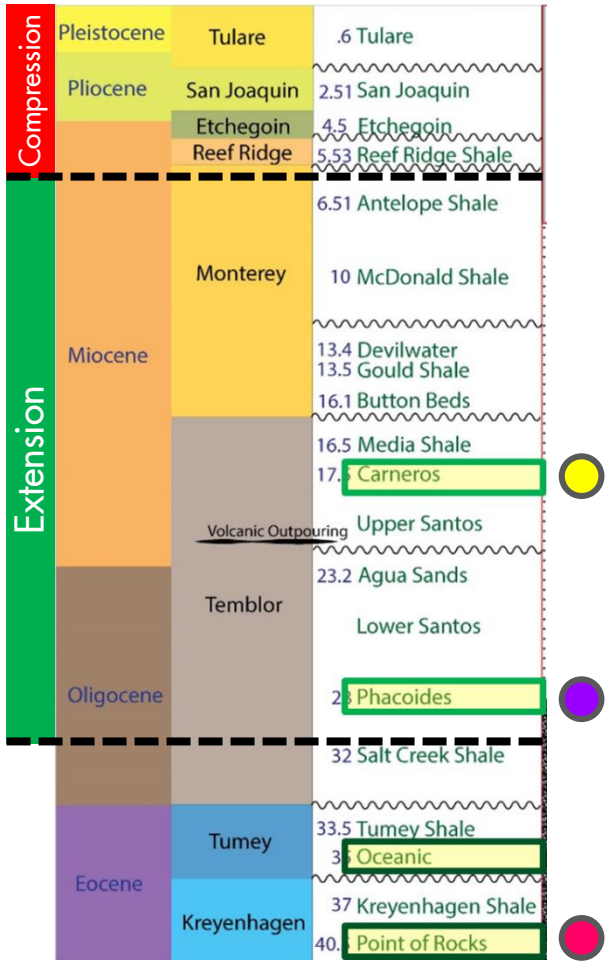


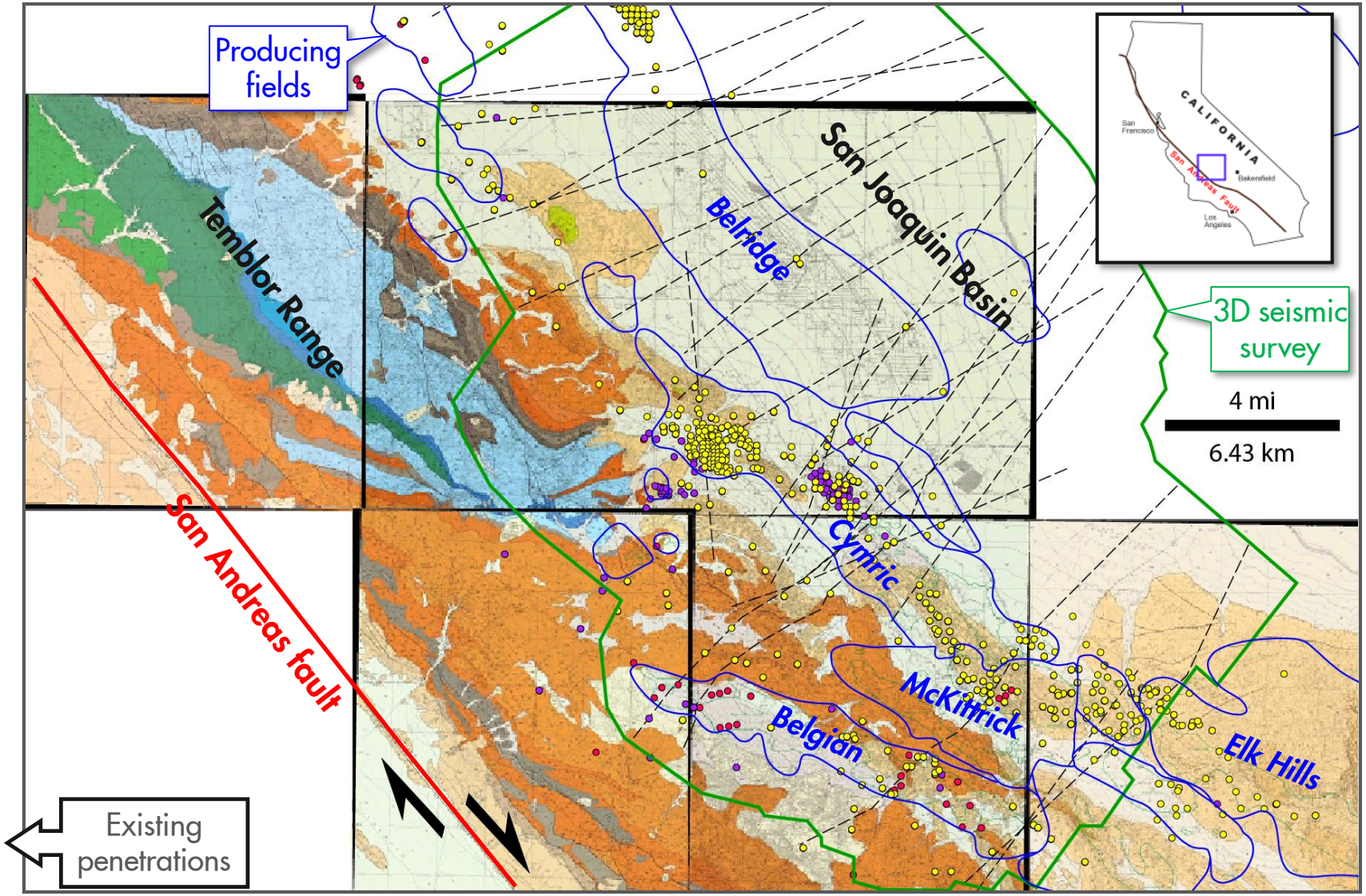
- Prolific basin with 100+ years of production
- Most recent discovery by Occidental Petroleum (Gunslinger, 2009)
- Aera Energy (Shell / Exxon JV) conventional exploration program since 2010



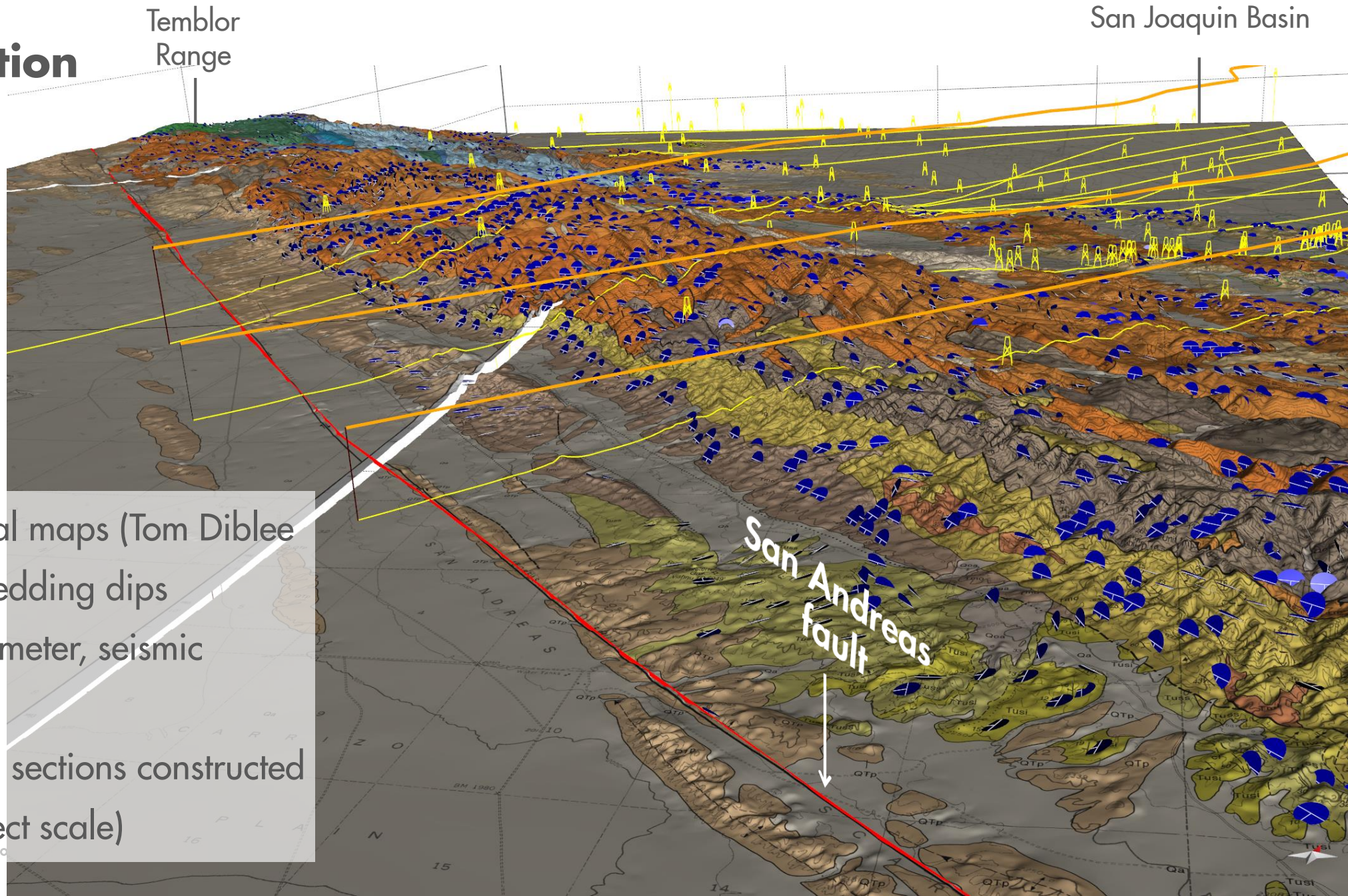
Geological Setting and Exploration AOI

Target Reservoirs



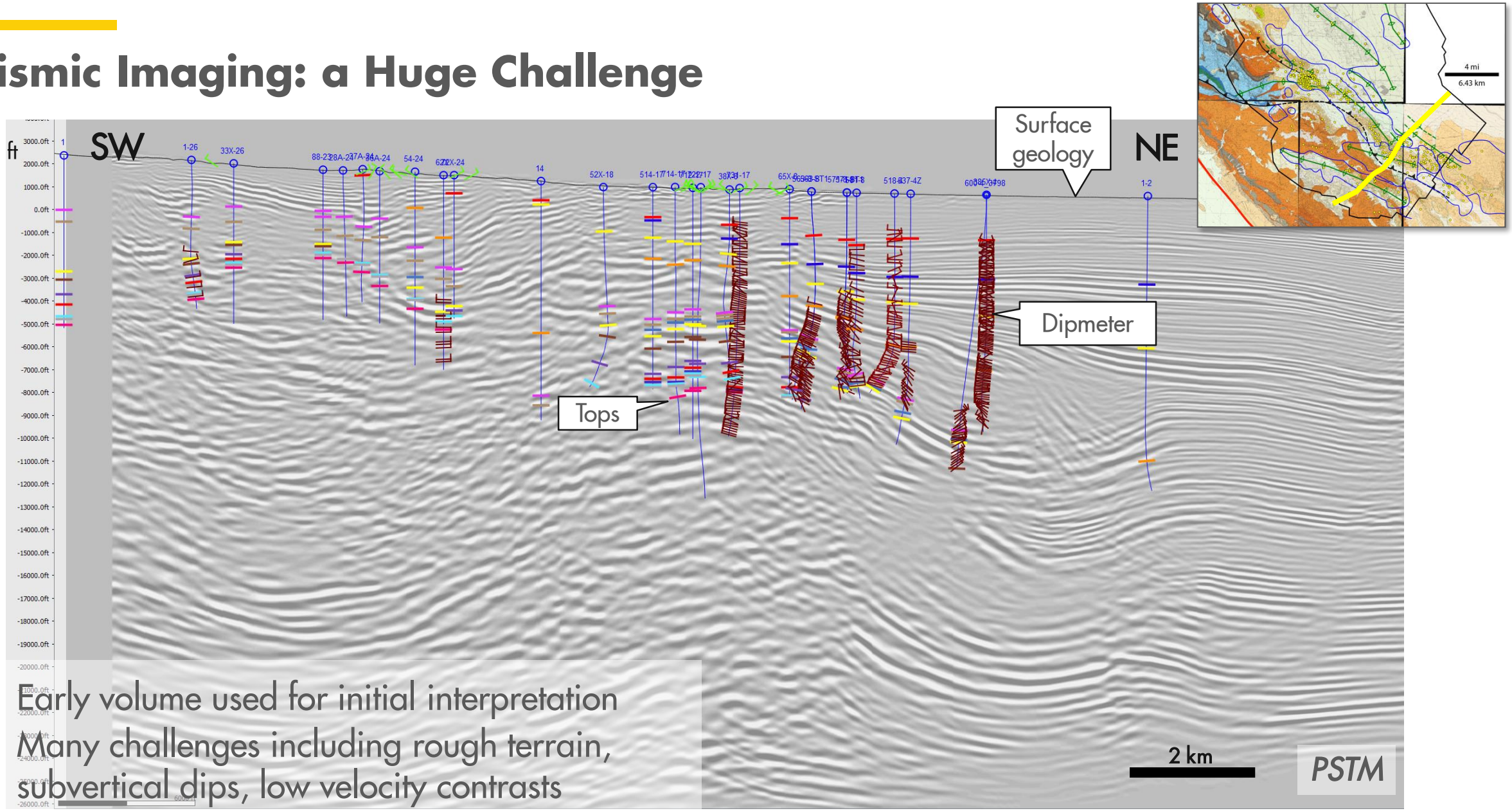


Data Integration



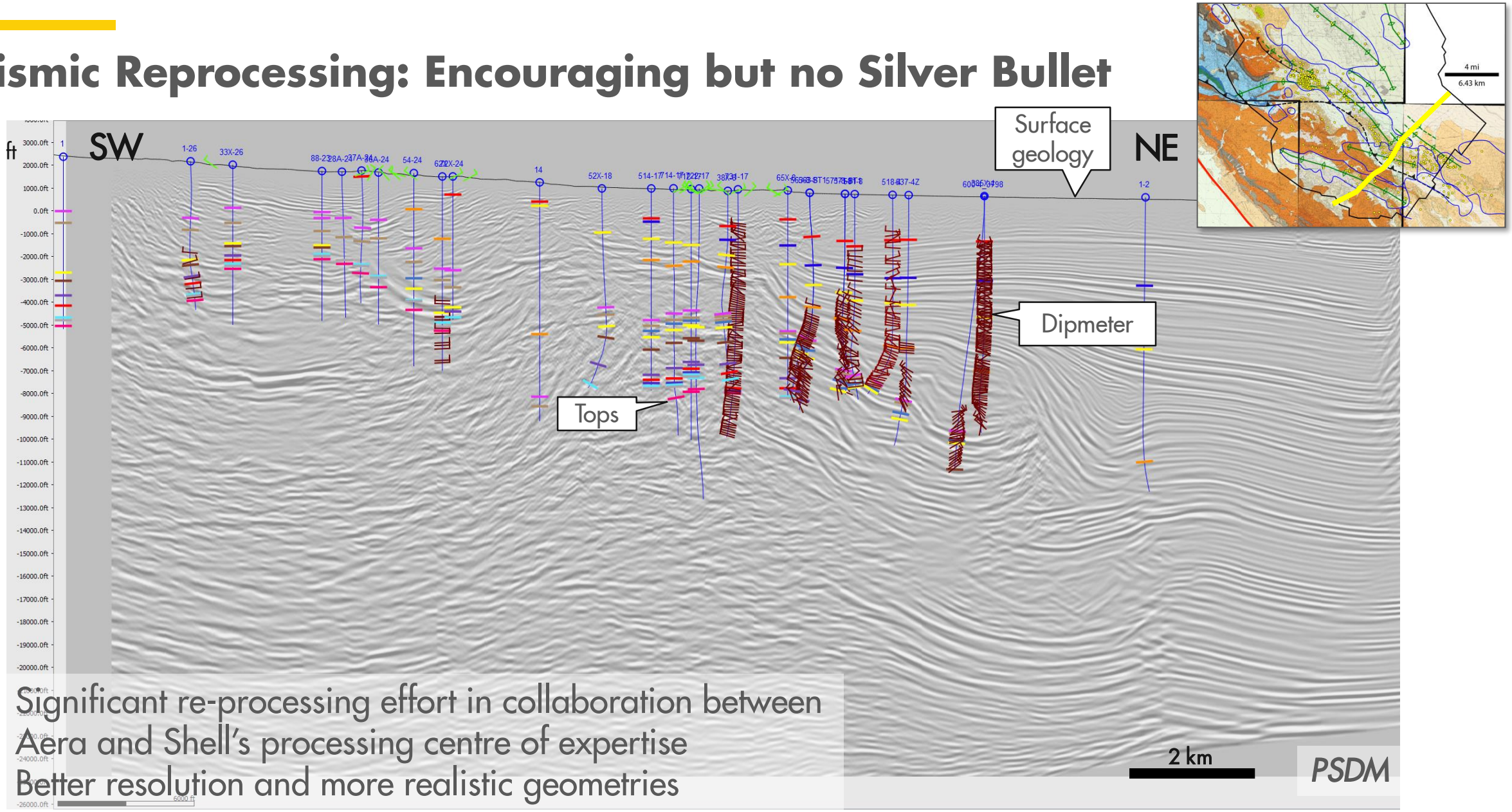
- Excellent geological maps (Tom Diblee & others), DEM, bedding dips
- Selected wells, dipmeter, seismic
- Field observations
- ~20 semibalanced sections constructed (regional & prospect scale)

Seismic Imaging: a Huge Challenge



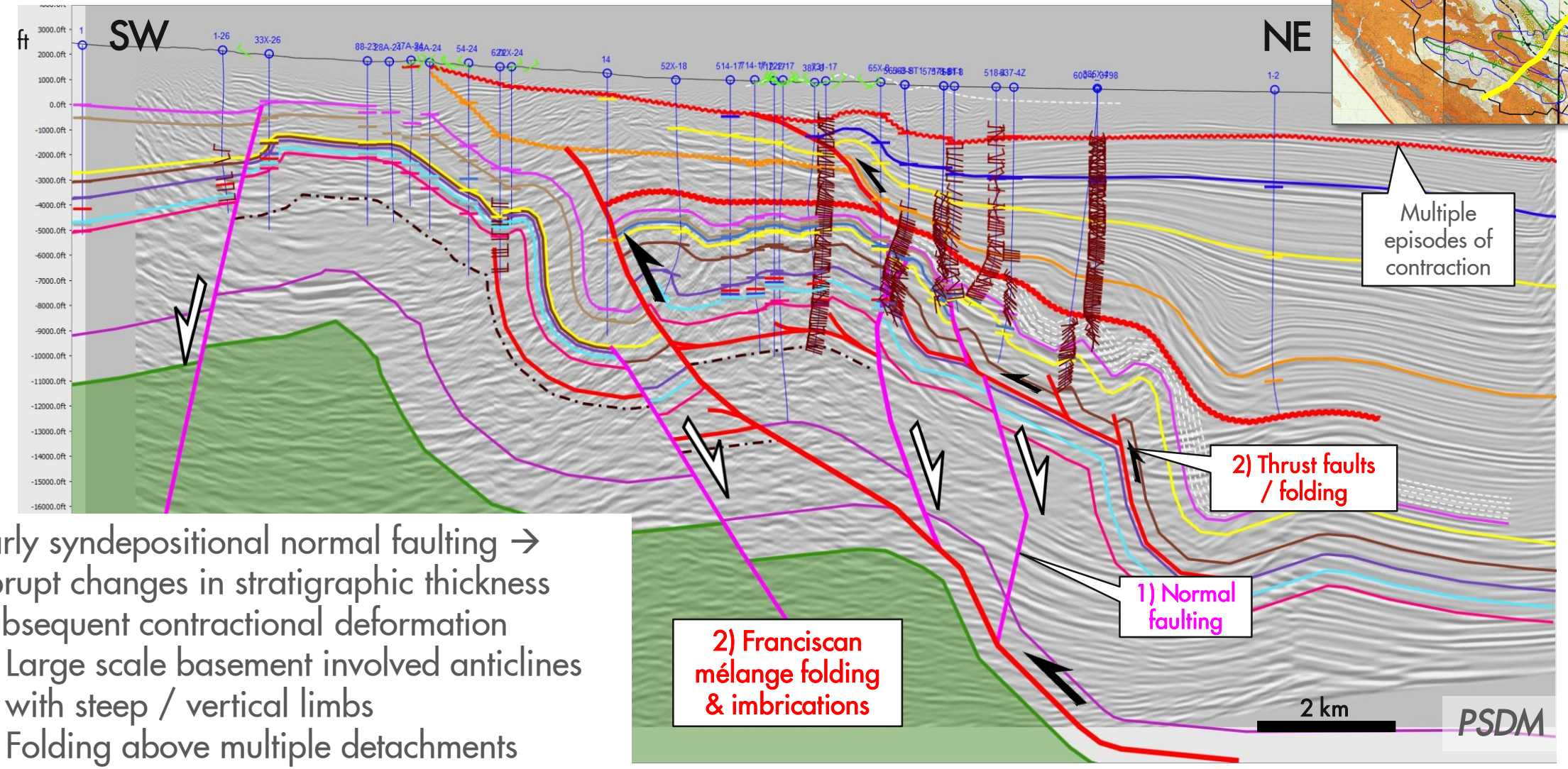
- Early volume used for initial interpretation
- Many challenges including rough terrain, subvertical dips, low velocity contrasts

Seismic Reprocessing: Encouraging but no Silver Bullet



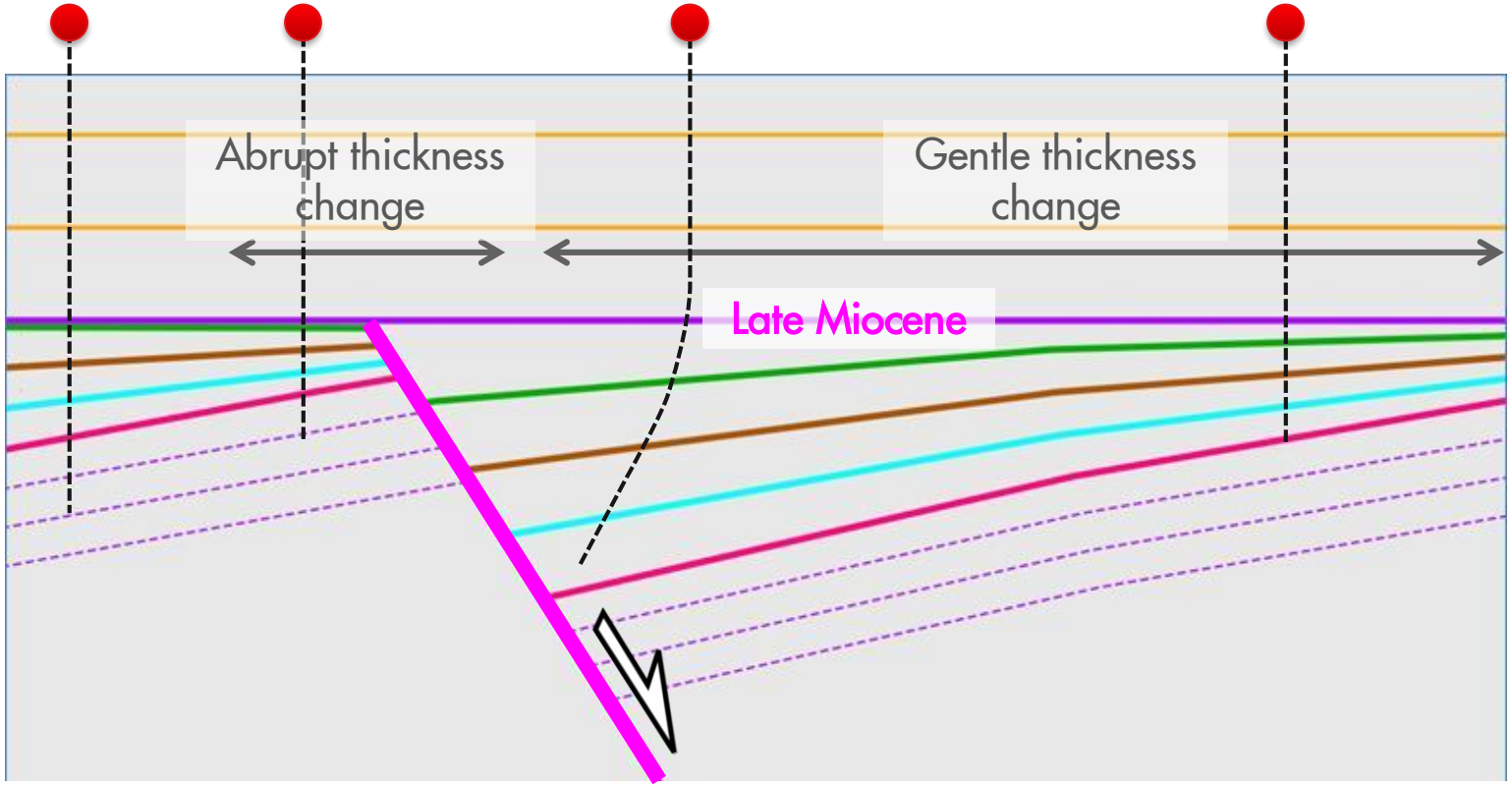
- Significant re-processing effort in collaboration between Aera and Shell's processing centre of expertise
- Better resolution and more realistic geometries

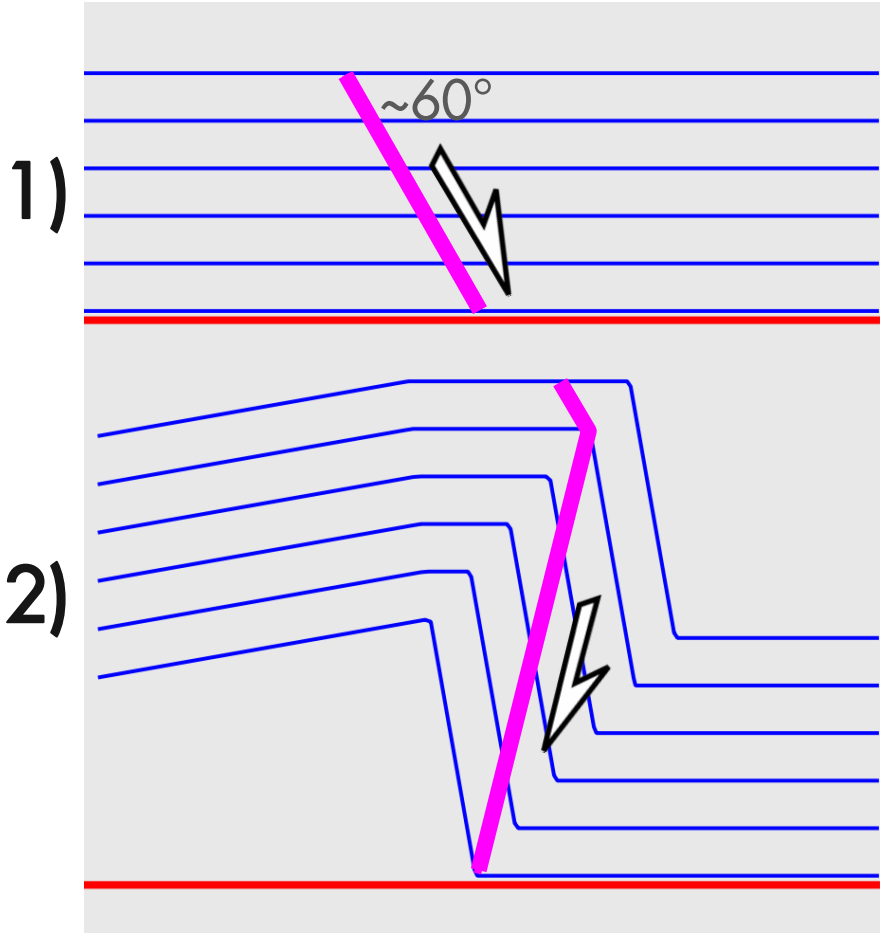
A Complex Regional Structural Framework



1. Early syndepositional normal faulting → abrupt changes in stratigraphic thickness
2. Subsequent contractional deformation
   - Large scale basement involved anticlines with steep / vertical limbs
   - Folding above multiple detachments

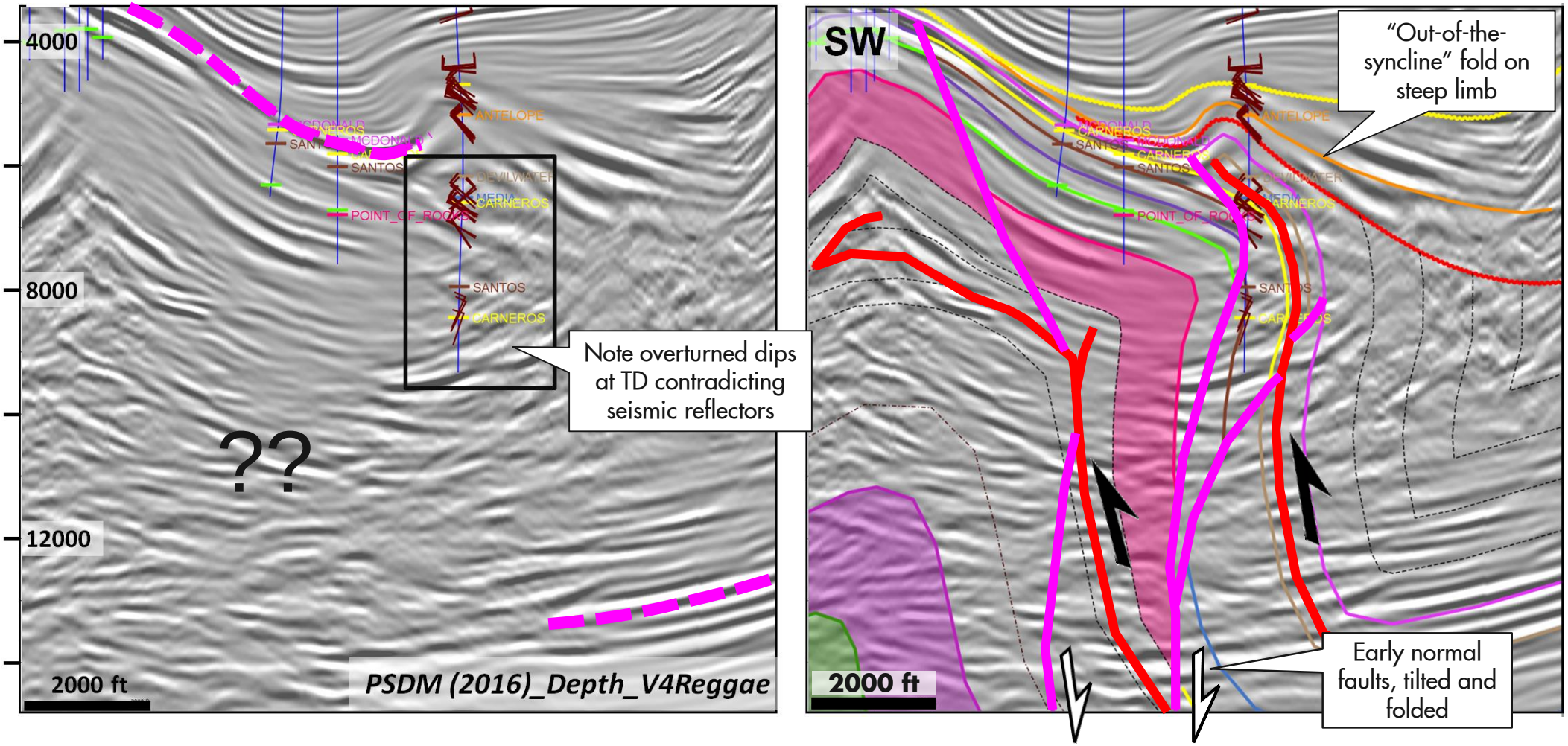
1) Oligo-Miocene Normal Faults, Folded and Tilted by Later Contraction



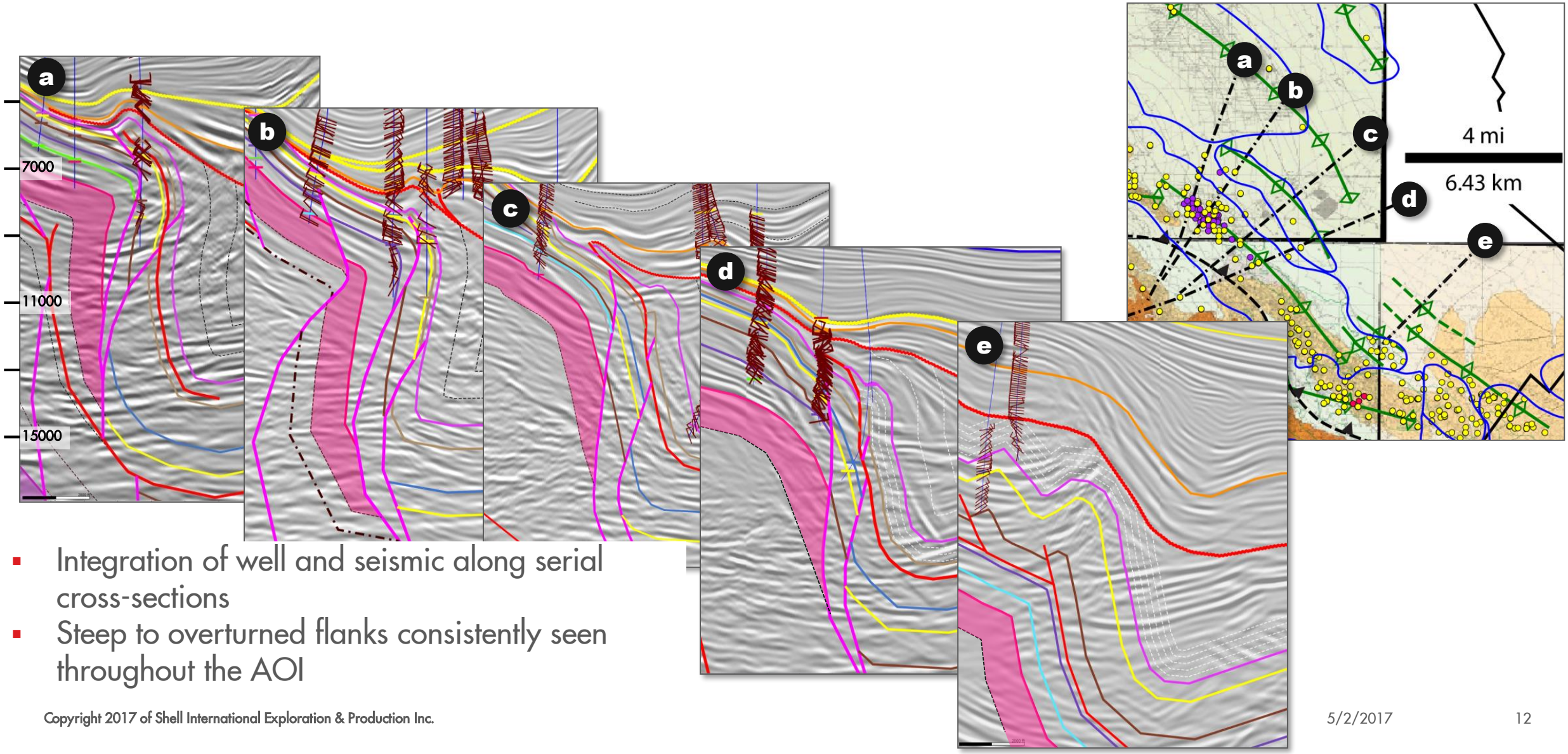


- Are never imaged in seismic
- Are recorded in well data, primarily, as abrupt thickness changes between areas of gentle thickness gradients and little folding.

2a) Large scale anticlines with steep / overturned limbs, often inferred but never imaged

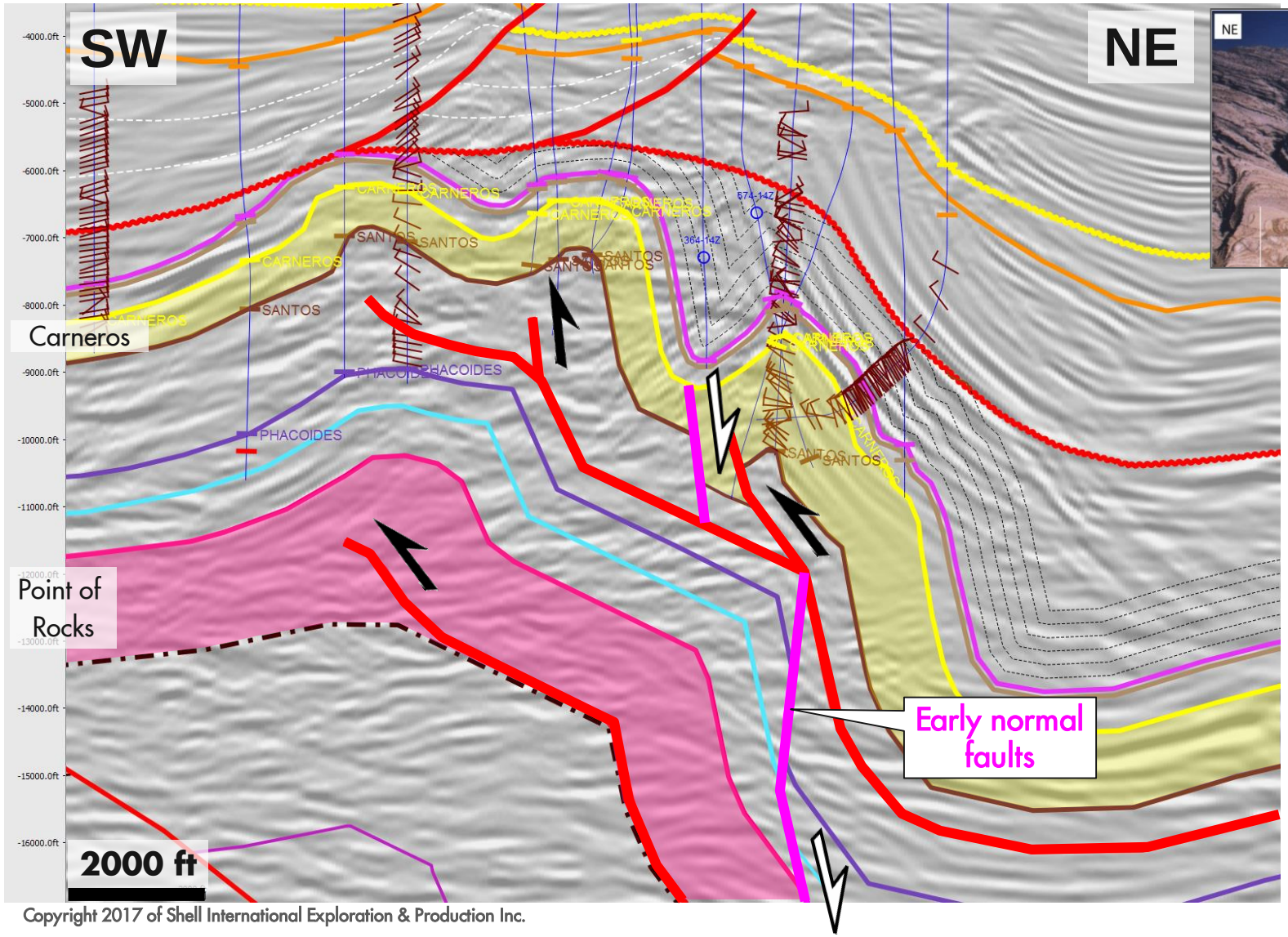


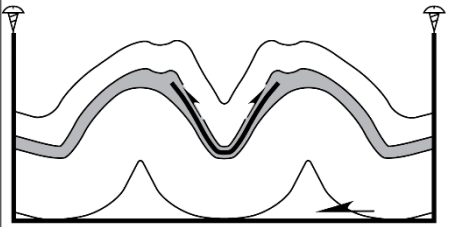
Maintaining along-strike consistency helps constrain interpretations



- Integration of well and seismic along serial cross-sections
- Steep to overturned flanks consistently seen throughout the AOI

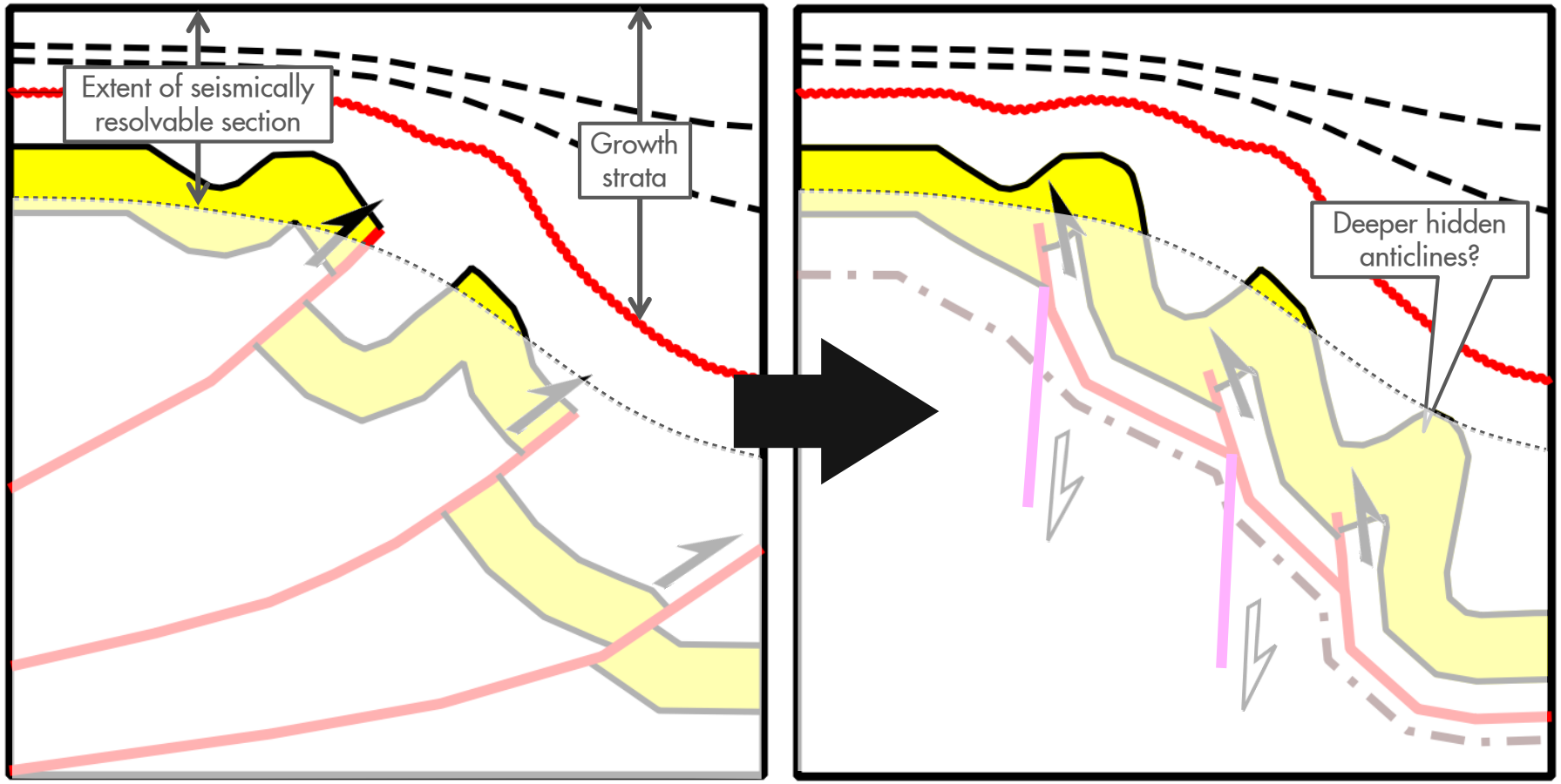
2b) Small scale parasitic folds on flanks of large anticlines





Field example, and model for out-of-syncline fold on limb of major anticline (Zagros, Iran)

A Paradigm Shift in Exploration Focus



- Steep flanks, not thrust faults
- Could these steep flanks harbor small undetected anticlines?
- No direct image, so less likely to have been discovered by previous exploration efforts

Conclusions

- The complexity of the San Joaquin basin and Temblor Range cannot be solved with seismic alone, but requires a truly integrated and multidisciplinary approach (seismic, wells, dipmeter, outcrop, DEM, etc…)
- A plausible interpretation must recognize multiple phases of deformation and address the geometric implications of structural overprinting
  a) Oligo-Miocene normal faulting
  b) Miocene-Present contractional deformation
- The new structural model suggests that exploration running room in the SJB may be found as 4-way closures in the poorly imaged flanks of the major anticlines

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