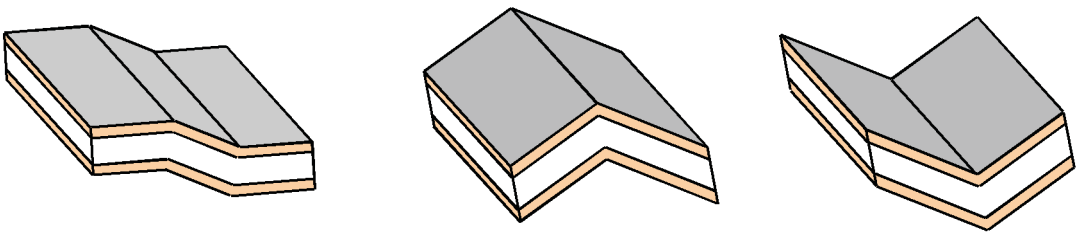
Basic concepts

monoclines ***anticlines*** ***synclines***



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Section 1A-1: Defining folds

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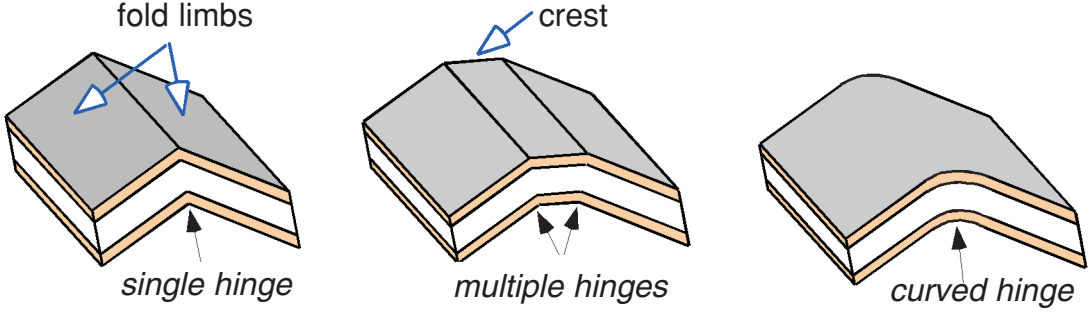
Basic concepts

anticlines



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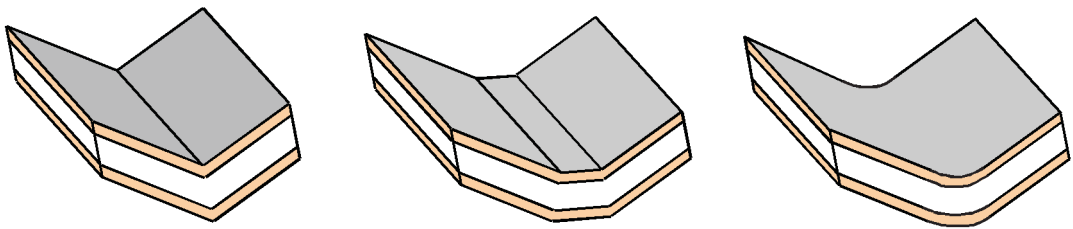
synclines



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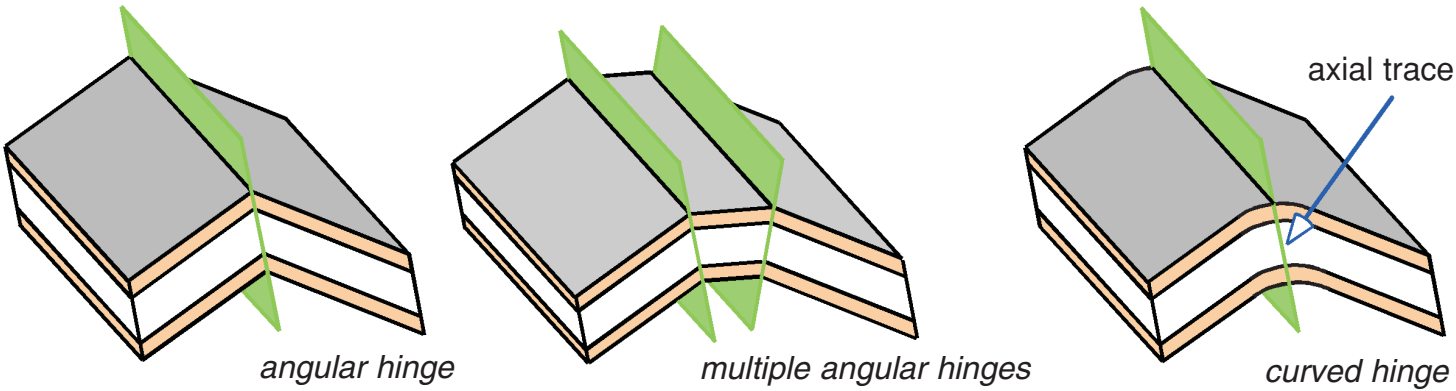
anticlinal axial surfaces



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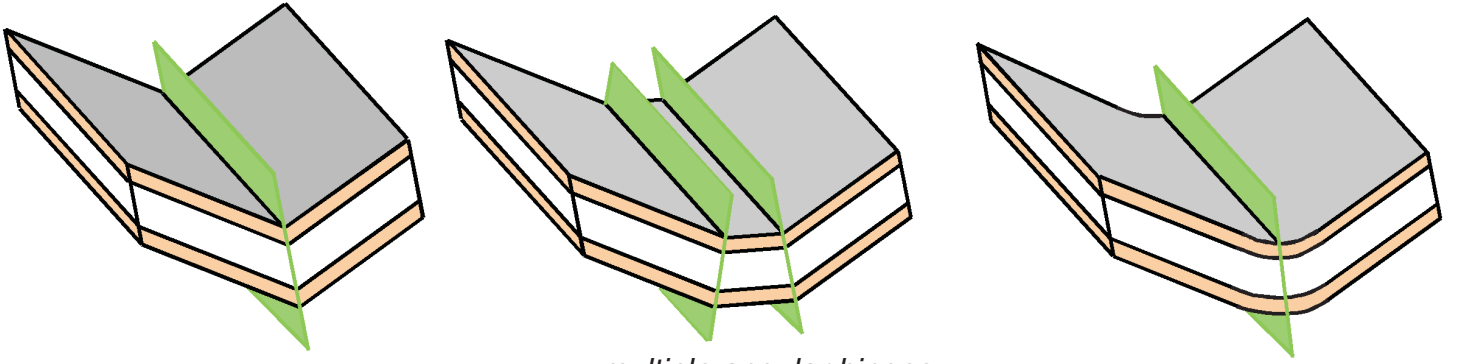
synclinal axial surfaces



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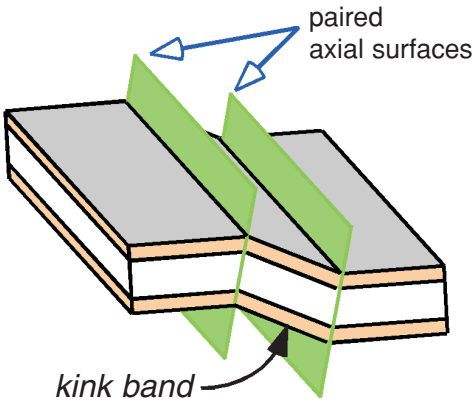

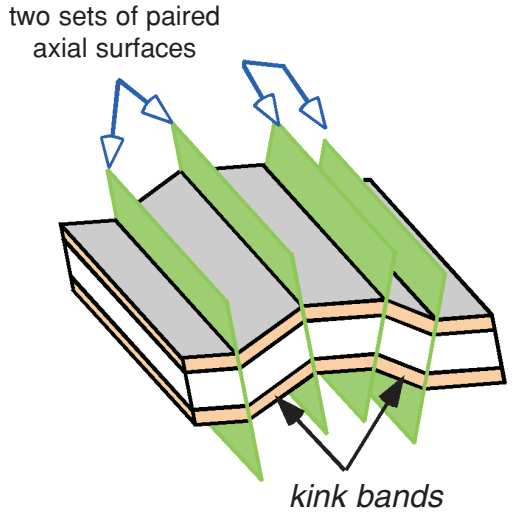

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Section 1A-1: Defining folds

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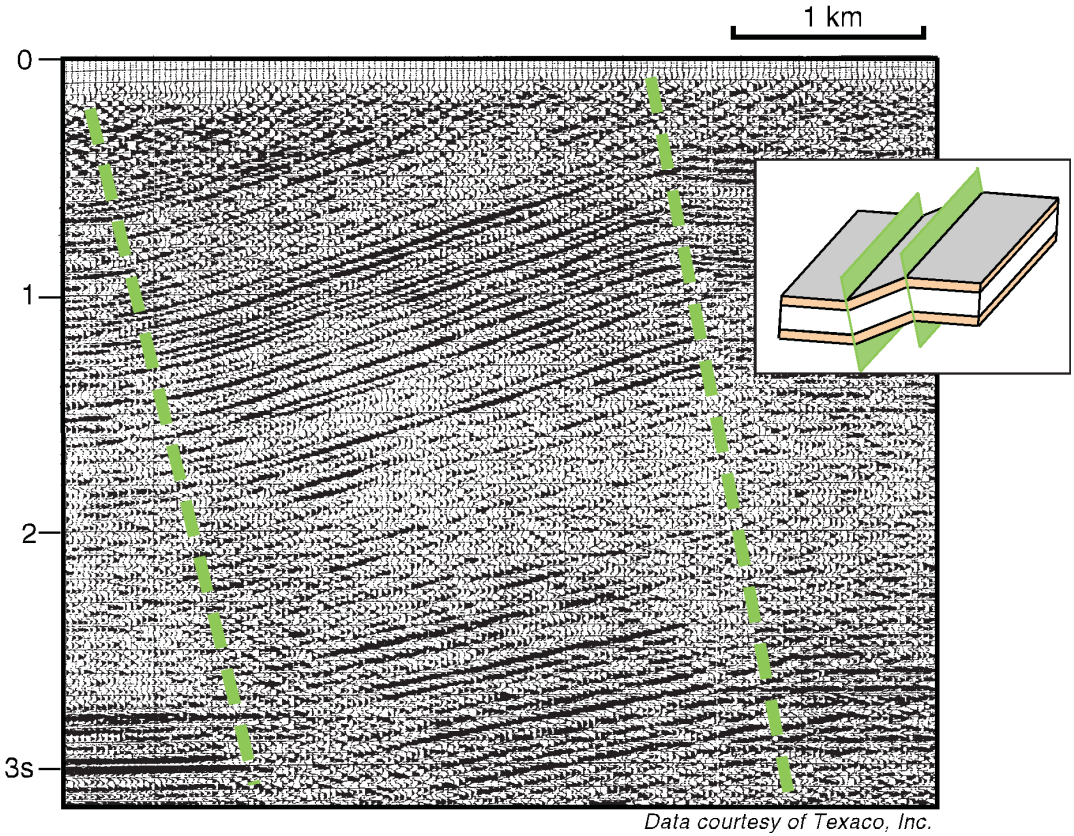
Folds in seismic sections

Monocline, San Joaquin Valley, California, U.S.A.



Data courtesy of Texaco, Inc.

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Section 1A-1: Defining folds

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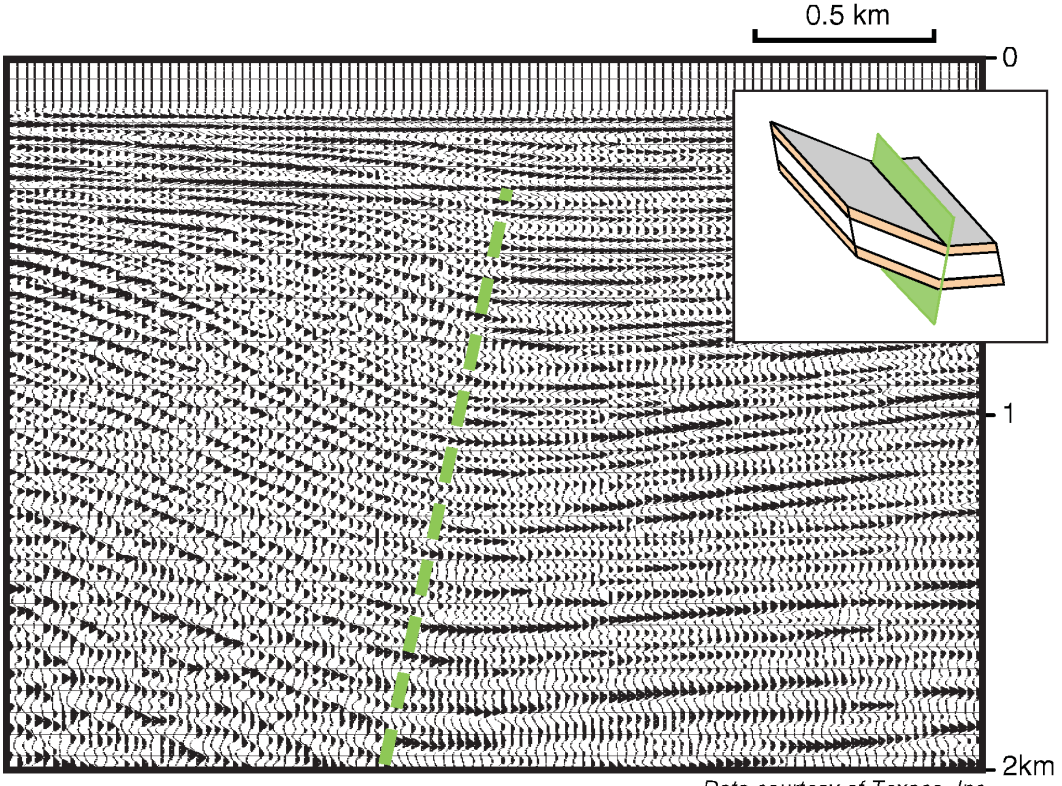
Folds in seismic sections

Syncline, Santa Barbara Channel, California, U.S.A.



Data courtesy of Texaco, Inc.

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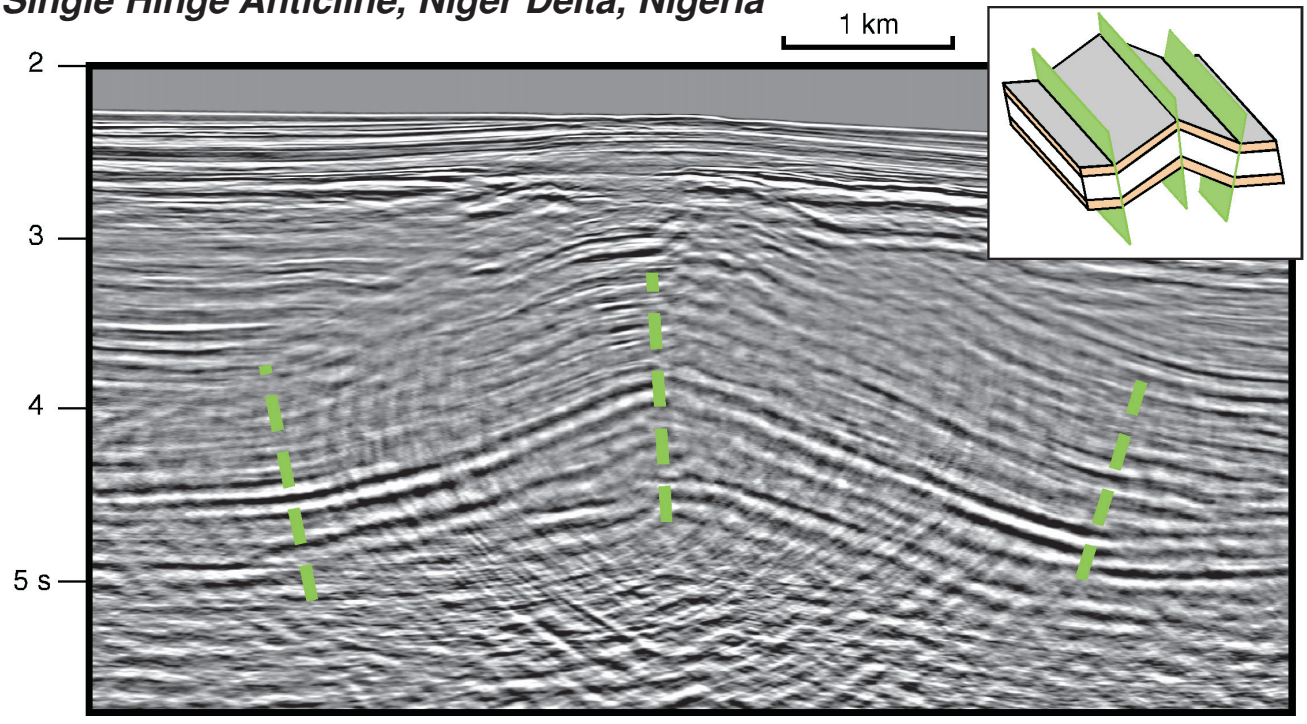
Folds in seismic sections

Single Hinge Anticline, Niger Delta, Nigeria



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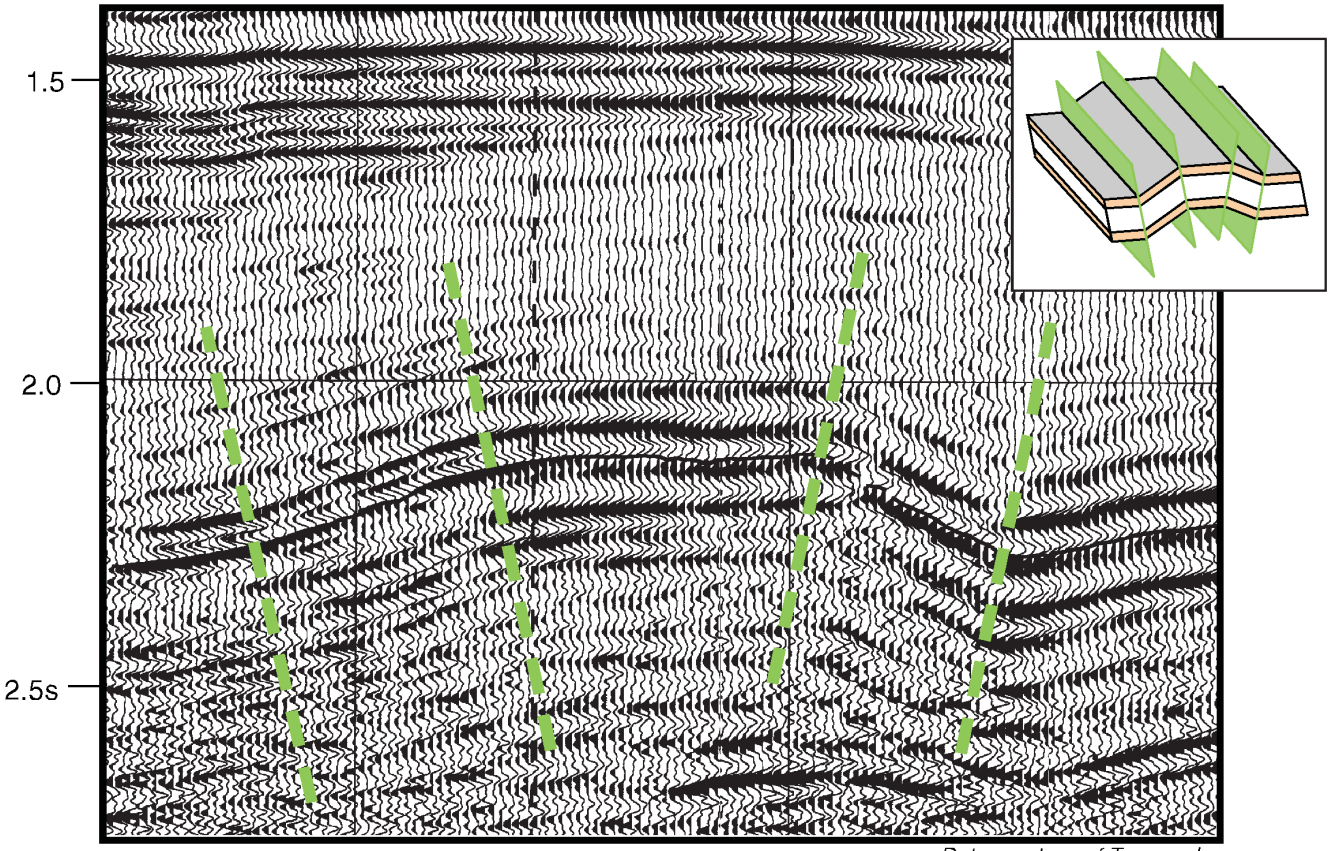
Folds in seismic sections

Multiple Hinge Anticline, Permian Basin, Texas, U.S.A.



Data courtesy of Texaco, Inc.

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Section 1A-1: Defining folds

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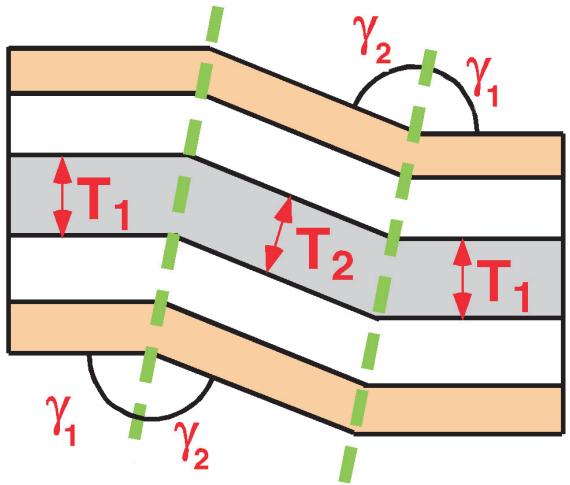
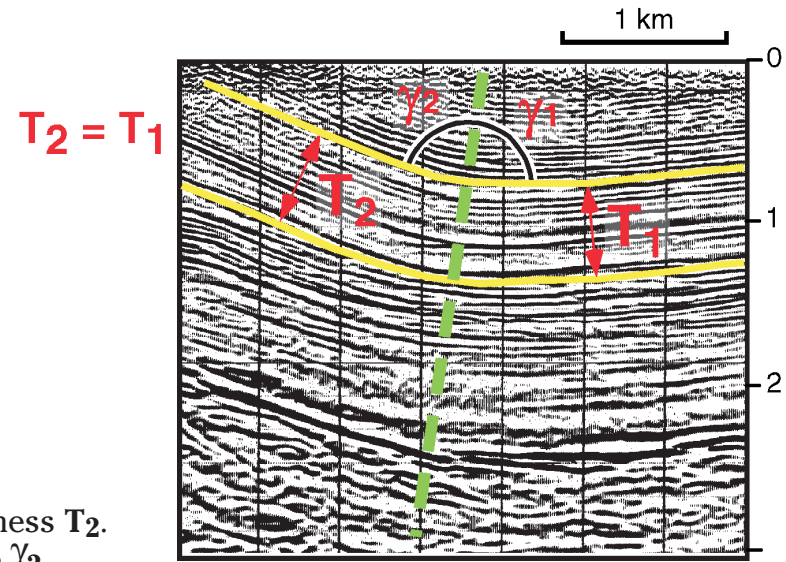
Folds and bedding thickness

Parallel fold model



Parallel fold, synclinal axial surface



Layer thickness is conserved: Bed thickness T_1 equals bed thickness T_2.
Bisecting axial surfaces: Interlimb angle γ_1 equals interlimb angle γ_2.

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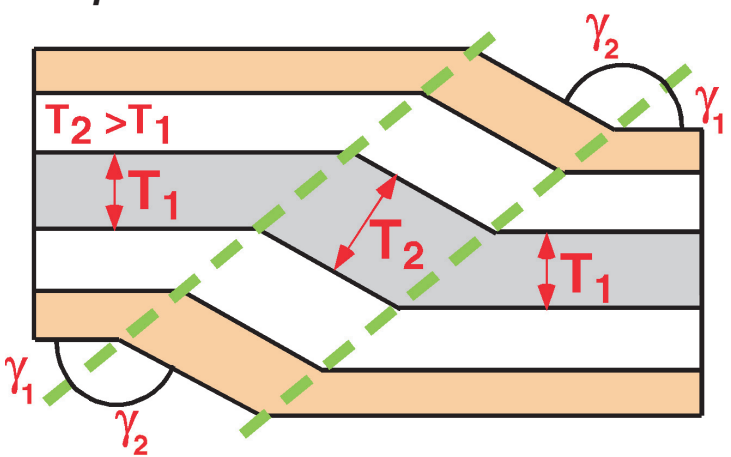
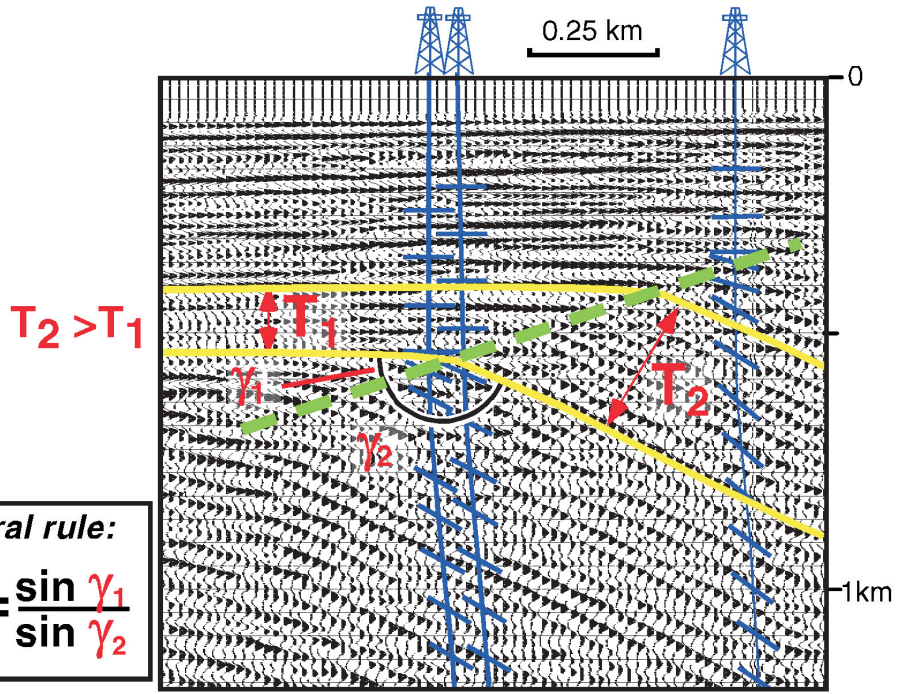
Folds and bedding thickness

Non-parallel fold model



Non-Parallel fold, anticlinal axial surface



general rule:

$$\frac{T_1}{T_2} = \frac{\sin \gamma_1}{\sin \gamma_2}$$

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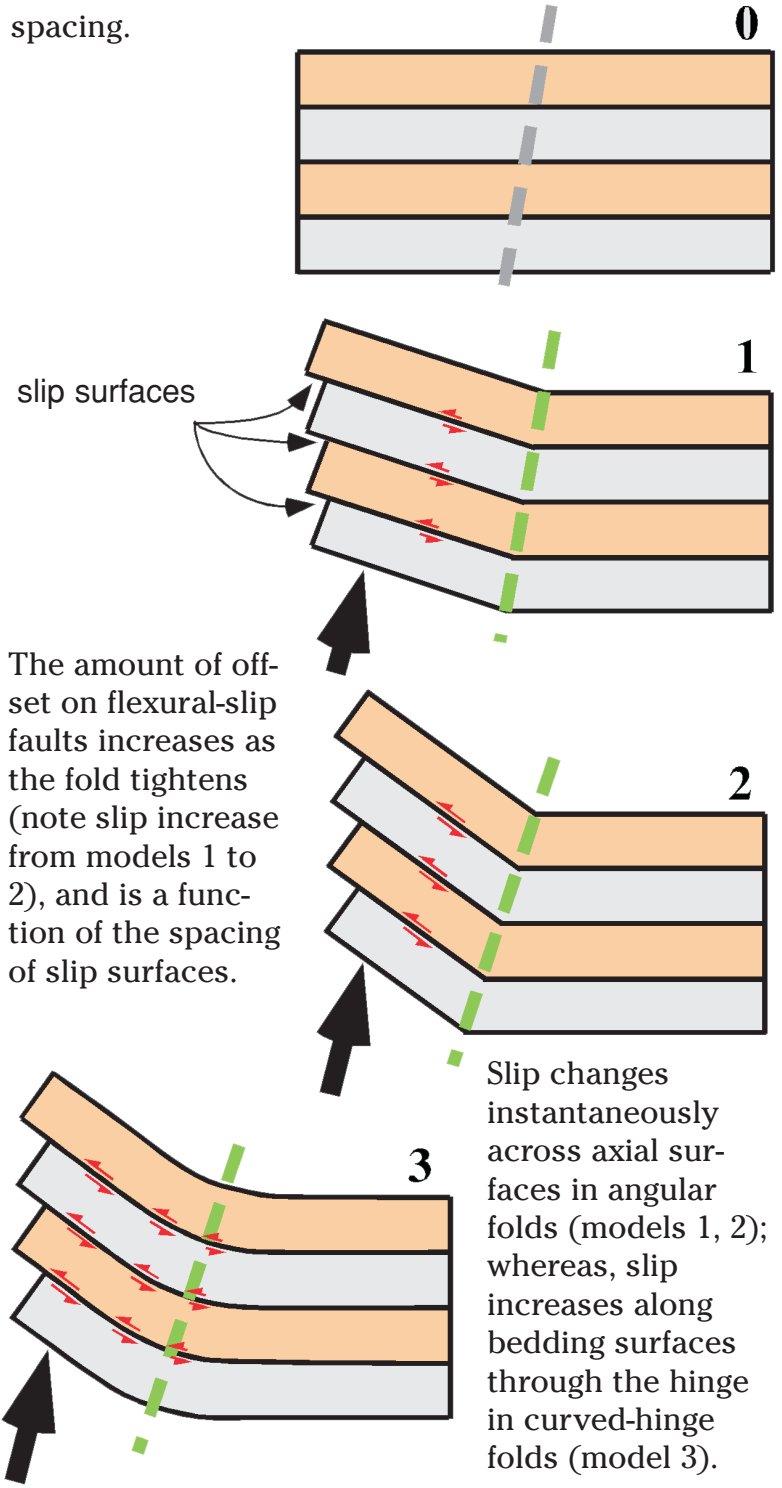
Parallel folds commonly form by a deformation mechanism called ***flexural slip***, where folding is accommodated by motions on minor faults that occur along some mechanical layering — usually bedding. Flexural-slip surfaces, which can be observed in core or outcrop, may vary in spacing from a few millimeters to several tens of meters in spacing.



The amount of offset on flexural-slip faults increases as the fold tightens (note slip increase from models 1 to 2), and is a function of the spacing of slip surfaces.

Slip changes instantaneously across axial surfaces in angular folds (models 1, 2); whereas, slip increases along bedding surfaces through the hinge in curved-hinge folds (model 3).

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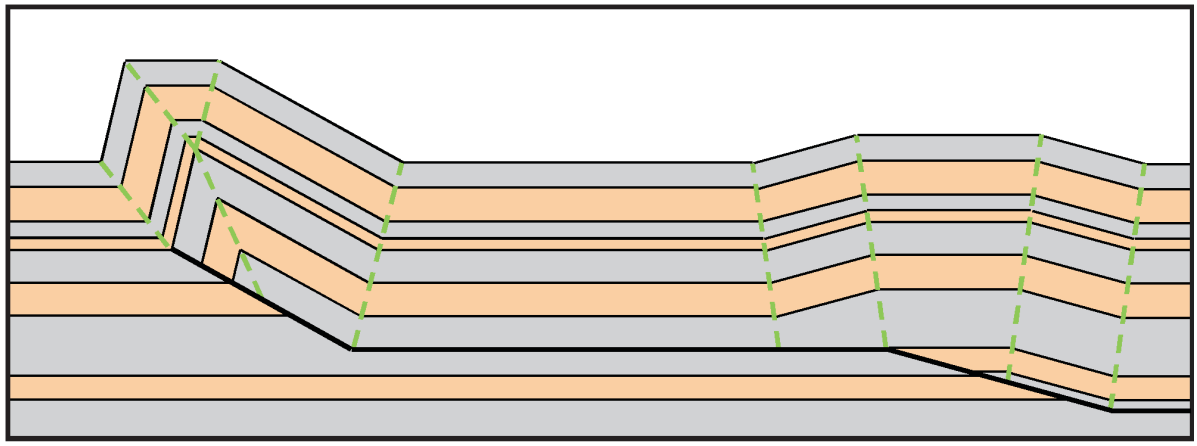
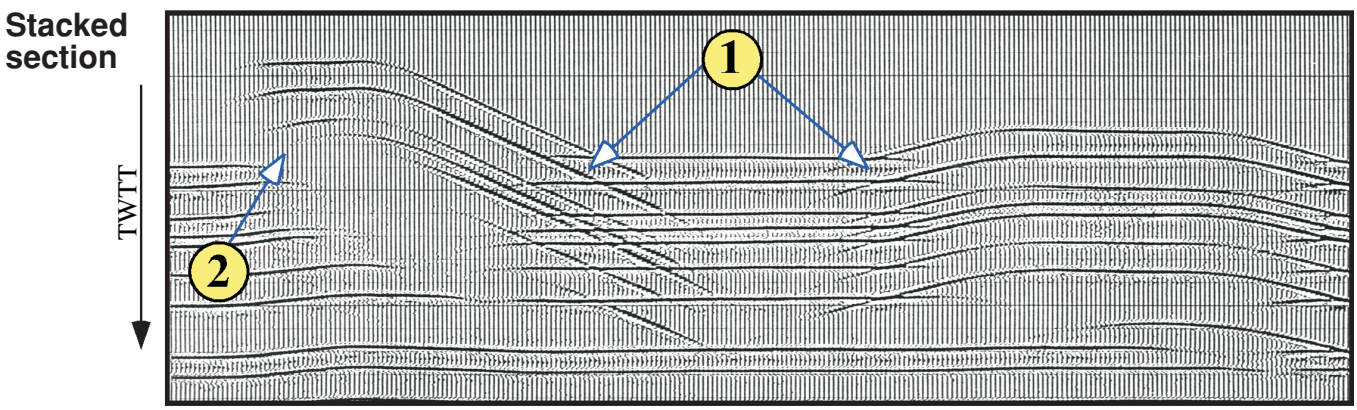
Shortcomings in seismic images of folds

Balanced model

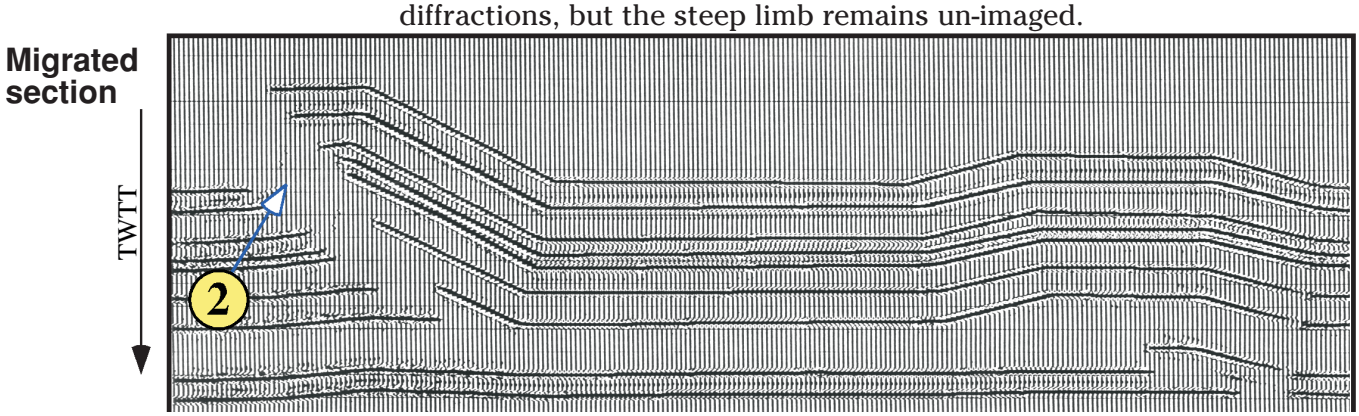


Overlapping reflections occur in synclines (1) on this stacked section; similar patterns persist in under-migrated sections. The steep limb is not imaged and diffractions are present (2).

Synthetic seismic



Proper migration removes overlapping reflections and collapses diffractions, but the steep limb remains un-imaged.



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Section 1A-1: Defining folds

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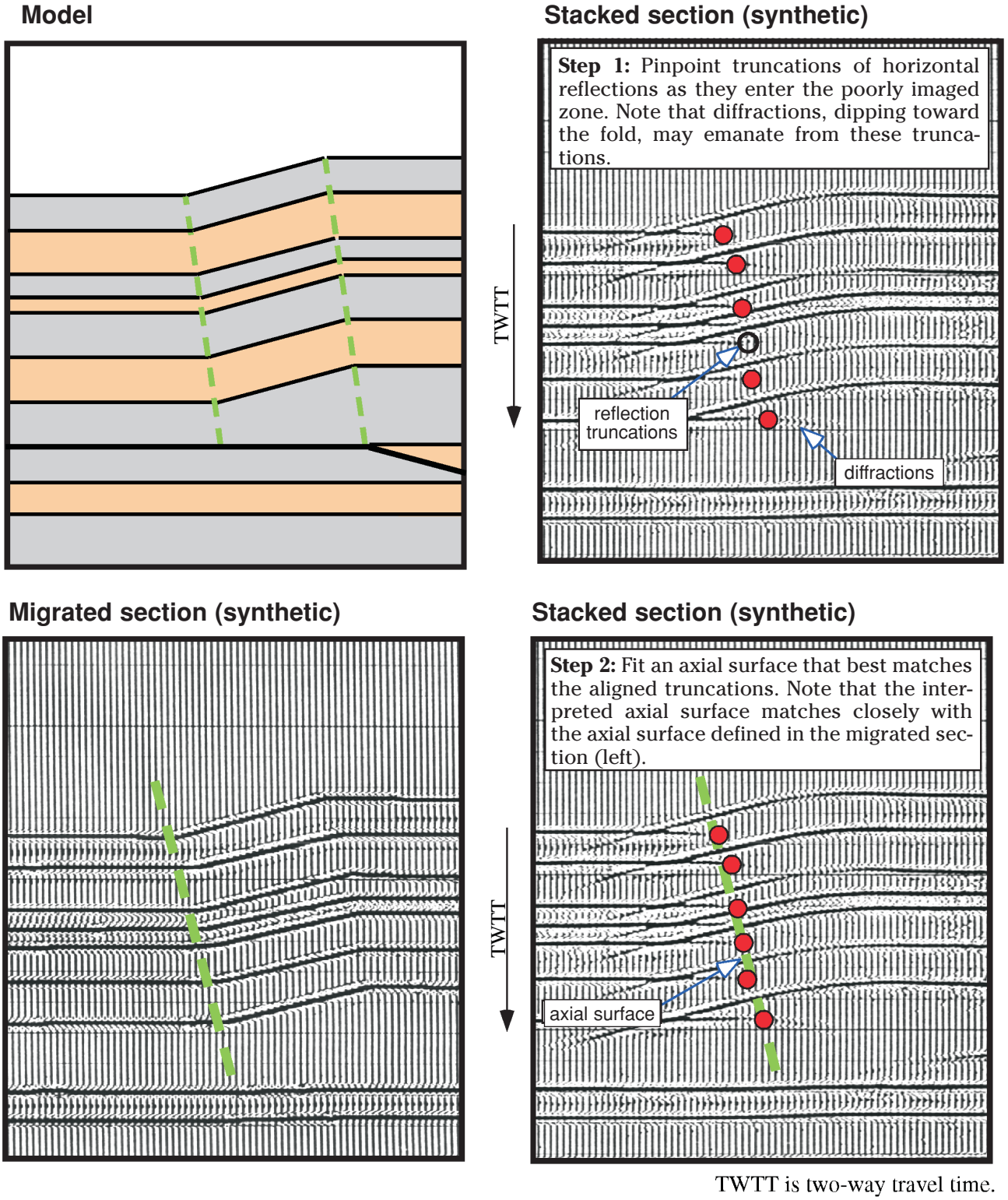
Locating axial surfaces in seismic sections



TWTT is two-way travel time.

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Section 1A-1: Defining folds

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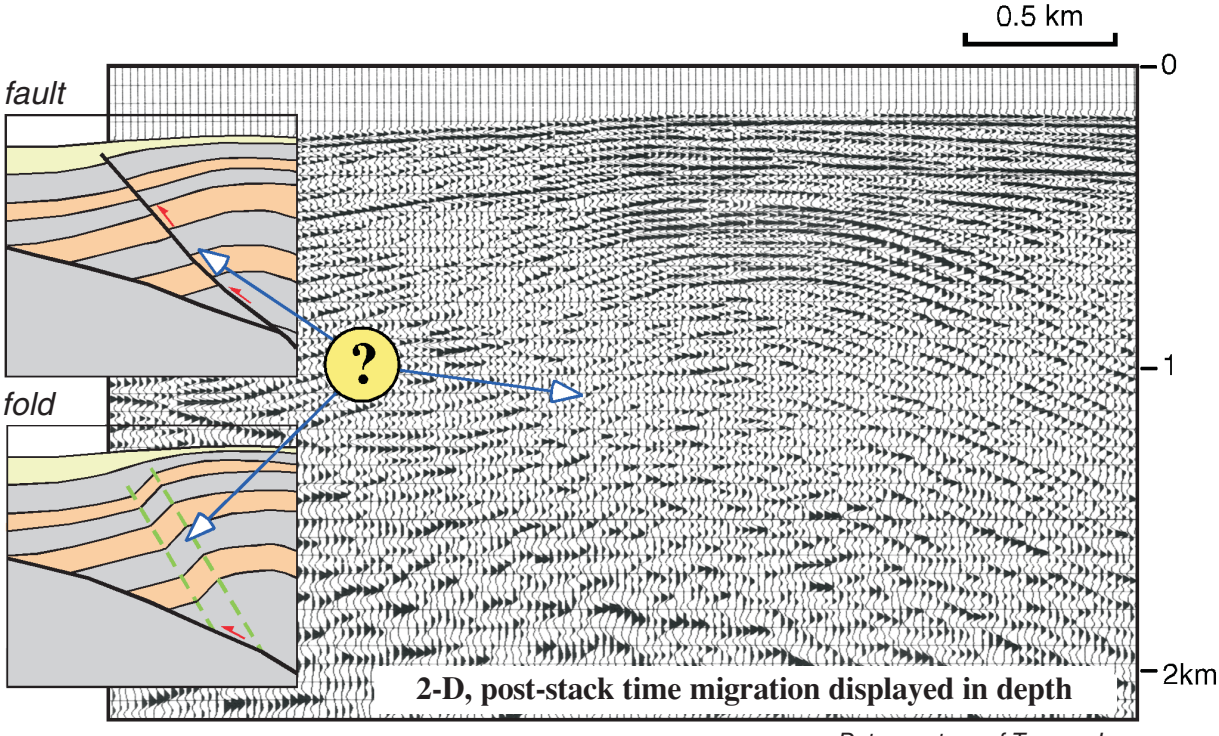
Interpreting folds in poorly imaged zones

A: Is the poorly imaged zone a fault or steep fold limb?



Data courtesy of Texaco, Inc.

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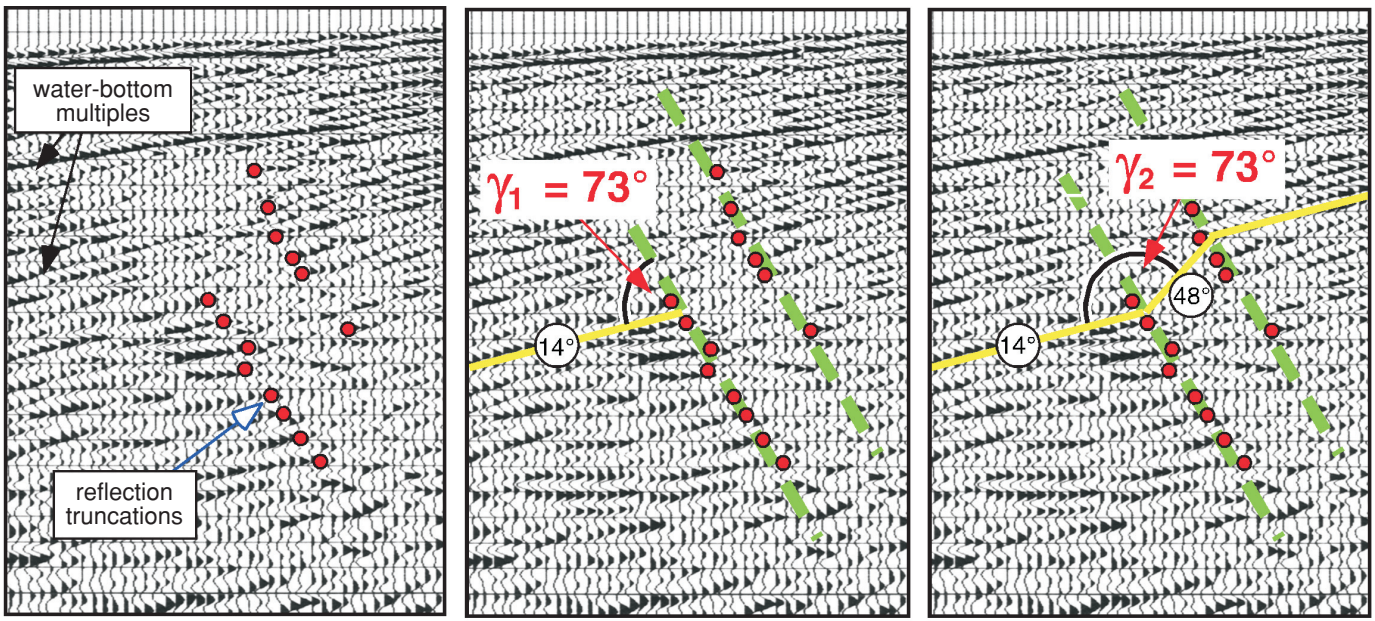
Interpreting folds in poorly imaged zones

B: Method for interpreting parallel folds in poorly imaged zones

Step 1: Pinpoint truncations of reflections as they enter the poorly imaged zone.

Step 2: Fit parallel axial surfaces that best match the aligned truncations. Measure the average dip outside of the fold limb and measure γ_1.

Step 3: Define the dip of beds in the kink band by making γ_2 equal to γ_1.



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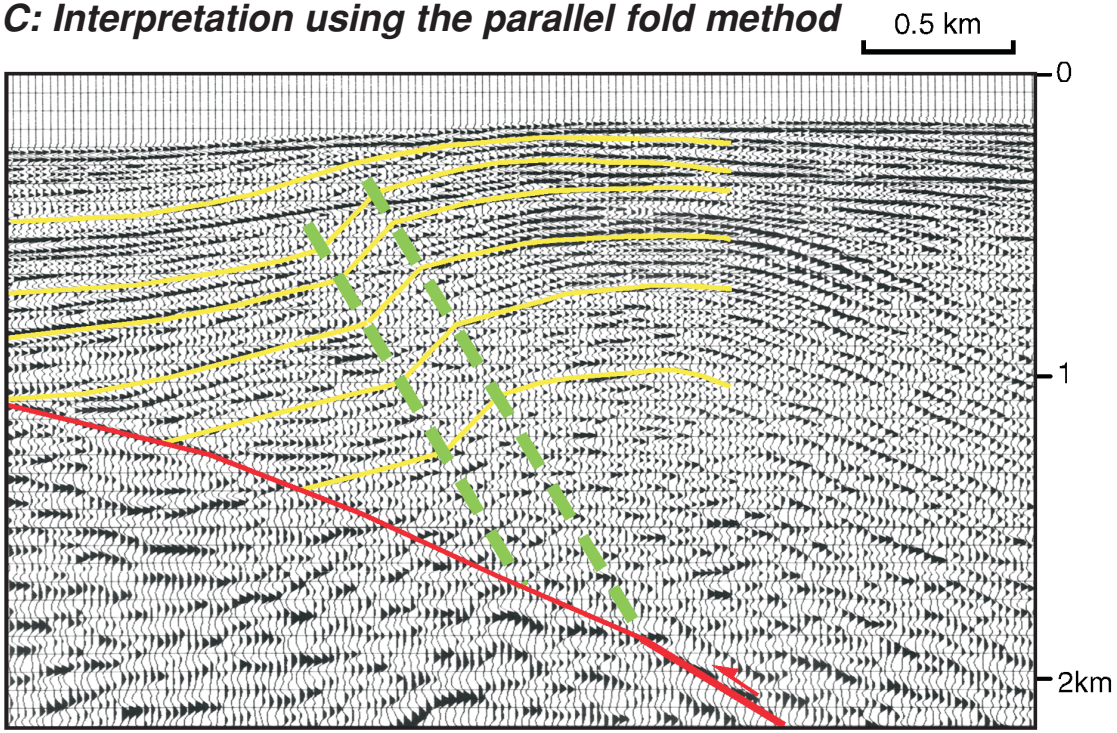
Interpreting folds in poorly imaged zones

C: Interpretation using the parallel fold method



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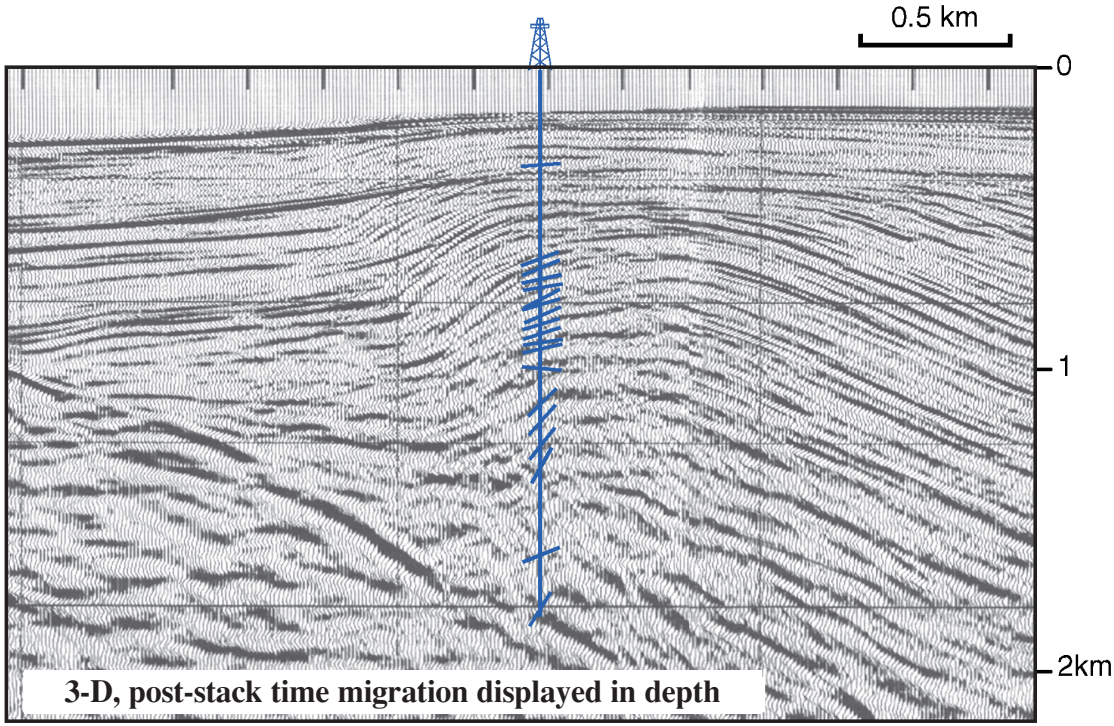
D: Confirmation of fold geometry with dipmeter log and 3-D seismic image



Data courtesy of Texaco, Inc.

In this example, 3-D seismic data and a dipmeter log confirm the presence of steeply dipping beds in the poorly imaged zone. The primary test of the fold interpretation, however, is whether or not the horizons correlate properly across the poorly imaged zone. If they do, a parallel fold interpretation is permissible. If they do not, a non-parallel fold or fault likely occupies the poorly imaged zone.

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