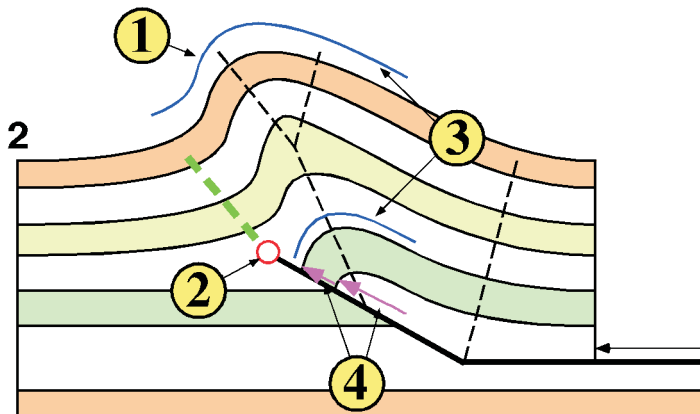
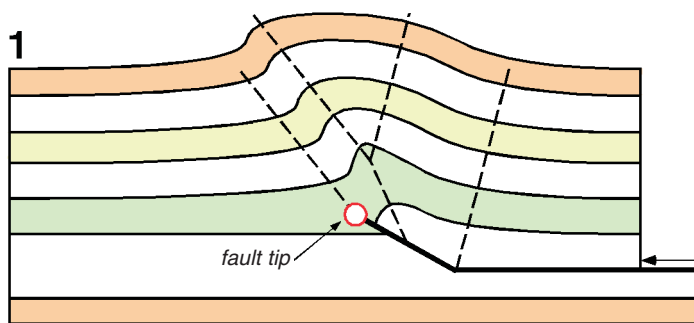
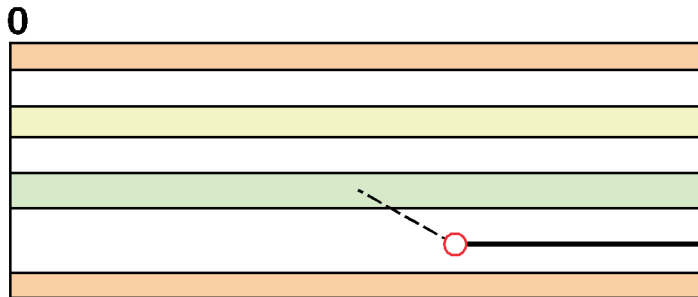


Basic concept

Schematic fault-propagation fold model



purple arrows denote slip on the base and top of the green unit

Common characteristics

Although fault-propagation folds exhibit a wide range of geometries, several characteristics are common to most structures, including:

- 1) folds are asymmetric, with forelimbs that are generally much steeper and more narrow than their corresponding backlimbs;
- 2) synclines are pinned to the fault tips;
- 3) folds tighten with depth; and
- 4) slip on the fault decreases upward, terminating within the fold.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basic concept

Field Example



Professor Bill Brown highlighting a fault-propagation fold in Cambrian Fort Sills limestone, Arbuckle Mountains, OK, U.S.A. (S.C. Hook)

Seismic Interpretation of Contractional Fault-Related Folds An AAPG Seismic Atlas

Studies in Geology #53

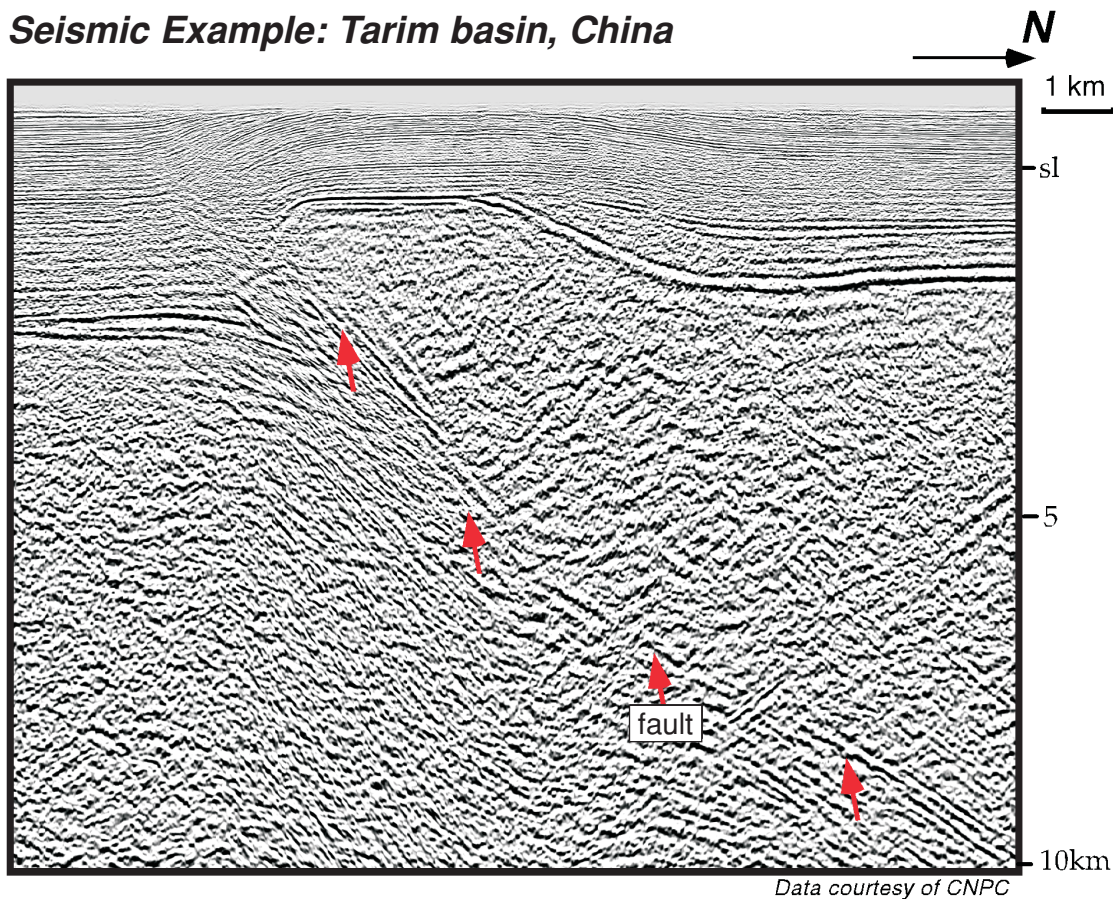
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basic concept

Seismic Example: Tarim basin, China



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

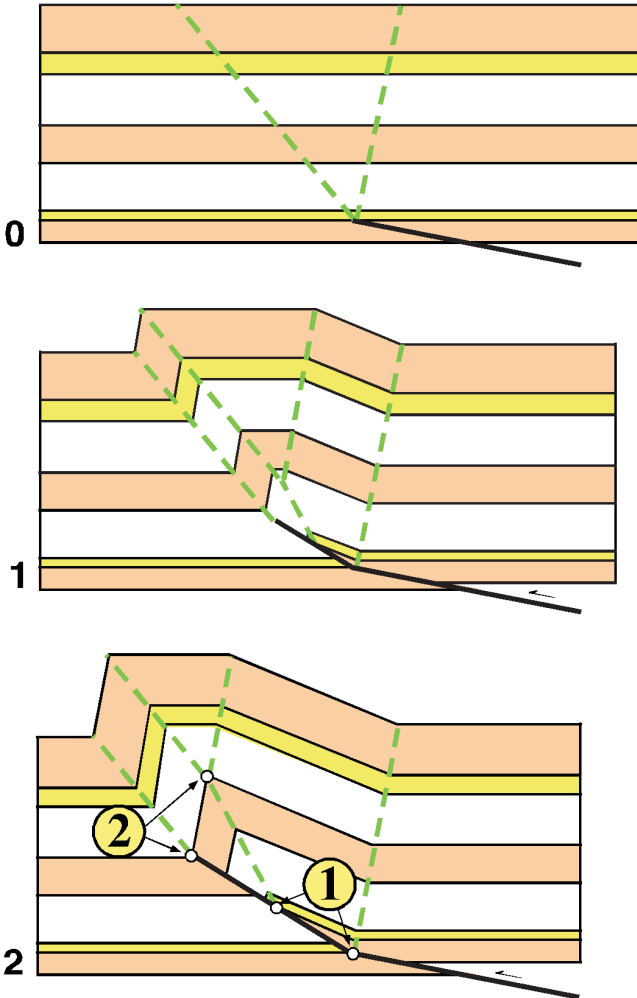
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Constant thickness fault-propagation folds

Kinematic Model



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

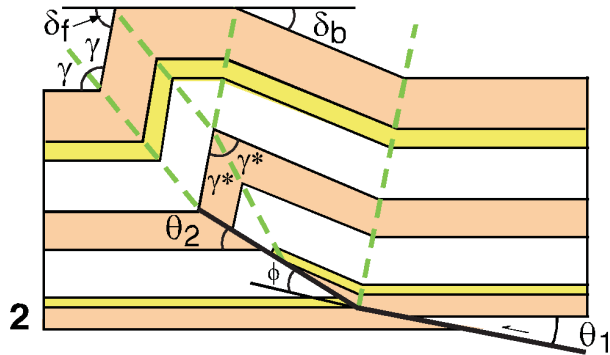
Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Constant thickness fault-propagation folds



FPF terminology

The following terms are used in the derivation and graphs that describe fault-propagation folds.

θ_1 = hanging wall cut-off (lower fault segment)

θ_2 = footwall cut-off (upper fault segment)

ϕ = change in fault dip

γ = forelimb syncline interlimb angle

γ^* = anticlinal interlimb angle

δ_b = backlimb dip

δ_f = forelimb dip

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

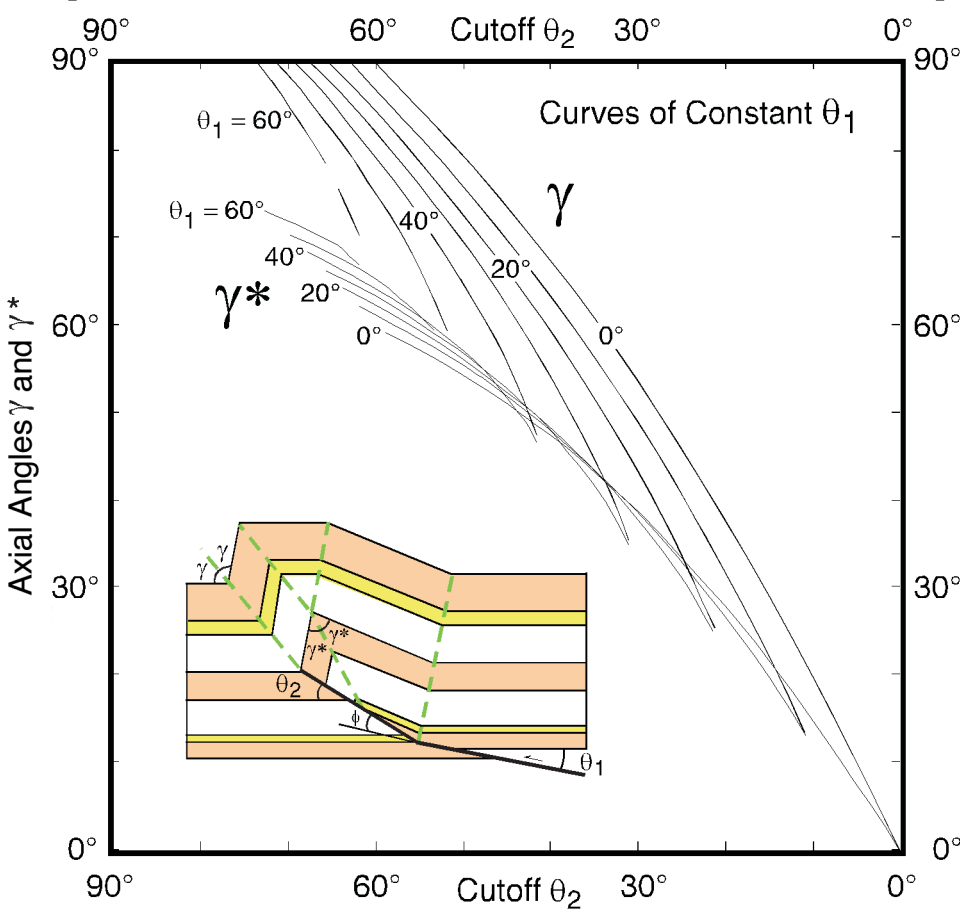
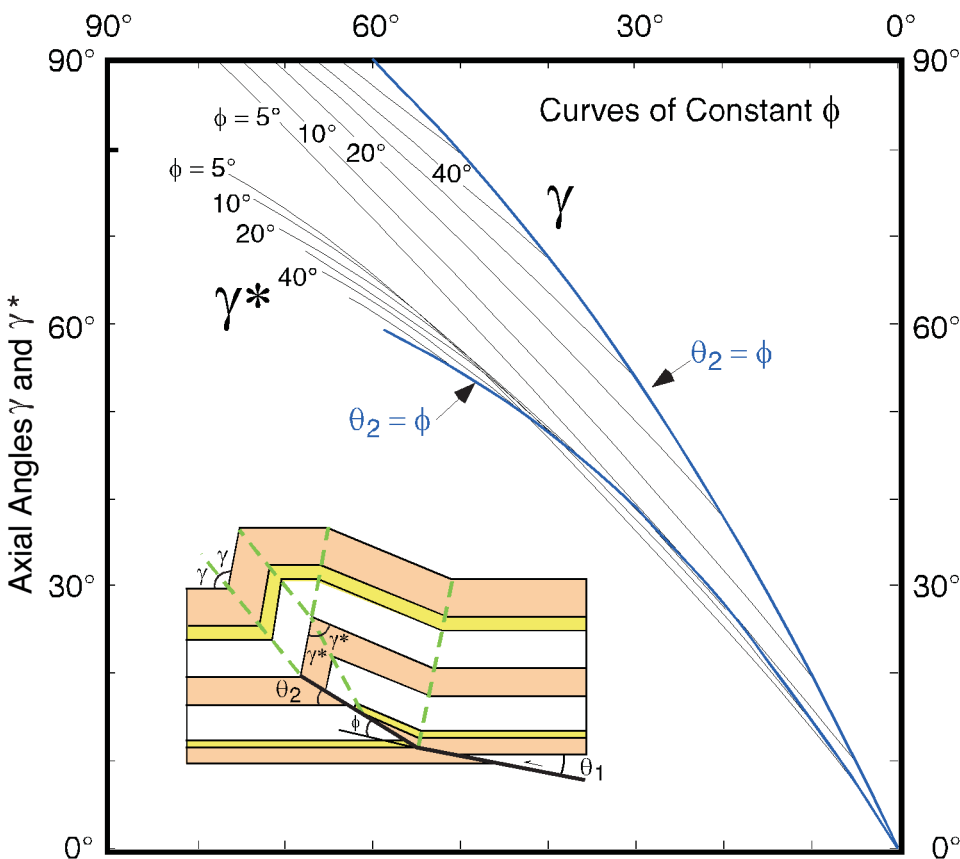
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Constant thickness fault-propagation folds

These graphs show the relationships between fault shape (θ_2) and fold shape (γ and γ^*) for constant thickness fault-propagation folds. The special case of ramping from a detachment is shown as the lines $\theta_2 = \phi$. These relations will be used to interpret a fault-propagation fold imaged in a seismic profile later in this section.



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

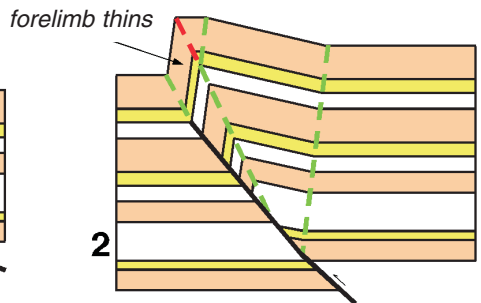
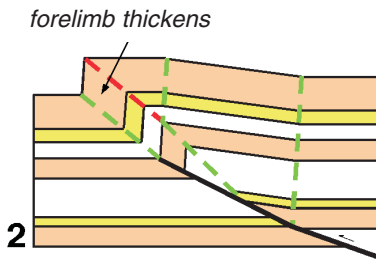
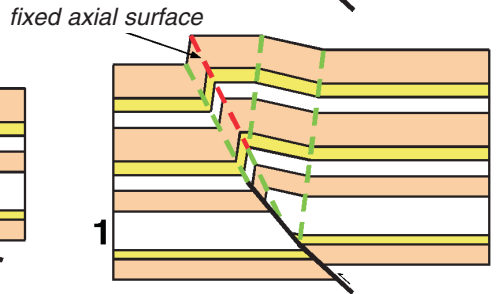
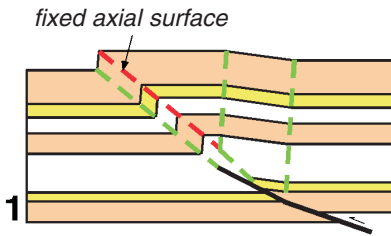
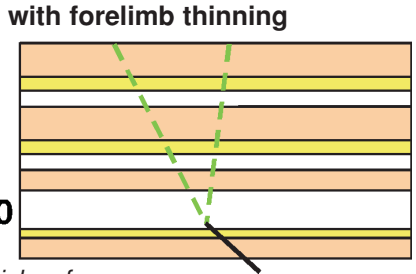
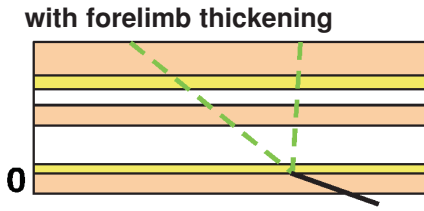
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Fixed-axis fault-propagation folds

Kinematic Models



Seismic Interpretation of Contractual Fault-Related Folds
An AAPG Seismic Atlas

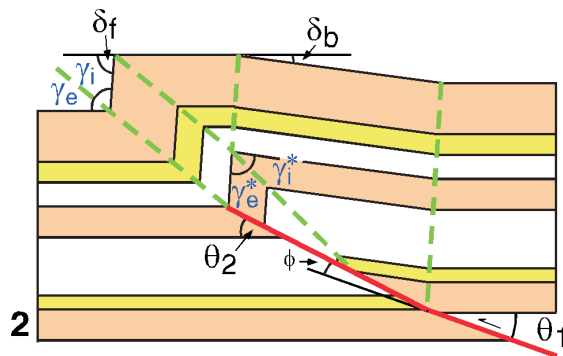
Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Fixed-axis fault-propagation folds



FPF terminology

Fixed-axis theory redefines the axial angles (γ values) associated with a fault-propagation fold. The remaining parameters (θ , ϕ , δ_b , and δ_f) are the same as in constant thickness fault-propagation folds.

γ_e = forelimb syncline exterior axial angle

γ_i = forelimb syncline interior axial angle

γ_e^* = anticlinal exterior axial angle

γ_i^* = anticlinal interior axial angle

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

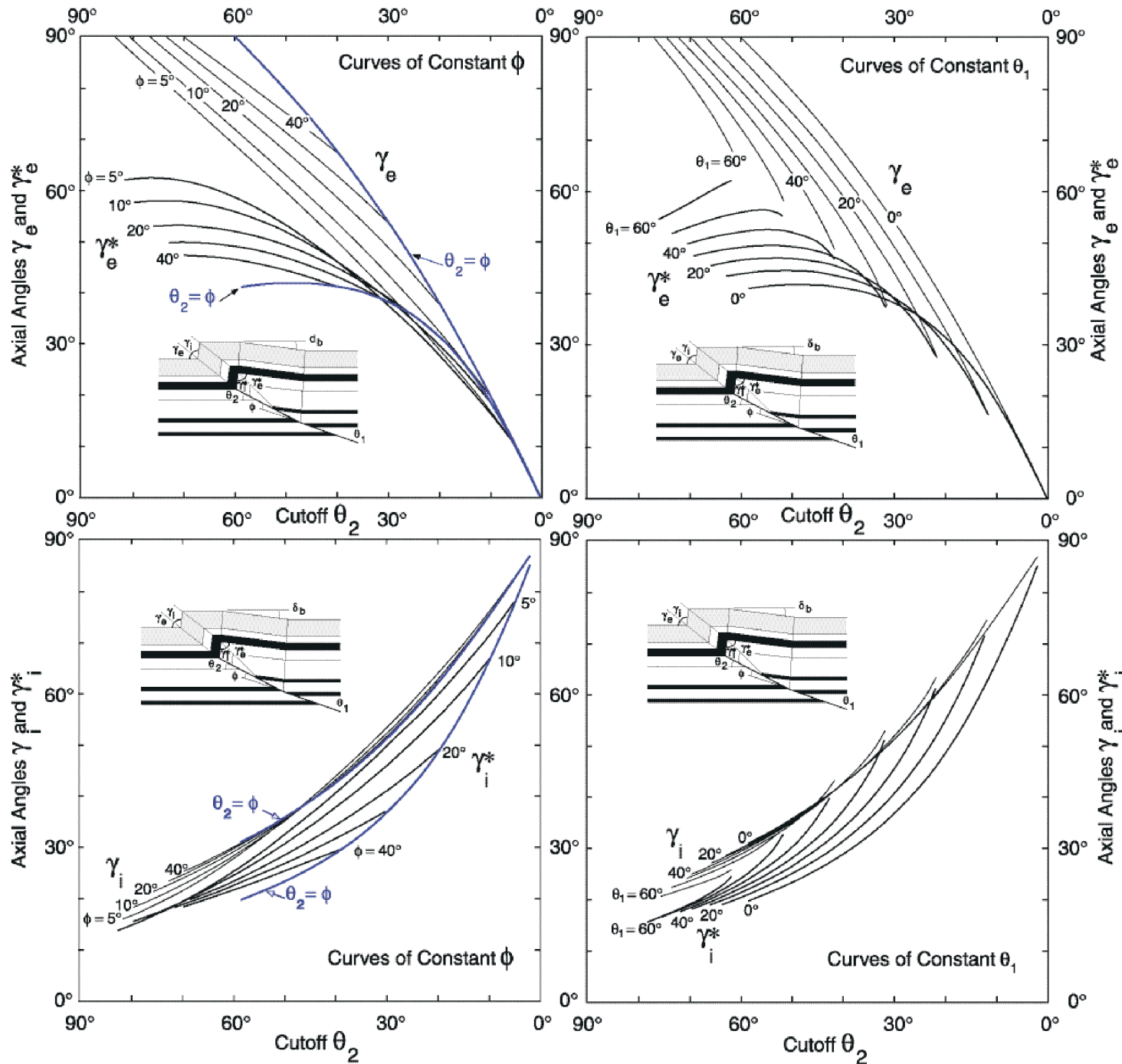
Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

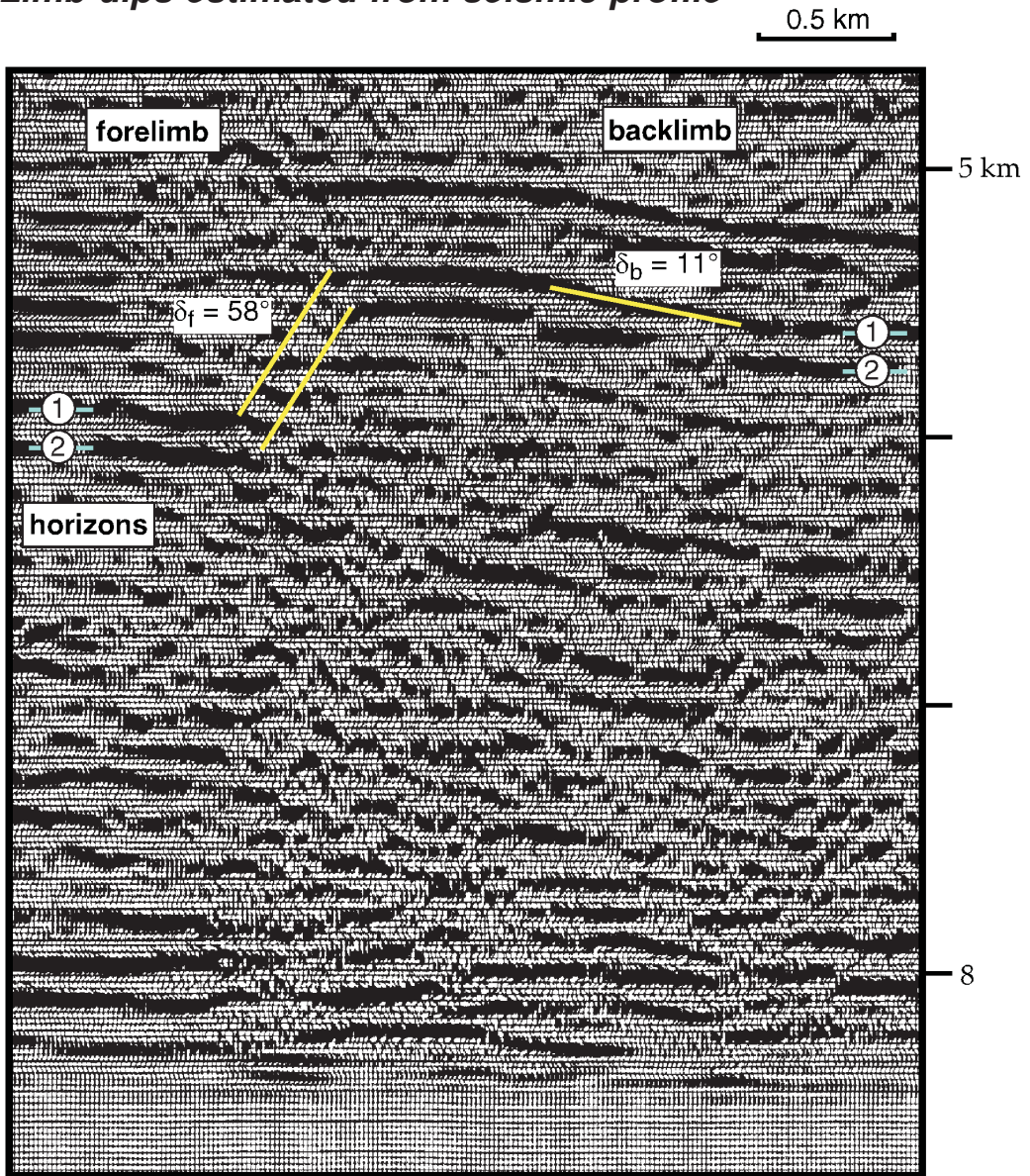
Fixed-axis fault-propagation folds



These graphs show the relationships between fault shape (θ_2) and fold shape ($\gamma_e, \gamma_e^*, \gamma_i, \gamma_i^*$) for fixed-axis fault-propagation folds. The special case of ramping from a detachment is shown on the two graphs at left as the lines $\theta_2 = \phi$. Note that separate graphs must be used to define the interior (γ_i, γ_i^*) and exterior (γ_e, γ_e^*) axial angles.

Seismic interpretation using fault-propagation fold theory

Limb dips estimated from seismic profile



Step 1: Limb dips are estimated in the seismic profile by interpretation of the reflector dips on the backlimb, and by correlation of horizons 1 and 2 across the poorly imaged forelimb.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

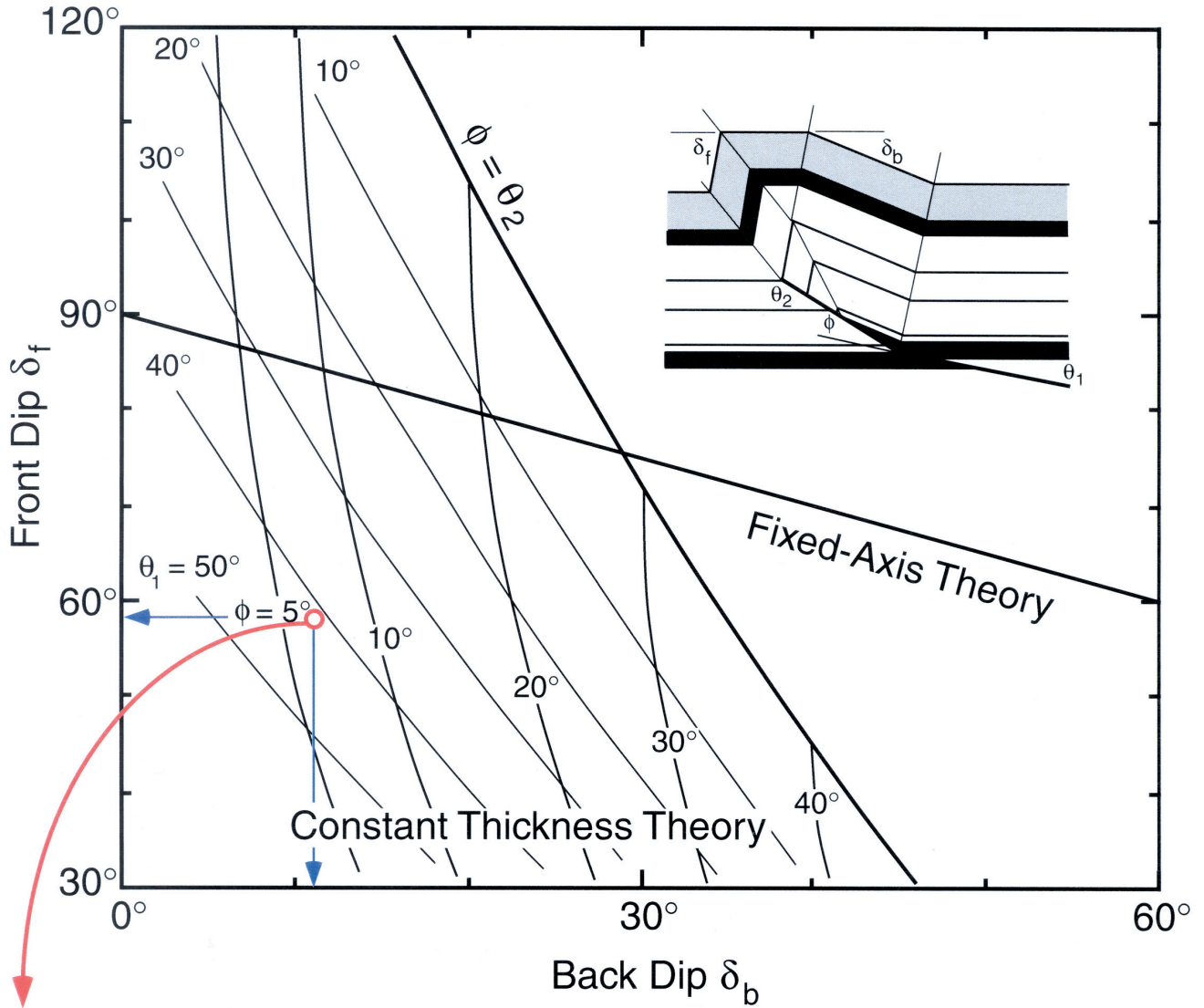
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Seismic interpretation using fault-propagation fold theory

Limb dips in fault-propagation folds



Step 2: Based on the forelimb ($\delta_f = 58^\circ$) and backlimb ($\delta_b = 11^\circ$) dips estimated on the seismic profile, the fold is inconsistent with fixed-axis theory. However, the structure may be interpreted as a constant thickness fault-propagation fold with a change in fault dip (ϕ) of 7° and an initial cutoff angle (θ_1) of 42° . On the following page, these values are used to predict the fold shape (γ and γ^*) and cutoff (θ_2) angles, and to generate an interpretation of the structure.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

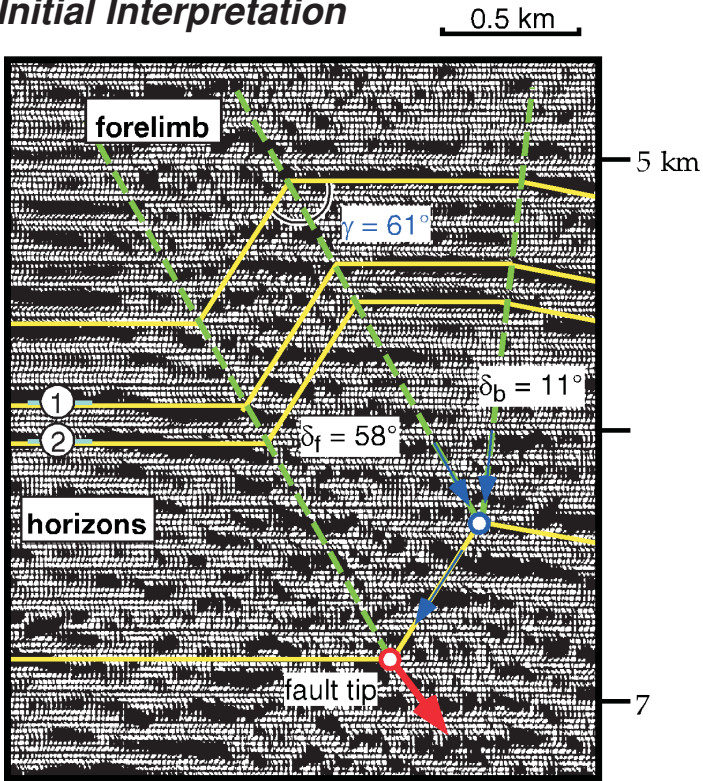
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Seismic interpretation using fault-propagation fold theory

Initial Interpretation



Step 3: To interpret the structure using constant-thickness fault propagation fold theory, the upper portion of the fold is interpreted using the kink method, where axial surfaces bisect the interlimb angles (see section 1A-1). This interpretation yields a forelimb interlimb angle (γ) of 61° .

The tip of the fault is located by projecting the axial surfaces that bound the fold crest to their point of intersection. From this intersection point, follow bedding along the forelimb (as defined by δ_f) until it intersects the forelimb synclinal axial surface. This intersection defines the tip of the fault.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

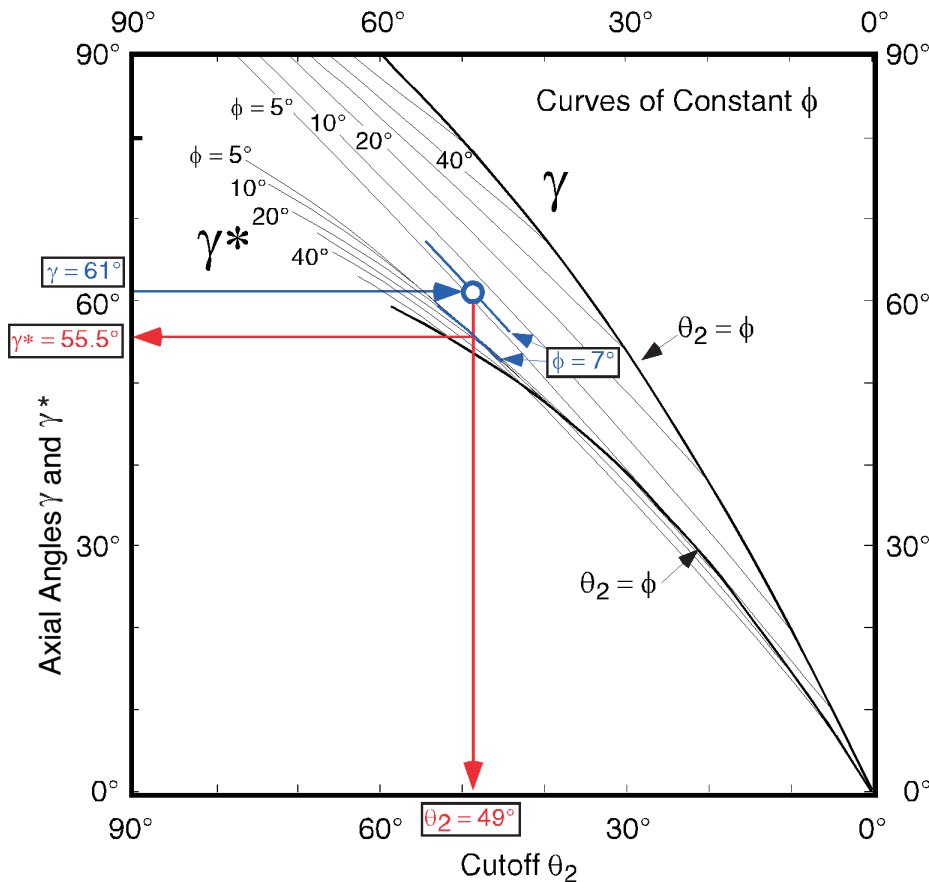
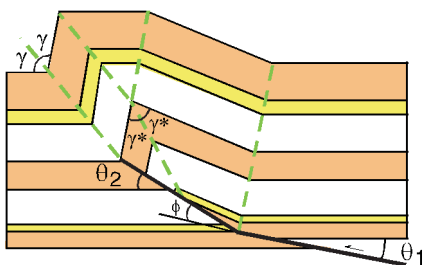
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Seismic interpretation using fault-propagation fold theory

Step 4: The remaining fault-propagation fold parameters (θ_2 and γ^*) are then determined from one of the two constant thickness fault-propagation fold graphs. Given a γ value of 61° and a change in fault dip (ϕ) of 7° (from preceding page), the theory predicts an interlimb angle (γ^*) of 55.5° and a cut-off angle (θ_2) of 49° . These values are used to complete the interpretation.



Seismic Interpretation of Contractural Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

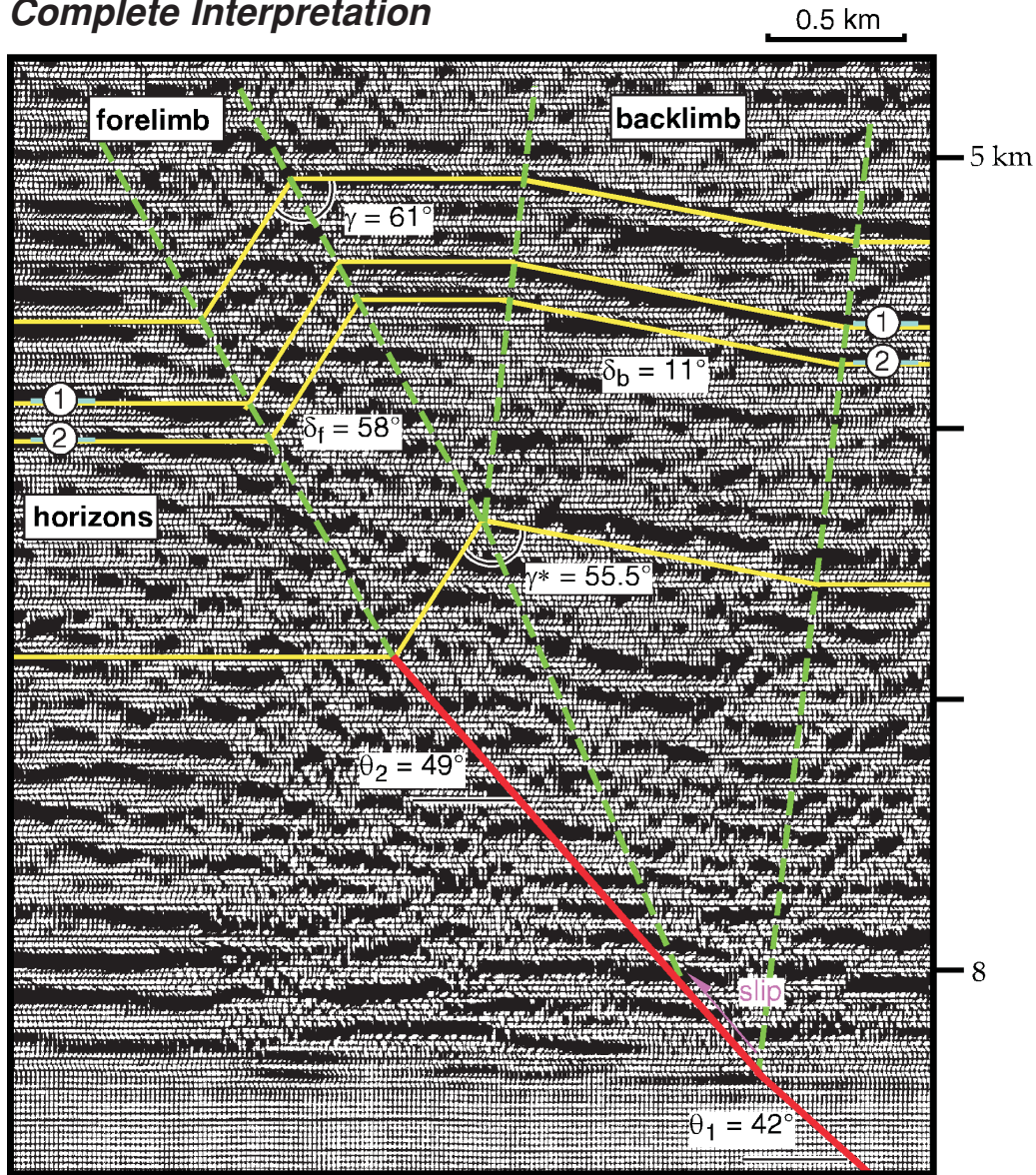
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Seismic interpretation using fault-propagation fold theory

Complete Interpretation



Step 5: The interpretation is completed by extending the fault down from its tip at an angle of 49° (based on θ_2) to the point where it intersects the backlimb synclinal axial surface. At this point, the fault shallows by 7° (based on ϕ) to a dip of 42° . The interior anticlinal axial surface bisects the interlimb angle between the forelimb and backlimb, and extends down to the fault. The distance between the point where this axial surface intersects the fault and the fault bend equals the fault slip at the bend.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

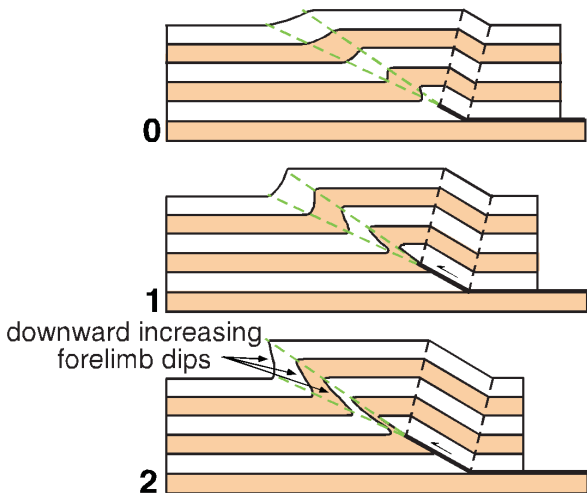
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Trishear fault-propagation folds

Kinematic model



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

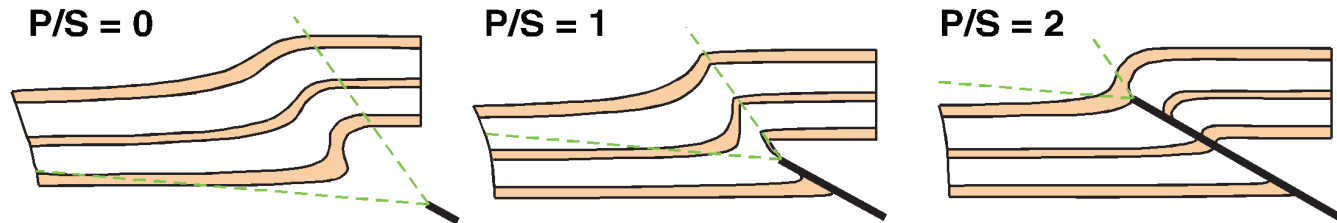
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Trishear fault-propagation folds

Propagation to slip ratio



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

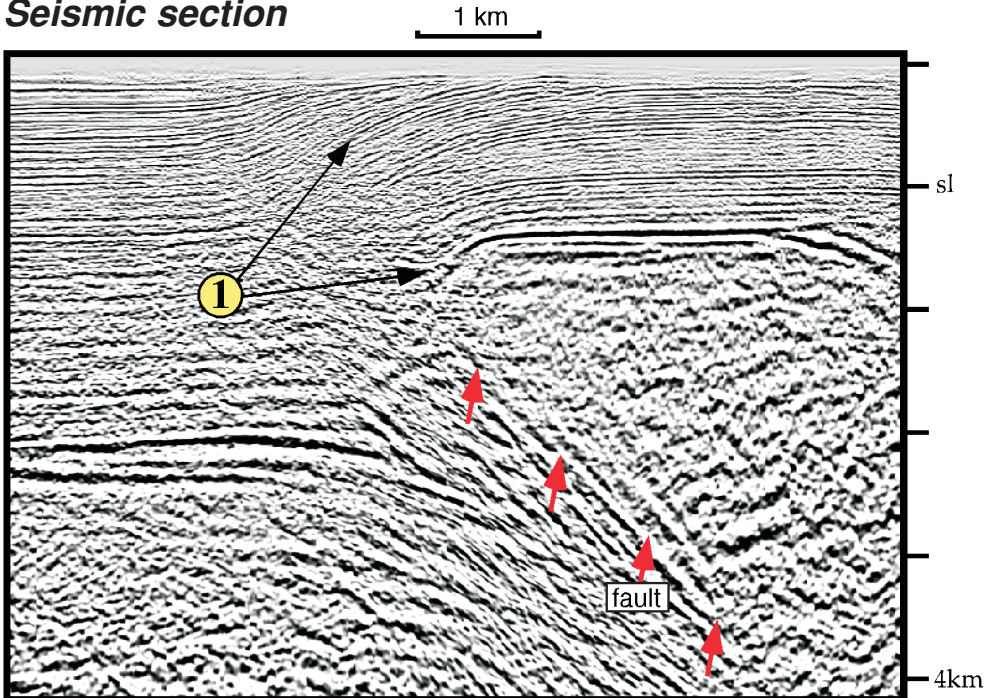
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Trishear fault-propagation folds

Seismic section



Data courtesy of CNPC

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

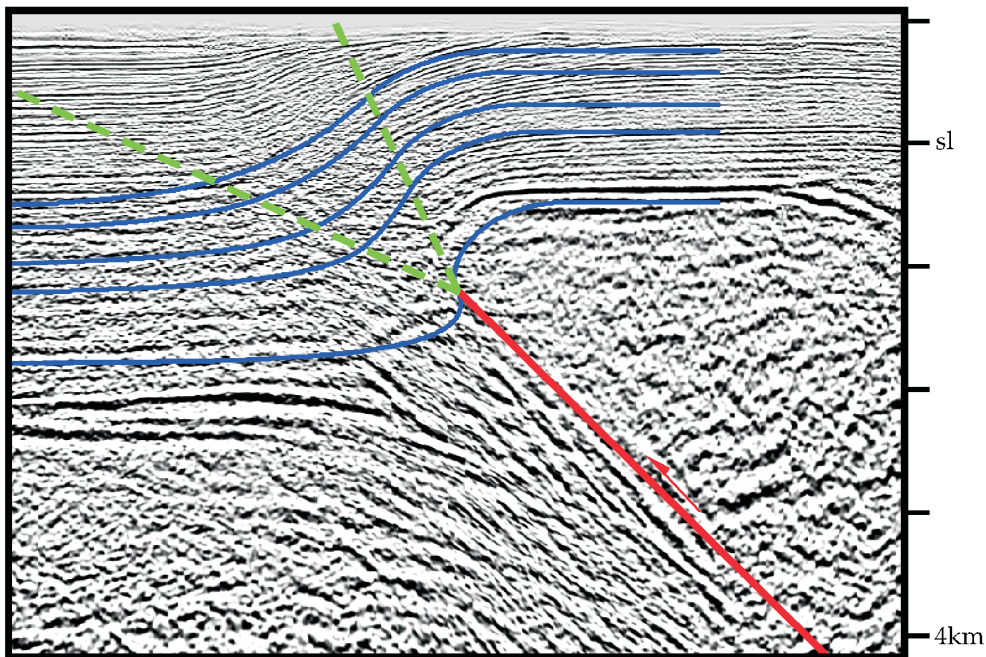
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Trishear fault-propagation folds

Trishear interpretation



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

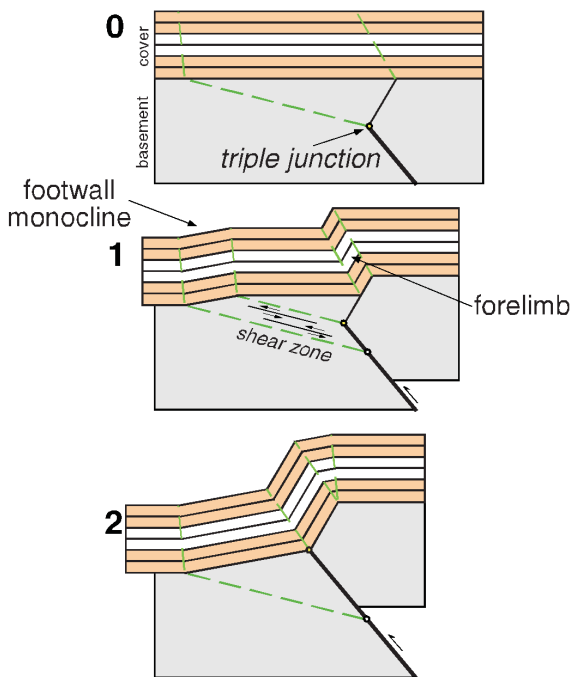
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basement-involved (drape) folding with migrating triple junctions

Kinematic model



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

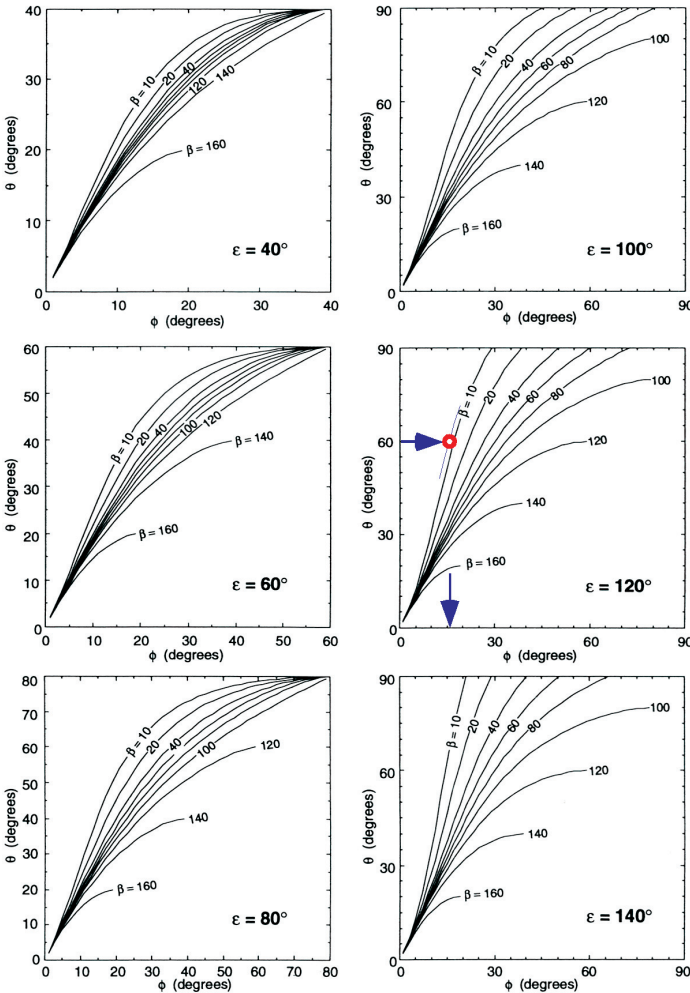
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basement-involved (drape) folding with migrating triple junctions

Fold and fault shape



These graphs describe relations among the five parameters that describe triple-junction folds. Each graph is for a specific ϵ value. When modeling structures imaged in seismic sections, ϵ is generally selected by interpreting the forelimb dip value (δ_f). The dip of the footwall monocline is also commonly resolved on seismic sections, leaving one additional parameter to be determined (ϕ or θ) before a unique solution can be obtained. From Narr and Suppe (1994).

Seismic Interpretation of Contractual Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basement-involved (drape) folding with migrating triple junctions

Triple junction fold terminology

Five parameters describe basement-involved triple junction folds, three of which must be specified to derive the remaining two values:

- θ_1 = hanging wall cutoff of lower fault segment
- ε = dip of upper fault segment (generally = $180^\circ - \delta_f$)
- β = dip of footwall monocline
- ϕ = dip of footwall shear orientation
- ψ = footwall angular shear



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

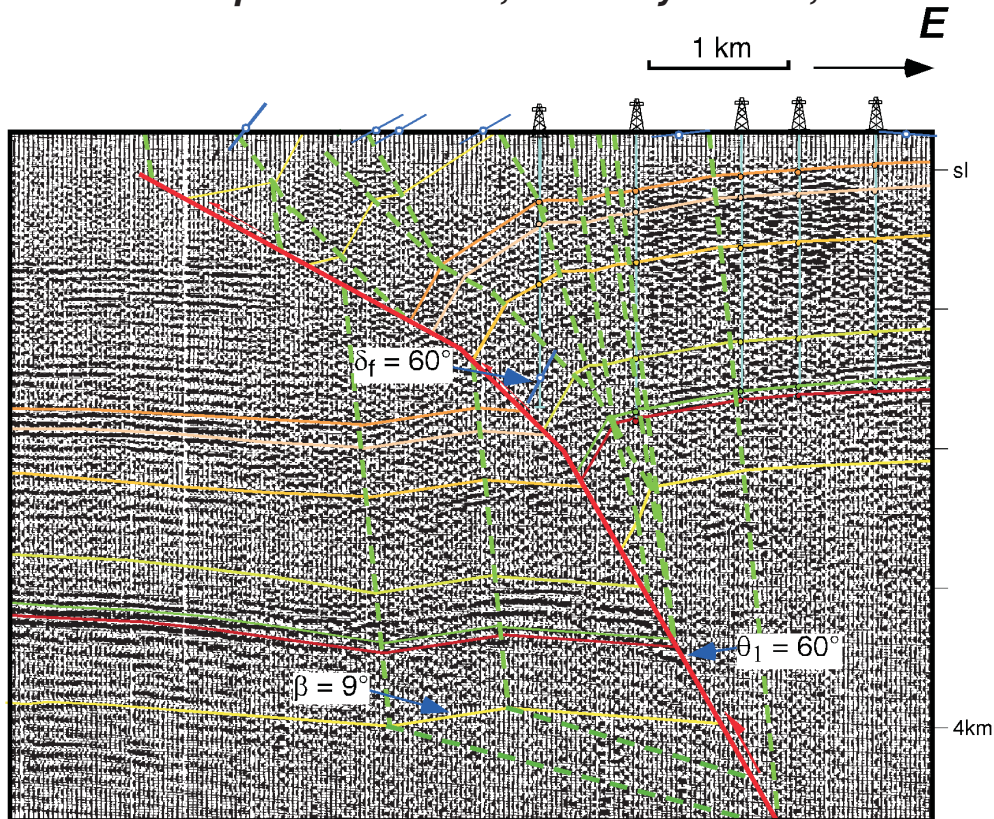
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Basement-involved (drape) folding with migrating triple junctions

Seismic Example: Orito Field, Putamayo basin, Colombia



Data courtesy of Ecopetrol and Texaco, Inc.

Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

Section 1B-2: Fault-propagation folds

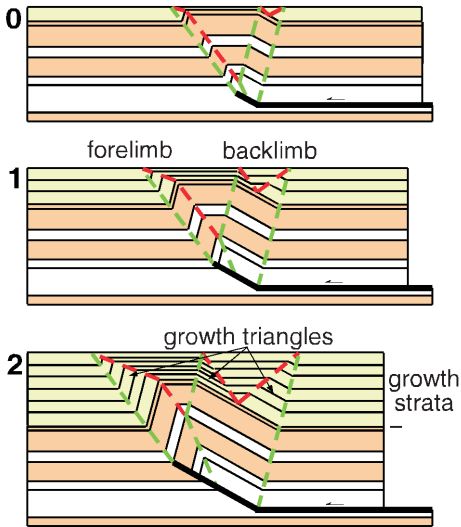
John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

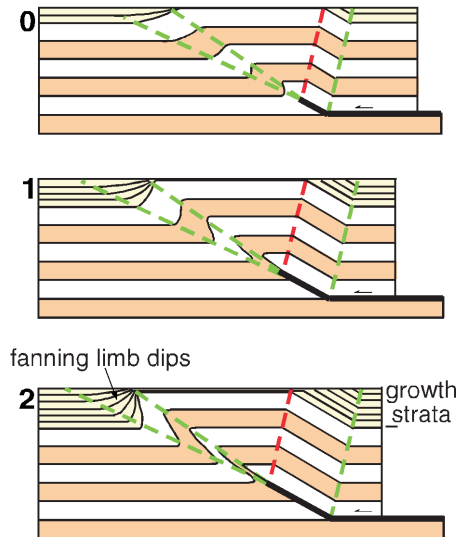
Growth fault-propagation folding

Kinematic models

Growth fault-propagation fold



Growth trishear fold



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

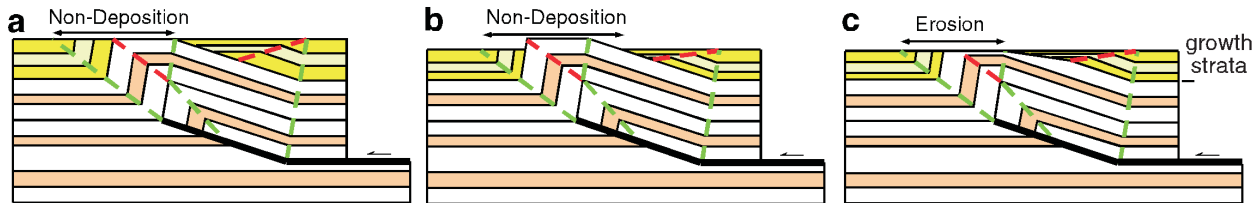
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Growth fault-propagation folding

Effects of low sedimentation rates



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

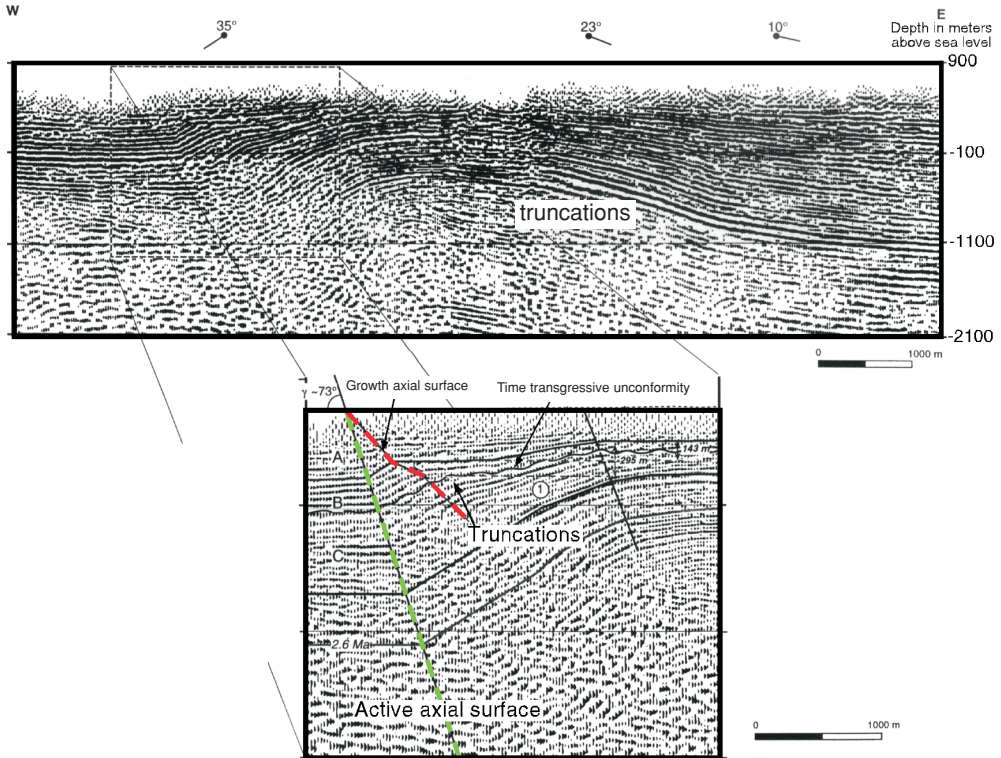
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Growth fault-propagation folding

Seismic Example: Bermejo anticline, Argentina



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

Section 1B-2: Fault-propagation folds

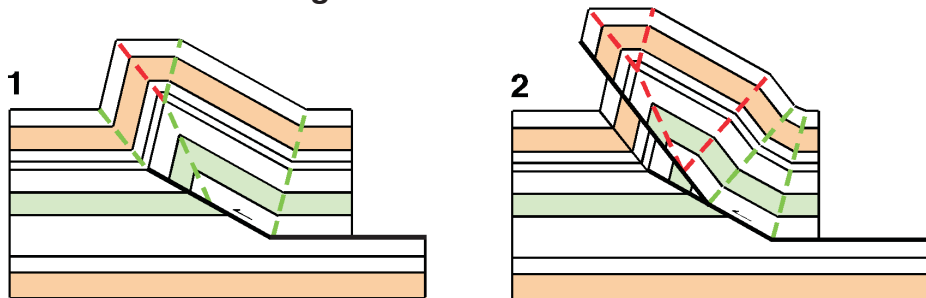
John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Breakthrough fault-propagation folds

Kinematic models

Forelimb breakthrough



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

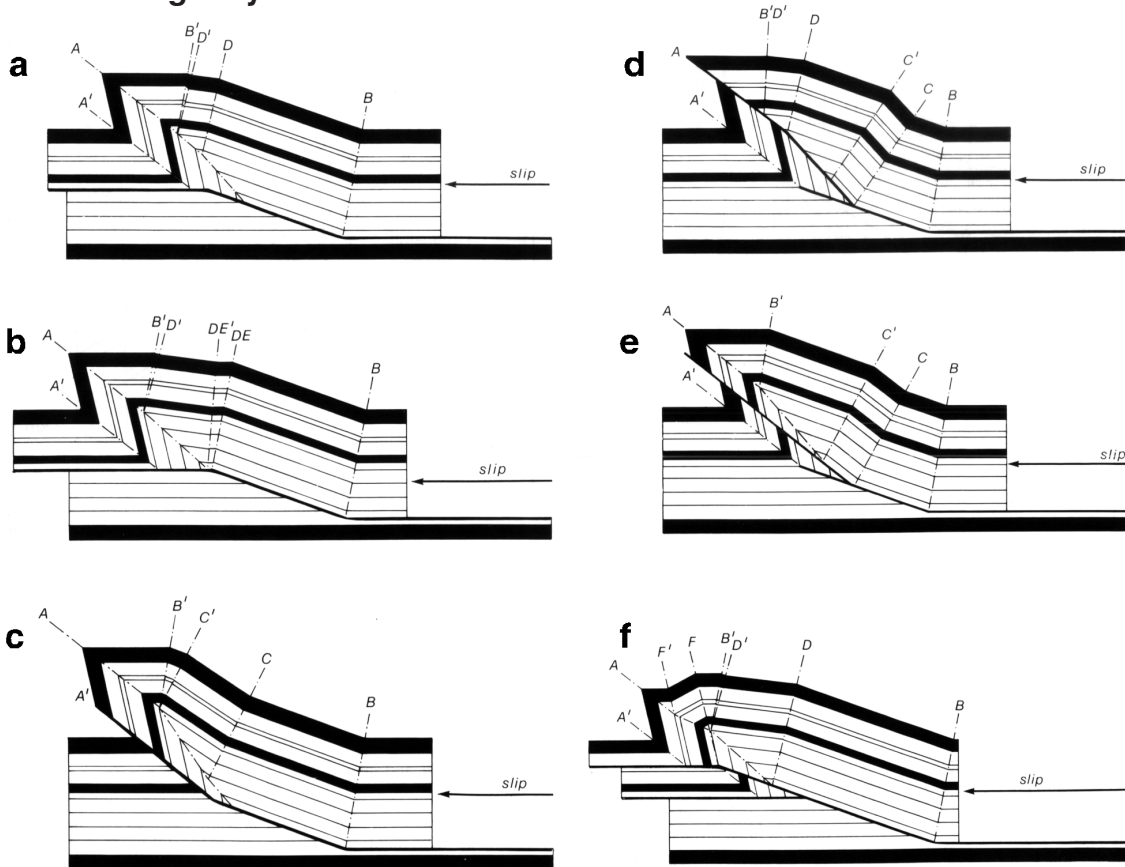
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Breakthrough fault-propagation folds

Breakthrough styles



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

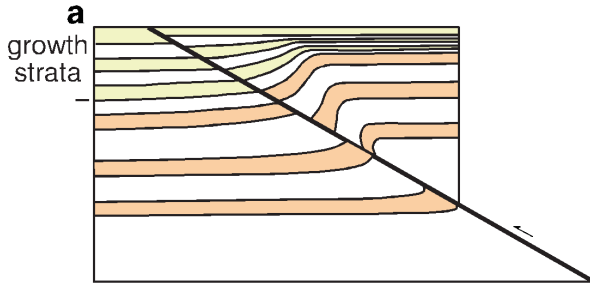
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

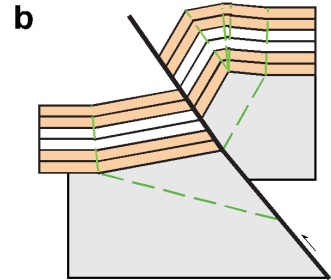
©2005 AAPG

Breakthrough fault-propagation folds

Trishear fold breakthrough



Triple junction fold breakthrough



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

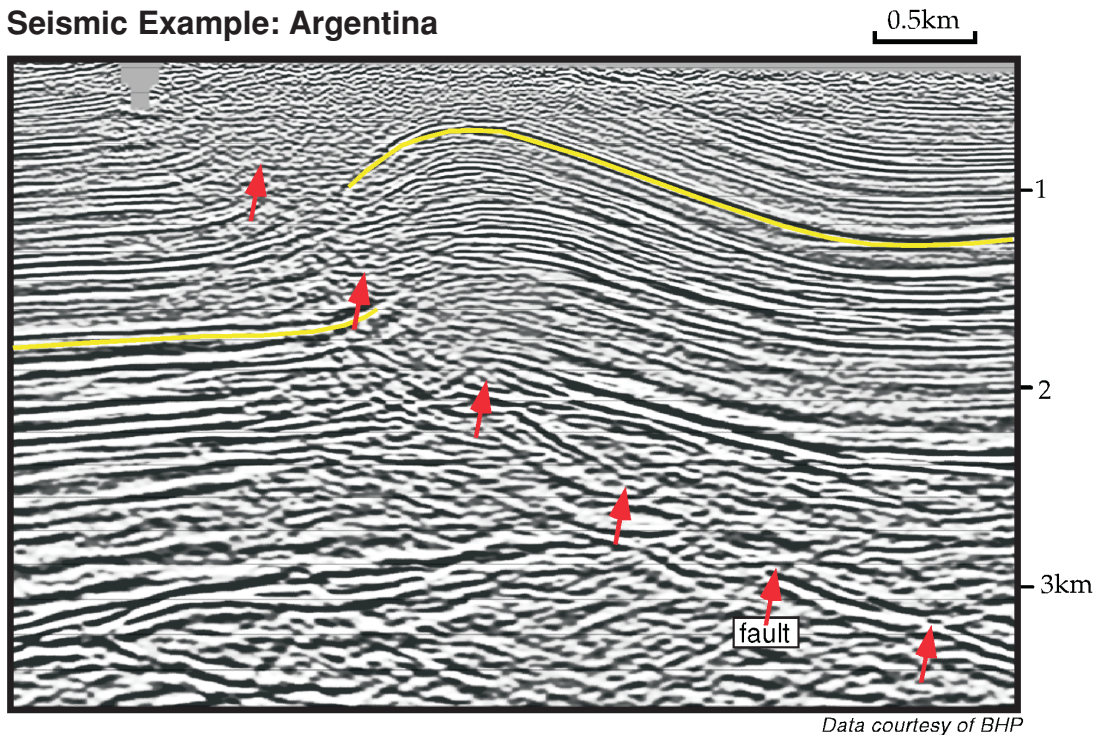
Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG

Breakthrough fault-propagation folds

Seismic Example: Argentina



Seismic Interpretation of Contractional Fault-Related Folds
An AAPG Seismic Atlas

Studies in Geology #53

Section 1B-2: Fault-propagation folds

John H. Shaw, Christopher Connors, and John Suppe

©2005 AAPG