Fault related folds: Geometry and kinematics
Outline

- Fault Related Folds (Fault Propagation, Fault Bend, Buckle)
- Pre-Tectonic, Syn-Tectonic, and Post-Tectonic Deposition
- Exercise
Fault Bend Folds

Fault Propagation Folds
Includes Trishear Folds

Decollement Buckle Folds
Growth Strata on Buckle Folds: Both limbs exhibit progressive limb rotation

Common above salt layers
QuickTime™ and a Video decompressor are needed to see this picture.
Outcrop scale buckle fold, Spanish Pyrenees
Halfway River, Northern Canadian Rocky Mountains
- Flat-ramp-flat geometry for fault surface
- Fault surface exists across entire cross-section
- Fold develops above ramp where limb angles related to fault dip
Shear in hangingwall can affect limb width and fold geometry.
Fault-Propagation Folds

Fault tip propagates thru cross-section

Fold develops above ramp with uniform forelimb angles

Original FPP has forelimb with same dip, trishear dips flatten upwards (trishear = reality)
Now let's move to Japan...

Downtown Osaka

Kuwana Anticline

Uemachi Upland/Fold
Trishear fault propagation fold from Osaka Basin, Japan
Note flattening of reflectors (upward) in forelimb and growth triangle
Uemachi Flexure (a trishear FPF): Osaka Basin
P-wave seismic profile

No vertical exaggeration, depth in meters

All seismic data courtesy of Japanese Geological Survey and Hanshin Corporation
Restoration of Uemachi P-wave profile

Narrow limb at surface

Sea Level

Restoration to Ma-1 (Blue)

1.1 Ma

Propagation of Fault Tip

Slip at Ma-1: 840 m, Propagation: 9700 m, Ramp Angle: 38 deg
Trishear angle: 6 deg, P/S ratio: 11.6
Uemachi ultra high resolution profile

Note resolution of data (some reflectors at 1 m spacing)

Reflectors steepen downward

Angular unconformity from Holocene sea level highstand

Depth in meters
Uemachi S-wave profile + line tracing

Note upwardly narrowing trishear envelope
Note flexural slip faults that terminate as parasitic folds beneath unconformity

Some of this strain may postdate deposition of younger strata

Backfilling occurs above flexural slip folds
Most of reflectors are growth strata
1.5-2.0 km of sediment fill in the last 1800 ka
Note homogeneous shear in forelimb
Dip profile of forelimb of Osaka Bay FPF/blind thrust

Most of reflectors are growth strata
1.5-2.0 km of sediment fill in the last 1800 ka
Note homogeneous shear in forelimb
Best fit trishear solution yields: steep (74 deg) thrust, 12km upward propagation (Fault tip from 15→3km) 10 deg apical angle
Fault Propagation Fold (Trishear) movie

QuickTime™ and a GIF decompressor are needed to see this picture.
Fault Propagation Fold (Trishear) movies (Stuart Hardy)
Fault Bend folding: Pregrowth strata

Bends in fault produce bending in hangingwall, marked by active axial surfaces
Fault Bend folding: Pregrowth strata

Fault Bend folding: Limbs widen self similarly

Growth triangle records progressively more slip with time

Inactive axial surfaces once at axial surfaces, now translated above thrust
Fault Bend folding: Limbs widen self similarly
Growth triangle records progressively less slip
Post tectonic deposition caps growth triangles
Exercise

What is the age of initiation of faulting?
What is the age of initiation of faulting? 13 Ma
What is the age of termination of faulting?
Exercise

What is the age of termination of faulting? 6 Ma
What is the slip rate on the thrust?
What is the slip rate on the thrust?
What is the slip rate on the thrust? 1 mm/yr