MECHANICAL ANALYSIS AND SEISMIC PROFILE OF THE GEOMETRY OF FAULT-RELATED FOLDS

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Outline

- Introduction
- Mechanical model of fault-related fold
- Influence of anisotropy on fold form
- Interpretation of the seismic profile
- Discussion and conclusions
Introduction

- Typical structures are fault-related folds that form over basement faults. Outcrops and seismic profiles show that the folds are typically asymmetric monoclines.
Break-thrust fold

Fault-bend fold

Fault-propagation fold

Detachment fold
The model does not include propagation of faults from the basement into the cover.
Influence of anisotropy on fold form

Isotropic: $\mu_n/\mu_s = 1$

anisotropic: $\mu_n/\mu_s = 3$

Triangular

Rectangular
Influence of anisotropy on fold form

Isotropic: $\mu_\alpha/\mu_\beta = 1$

anisotropic: $\mu_\alpha/\mu_\beta = 3$

Triangular

Rectangular
Comparison with trishear and kink band descriptions

Trishear

Kink band
Friedman et al. (1980) conducted experiments using lubricated layers of limestone and sandstone.
A fold in clay material overlying a basement normal fault in an experiment by Withjack et al. (1990).
24 people indicated that they were specialists or had a good working knowledge in structural geology and/or seismic interpretation, respectively.
The key features of the five structural end-member models used in the analysis of the interpreted seismic images.

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<th>Model</th>
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<th>Kinematic style</th>
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<td>FP(^a) from D(^b) with folding</td>
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<td>Faulted, no change in HW fold tightness</td>
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<td>No faults above D</td>
<td>Folding above D</td>
<td>Kink fold</td>
<td>Kink fold</td>
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</table>

\(^a\) FP = forward-propagating fault.
\(^b\) D = Detachment.
\(^c\) FW = footwall.
\(^d\) HW = hanging wall.
Composite spatial analysis of all interpretations

Fault only

Distributed strain only
Discussion

- We realize that the model is similar to the seismic profile, but the model can’t be interpreted the “kink band” of the profile.

- In the forelimb of folds in anisotropic cover are nearly uniform with depth and resemble the fold forms produced by the kink band construction.
Conclusions

- Our model show that the geometry of the forelimb is largely influenced by the **rheology of the cover** and the **degree of anisotropy** in the cover.

- Most of the theoretical models are characterized by propagation of a **single-strand, continuous thrust fault**. A significant number of participants interpreted discontinuous fault geometries.
Discontinuous fault geometries are usually observed at outcrop analogues for deepwater fold-thrust belts. The rheology of deepwater sedimentary systems with unconsolidated sand and shale seems to inhibit brittle faulting, promoting distributed deformation.

The model does not include propagation of faults from the basement into the cover. Thus the model can’t be exactly interpreted the seismic profile.
Thank you for your attention.
\[ \sigma_n = \mu_n \varepsilon_n \]

\[ \tau_s = \mu_s \gamma_s \]

\[ \tau_s = \sigma_n \]

\[ \frac{\mu_n}{\mu_s} > 1 \quad \gamma_s < \varepsilon_n \]

\[ \frac{\mu_n}{\mu_s} < 1 \quad \gamma_s > \varepsilon_n \]
Influence of basement-cover contact on fold form

- Stearns (1978) deduced that whether the cover rock is thinned depends on the basement-cover contact.

- Sedimentary cover that is nearly constant in thickness through the forelimb was detached from the basement, while cover rock that is thinned in the forelimb was welded to the basement.
We have added a thin film at the basement-cover contact into the mechanical model.

\[ \frac{\mu_f}{\sqrt{\mu_n \mu_s}} = 0 \]

Free slip

\[ \frac{\mu_f}{\sqrt{\mu_n \mu_s}} \gg 1 \]

To welded

Measure of resistance to slip at basement/cover contact:

\[ \frac{\mu_f}{\sqrt{\mu_n \mu_s}} \]
The largest influence on the anticlinal hinge and backlimb geometry.
Efforts to explain fault-related folds have followed three largely divergent paths: theoretical analysis, experimentation, and kinematic analysis.