EXPERIMENTAL DEFORMATION AND FOLDING IN PHYLLITE AND PALEOSTRESS ANALYSIS FROM TRIANGULAR PLOT

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References


Outline

- Introduction
- Experimental method and results
- Stress-strain results
- Intersections of kink
- Triangular plot
- Conclusions
Introduction

- Two main approaches to the study of folding: first, geologic field study; and, second, theoretical and experimental studies of models.
- In previous study, they was demonstrated with a suitably scaled model material, such as clay, pitch, rubber, and so on.
- Use the approach of investigating the folds that can be produced experimentally in specimens of the strongly foliated rocks such as phyllite.
Definition of kink band

- These consist ideally of parallel-sided domains with sharp boundaries at which the foliation is bent through a large angle.
Experimental method

- Most experiments have been run at 5 kb confining pressure. The strain rate was about $4.8 \times 10^{-4}$ per second.
Experimental method

- (1) Anisotropic material—strongly foliated rocks such as slates, phyllites, and mica schists.

- (2) Constrained deformation—
  
  a. End friction: friction between the end piece and the end of the specimen gives rise to a resistance on the end of the specimen when it tends to move nonaxially.

  b. Jacket constraint: the specimens were enclosed in thick metal jackets to ensure that deformation, such as folding, would be distributed through the specimen on a small scale.
Effective constraint from end friction

No effect of end friction and jacket constraint

Effect of jacket constraint

Deform axially under axial load and be distributed through the specimen on a small scale.

Effective constraint from end friction

Effect of end friction and jacket constraint
Experimental results

- Influence of different angle $\alpha$ and jackets in experiments with examination in reflected light or microscopic study in transmitted light.

For examination in reflected light

For microscopic study in transmitted light.
\( \alpha = 0^\circ \), in Reflected light

Specimens compressed parallel to foliation in different jackets.

In rubber jacket

In copper jacket
$\alpha = 0^\circ$, large strain in transmitted light

A typical sequence of deformation in specimens shortened parallel to foliation in brass jackets.

Through a microscope in transmitted light the change from dark to light is seen to be accompanied by changes the deformed zone (kink) of the foliation from the undeformed domains and change from transparent to frosted in the quartz.
$\alpha = 10^\circ$
\[ \alpha = 45^\circ, 90^\circ \]

- In rubber jacket
- In brass jacket
- Mica-rich layer

17.5%  28%

\[ \alpha = 45^\circ \]

\[ \alpha = 90^\circ \]

Enlargement of D
Stress-strain results

Influence of angle $\alpha$ to Stress-strain curves

Effect of confining pressure to stress-strain curves

in brass jackets
Angles $\Phi$ and $\Phi_k$ of kinks

- $\phi \approx \phi_k$
- $\phi < \phi_k$

In the mica-richer specimens
Specimens richer in quartz layers

$60^\circ$
Their axial planes are subperpendicular to the axis of compression.

I undeformed domain
II.III initial kink
IV intersections of kink
Ideal model of kink intersections

- With increasing deformation, the kink boundaries become widening.

- Shortening:
  - 10-30%
  - 30-45%
  - 45-50%

- Figure captions:
  - a
  - b
  - c
  - d

- Note: Percentage values indicate the deformation range.
Srivastava et al. (1998) used triangular plots for paleostress analysis from kink band.

\[
\phi + \phi_k + \psi = 180^\circ.
\]

- \(\phi = 60^\circ\)
- \(\phi_k = 90^\circ\)
- \(\psi = 30^\circ\)
The most realistic $\alpha$ value of the data near the paleostress line are projection parallel to the $\Psi$-lines in the graph.

Plot 6  $\alpha \approx 11.5^\circ$
Plot 8  $\alpha \approx 3.5^\circ$
Plot 13 $\alpha \approx 3^\circ$
Conclusions

- When the foliation of specimens parallel to the axis of compression ($\alpha=0^\circ$) in metal jackets will intersect to the network.
  1. $\alpha=10^\circ$, the intersections of kink are rare.
  2. $\alpha=45^\circ$, the sliding along the foliation replace the kinking.
  3. $\alpha=90^\circ$, failure is largely by rupture.

- The width of kink increase with the shortening, but the angle $\Phi$ and $\Phi_k$ don’t change with the shortening. The degree of the angle is relative to the composition of the rock mineral.
The intersections of kink form the chevron fold that axial plane normal to the axis of compression.

Using of the kink-band triangle is suitable for the determination of maximum compressive stress orientation from kink-band structures. In practice, it is better to measure a large number of kink-bands.
Thank you for your attention!!
\( \alpha = 0^\circ \), large strain in Reflected light

Short specimens compressed parallel to foliation in copper jackets

14%  30%  45%

Shortening

70%

Enlargement of D
The stress-strain curves for phyllite compressed parallel to the foliation in various constraining jackets at 5 kb confining pressure.

a. Brass (15)  
b. Copper (11)  
in rubber jackets
Kink intersections

Classifying the intersection of kink according to the width and the form of kink boundaries
Stress-strain curves for tests in compression at various angles to the foliation at 5 kb confining pressure:

a, in rubber jackets

b, in thick brass jackets
Stress-strain results

Stress-strain curves of metals used for constraining jackets

The stress-strain curves for phyllite compressed parallel to the foliation in various constraining jackets at 5 kb confining pressure.

- a. Brass (15)
- b. Copper (11)
- c. Ni-Cr-Mo steel (2)
- d. High-C steel (1)
Table 2. Results from triangular plots of the individual kink-bands. Bold numbers indicate the optimum value of the angle $z$ (between the $\sigma_1$-axis and the unrotated layering). The examples and kink-band angles ($\phi$ and $\psi$) are adopted from table 1 in Gay and Weiss (1974).

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The initially circular cross section becomes elliptical with the minor diameter always lying in the plane of the foliation. In the central part of a specimen with 20 per cent over-all shortening there is only about 1 per cent increase in the minor diameter, whereas the major diameter shows an increase of about 30 per cent.