A review of deformation bands in reservoir sandstones: geometries, mechanisms and distribution


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Outline

Introduction
• What is Deformation Band (DB)?
• DB Classification

Discussion
• Factors controlling deformation band mechanisms
• Ways they occur in different tectonic settings
• Deformation bands and fluid flow

Conclusions
Introduction

What is deformation band?
- Tabular structure formed in highly porous rock with porosity of ≥ 15%
- Porosity of < 15% or down to a few percent.
- Thickness of single band is few millimeters
- Higher cohesion, lower porosity and permeability due to pore space loss and grain fracture
- Start out as single structures, develop into clusters or multi-clustered zones prior to the formation of a through-going slip surface
Introduction

Types of deformation bands

Kinematic classification
Introduction

Types of deformation bands

Mechanism classification

- Cataclasis band: sliding and rotational actually fracture
- Non-cataclasis band: sliding and rotational
Discussion

Conditions controlling deformation band mechanisms

<table>
<thead>
<tr>
<th>Variable</th>
<th>Granular flow</th>
<th>Cataclasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burial depth (confining stress)</td>
<td>Shallow</td>
<td>Deep</td>
</tr>
<tr>
<td>Lithification</td>
<td>Unconsolidated</td>
<td>Well lithified</td>
</tr>
<tr>
<td>Fluid overpressure</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Cement strength</td>
<td>FeO(OH) (low)</td>
<td>CaCO$_3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SiO$_2$ (high)</td>
</tr>
<tr>
<td>Grain roundness</td>
<td>Angular</td>
<td>Rounded</td>
</tr>
<tr>
<td>Grain sorting</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Mineralogy (grain strength)</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Phyllosilicate content</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Grain size</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
</tbody>
</table>

Porosity reduction
Discussions

Conditions controlling deformation band mechanisms

Burial depth
- **SHALLOW BURIAL** (< 1 km)
  - Packing density
  - Mechanical compaction

- **MODERATE BURIAL** (1 km - 3 km)
  - Pressure
  - Chemical compaction

- **DEEP BURIAL** (> 3 km)
  - Cataclasis + pressure-solution

Grain strength
- Strong -> granular flow
- Weak -> cataclasis

Grain size
- **COARSE GRAIN** (> 0.375 mm)
- **FINE GRAIN** (< 0.375 mm)

Grain sorting
- **POOR SORTING**
- **GOOD SORTING**
Discussion

Conditions controlling deformation band mechanisms

Phyllosilicate content (%)
Deformation bands in the extensional regime

- Deformation band tend to accumulate in zones or clusters
- Type of deformation band: CSB
- Formation of conjugate sets of bands or band clusters dipping in opposite directions and mutually cross-cutting each other
- Deformation band zones dictate or strongly influence the location and orientation of faults (Aydin & Johnson 1983; Shipton & Cowie 2001)
Deformation bands in the contraction regime

Reverse Fault, Thrust

- Deformation bands appear evenly distributed
- Types of deformation band: SECB, PCB, CSB
- SECB consistently define high dihedral angles (70–100 degree)
- CSB in the contraction regime show angles in the range 40–75 degree
Discussion

**Deformation bands and fluid flow**

Deformation band all reduce porosity and permeability
Conclusions

• **Permeability decrease with increase of cataclasis.** Cataclasis increases with burial depth due to the increase in stress across grain contacts from overburden, factors influencing cataclasis deformation mechanism: grain size, grain roughness, grain sorting, mineralogy strength,…

• **CSB** can form both in **contraction and extensional regimes**.

• **SECB** and **PCB** form under low differential stress most easily obtained in the **contraction regime**.

• **DBs** developing prior to fault formation dictate or strongly influence the location and orientation of faults.

• **DBs** have lower porosity and **permeability up to 6 orders of magnitude** less than the host rock.
~ Thank you~