Strain Localization and Ductile Failure in Feldspar Rocks

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Shear Zones Cutting Through Lower Crust

SE Madagaskar
Quartzofeldspathic Granulites
700°C-800°C
~ 600-800 MPa

Cap de Creus
Metasediments
400°C-500°C
~ 250 MPa
Anorthositic Granulites, Norway

Grain Size

40 mm

µm-scale

Shear Zone in Metabasites, Ivrea Zone

UM Plag/Amph/CPX $\gamma \gg 10$

Mylonite

$\gamma \sim 1-10$

Clinopyroxene

4 mm
Synthetic Rocks at Hydrous Conditions

- Lab Data vs. Field Observations

- Stress estimates from shear zones

- Viscosity from postseismic relaxation models

- Mylonite grain size

- Shear strain rate: $10^{-12} \text{s}^{-1}$

- Power Law Creep

- Wet aggregates

- Diopside - 700°C

- Olivine - 700°C

- Anorthite - 700°C

- Anorthite - 900°C

- Olivine - 900°C

Rybacki et al., JGR 2006; Dimanov and Dresen, JGR 2005; Mei and Kohlstedt, JGR 2000
Ductile Failure in Feldspar Rocks

$\sigma$: 2 – 80 MPa, $T$: 900°C-1200°C, $P_c$: 100 - 400 MPa, 26 samples, 40% deformed in linear viscous creep to failure at $\gamma < 5$

Mag. x 50, $\gamma < 2.0$

Cavity

Crack

Mag. x 100000, $\gamma = 4$
Localization and Failure

pure An 1100°C

\[ \dot{\gamma} \approx 2 \cdot 10^{-4} \text{s}^{-1} \]

AnDi-mixture \( \sim 2 \cdot 10^{-5} \text{s}^{-1} \)

\[ \dot{\gamma} \approx 5 \cdot 10^{-5} \text{s}^{-1} \]

\[ \dot{\gamma} \approx 2 \cdot 10^{-5} \text{s}^{-1} \]

1100°C

Cavitation, Failure
SEM BSE Images of Cavity Bands

Rybacki, Wirth and Dresen, GRL, 2008,
JGR, 2010
Cavity bands in optical thin sections
Pores, Cavities in TEM BF

1150 °C, $\gamma \sim 3.5$
SiO$_2$ Glass in Shear Bands (FIB STEM)
Conclusions

• Where strength at lower crustal depth is limited by fine-grained mylonite shear zones it is expected to be low

• Accelerated postseismic creep in fine-grained mylonitic shear zones in the near field is probably linear viscous

• Cavitation in fine-grained feldspar aggregates occurs at flow stresses 5-20 times lower than confining pressure

• Cavitation in ultramylonite shear zones may lead to episodic slip acceleration, porosity/permeability increase and ductile failure