

UNIVERSITÀ  
DEGLI STUDI  
DI PADOVA

Tesi di Laurea Triennale in Scienze Geologiche  
20 luglio 2016

# Simulazione numerica dello sviluppo della LPO indotta da deformazione in aggregati cristallini di plagioclasio

Numerical simulations of strain-induced LPO development in plagioclase crystal aggregates

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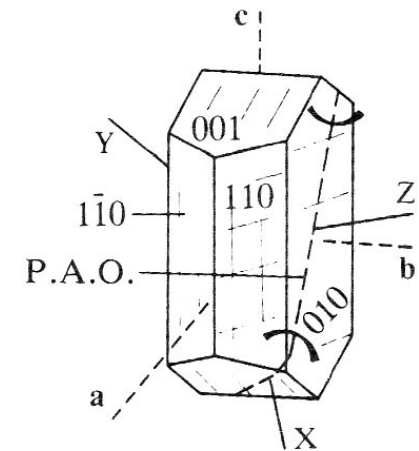
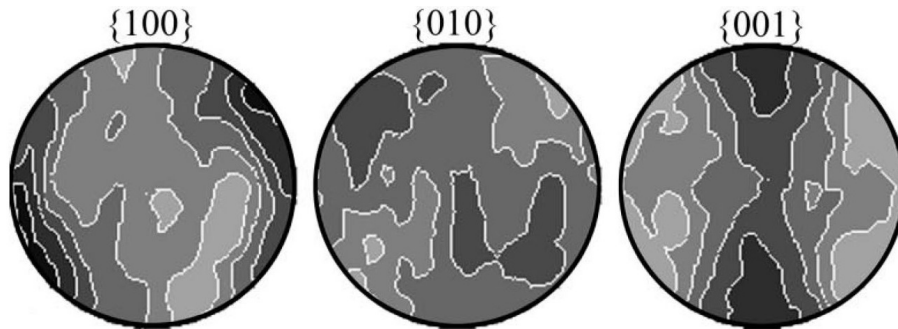
LAUREANDA  
GIULIA FEDRIZZI

RELATORE  
PROF. MANUELE FACCENDA

# Introduzione

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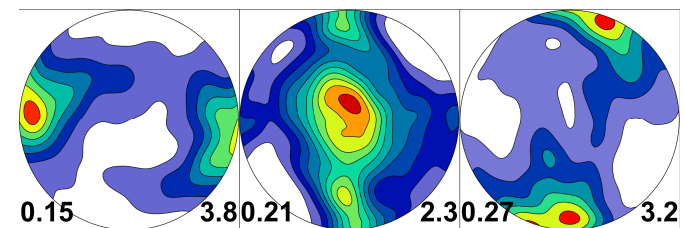
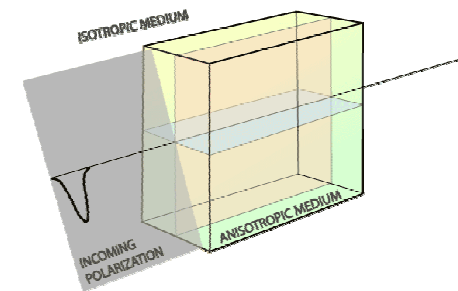
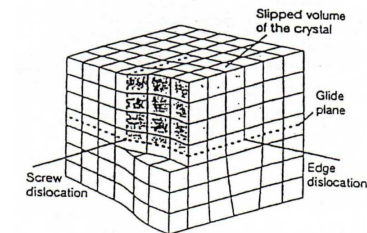
- Studio della LPO di cristalli di plagioclasio ( $An_{60}$ )
- Dati sperimentali: Heidelberg et al., 2000



Labradorite  
Deer, Howie, Zussman, 1994

# Introduzione

- Obiettivo:
  - Sistemi di slip + Meccanismi di deformazione
  - Anisotropia sismica
- Programmi utilizzati:
  - D-Rex (Kaminski et al., 2004), per le simulazioni LPO (fortran)
  - MTEX (Mainprice et al., 2011), per la visualizzazione dei dati di output, proiezioni stereografiche (MatLab)



Plot con MTEX

# Metodo numerico: D-Rex

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Input (1):

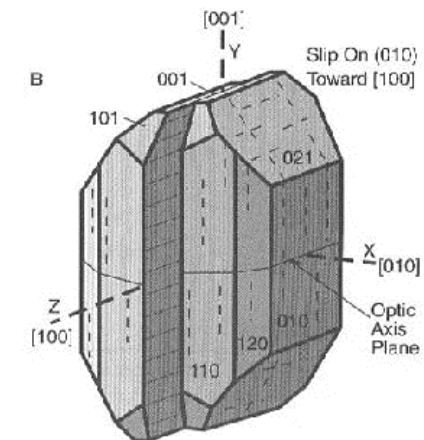
- Orientazione iniziale (random)
- Quantità di deformazione  $\gamma = 7.5$
- Gradiente di velocità (simple shear)
- Minerale e numero di cristalli (1000)
- Attività degli slip systems, per il plagioclasio:

[100] (010)

[001] (010)

[100] (001)

[010] (001)



Il sistema di slip [100](010) di un'olivina

# Metodo numerico: D-Rex

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Input (2):

- Ricristallizzazione dinamica
  - Grain Boundary Mobility

$$\frac{df_m^v}{dt^*} = -M_m^* df_m^v (E_m^v - \bar{E}_m)$$

- Parametro di nucleazione ( $\lambda$ )

$$E = \exp(-\lambda \rho^2) \rho \mu b^2$$

- Valore soglia di volume per Grain Boundary Sliding ( $\chi$ )

$$\chi \equiv \frac{f_{gbs}}{f_o}$$

# Proprietà elastiche

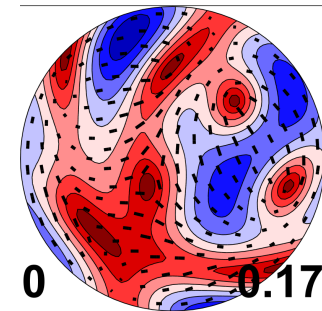
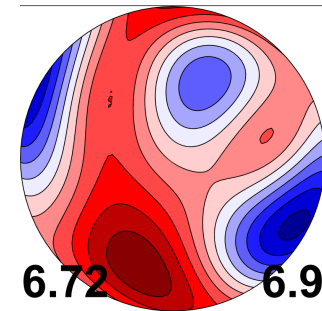
Tensore elastico  $C_{ij}$  (notazione di Voigt) per il singolo cristallo di plagioclasio  $An_{60}$

$$C_{ij} = \begin{bmatrix} 109.3 & 53.1 & 42.1 & 7.6 & 1.2 & -7.7 \\ 53.1 & 185.5 & 21.9 & -2.9 & 0.7 & -6.8 \\ 42.1 & 21.9 & 164.1 & 0.2 & 2.5 & 0.7 \\ 7.6 & -2.9 & 0.2 & 22.2 & 0.2 & 1.4 \\ 1.2 & 0.7 & 2.5 & 0.2 & 33.1 & 2.8 \\ -7.7 & -6.8 & 0.7 & 1.4 & 2.8 & 36.8 \end{bmatrix}$$

Da Brown et al., 2016

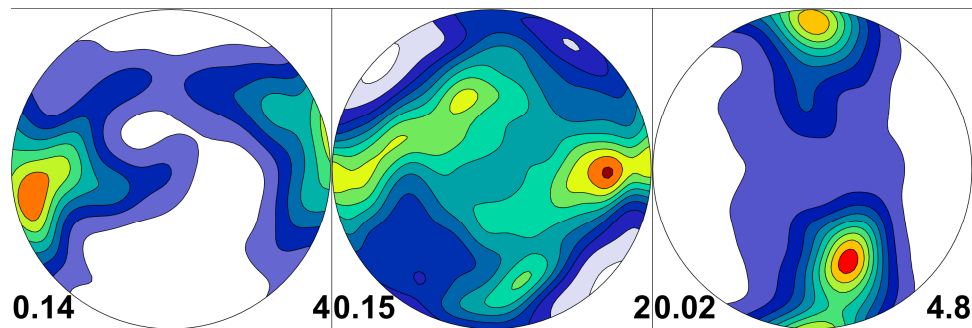
Media di Hill

$$C_{ij}^{Hill} = \frac{C_{ij}^{Voigt} + C_{ij}^{Reuss}}{2}$$



Plot con MTEX

# Risultati – LPO

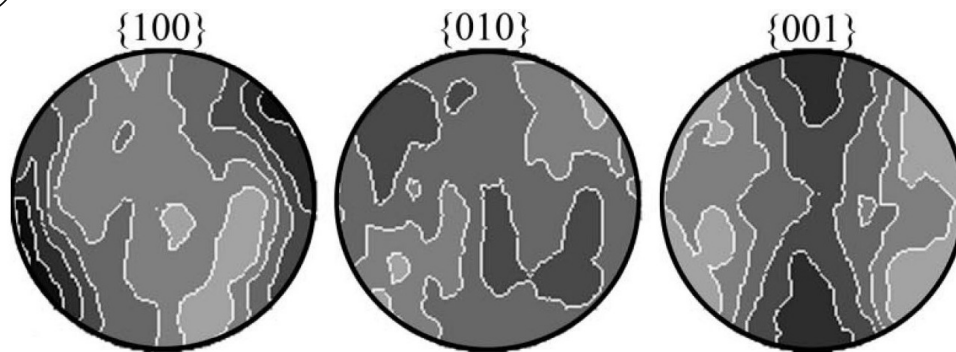
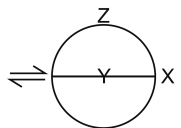


$$\gamma = 7.5$$

$$\text{Mob} = 5$$

$$\chi = 0.99$$

$$\lambda = 1$$



Slip system

nCRSS

[100] (010)

3

[001] (010)

(Non attivo)

[100] (001)

1

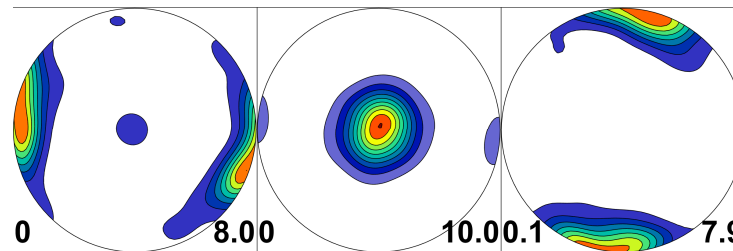
[010] (001)

2

Heidelbach et al. 2000

# Risultati – influenza di $\chi$

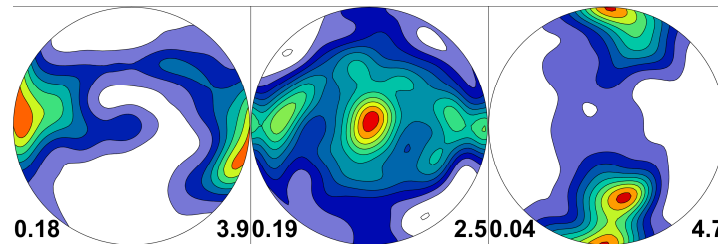
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Mob = 5

$\chi = 0$

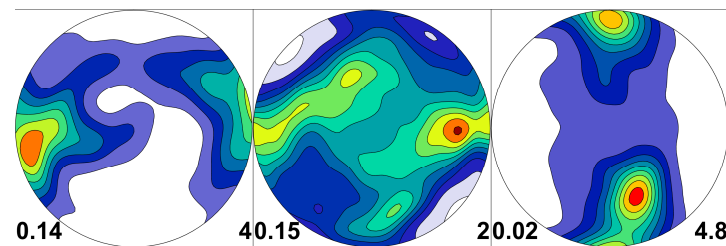
$\lambda = 1$



Mob = 5

$\chi = 0.90$

$\lambda = 1$



Mob = 5

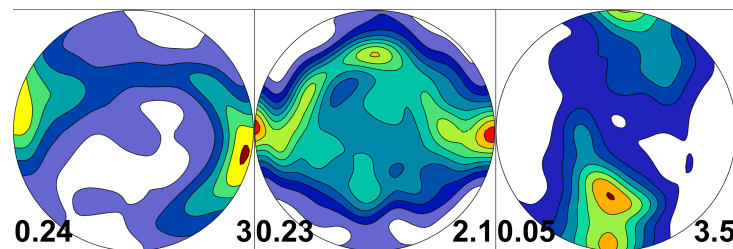
$\chi = 0.99$

$\lambda = 1$



# Risultati – influenza di Mob

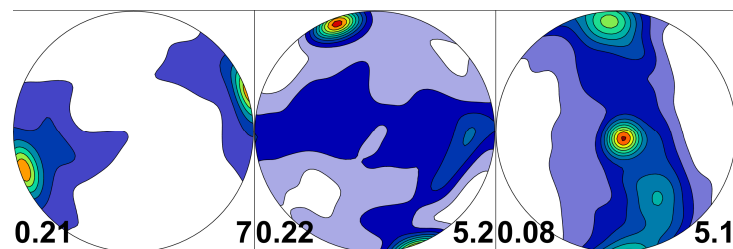
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Mob = 0

$\chi = 0.90$

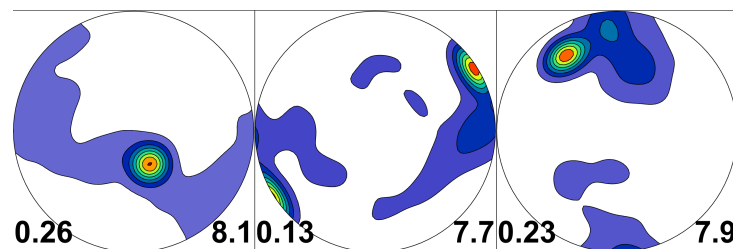
$\lambda = 1$



Mob = 50

$\chi = 0.90$

$\lambda = 1$



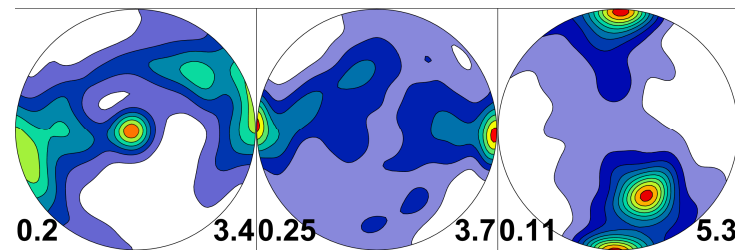
Mob = 150

$\chi = 0.90$

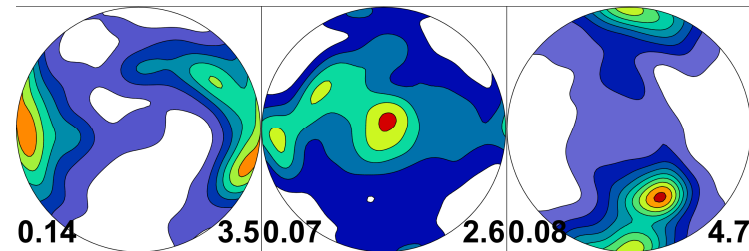
$\lambda = 1$

# Risultati – influenza di $\lambda$

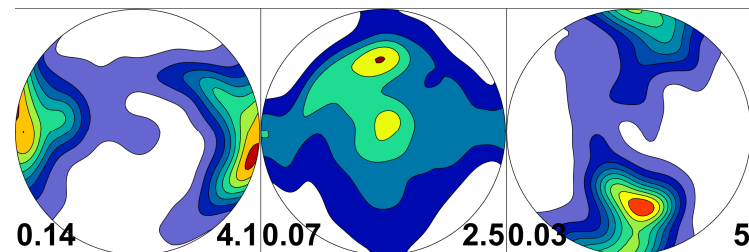
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Mob = 5  
 $\chi = 0.90$   
 $\lambda = 0$



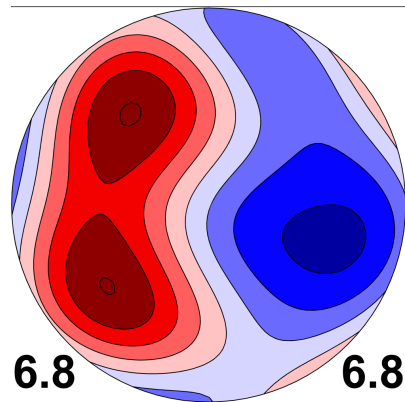
Mob = 5  
 $\chi = 0.90$   
 $\lambda = 50$



Mob = 5  
 $\chi = 0.90$   
 $\lambda = 100$

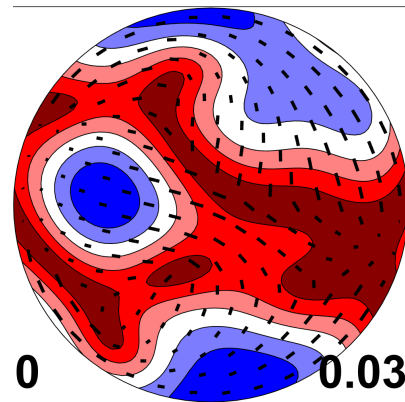
# Risultati – anisotropia sismica

Vp



AVp = 1.5 %

dVs



AVs = 0.8 %

$\gamma = 7.5$ ,  $Mob = 5$ ,  $\chi = 0.99$ ,  $\lambda = 1$

Slip system	nCRSS
[100] (010)	3
[001] (010)	(Non attivo)
[100] (001)	1
[010] (001)	2

# Conclusioni

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- Dislocation creep poco attivo
- Ricristallizzazione dinamica poco efficiente
- Anisotropia sismica:

Questa CPO

**AVp = 1.5 %**

**AVs = 0.8 %**

Singolo cristallo

AVp = 8.2% ÷ 12 %

AVs = 14 %

Minerale	AVp (singolo cristallo)	AVs (singolo cristallo)
Miche (Bt)	fino a 64 %	fino a 115 %
Anfibolo (Hb)	27.1 %	30.7 %
Pirosseno (Aug)	24.3 %	18.0 %

- Calibrazione del programma per il Plagioclasio

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