Universiteit Utrecht

in collaboration with:

UNIVERSITY OF OXFORD

Faculty of Geoscience

Earth, Structure & Dynamics

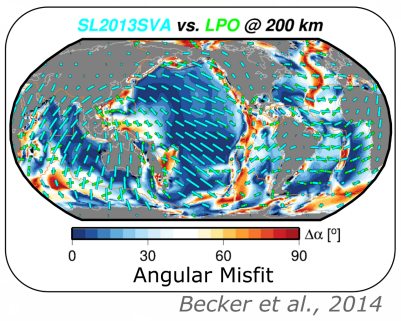
MSc. Project

Experimental investigation of complex plastic strain paths using Equal Channel Angular Pressing (ECAP)

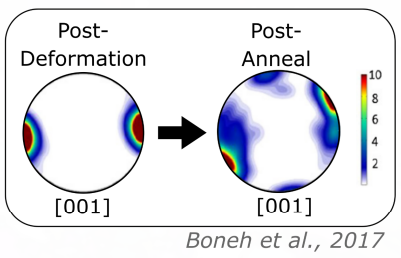
Diede Hein, David Wallis & Lars Hansen

I. INTRODUCTION

- Models struggle to predict Crystallographic Preferred Orientations (CPO) in regions of complex straining[1].
- Post-deformation annealing yields interesting CPO behaviour[2].
- An experimental analog is required to benchmark models and improve predictions.
- ECAP is a metallurgic technique able to generate complex strains in combination with varied annealing treatments[3].



Becker et al., 2014

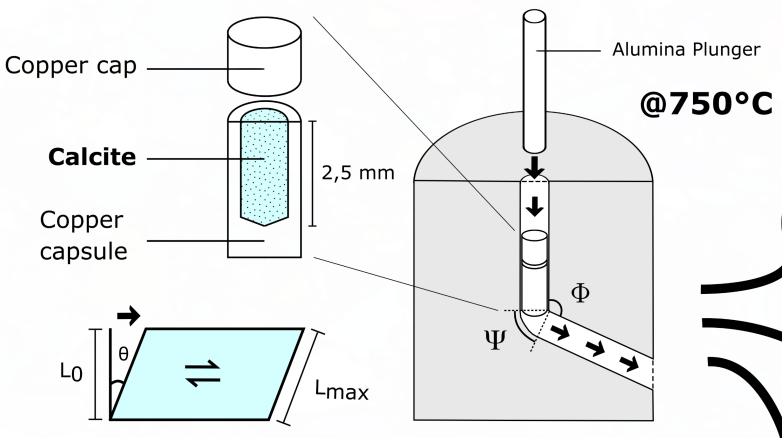


Boneh et al., 2017

II. KEY OBJECTIVES:

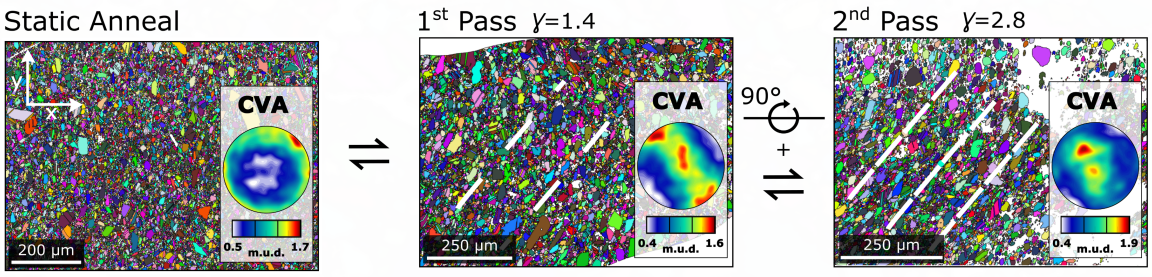
- Adapt ECAP to geological materials.
- Study complex strain path microstructures.
- Test the ability of the Visco-Plastic Self Consistent model[4] (VPSC) to predict complex deformation CPO .

III. METHODS & RESULTS



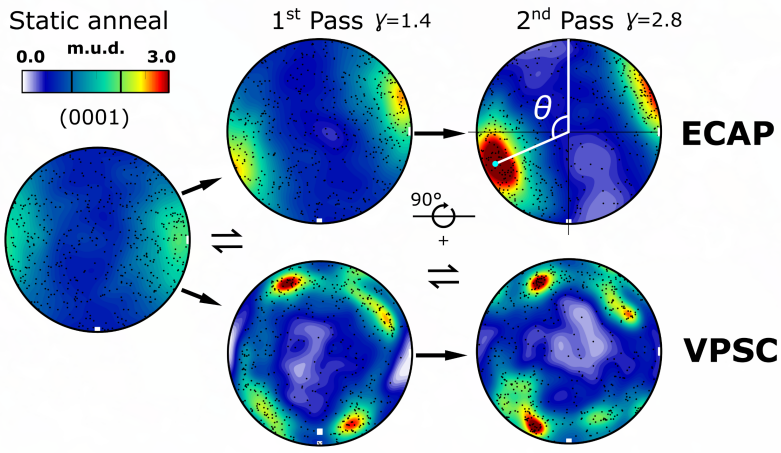
- Induces **simple shear** into the sample.
- Allows for **multiple passings** of the sample, including **rotations** to **generate complex strain**
- Study post-deformation **annealing trends along sample length**.

Microstructure evolution along a complex strain path:

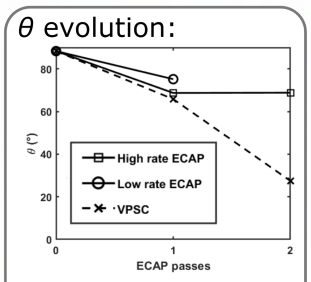


- **Grain growth**, formation of **foliation**, & incipient **grain boundary migration** recrystallisation.
- **Intracrystalline Vorticity Axes** (CVA) confirm **simple shear**.
- **Subgrain sizes** agree with **dislocation creep** flow laws.

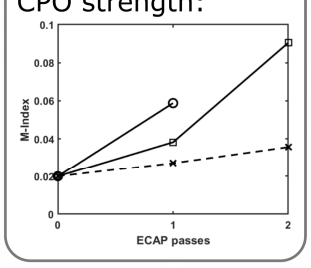
Experimental vs. predicted CPO evolution along a complex strain path:



θ evolution:



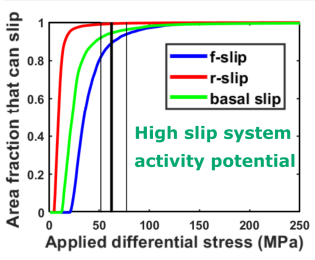
CPO strength:



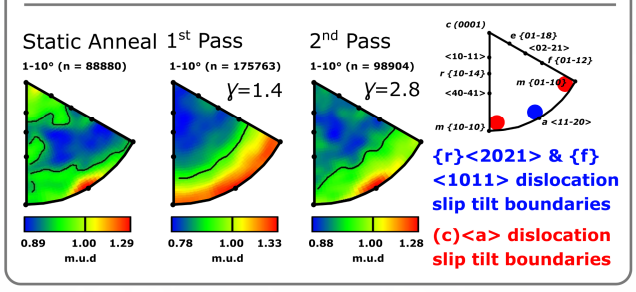
- **ECAP** completely **overprints pre-existing CPO**.
- Formation of a **strong deformation CPO**.
- **VPSC** predicts **additional c-axis clusters** and significantly **underestimates CPO strength** during complex straining.

Further constraints on microstructure evolution through:

Schmid factor Analysis



Local misorientation Analysis



IV. CONCLUSIONS

- ECAP is a promising experimental technique to investigate rheological characteristics of complex strain.
- Complex straining can overprint pre existing CPO through combined slip system activity.
- VPSC severely *underestimates* CPO strength and predicts additional clusters at small strains, revealing potential areas of improvement.

V. FUTURE WORK

- Improve methodology towards higher temperatures, higher strains, longer samples, and chemical controls.
- Further investigate cause(s) of discrepancy between model and experiment and propose modifications.
- Expand technique to Olivine and other geological materials.

Acknowledgements:

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References:

1) *Becker, T. W., Conrad, C. P., Schaeffer, A. J., & Lebedev, S. (2014). Origin of azimuthal seismic anisotropy in oceanic plates and mantle. Earth and Planetary Science Letters, 401, 236-250.*
2) *Boneh, Y., Wallis, D., Hansen, L. N., Krawczynski, M. J., & Skemer, P. (2017). Oriented grain growth and modification of 'frozen anisotropy'in the lithospheric mantle. Earth and Planetary Science Letters, 474, 368-374.*
3) *Nejnoto, M., Horita, Z., Furukawa, M., & Langdon, T. G. (1998). Equal-channel angular pressing: A novel tool for microstructural control. Metals and Materials, 4(6), 1181-1190.*
4) *Lebensohn, R. A., & Tomé, C. N. (1993). A self-consistent anisotropic approach for the simulation of plastic deformation and texture development of polycrystals: application to zirconium alloys. Acta metallurgica et materialia, 41(9), 2611-2624.*