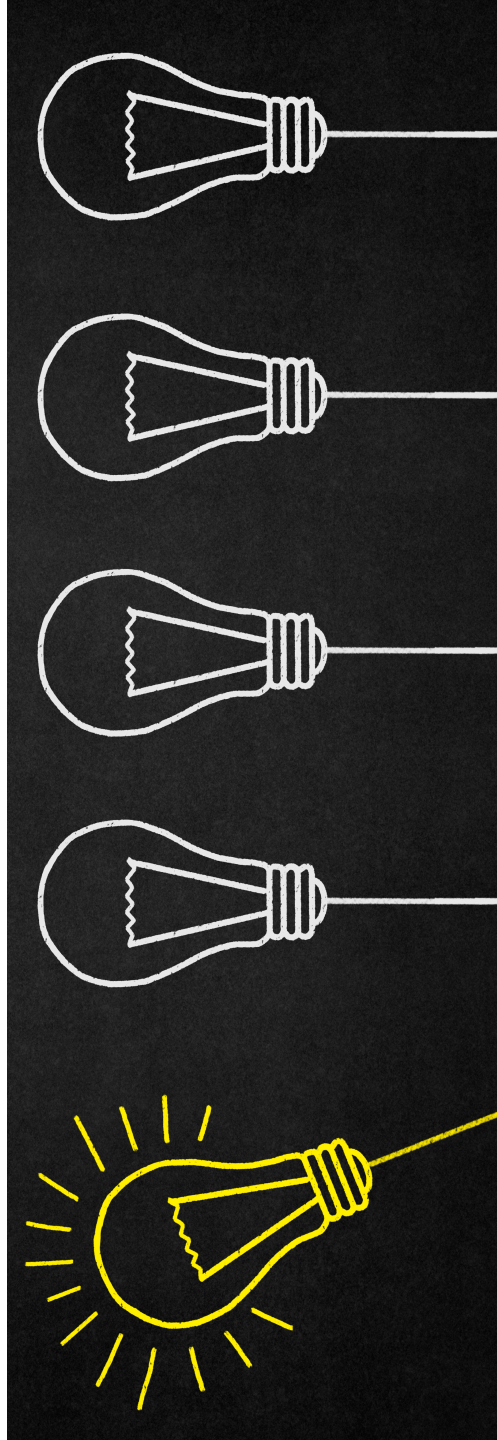
Microstructures reveal brittle and viscous flow during exhumation of the high-temperature lower crust from site U1473A, Atlantis Bank, Southwest Indian Ridge (IODP Expedition 360)

PhD Candidate: Rhander Taufner Altoé

Summary

- Introduction
- The research problem
- Objectives
- Methods
- The Atlantis Bank OCC and hole U1743A
- Results
- Final remarks







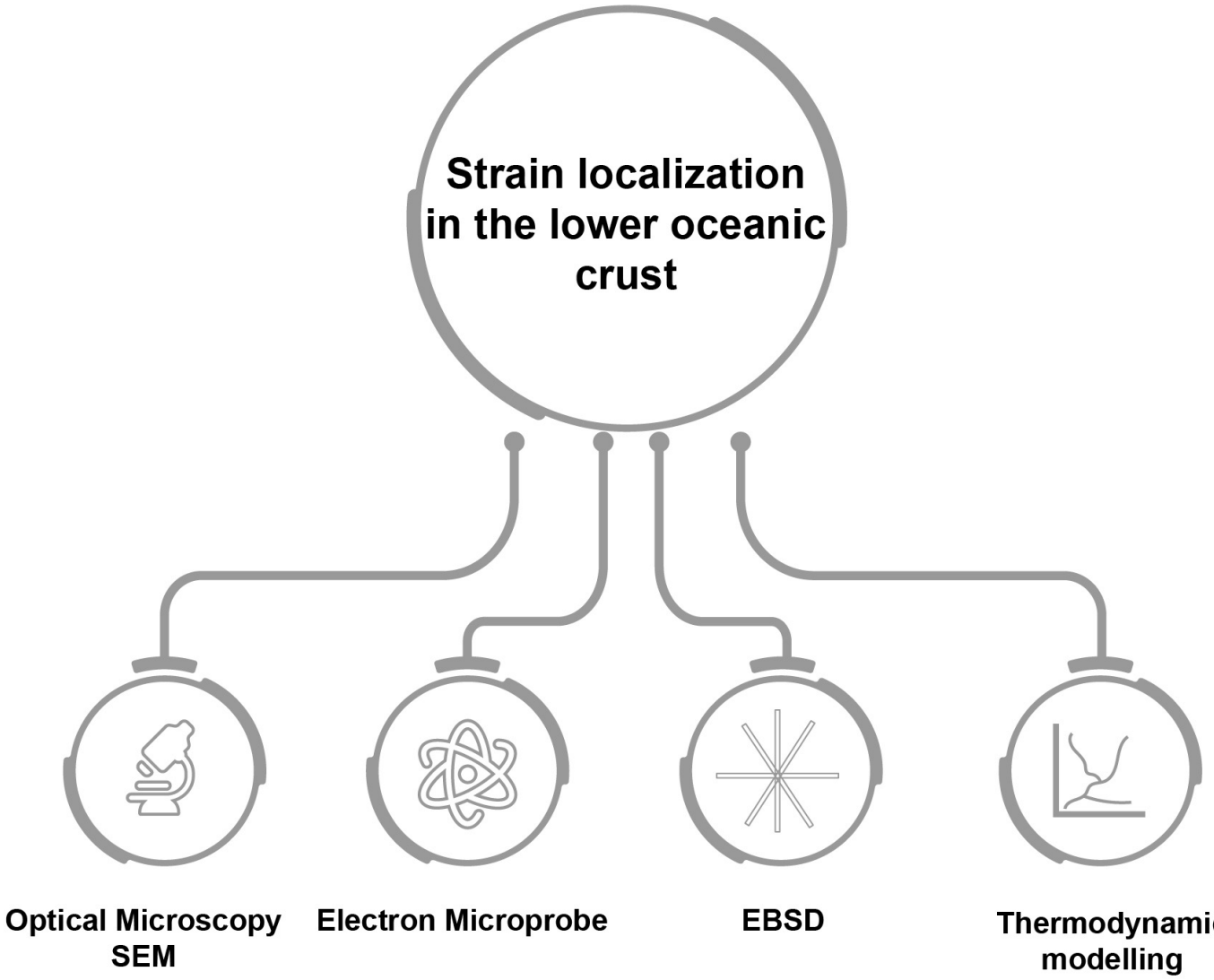
The research problem and motivation

- What are the processes responsible for strain localization during detachment faulting?
- What is the role of shear zones as anisotropic channels for fluid circulation along the gabbroic lower crust?

Objective

We aim to characterise the dominant deformation mechanisms active during shear zone deformation in the lower crust and to assess their influence on the mechanical behaviour of the lower oceanic crust.

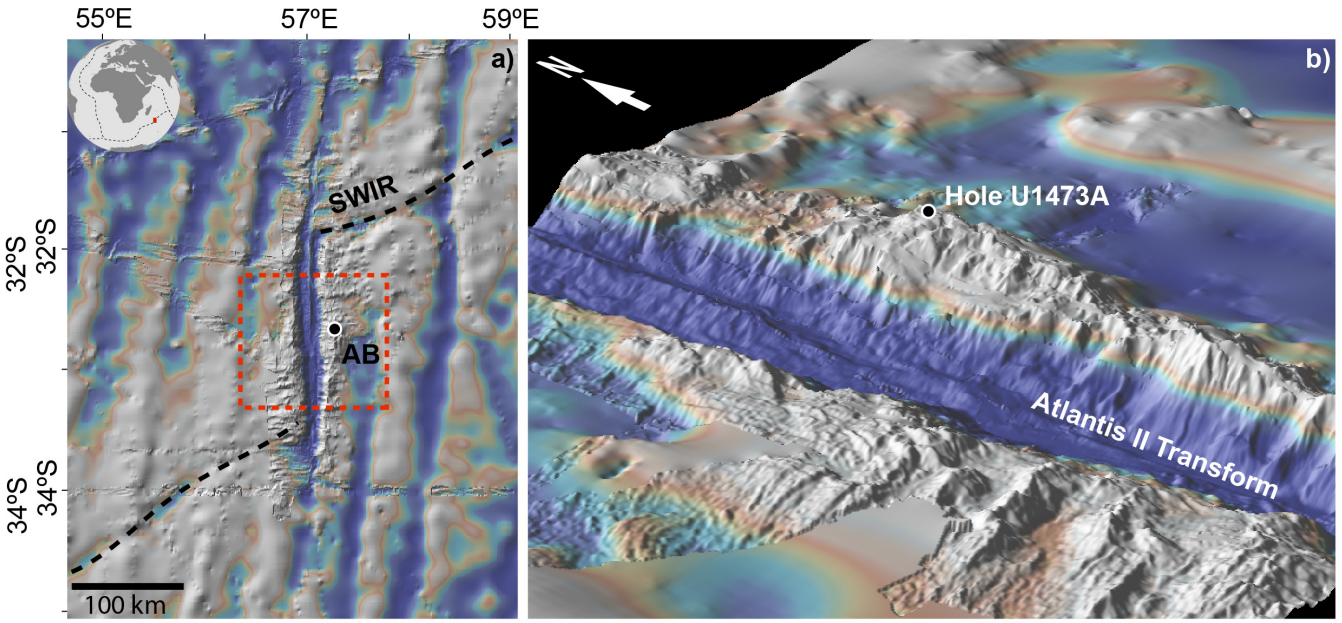
Methods

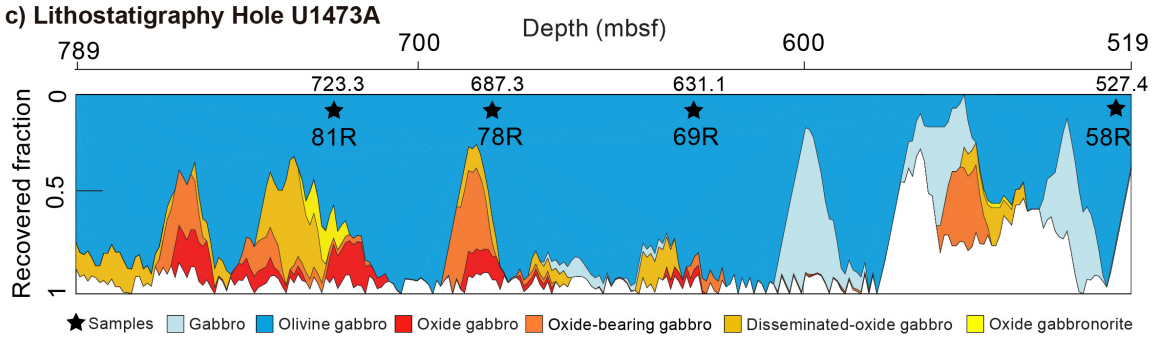

Strain localization in the lower oceanic crust
Optical Microscopy SEM
Electron Microprobe
EBSD
Thermodynamic modelling

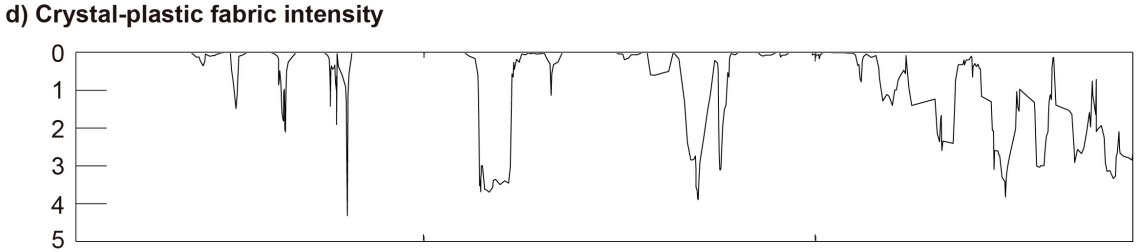
The Atlantis Bank and hole U1473A

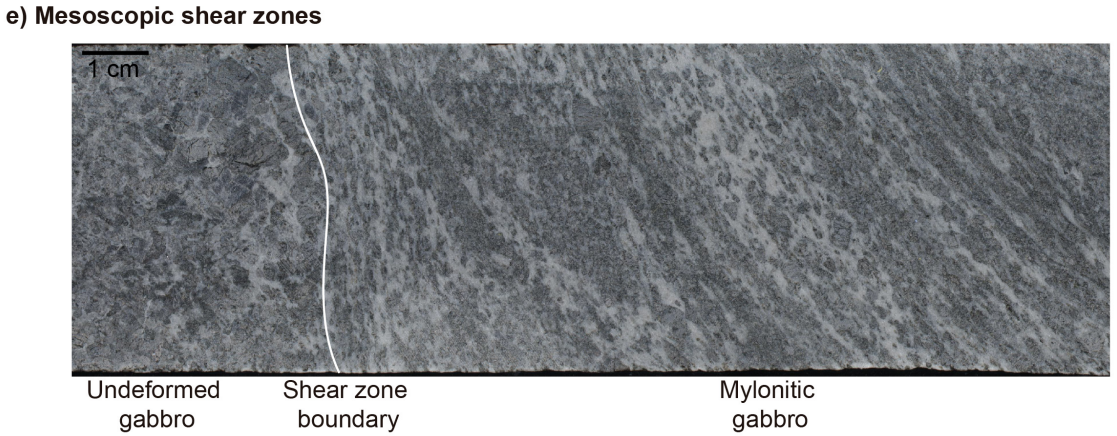
Figure 1

a) Location of the Atlantis Bank.
b) Location of hole U1473A at the edge of the Atlantis II Transform fault







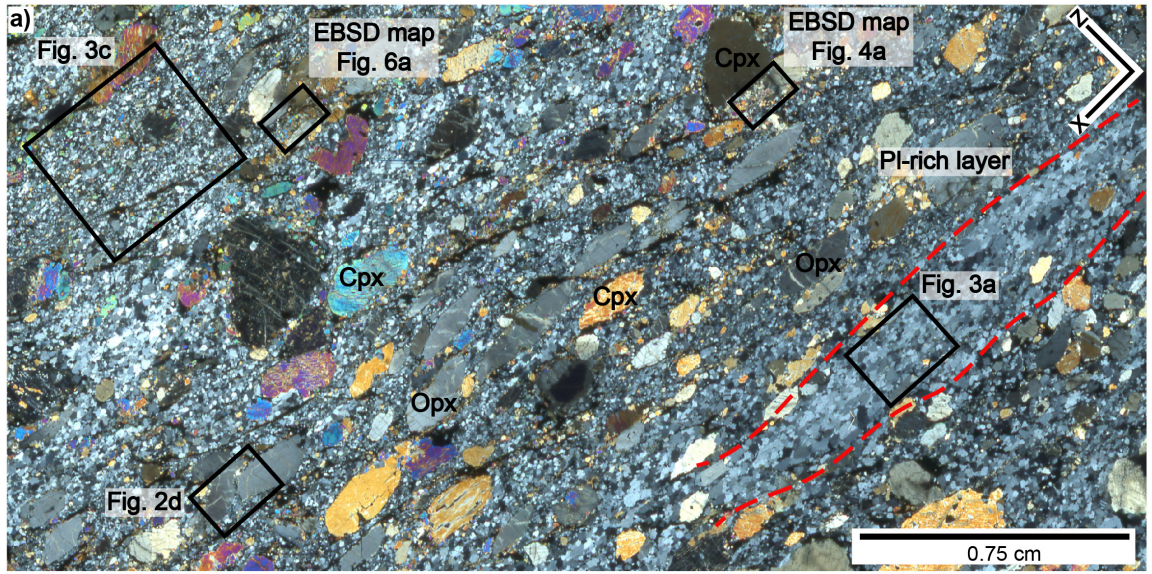


(e) Representative mesoscopic shear zone in abrupt contact with undeformed gabbro.

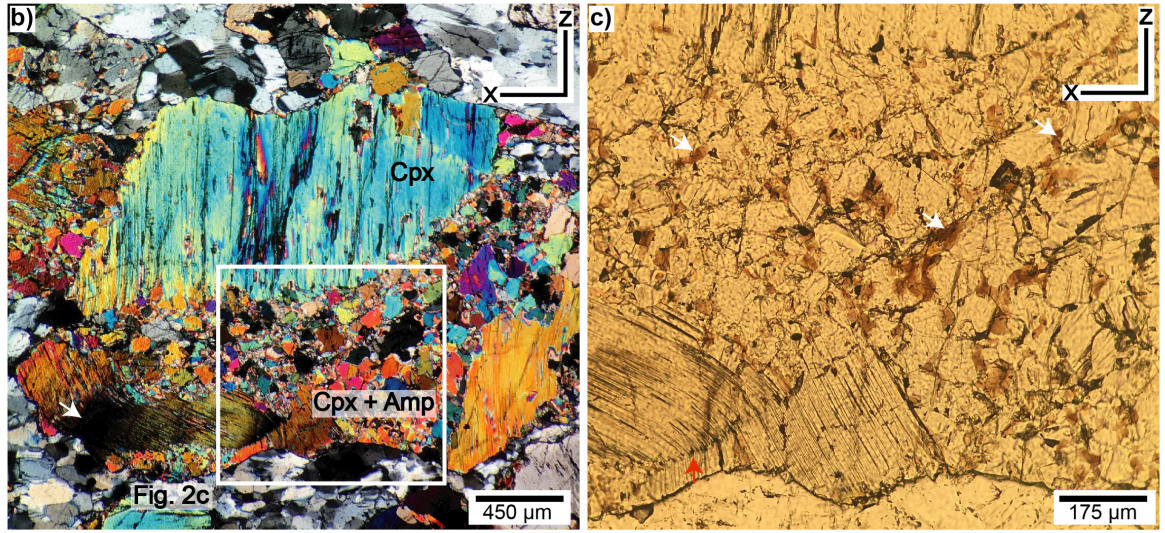
Representative deformation microstructures

Figure 2

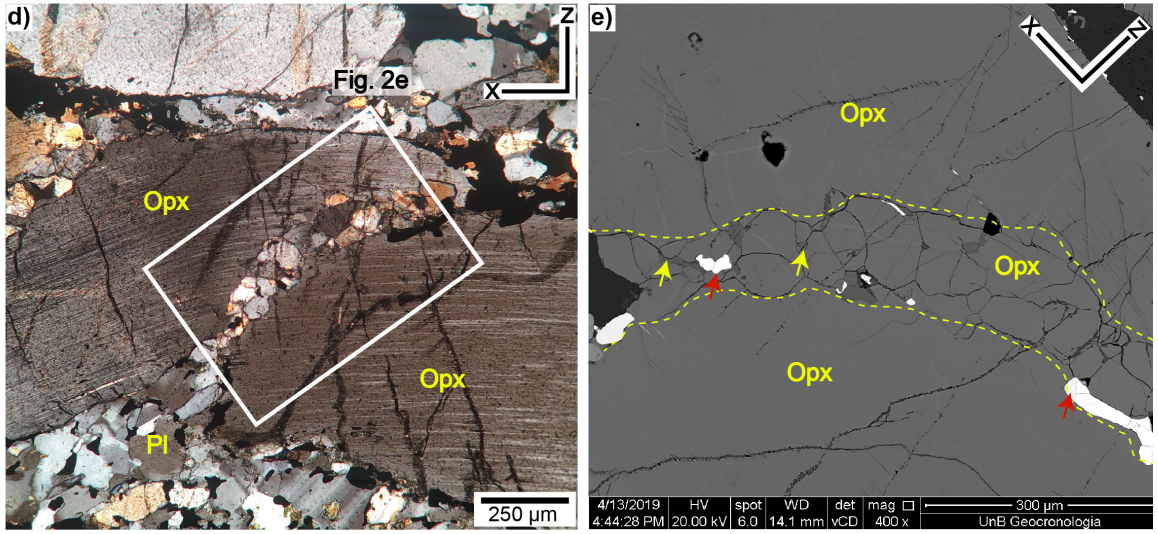
a) Mylonitic foliation defined by alternating bands of plagioclase-rich layers and the polyphase matrix



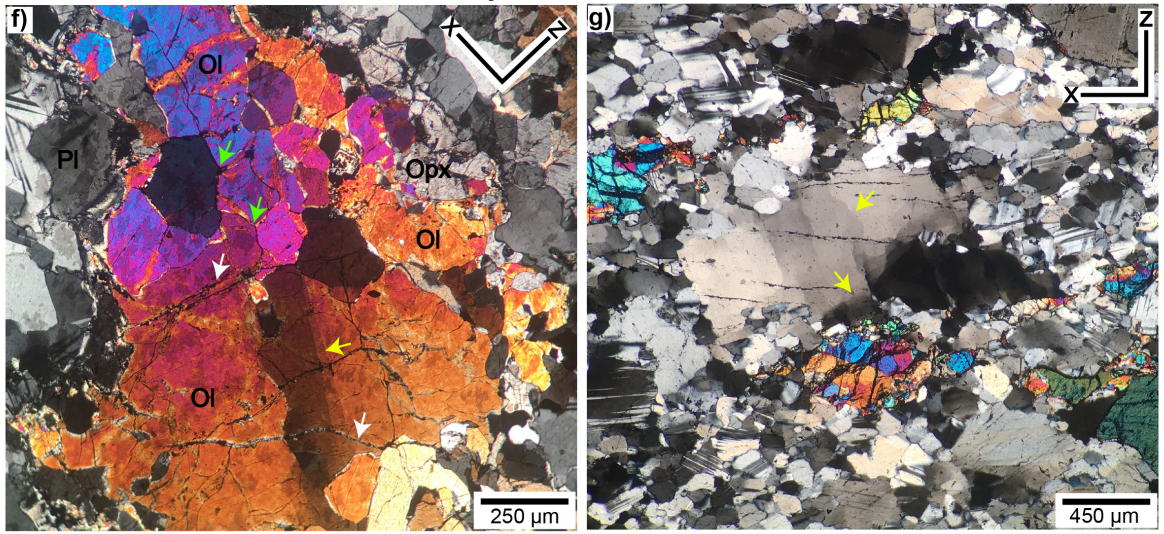
b) and c) Intracrystalline plasticity in Cpx clasts and amphibole at the boundaries of recrystallized Cpx grains



d) and e) Healed microfractures in Opx clasts



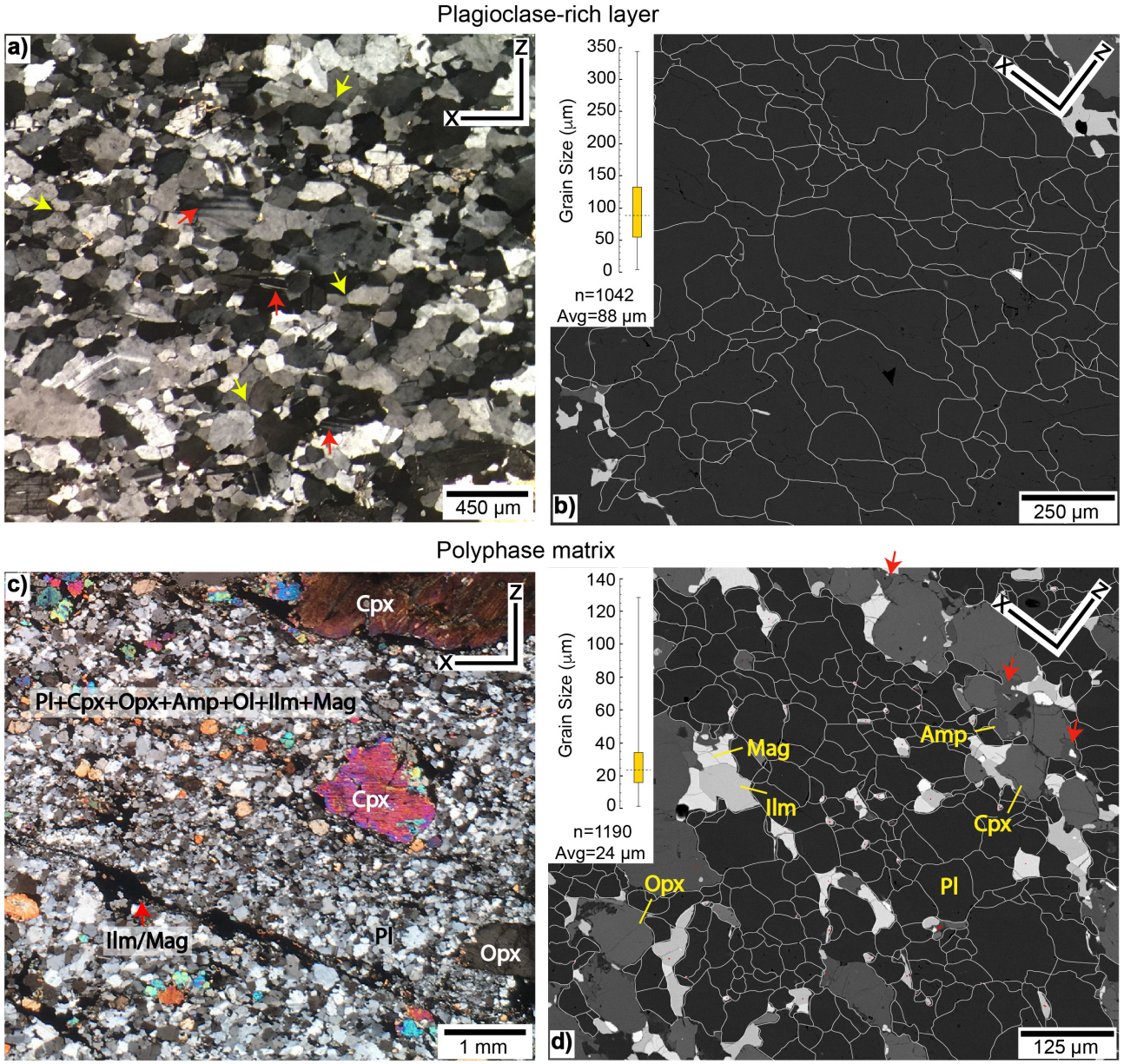
f) and g) Intracrystalline plasticity in Ol and Pl clasts. Grain size reduction by SGR



Representative deformation microstructures

Figure 3

Plagioclase grain-size analysis of the plagioclase-rich (a) and (b), and the polyphase matrix (c) and (d)



d) Red arrows are amphibole grains at pressure shadows of pyroxene grains.

EBSD-derived analysis

Intracrystalline plasticity in Cpx clast and recrystallised grains from inset box in Figure 2a

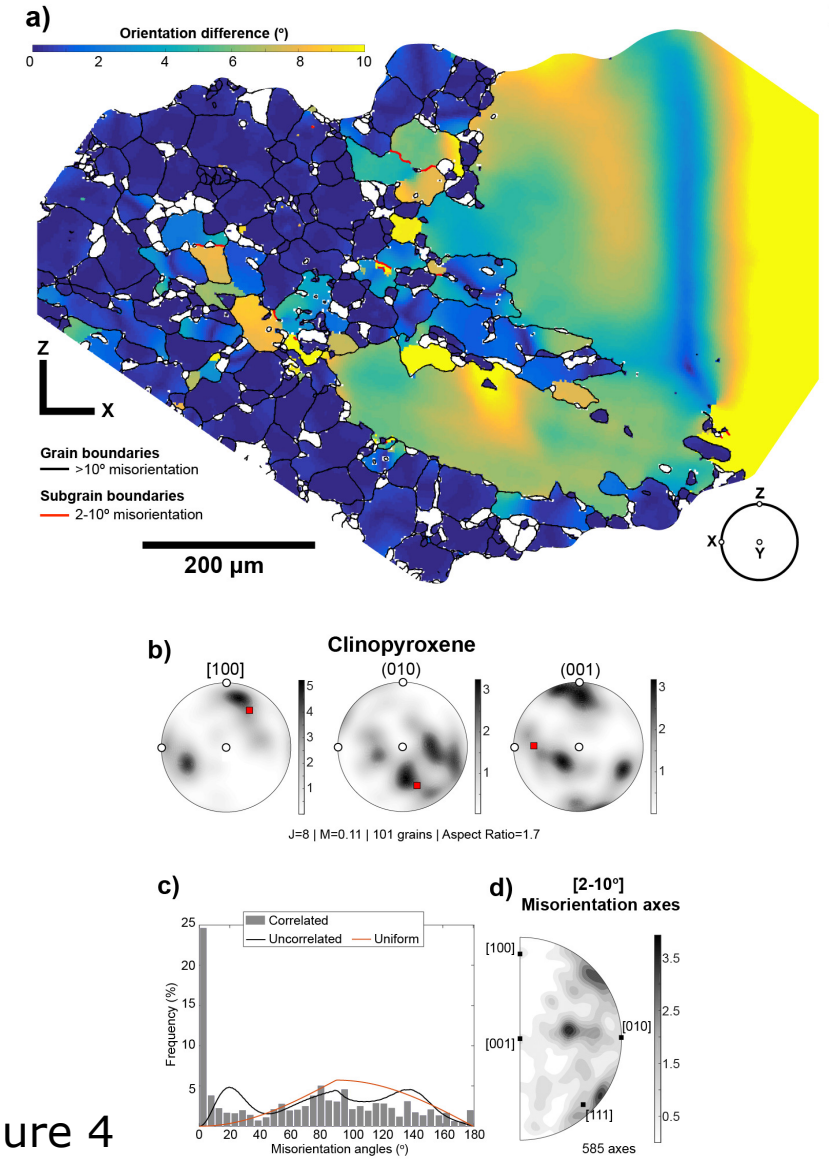


Figure 4

Dislocation creep in plagioclase-rich layers

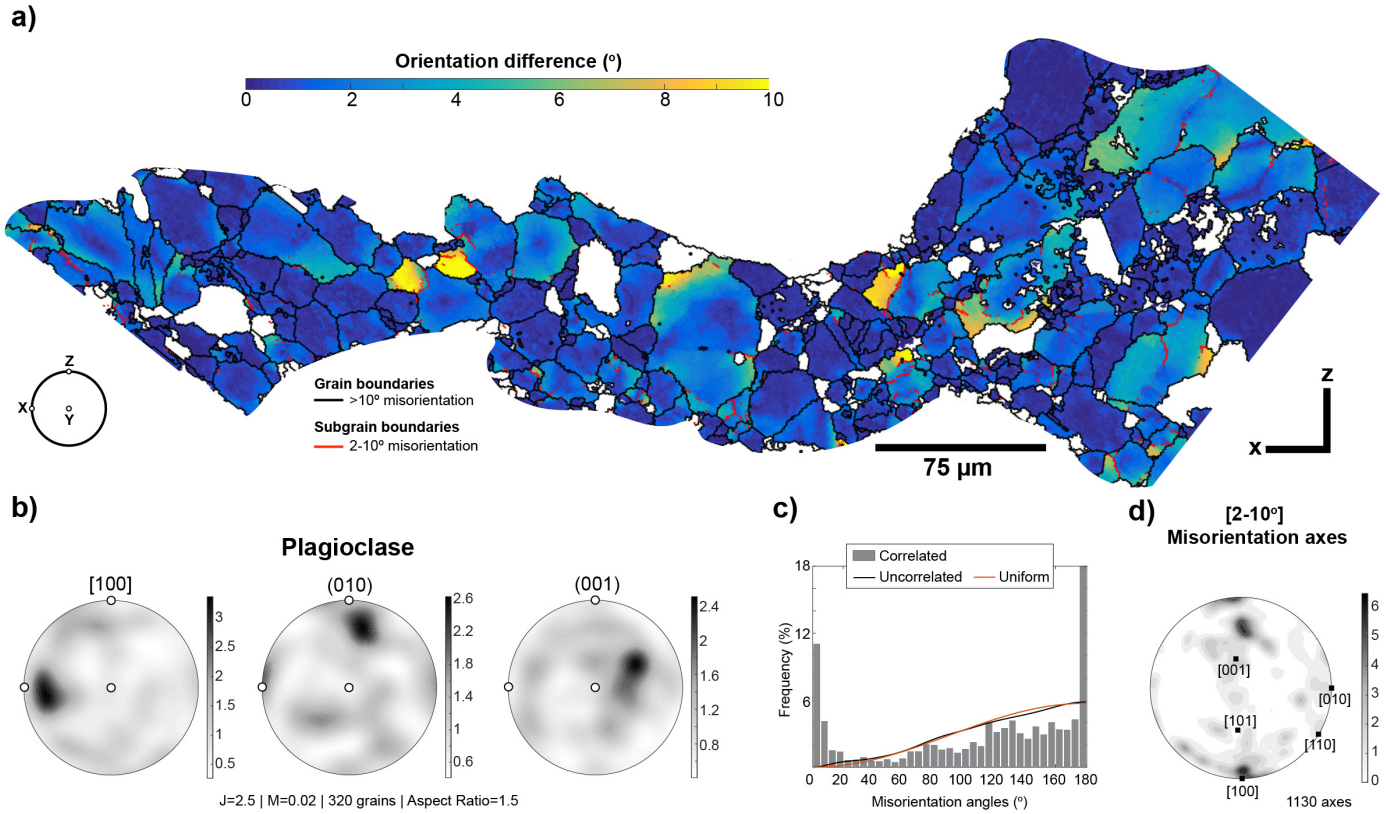


Figure 5

EBSD-derived analysis

EBSD analysis of the fine-grained and strain free polyphase matrix from the selected area in Fig. 2a.

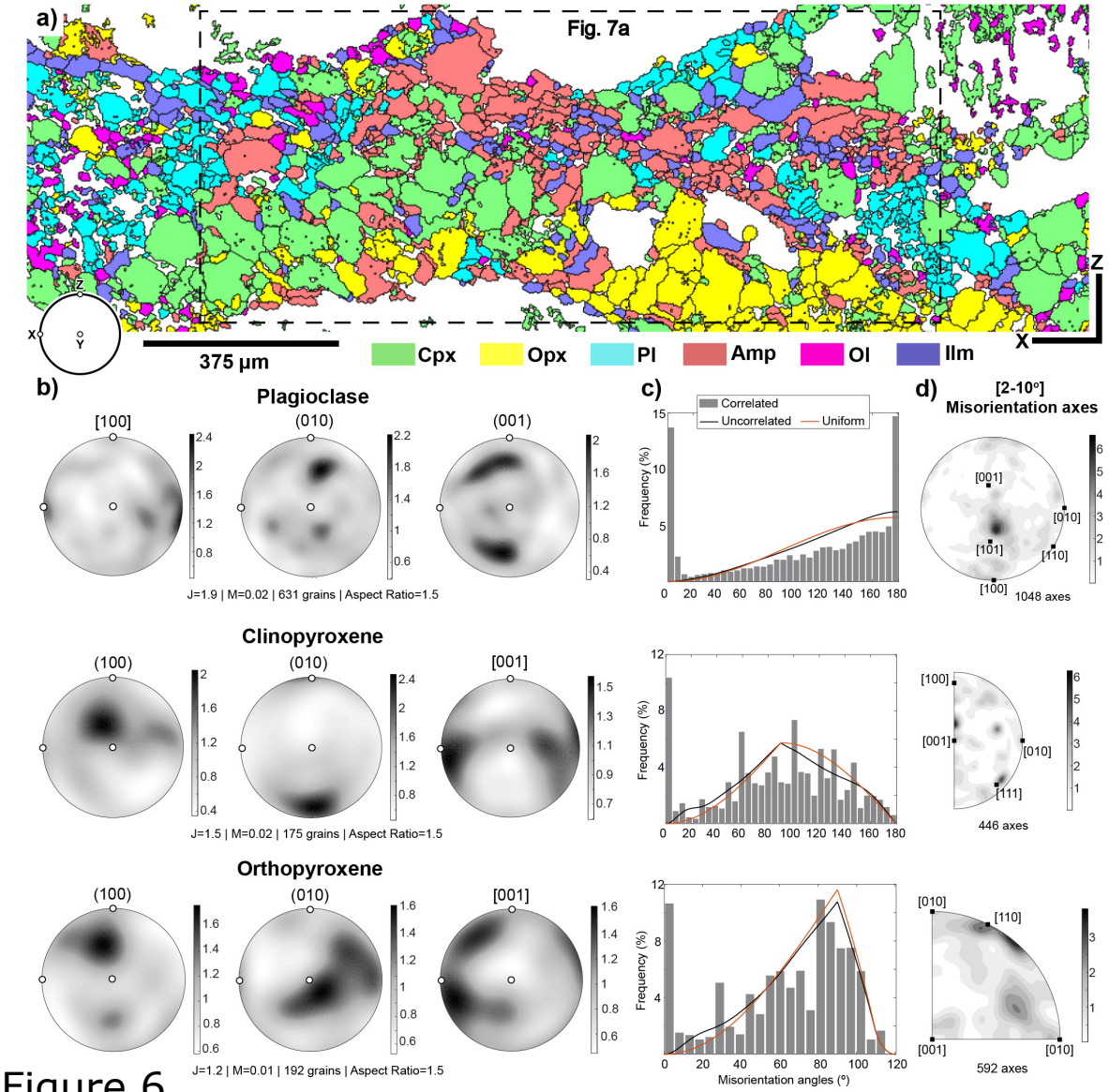


Figure 6

Intragranular misorientation map showing that amphibole grains are virtually free of dislocations. Dashed are from Fig. 6a

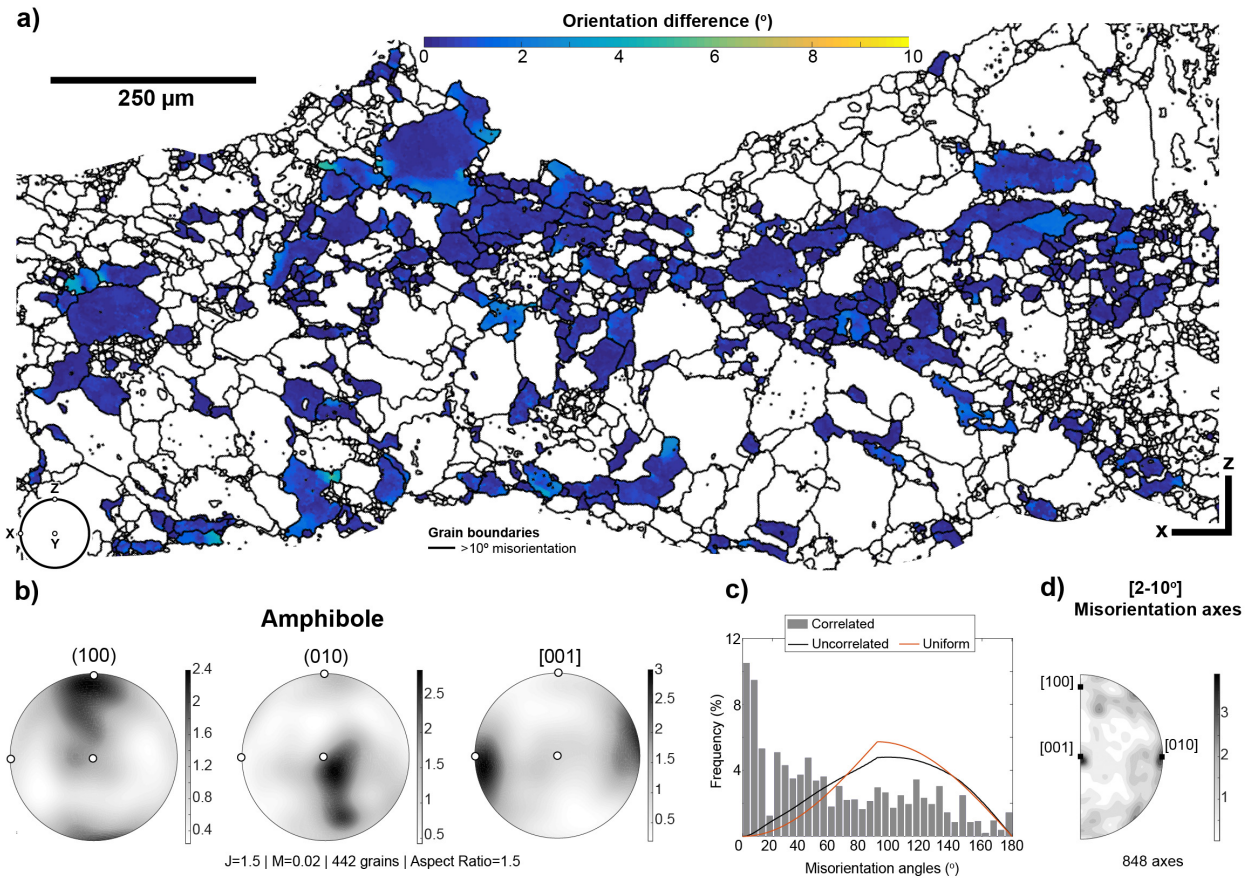
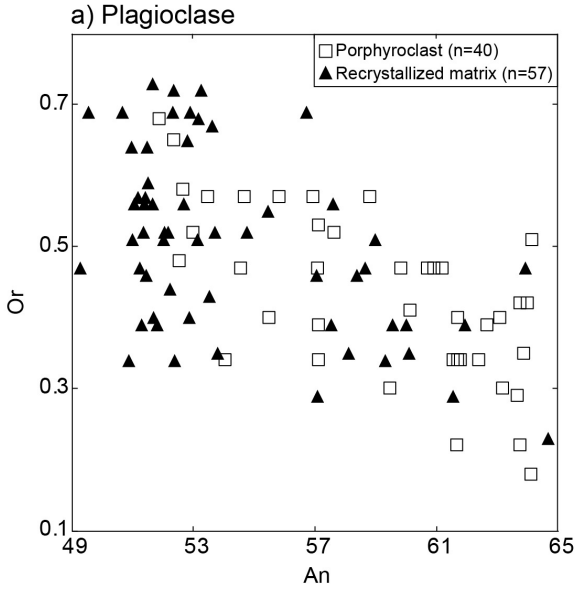
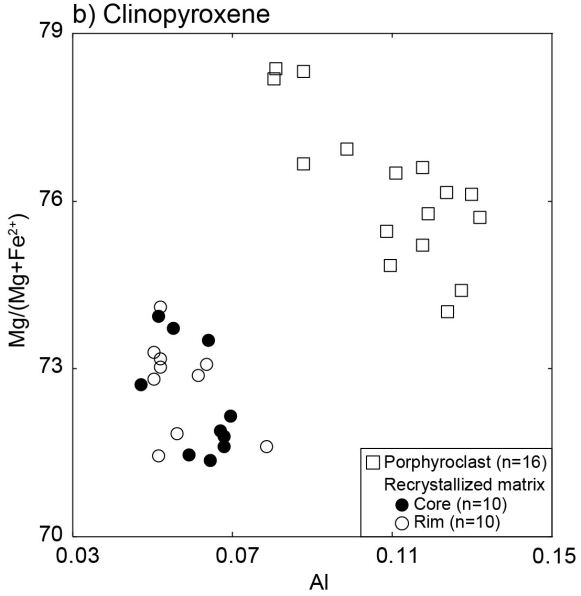


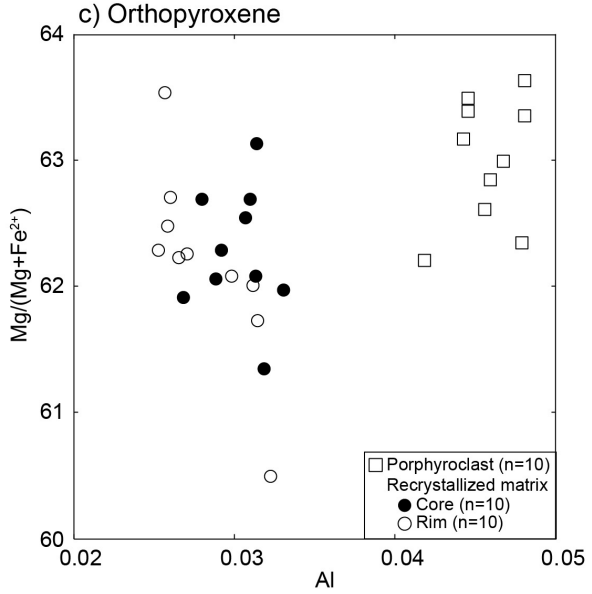
Figure 7

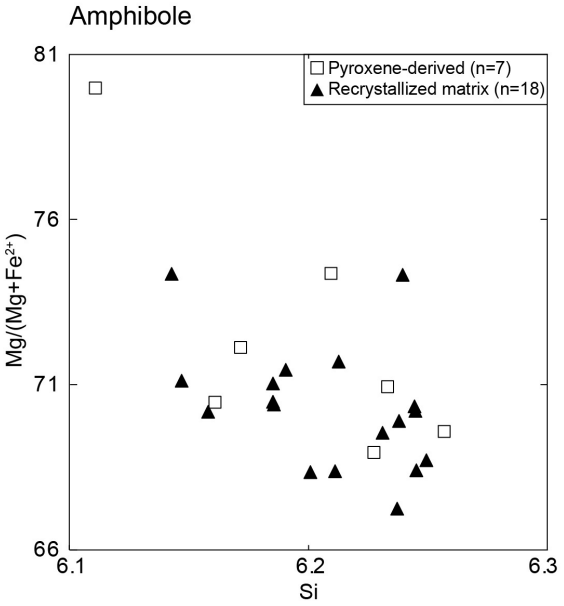
Microprobe-derived analysis

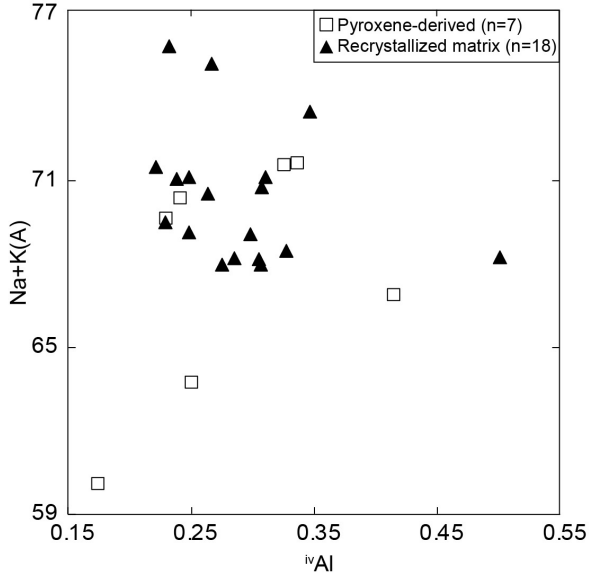
(a) The An content in porphyroclasts and recrystallised grains of plagioclase overlaps. (b) and (c) The #Mg and Al content in recrystallised grains of clinopyroxene and orthopyroxene is lower than in the porphyroclasts.



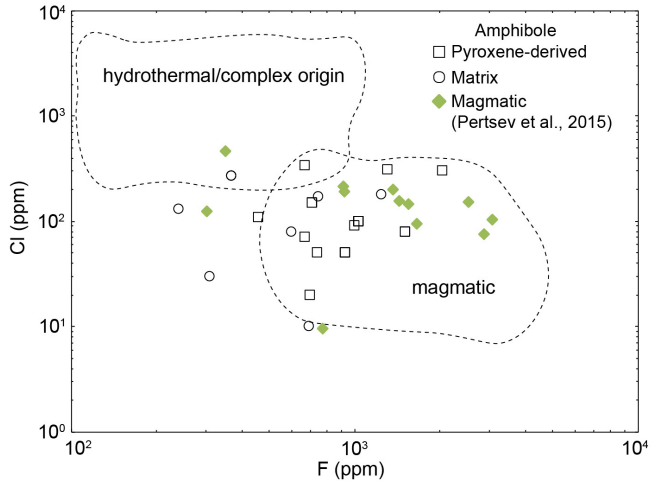






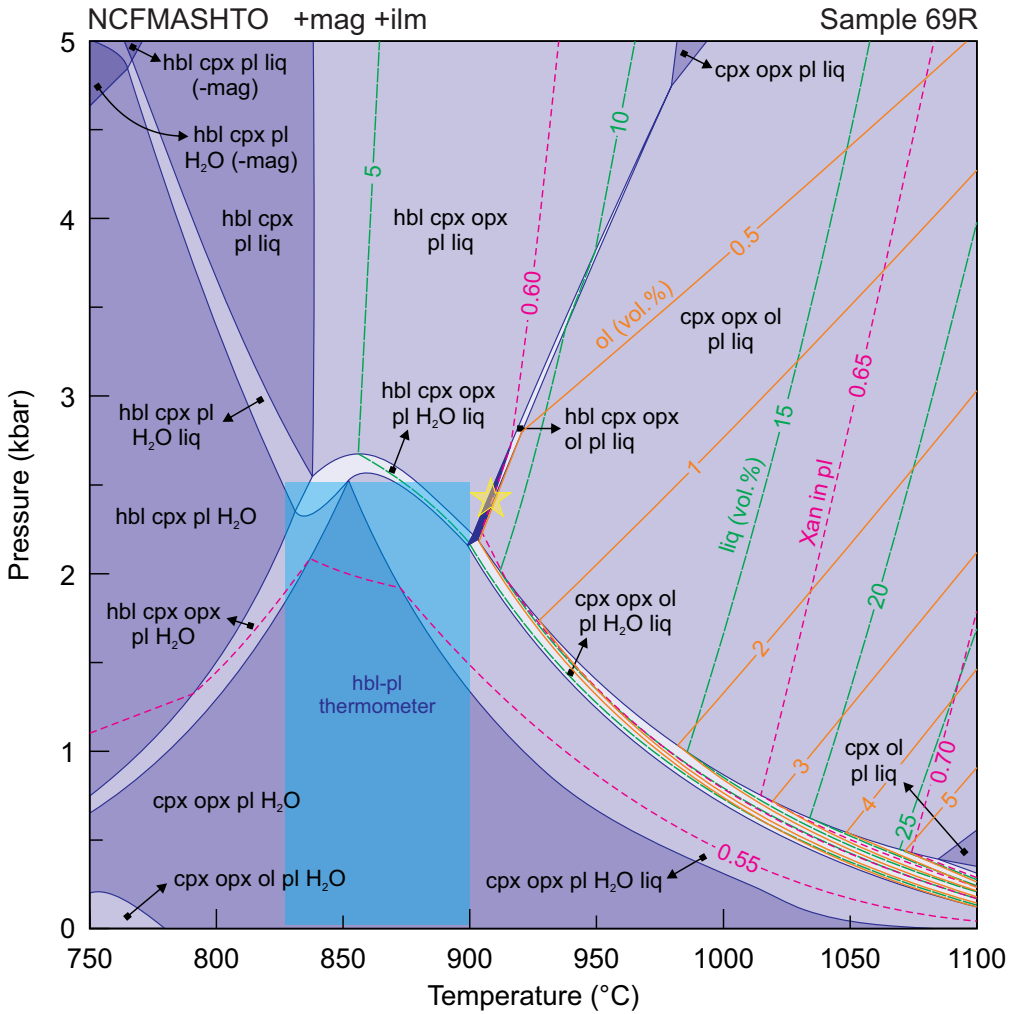


The values of F and Cl in amphibole are interpreted as formed from interaction of magmatic fluids and the rock

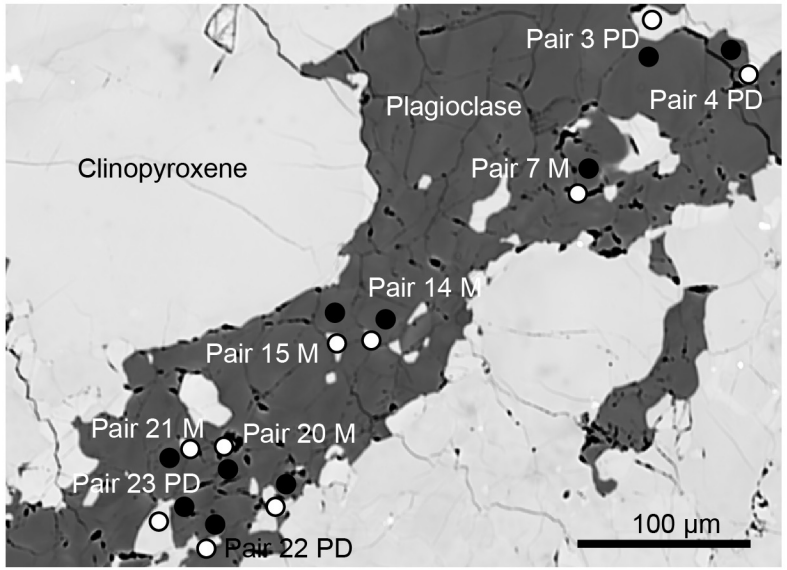


Thermodynamic analysis

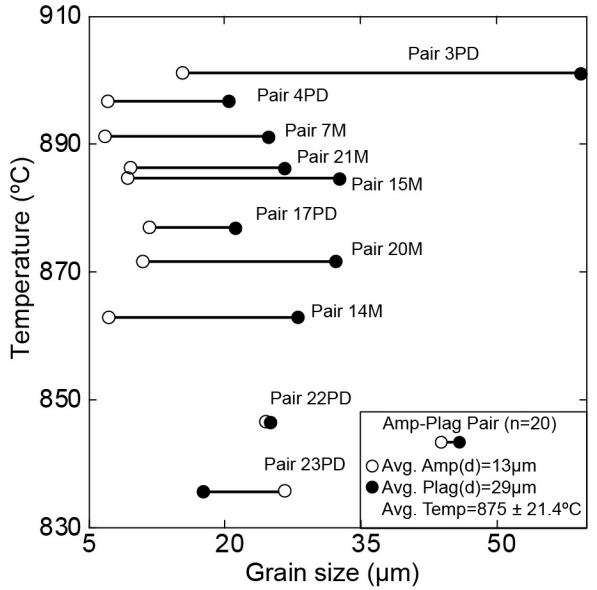
Estimated conditions of deformation are approximately 900–920 °C and 2.2–2.7 kbar, indicated by the dark blue field. The light blue field represents temperature ranges estimated using Holland and Blundy (1994) hornblende-plagioclase thermometer.



A) Plagioclase-amphibole geothermometry



B) Plagioclase and amphibole equilibrium temperature



Final remarks

- Strain accommodated in shear zones by brittle and plastic deformation mechanisms in the presence of melt at ~ 900–920 °C and 2.2–2.7 kbar;

- Grain size reduction is mainly achieved by subgrain rotation recrystallization;

- Plagioclase-rich layers deform by dislocation creep with slip along the (010)[100];

- Strain was localized in the polyphase matrix by oriented-grain growth during diffusion-assisted grain boundary sliding;

- Amphibole grew at the expense of pyroxene grains possibly due to in situ melt-consumption and back-reaction during shearing and exhumation of the crust, further decreasing the grain size of the aggregate and enhancing phase mixing;

- We highlight the role of fluids in promoting reaction-softening that contributes to the development of fine-grained shear zones in otherwise dry gabbroic rock which exerts a significant control on the overall rheological behaviour of the lower oceanic crust.