Eclogitization kinetics of continental granulites

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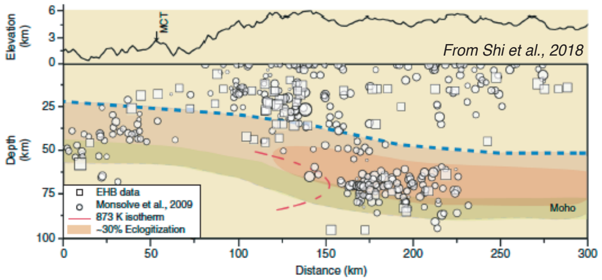
Motivation

Eclogitization concommitant with deformation of crustal rocks has been proposed for explaining seismicity at depth in convergence zones (Austrheim & Boundy., 1994, Shi et al., 2018, Incel et al., 2019).



But what are the different mineral phases involved, the location where they start to nucleate and how reaction propagates in and between the grains ?

What are the caracteristics of the eclogitization of granulites that have been metastably preserved to high pressures ? Can we quantify the kinetics of this (these) metamorphic reaction(s) ?

Methods

- 10µ - 20µ powder generated from natural felsic granulite (Holsnoy, Norway). pl: 95 % grt + cpx ± amp ± scp : 5%.
- Piston cylinder static experiments for different time spans, and at different P-T conditions above the reaction(s).
- Deformation experiments in a Griggs-type apparatus equipped with ultrasonic monitoring, performed at the same conditions than static experiments, at different strain rates (e.g. 10^{-5} -10^{-6} s^{-1}).

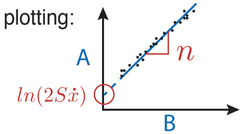
- Grain analysis by EBSD data acquisition and analysis, together with grain segmentation by B&W thresholding and eye control on BSE images.
- Growth-controlled kinetics quantification when nucleation is fast as in Perrillat et al., 2003:

$$x(t) = 1 - e^{-2S\dot{x}t^{n}}$$

% of product phase ($x(t)$); time (t); growth rate ($\dot{x}$); grain boundary area (S)

$\dot{x}$ and n are determined for constant *P,T* experiments by plotting:

$$\underbrace{ln\left[ln\left(\frac{1}{1-X}\right)\right]}_{A} = ln(2S\dot{x}) + n \cdot \underbrace{ln(t)}_{B}$$

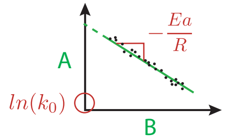


$$\dot{x} = k_0 \cdot T \cdot e^{-\frac{Ea}{RT}} \cdot \left(1 - e^{-\frac{\Delta Gr}{RT}}\right)$$

growth rate constant (k_0); temperature (T); activation energy (Ea); Gibbs free energy of the reaction (ΔGr)

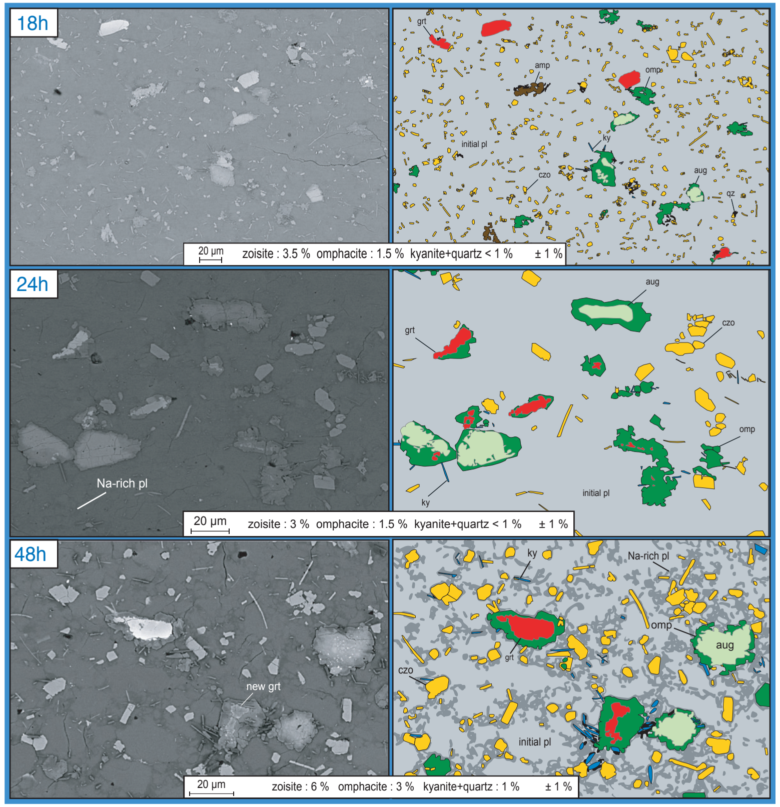
k_0 and Ea are determined for experiments of same duration at different *T* by plotting :

$$\underbrace{ln\left[\frac{\dot{x}}{T\left(1 - e^{-\frac{\Delta Gr}{RT}}\right)}\right]}_{A} = ln(k_0) - \frac{Ea}{R} \cdot \underbrace{\frac{1}{T}}_{B}$$

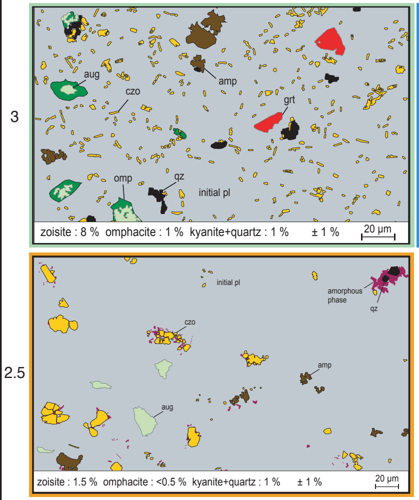


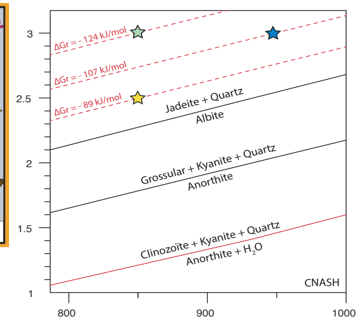
First results : kinetics caracterization

Effect of time at 3 GPa - 950 °C



Effect of pressure and temperature after 24h





Conclusions and outlook

- In static experiments, the Ca-plagioclase system is the more reactive, via plagioclase breakdown and zoisite nucleation (enhanced by distance to the reaction) and subsequent growth (enhanced by temperature). First nuclei of zoisite seem to coalesce in larger grains by a ripening process (Ostwald ripening ?).
- After 48h at 950°C - 3 GPa, jadeite formation from Na-plagioclase breakdown, as seen in previous deformation experiments, is not observed. Only omphacite coronas grow around previous clinopyroxenes and garnets when *P* and *T* are high enough.

- Longer (96-120h) static experiments at 850 & 950°C - 2.5 & 3 GPa are required for kinetic quantification.
- Deformation experiments at 850°C - 2.5 GPa will be performed for comparison with special attention paid on the deformation localization on reaction products

References

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