The cutting edge of fluid inclusion re-equilibration research

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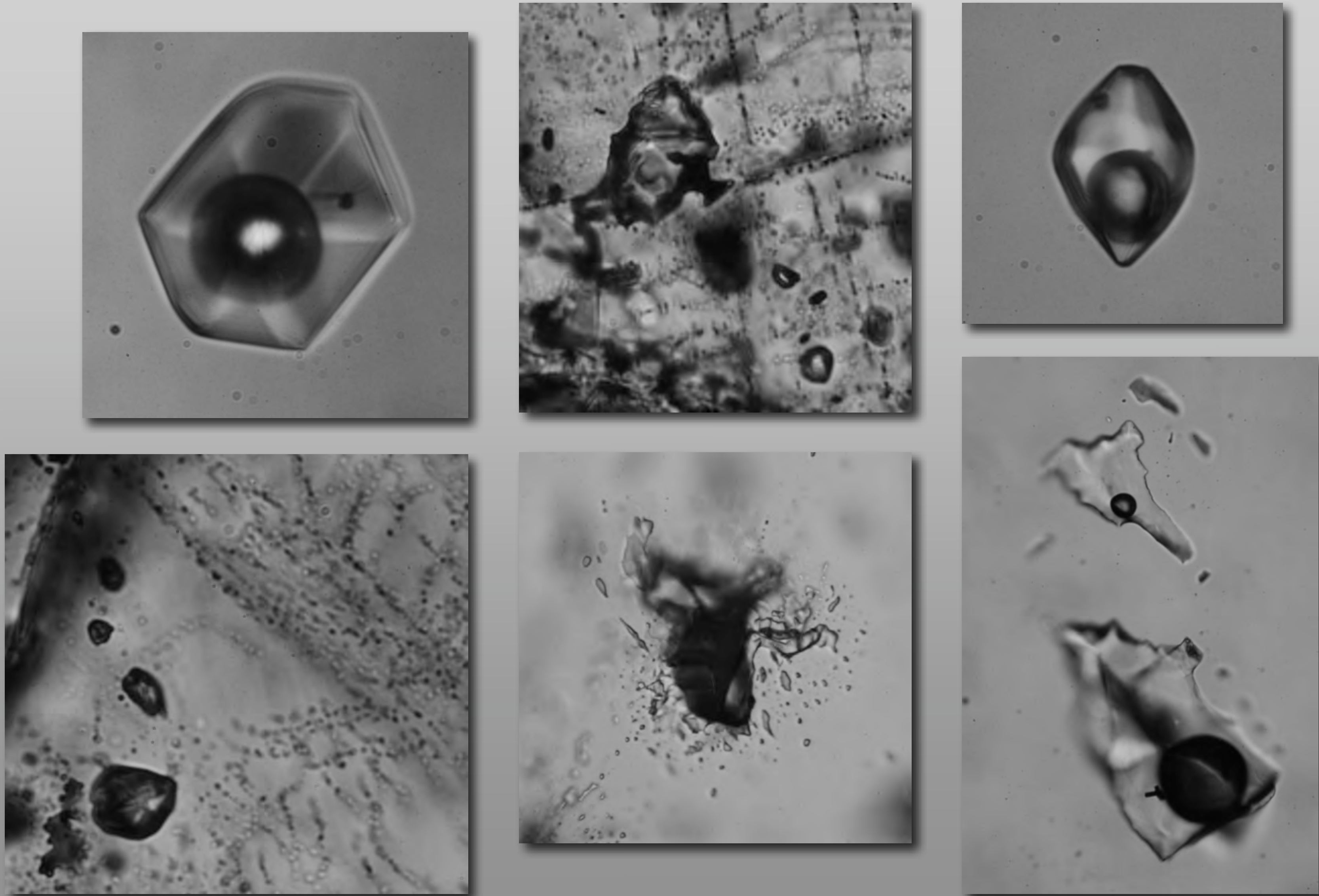
http://fluids.unileoben.ac.at

Was this fluid inclusion modified by natural processes?



Main objective fluid inclusion research (in general) :

estimation of fluid properties (density and composition)
at trapping conditions in the geological past

Requiered knowledge: post-entrapment modifications

(similar to theoretical considerations in isotope geology / geochemistry)

Modified in what?

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Modified in what?

1. shape

2. relative position
3. total volume
4. composition
5. density

Main objective fluid inclusion research (in general) :

estimation of fluid properties (density and composition)
at trapping conditions in the geological past

Required knowledge: post-entrapment modifications

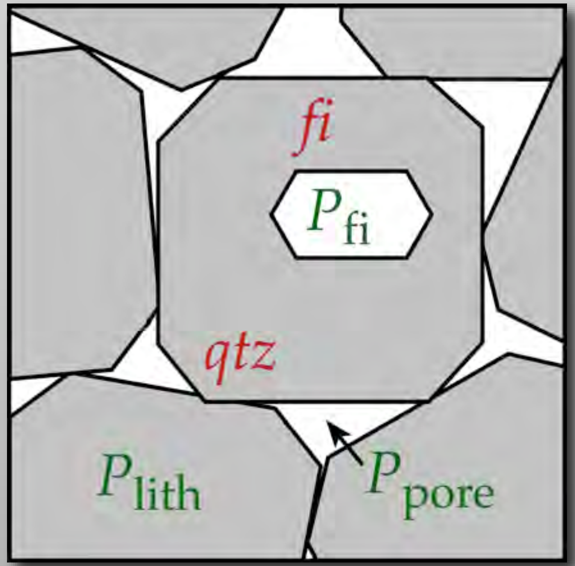
(similar to theoretical considerations in isotope geology / geochemistry)

corresponding processes:

Modified in what?

Modified in	Corresponding processes
1. shape	1. internal recrystallisation (irregularities, „implosion halo“)
2. relative position	2. migration (recrystall.)
3. total volume	3. (partly) decrepitation
4. composition	4. diffusion
5. density	5. diffusion, decrepitation

System definition

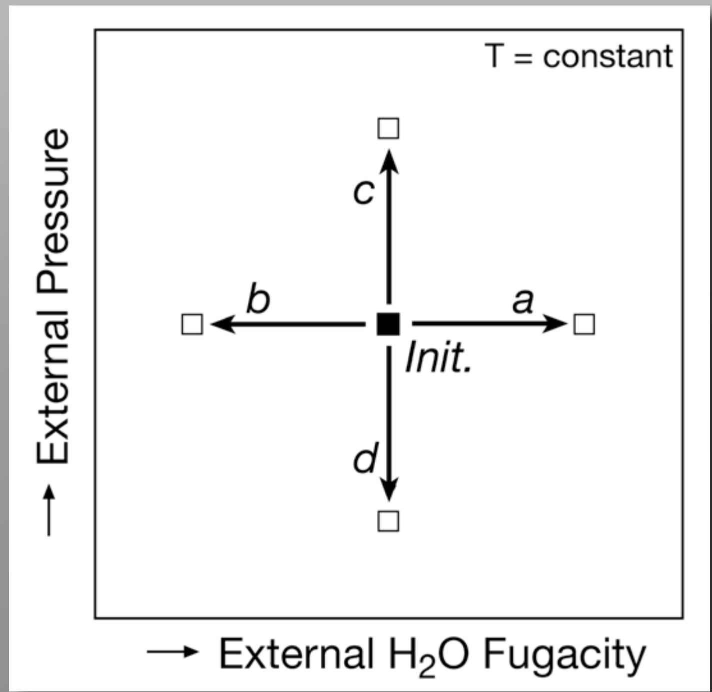


factors that may affect fluid inclusions:

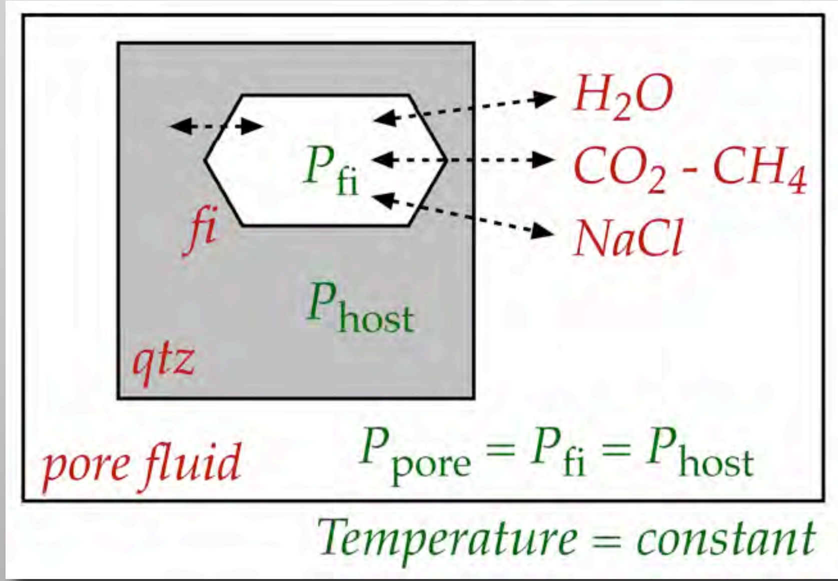
1. fluid component fugacity gradients
2. hydrostatic pressure gradients
3. differential stress (lithostatic): rock deformation

framework conditions:

temperature
total hydrothermal/static pressure



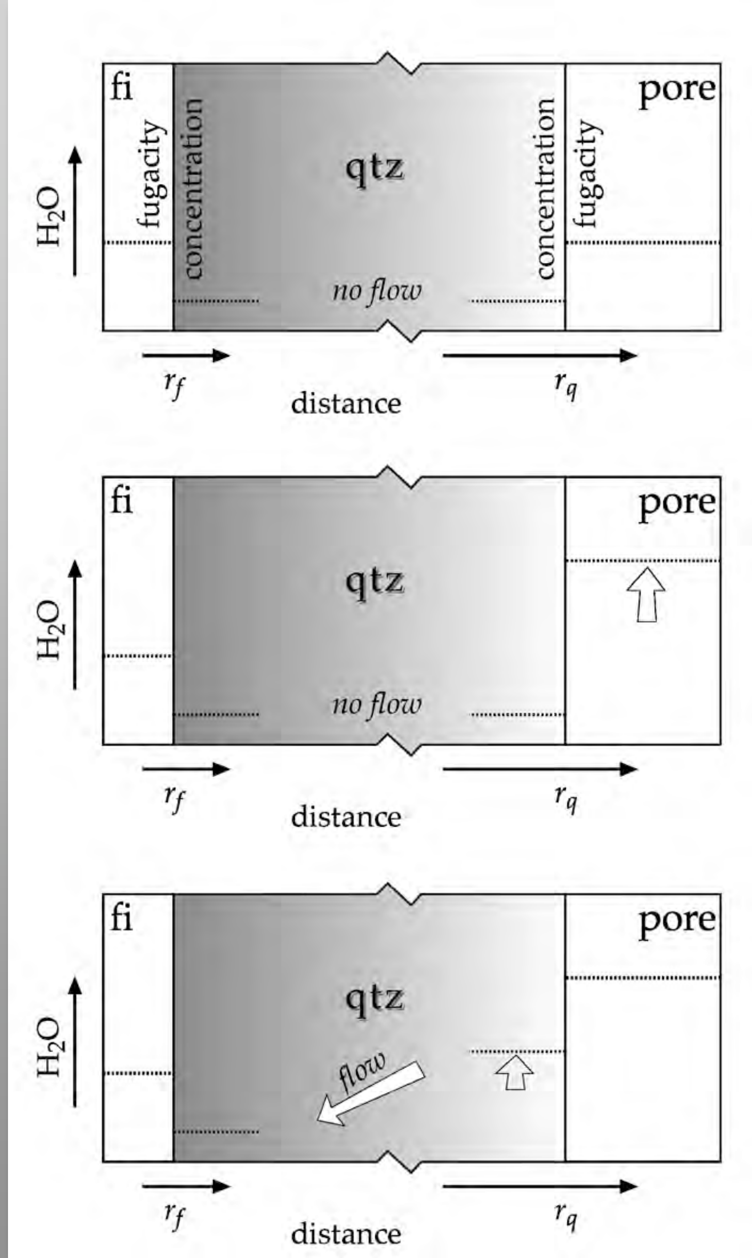
Fugacity Gradients : Diffusion



Experimental work:

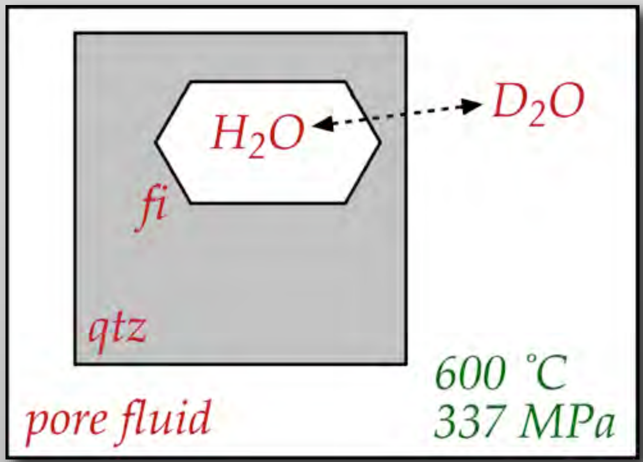
synthetic fluid inclusions
natural fluid inclusions

constant temperature
constant pressure

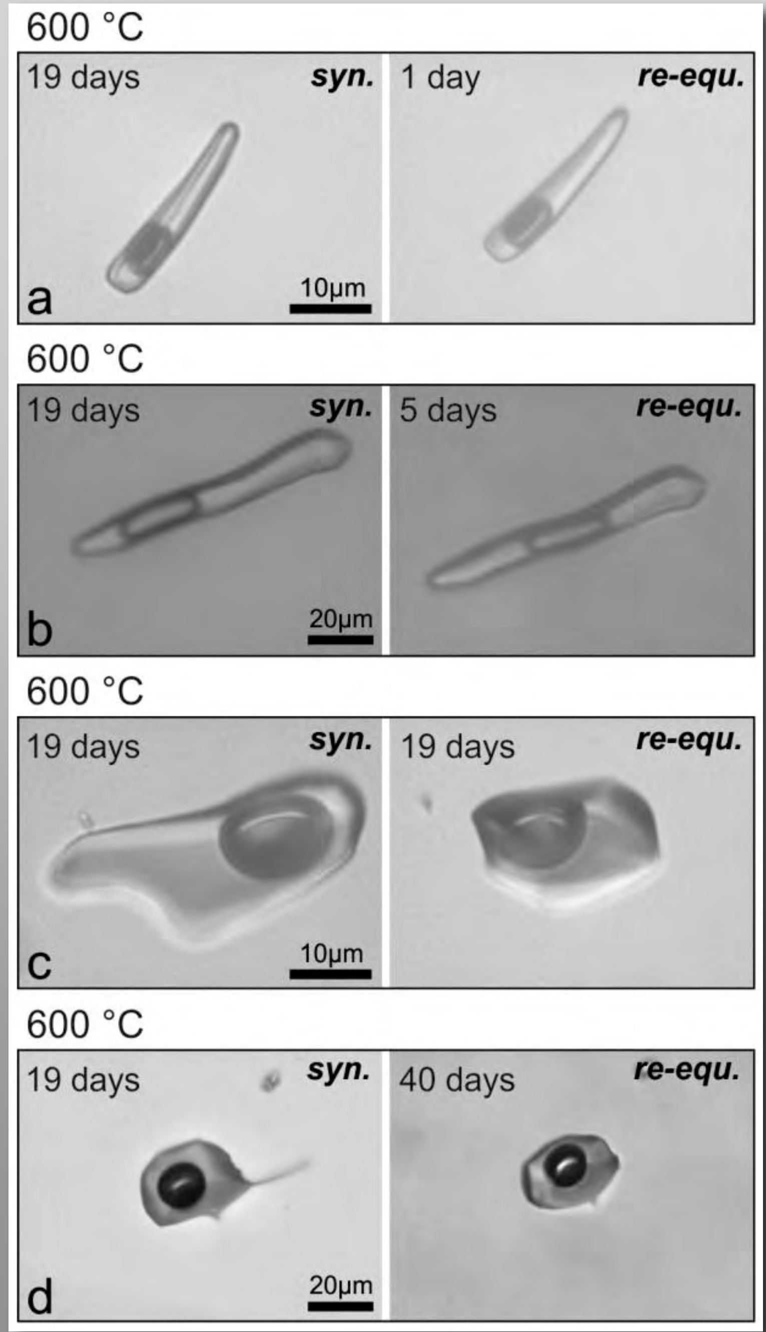


diffusion model Bakker (2009) Lithos, vol.112, 277-288.

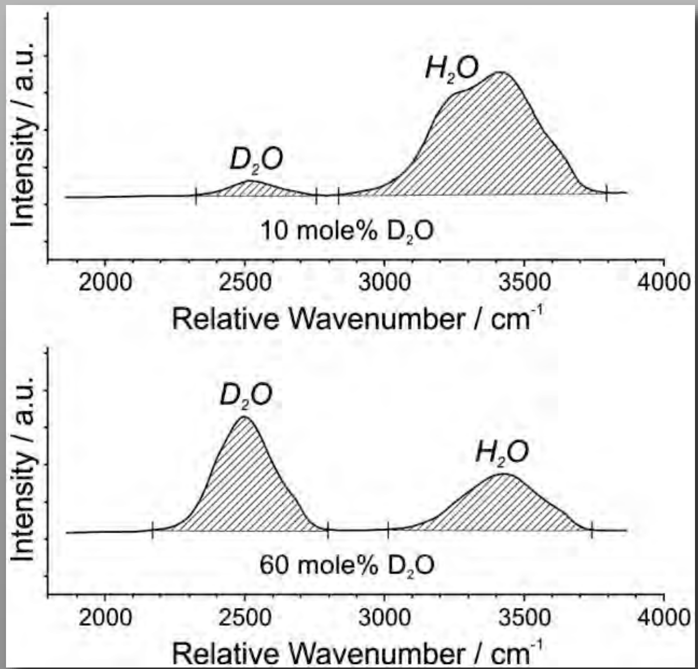
Experiment 1



Synthetic Fluid Inclusions



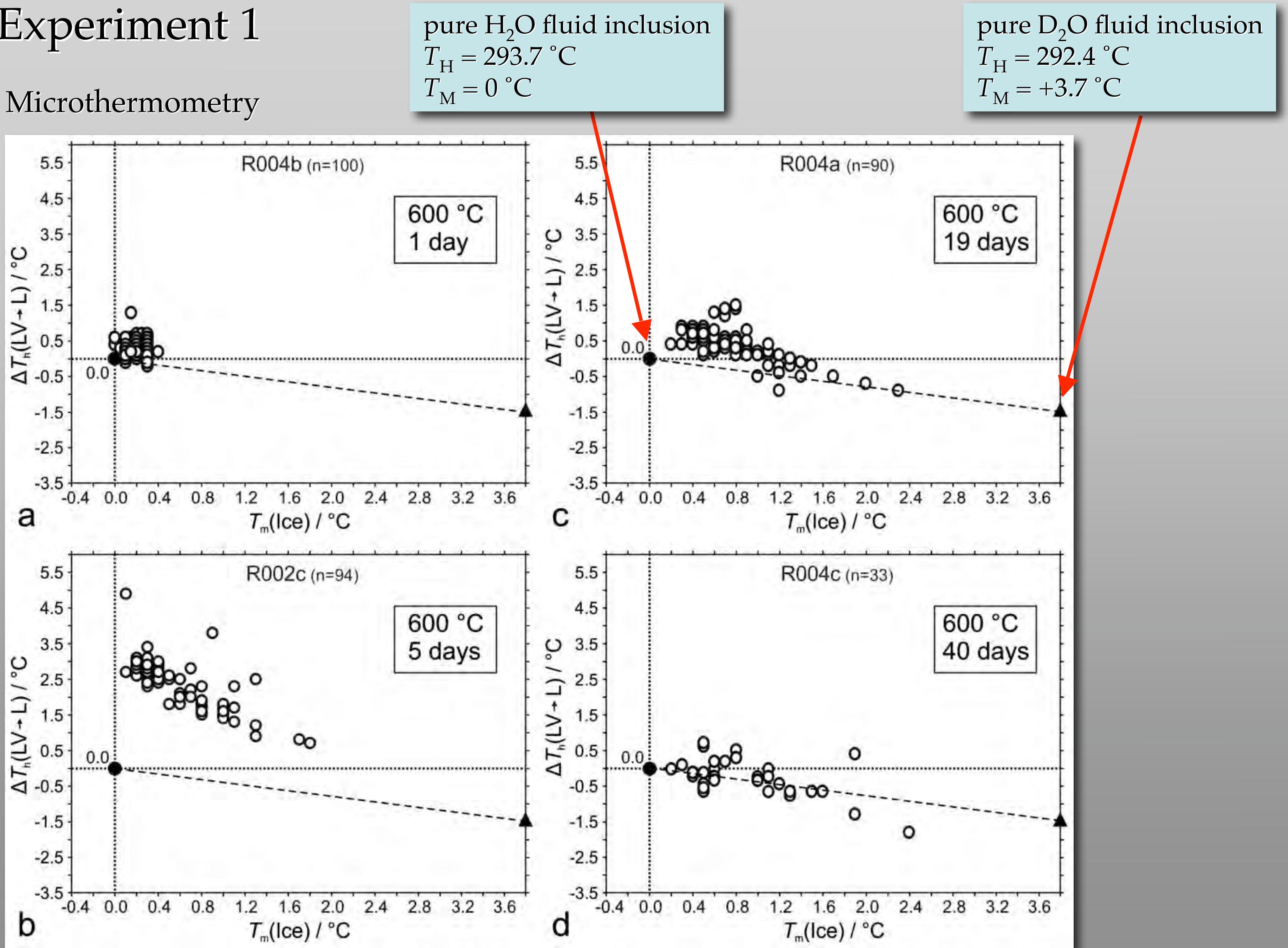
Raman spectroscopy



Doppler, Bakker, Baumgartner (2013) Lithos

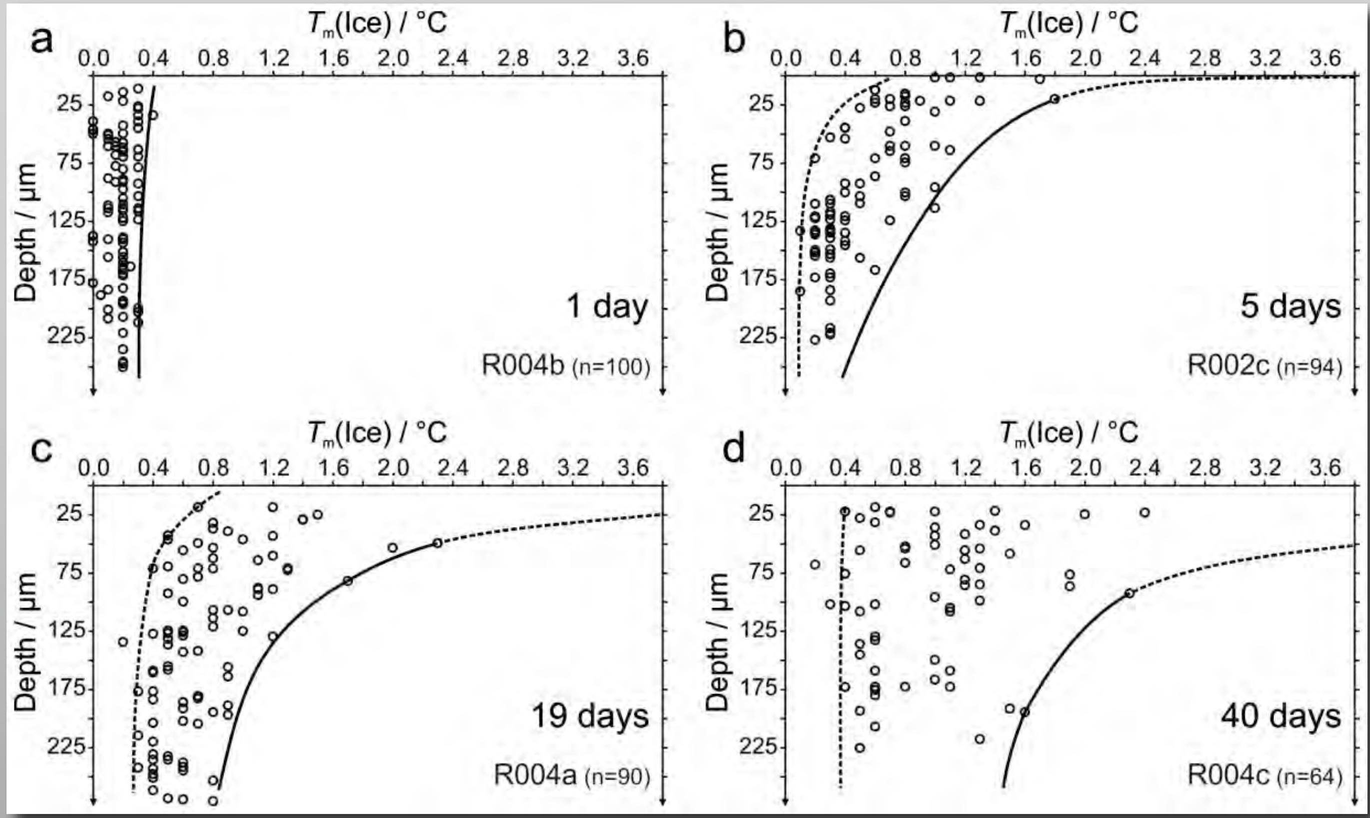
Experiment 1

Microthermometry

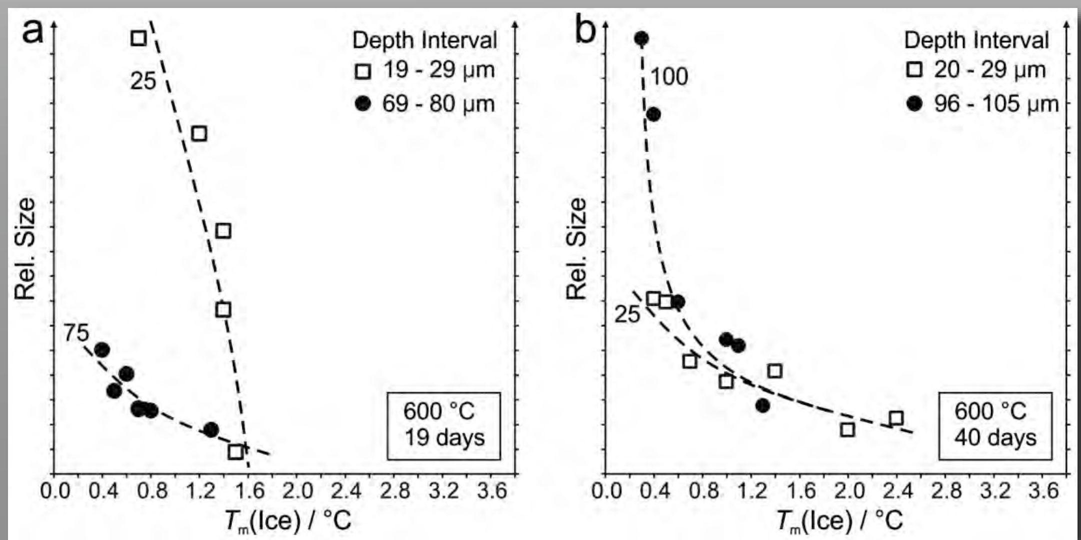


Experiment 1

depth profiles

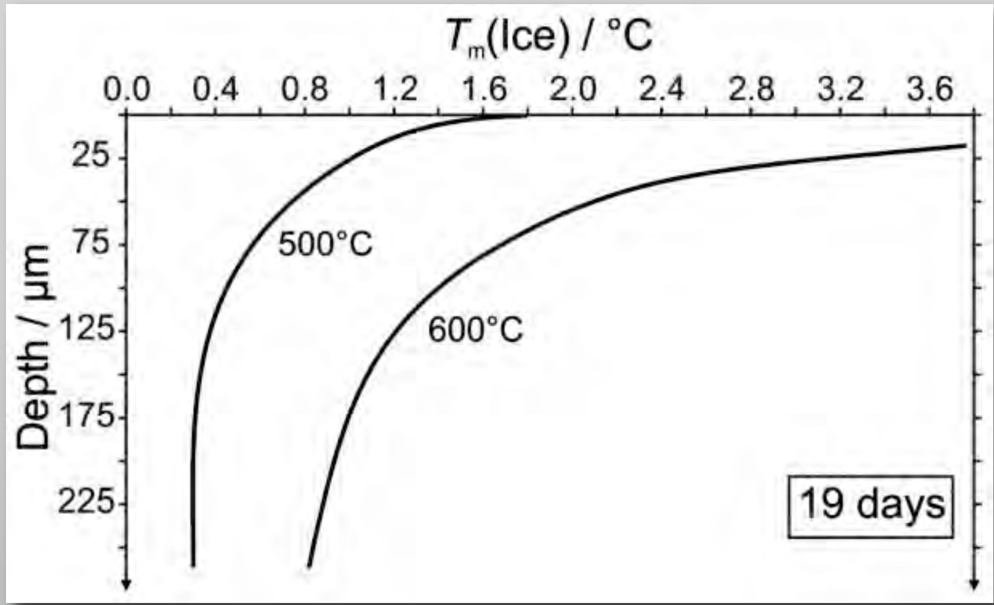


size profiles

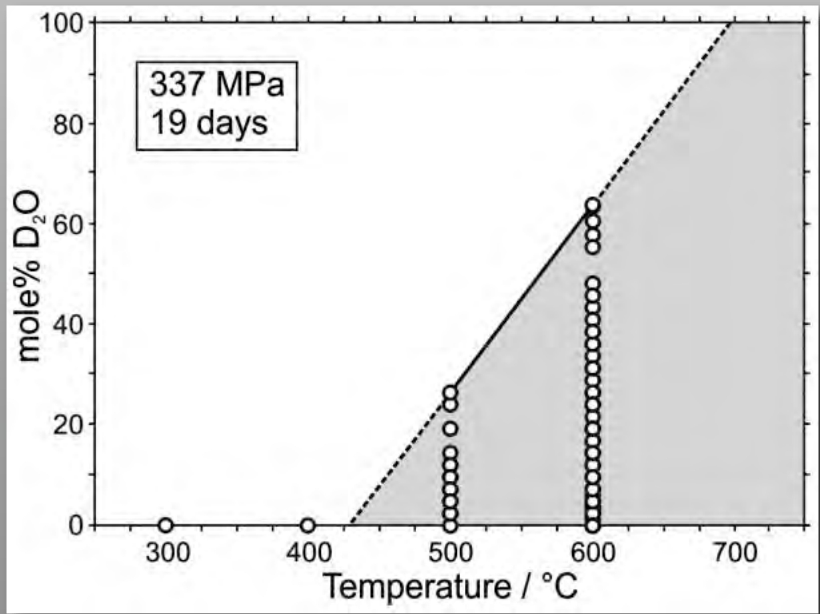


Doppler et al. (2013) Lithos

Experiment 1

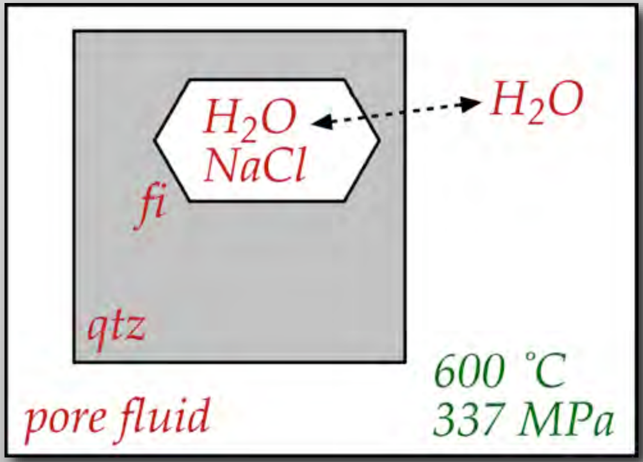


Temperature



Doppler et al. (2013) Lithos

Experiment 2



f(H_2O) inclusion = 156.2 MPa

f(H_2O) pore = 175.4 MPa

expected diffusion process:

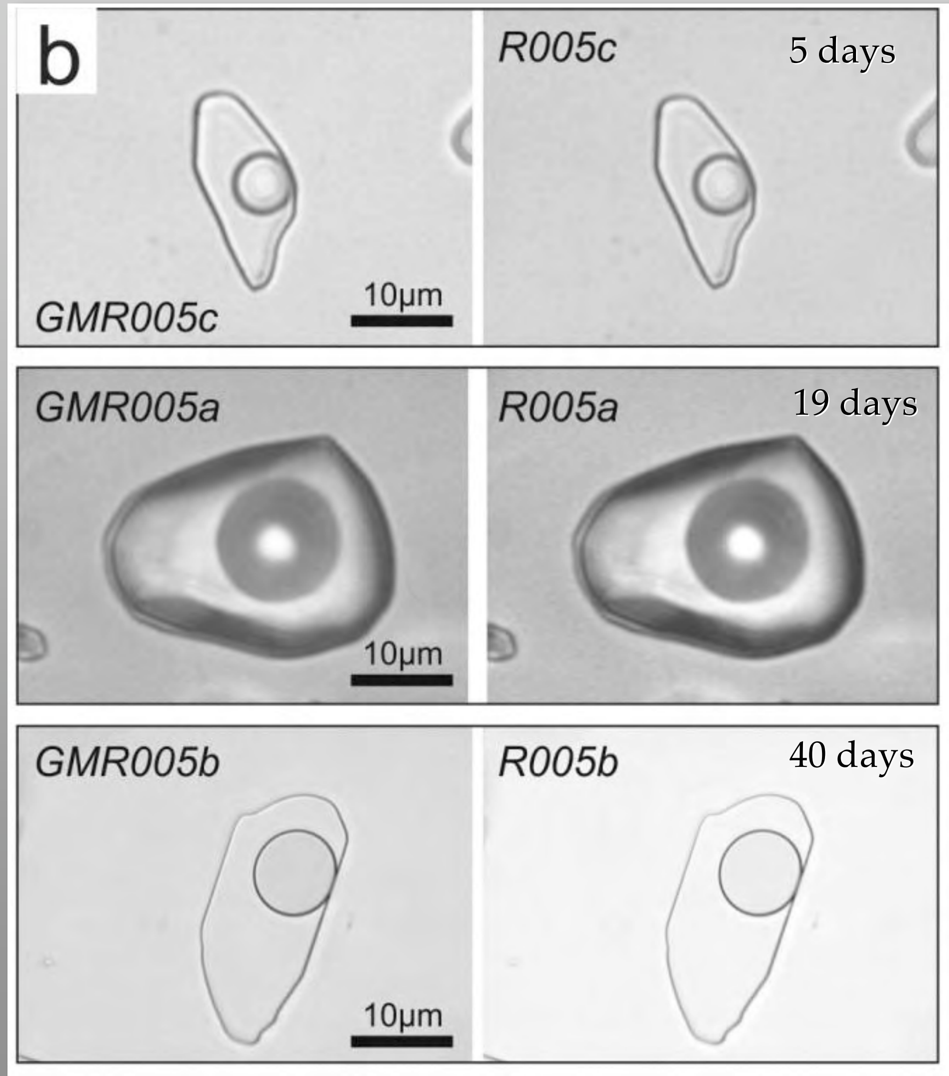
H_2O diffusion into fluid inclusions

↓

side effect: internal pressure increase

Synthetic Fluid Inclusions

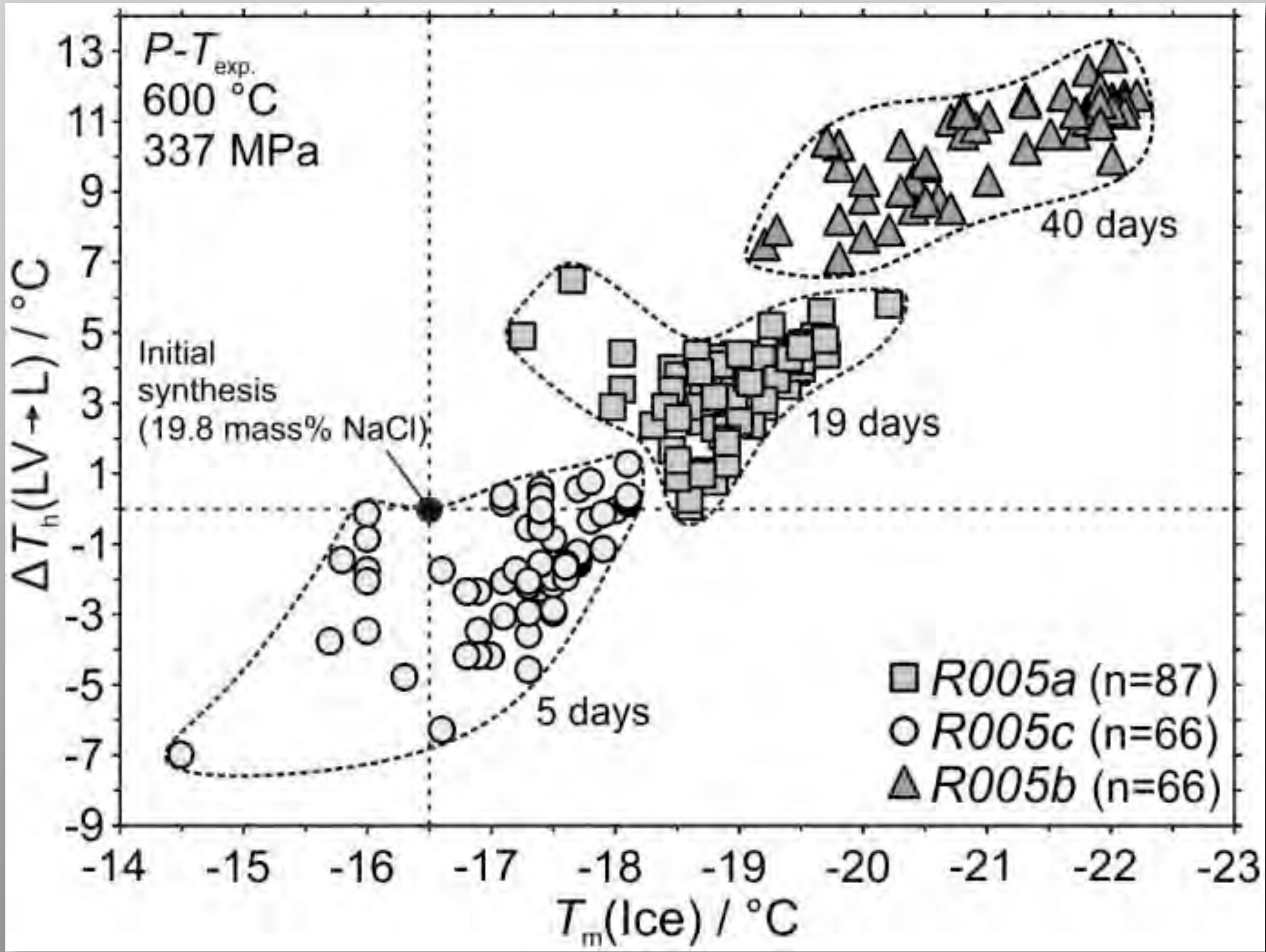
synthesis (19 days) re-equilibration



Doppler, Bakker (in prep.)

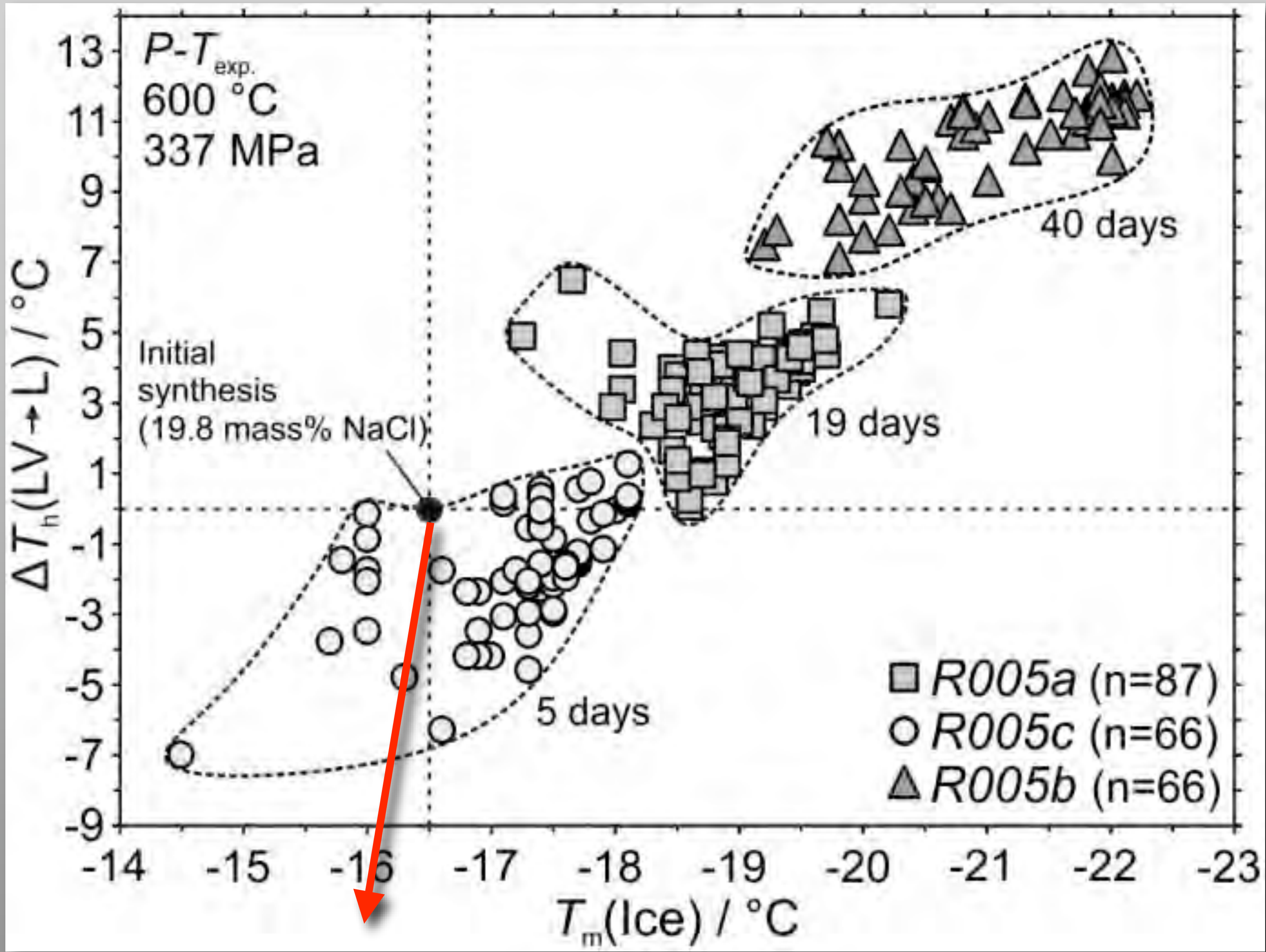
Experiment 2

Microthermometry



Experiment 2

Diffusion model



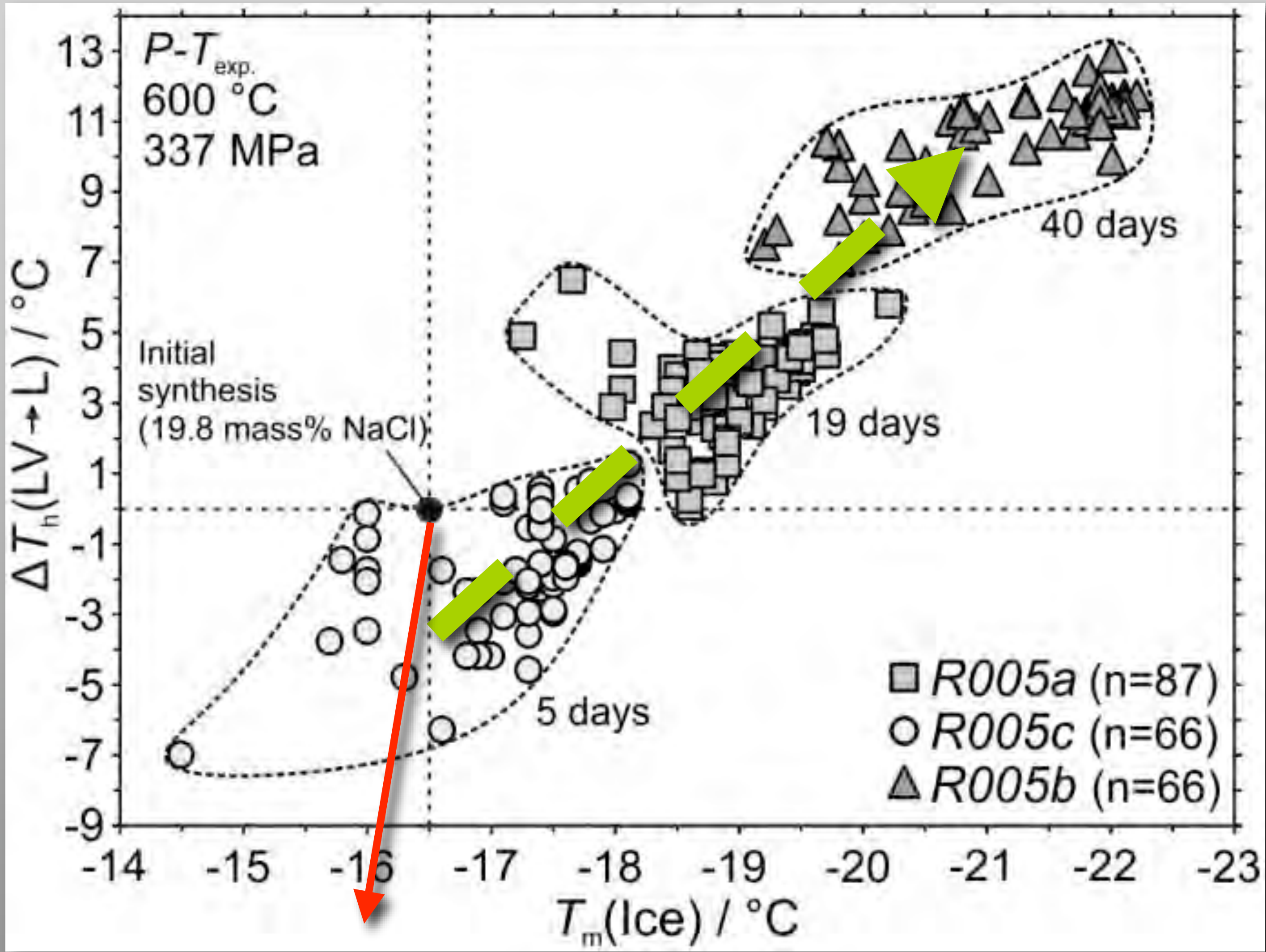
diffusion model Bakker (2009) Lithos, vol.112, 277-288.

maximum changes:
+ 2 amount % H_2O

ΔT_h = - 12 °C
T_m = -16 °C
P_{intern} = 372 MPa

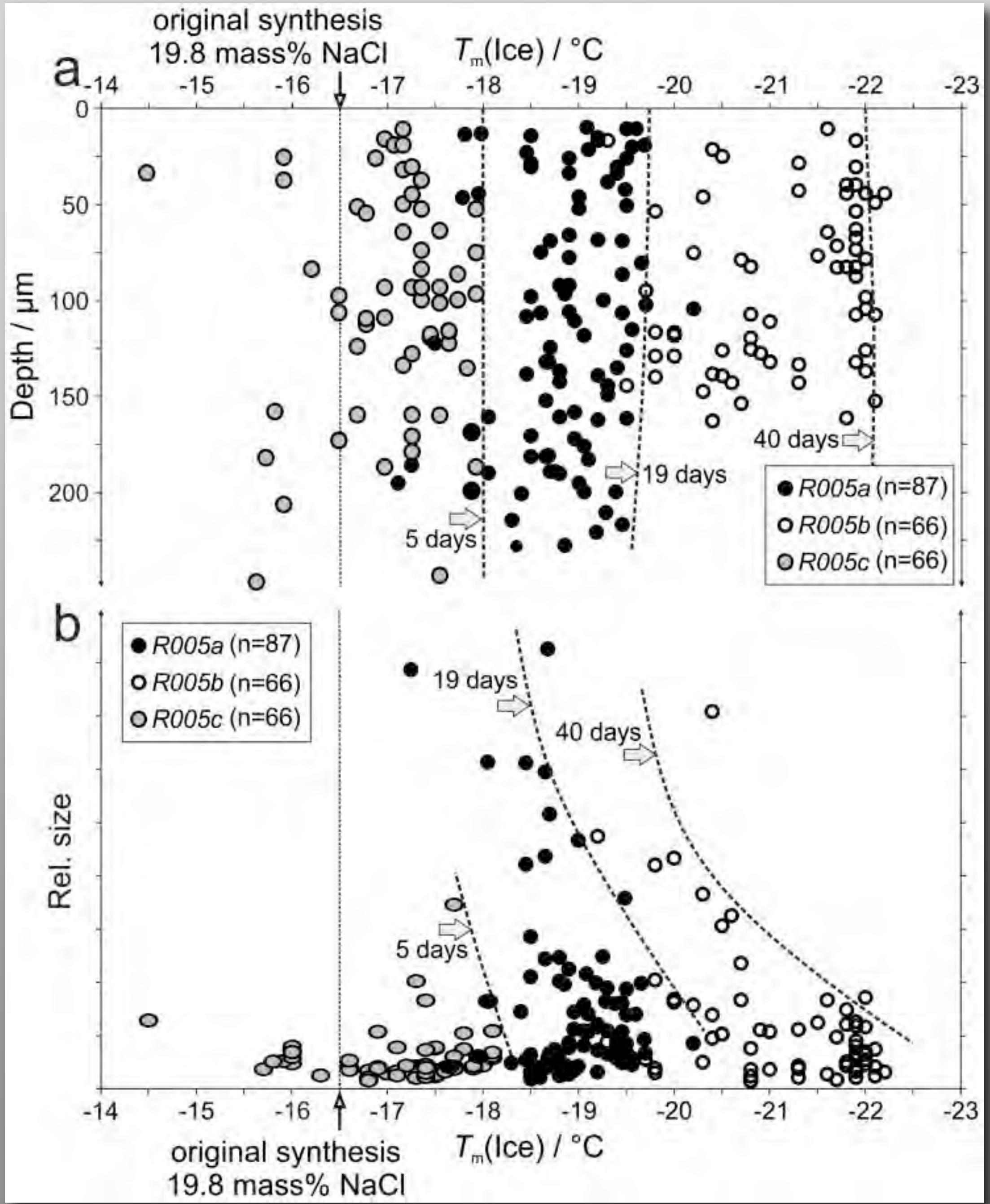
Experiment 2

Deformation (internal over-pressure): preferential H_2O loss



see also Bakker RJ, Jansen JBH (1994)
A mechanism for preferential H_2O leakage fromfluid inclusions in quartz, based on TEM observations.
Contributions to Mineralogy and Petrology, v. 116, 7-20

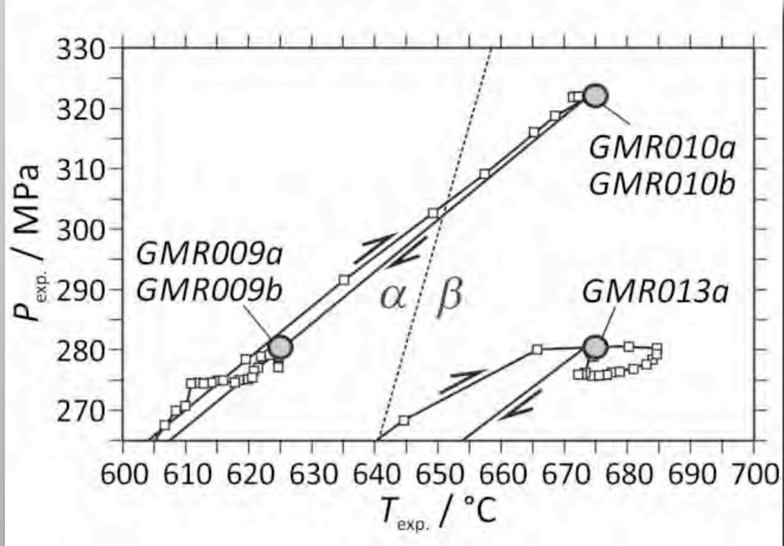
Experiment 2



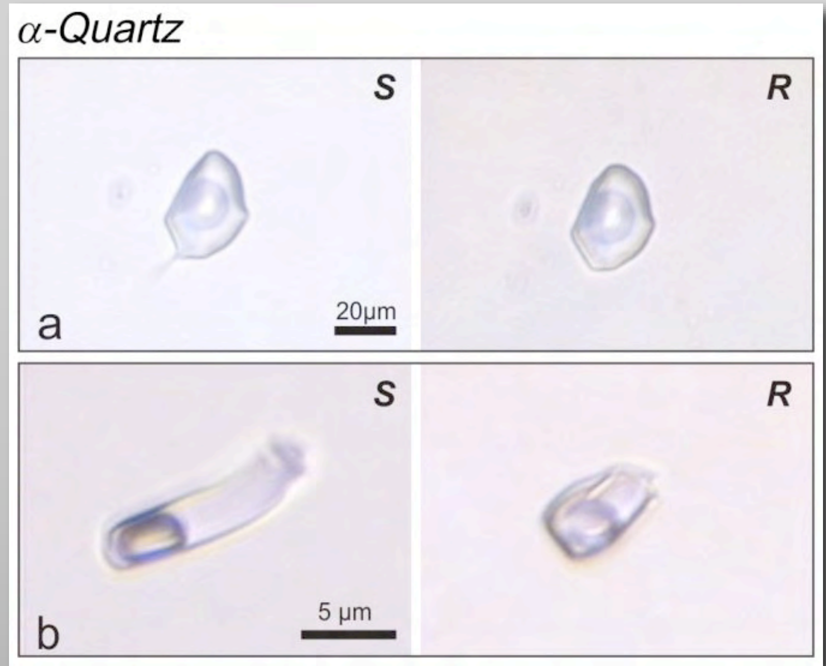
Experiment 3

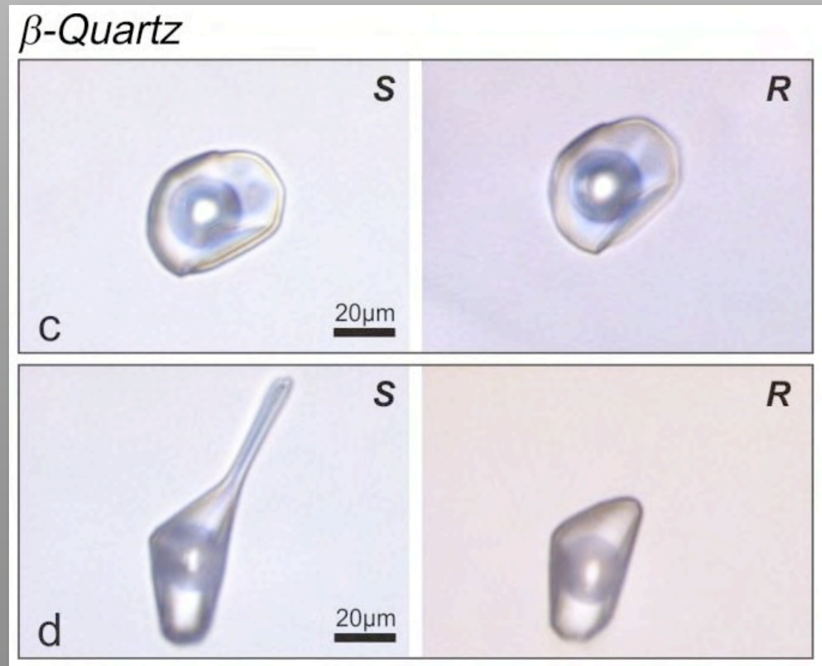
Synthetic Fluid Inclusions

α–β quartz transition



Doppler & Bakker (2014) Lithos, vol. 198-199, 14-23





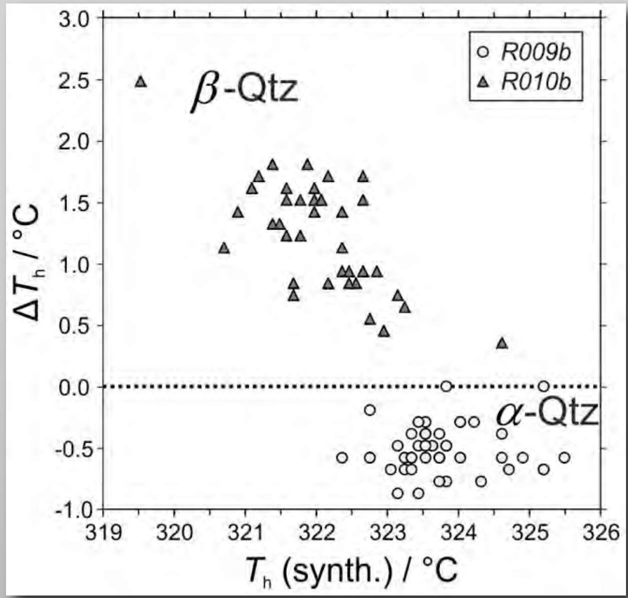
Experimental conditions:

β-quartz
675 ˚C
320 MPa

α-quartz	β-quartz
625 ˚C	675 ˚C
280 MPa	280 MPa

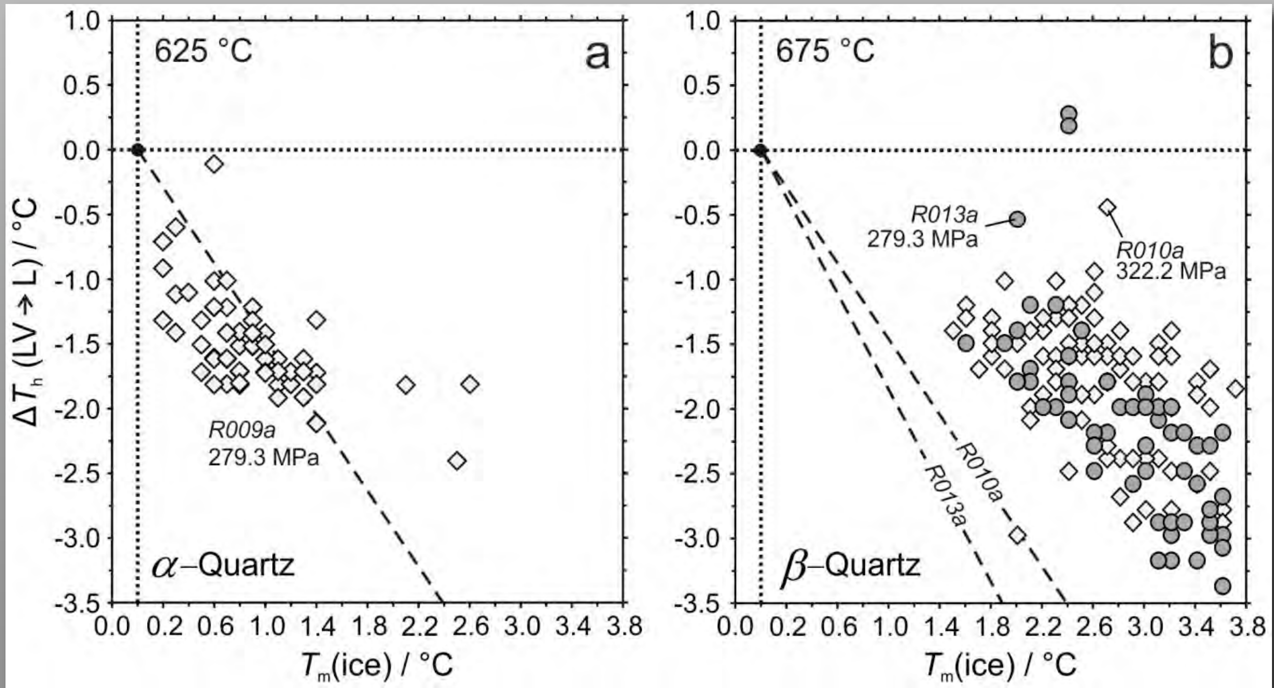
Experiment 3

α–β quartz transition



H_2O synthesis

H_2O re-equilibration



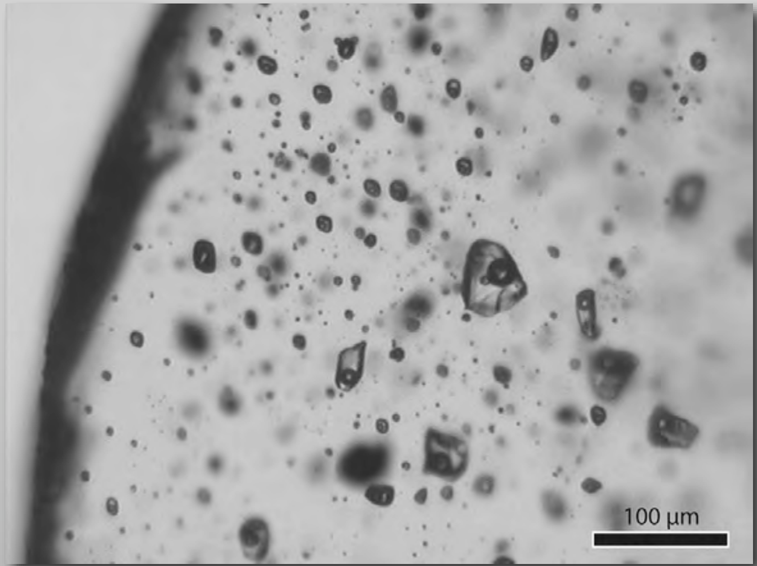
H_2O synthesis

D_2O re-equilibration

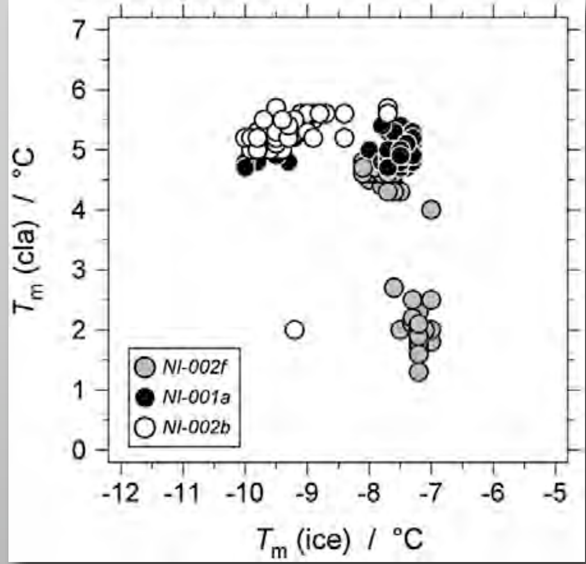
Experiment 4

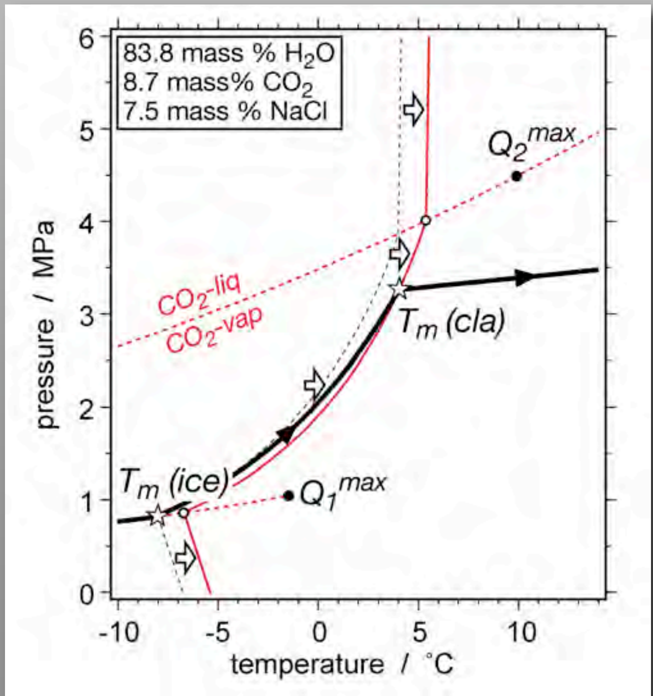
natural fluid inclusions

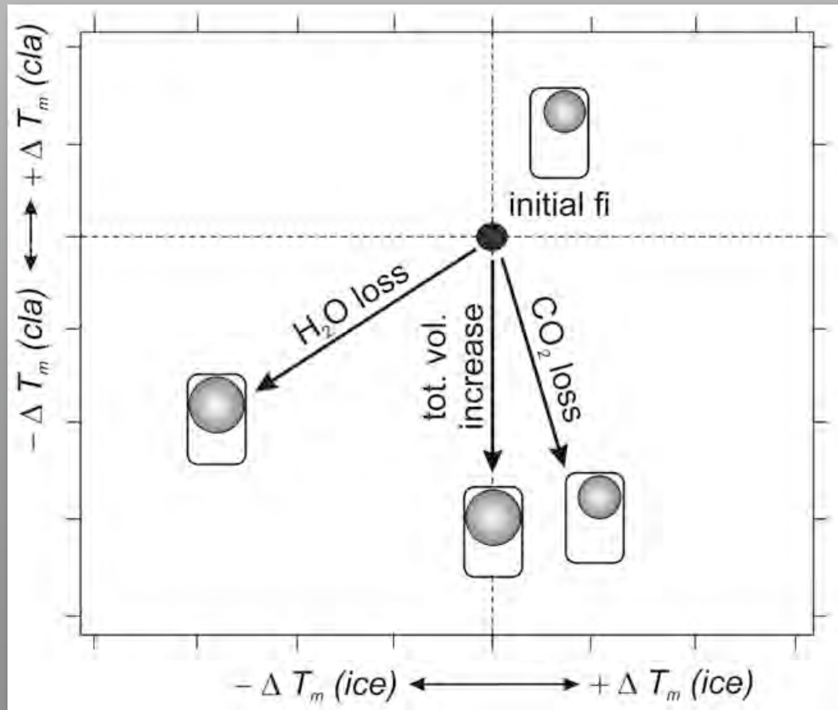
Baumgartner, Bakker & Doppler (2014)
Contrib. Mineral. Petrol., vol. 167



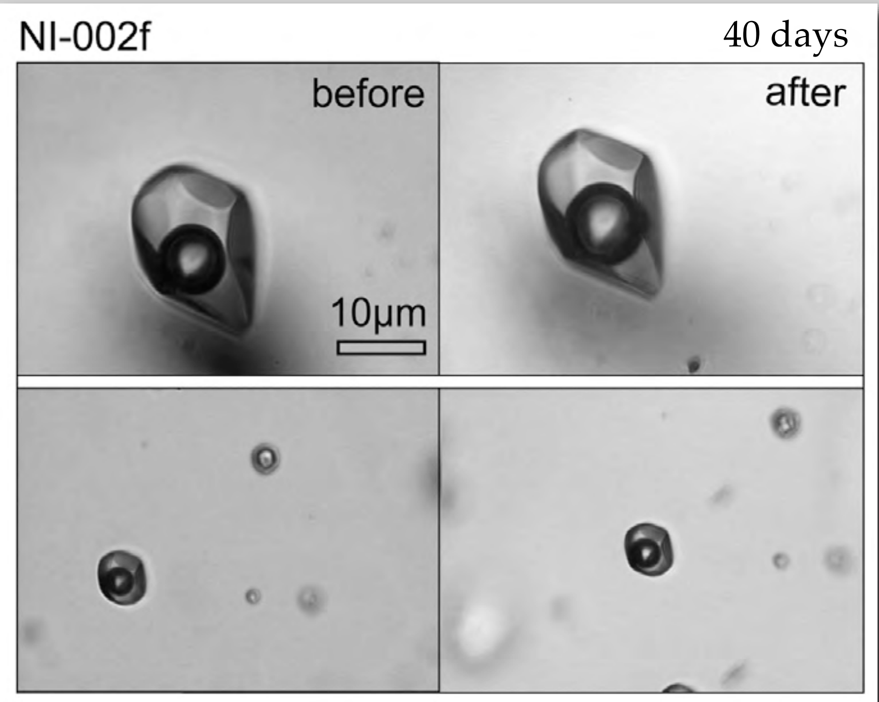
Bulk composition and density are calculated with software „FLUIDS“ (Bakker, 2003) and „CLATHRATES“ (Bakker, 1997)





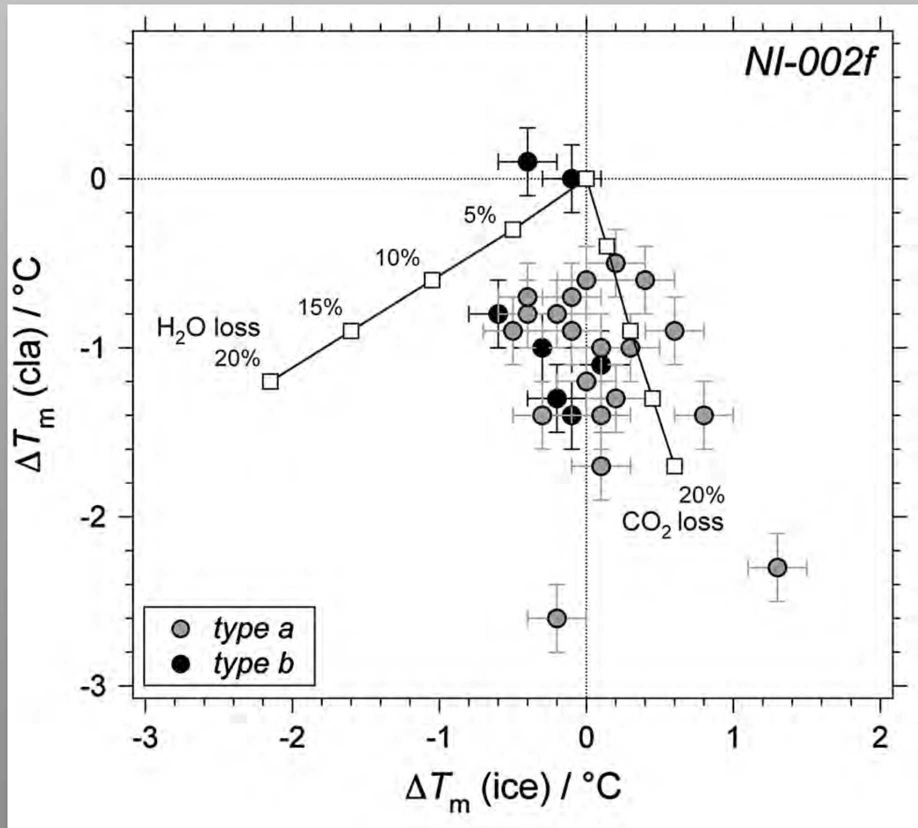


Experiment 4

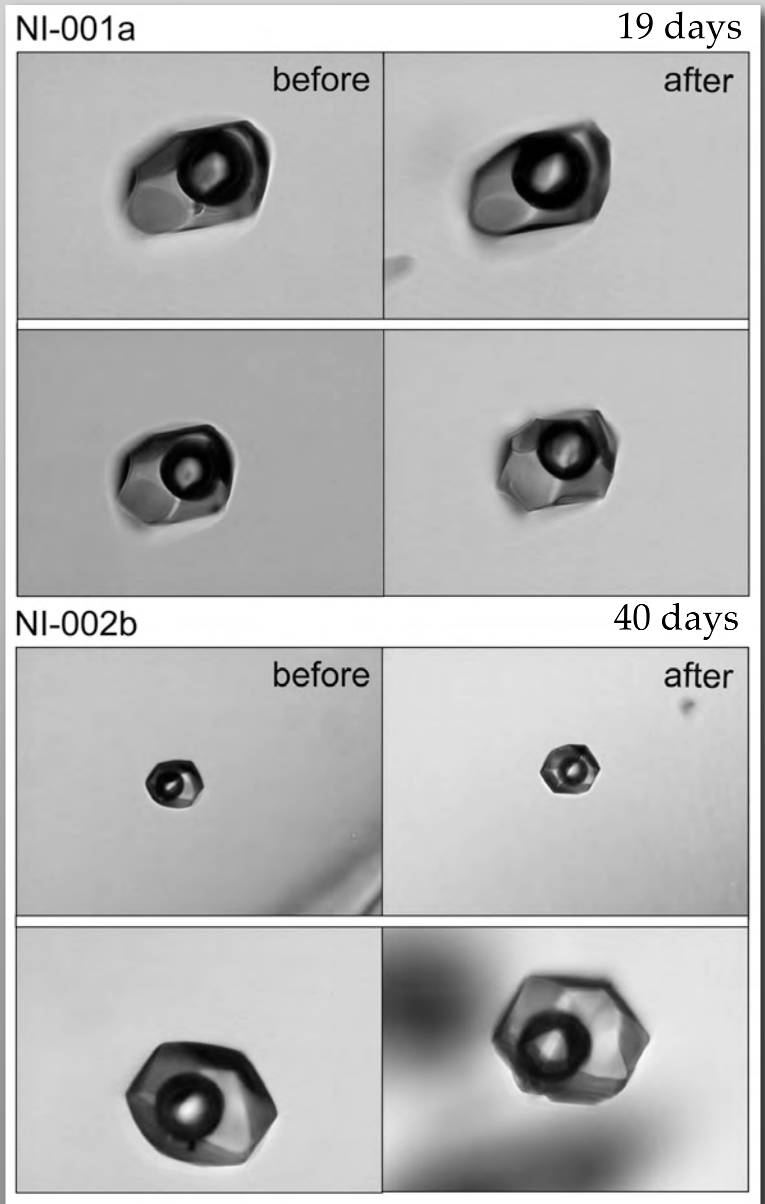


Experimental conditions: 600 ˚C, 308 MPa

$\Delta f(H_2O)$ = -12 MPa
$\Delta f(CO_2)$ = +59 MPa
ΔP = -2 MPa

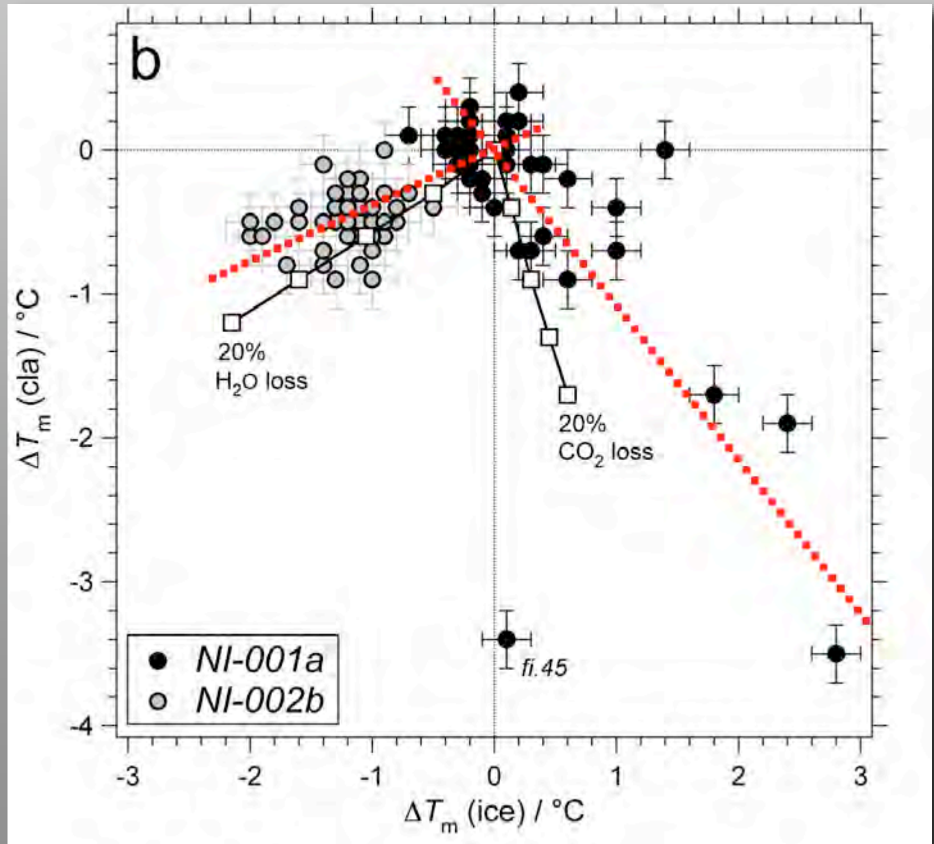


Experiment 4

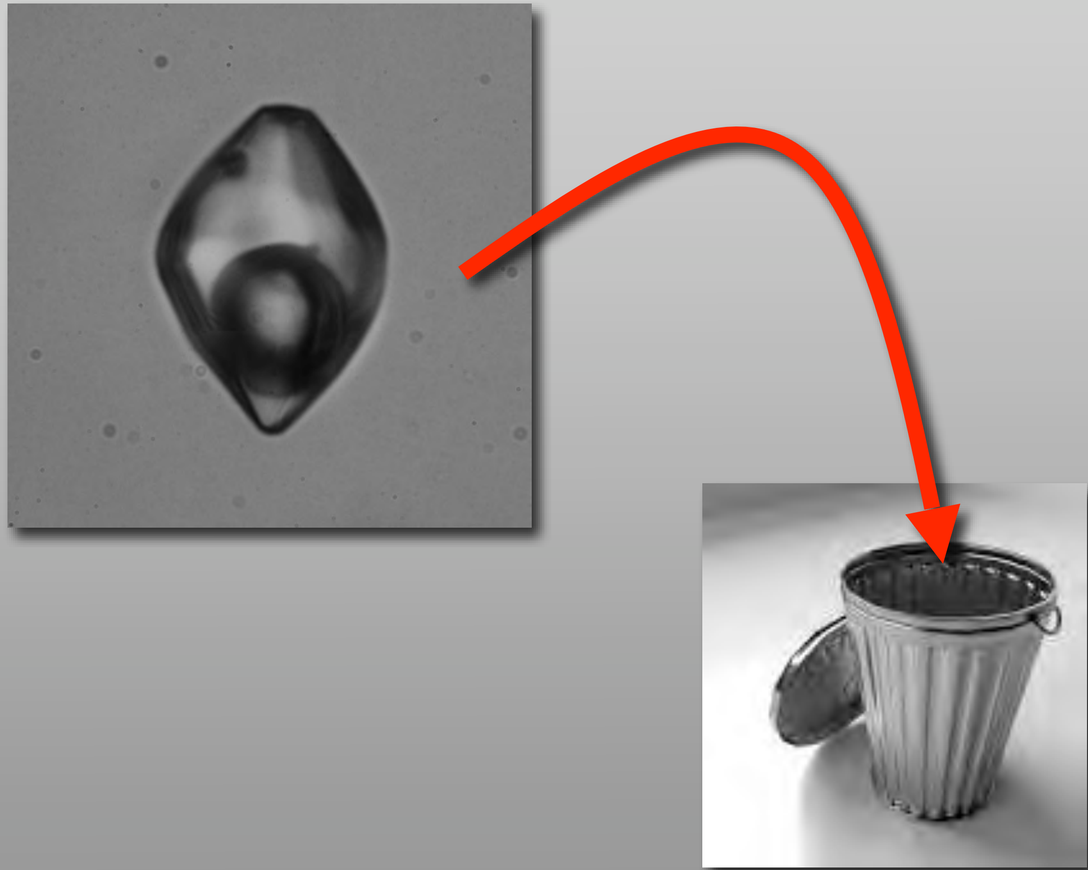


Experimental conditions: 600 ˚C, 396 MPa

$\Delta f(H_2O)$ = -80 MPa
$\Delta f(CO_2)$ = +62 MPa
ΔP = -100 MPa



Wrong Conclusion



Right Conclusions

use knowledge from experimental work and thermodynamic modelling
to interpret natural samples

re-equilibration processes at 300 - 675 ˚C, 300 - 400 MPa

1. bulk diffusion (short runs), all fluid components
2. preferential H_2O-loss, local deformation (long runs)
3. phase transition of host mineral

conditions of preservation of fluid in natural inclusions

means to recognize re-equilibration of a natural fluid inclusion assemblage

Thank you for your attention!

Fluid Inclusion Laboratory Leoben FILL

http://fluids.unileoben.ac.at

Fluid Inclusion Team
University of Leoben