

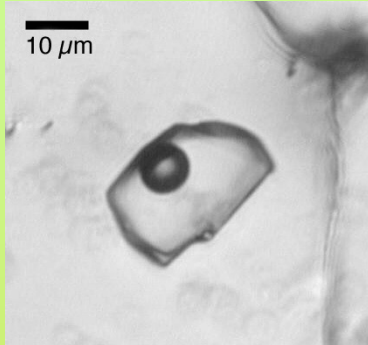
# Low Temperature Raman-Spectroscopy with Fluid Inclusions: Fundamental Properties of Water and Brines



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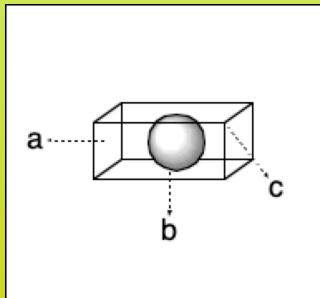
# Fluid Inclusions in Geosciences



natural samples of palæo-geological fluids

primary goal: V-X properties

# Fluid Inclusions in Chemistry / Physics



micropores (1 to 100  $\mu\text{m}$ )

experimental constant-volume microvessels

# Prerequisites of Fluid Inclusion Research

## Means of Effecting and Measuring the System

### 1. Microthermometry

Linkam Stage

-196 to + 600 °C

### 2. Raman-spectroscopy

LabRAM (Jobin Ivon)

confocal-Raman spectrometer

frequency-doubled Nd-YAG laser (100 mW, 532.2 nm)

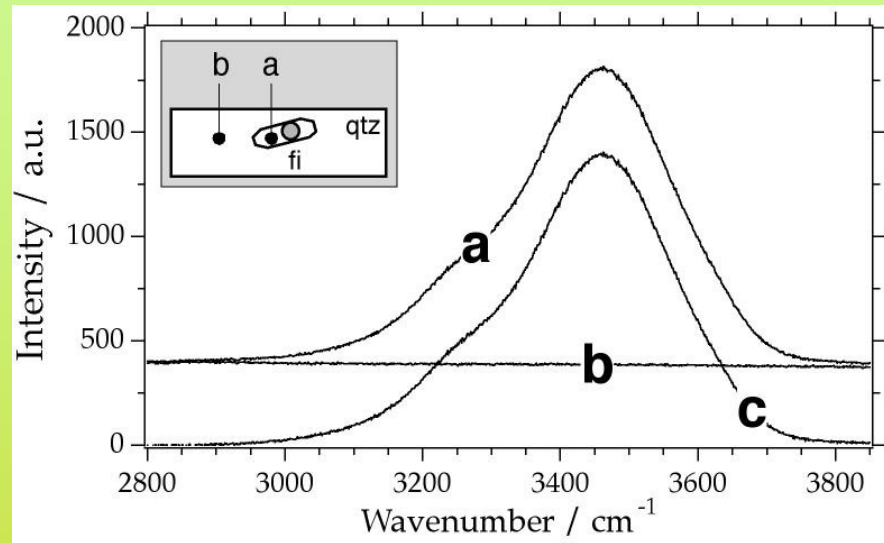
## “Simple” Fluid System

### Synthetic Fluid Inclusions

## References

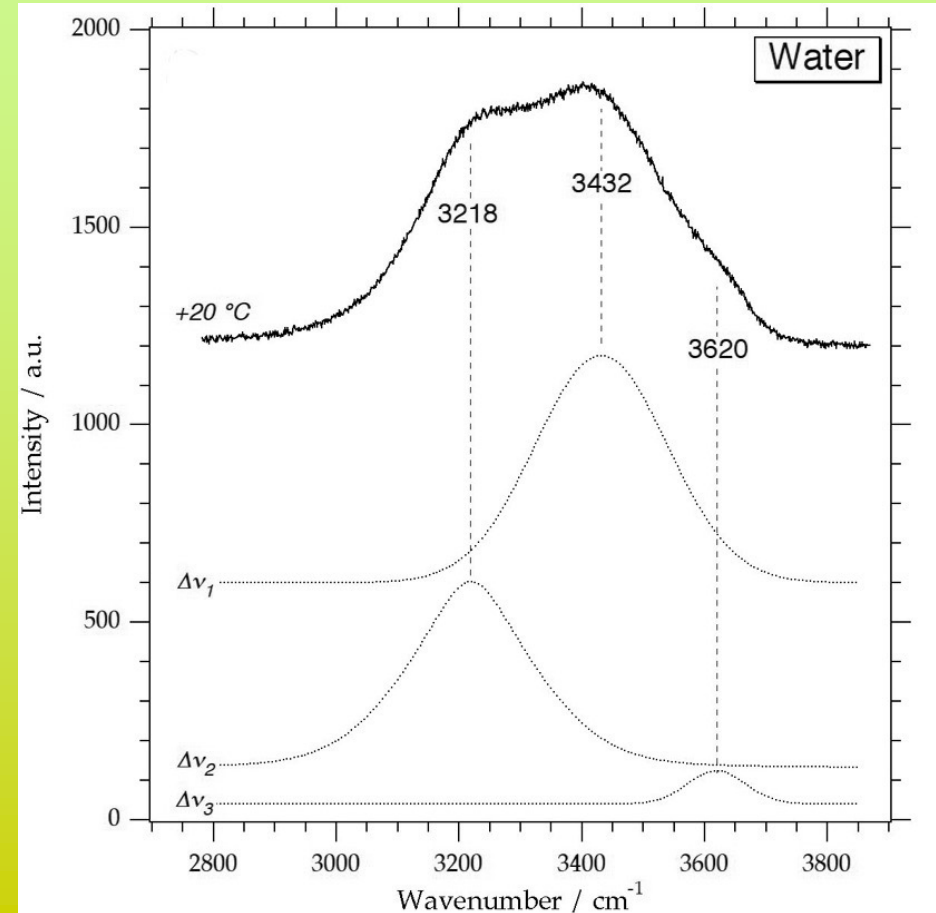
# Analysis of the spectrum of aqueous liquid solutions

background correction

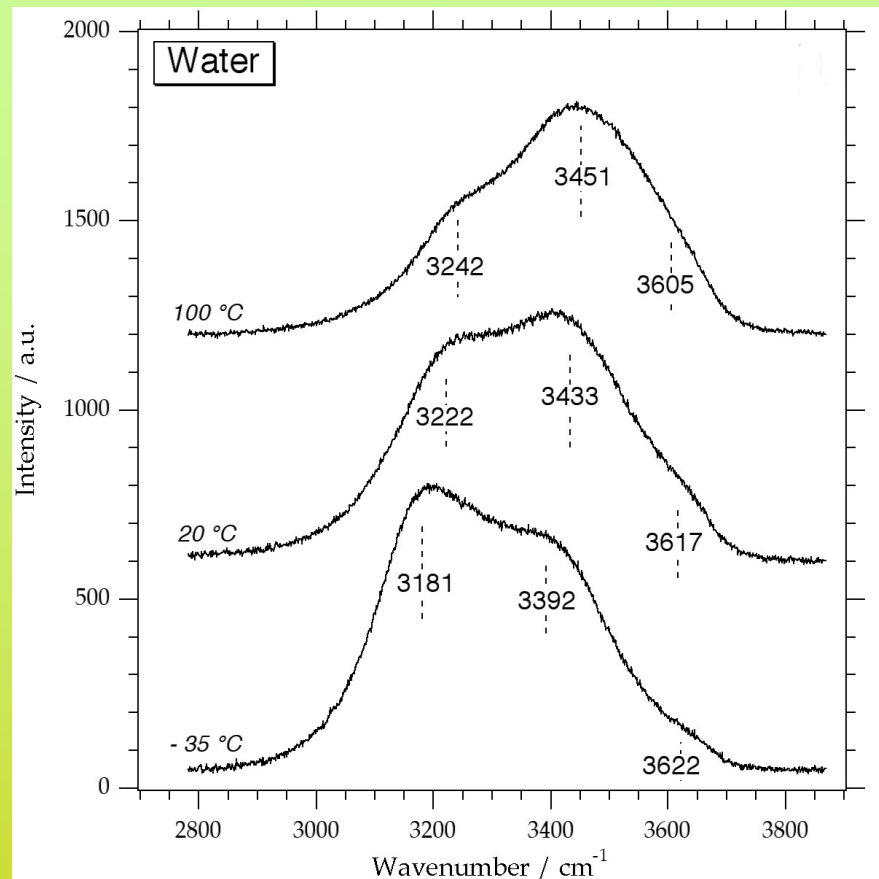


Best-fit  
Gaussian-Lorentzian Components

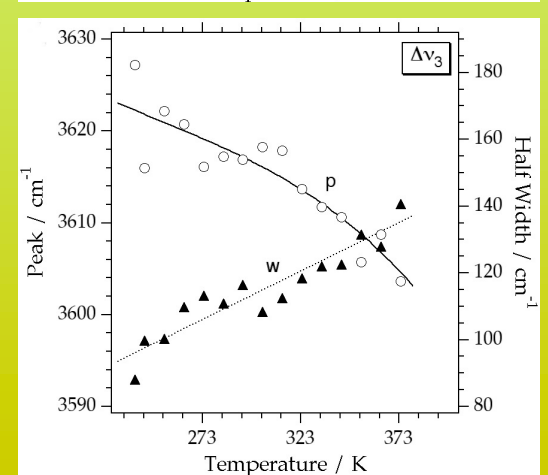
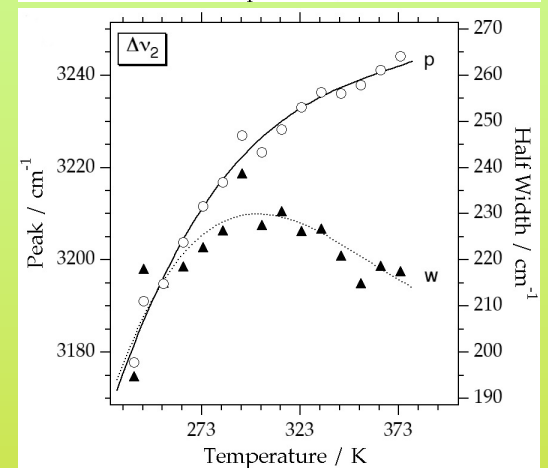
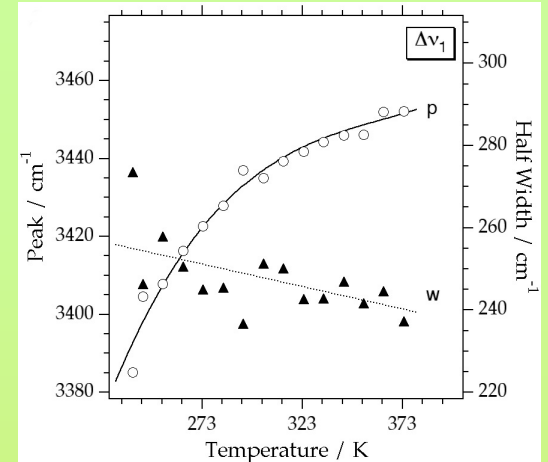
3 arbitrary deconvoluted bands



# Water-spectra at variable temperatures

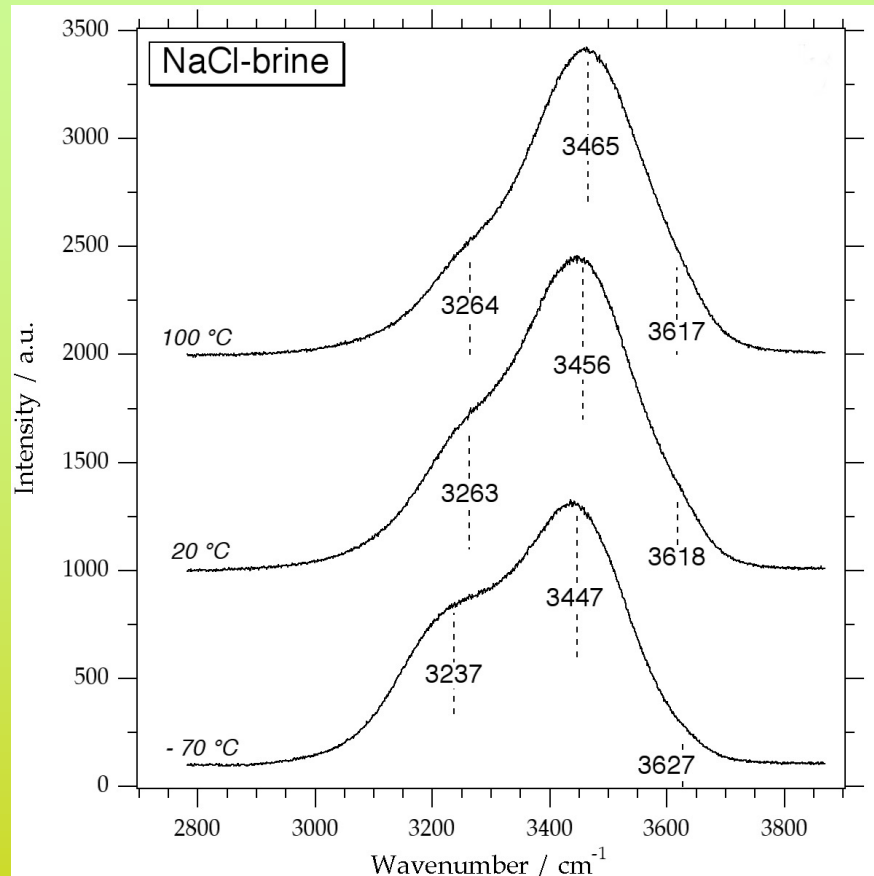


metastable water in the range of 0 to -40 °C

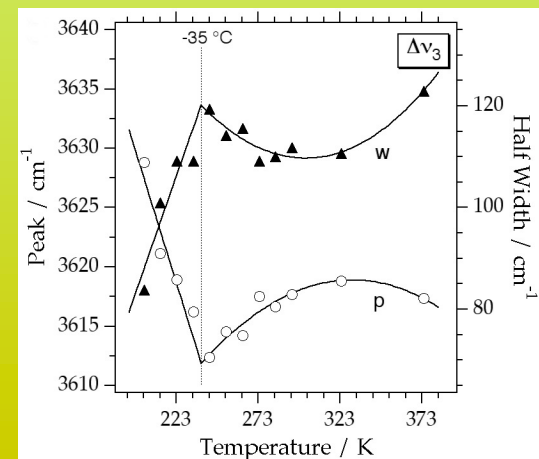
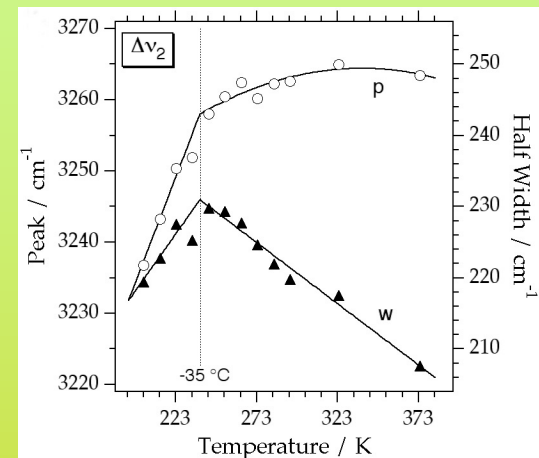
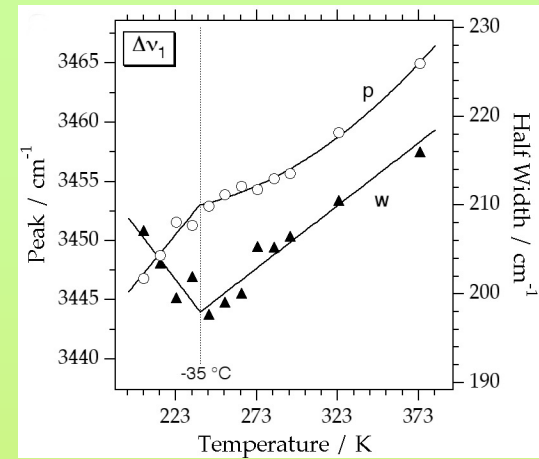


# Brines (aq.liq)

23.2 mass% NaCl

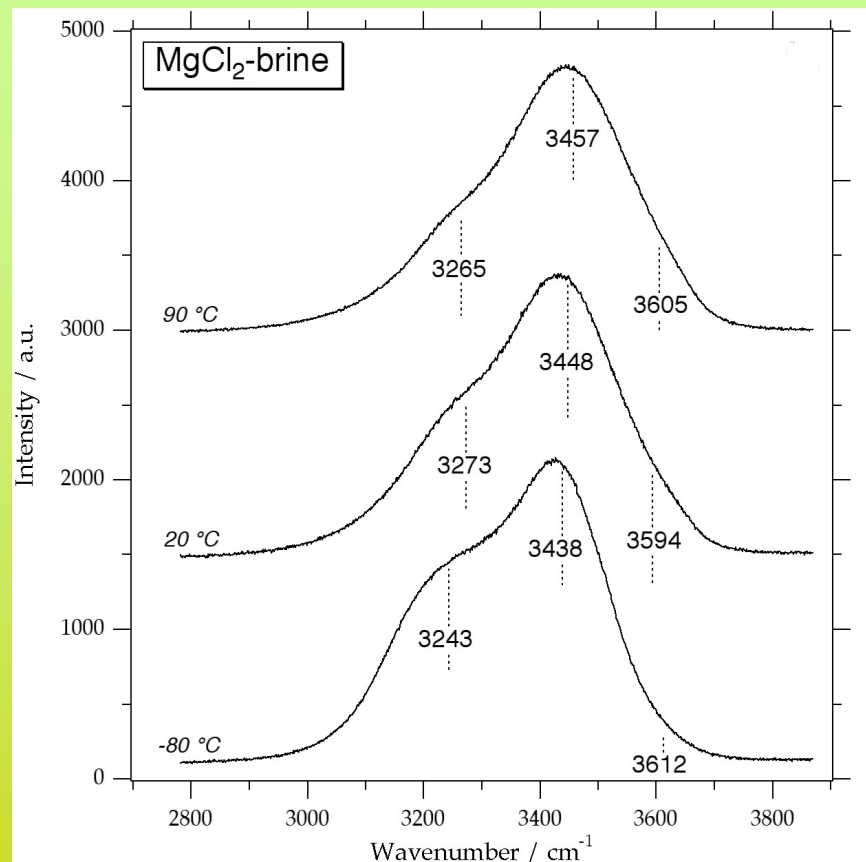


metastable brine in the range of -20 to -82 °C



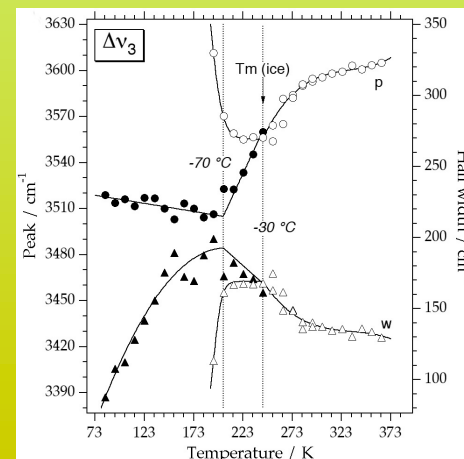
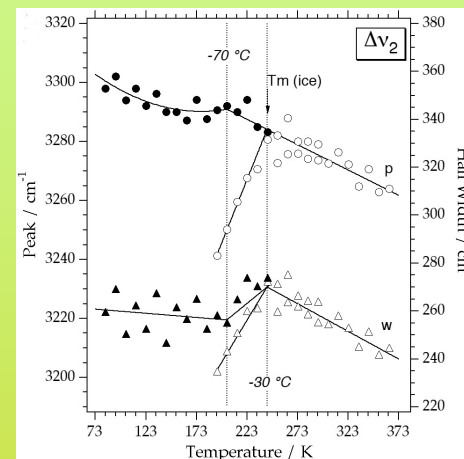
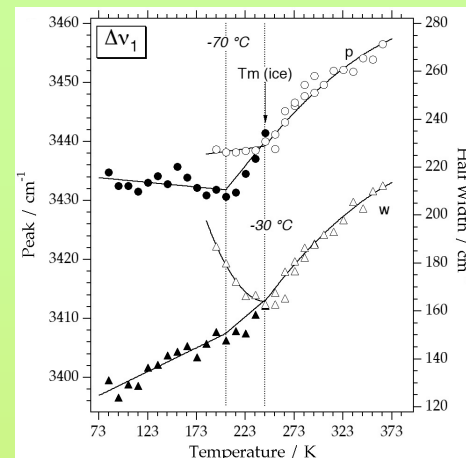
# Brines (aq.liq)

20.2 mass%  $\text{MgCl}_2$

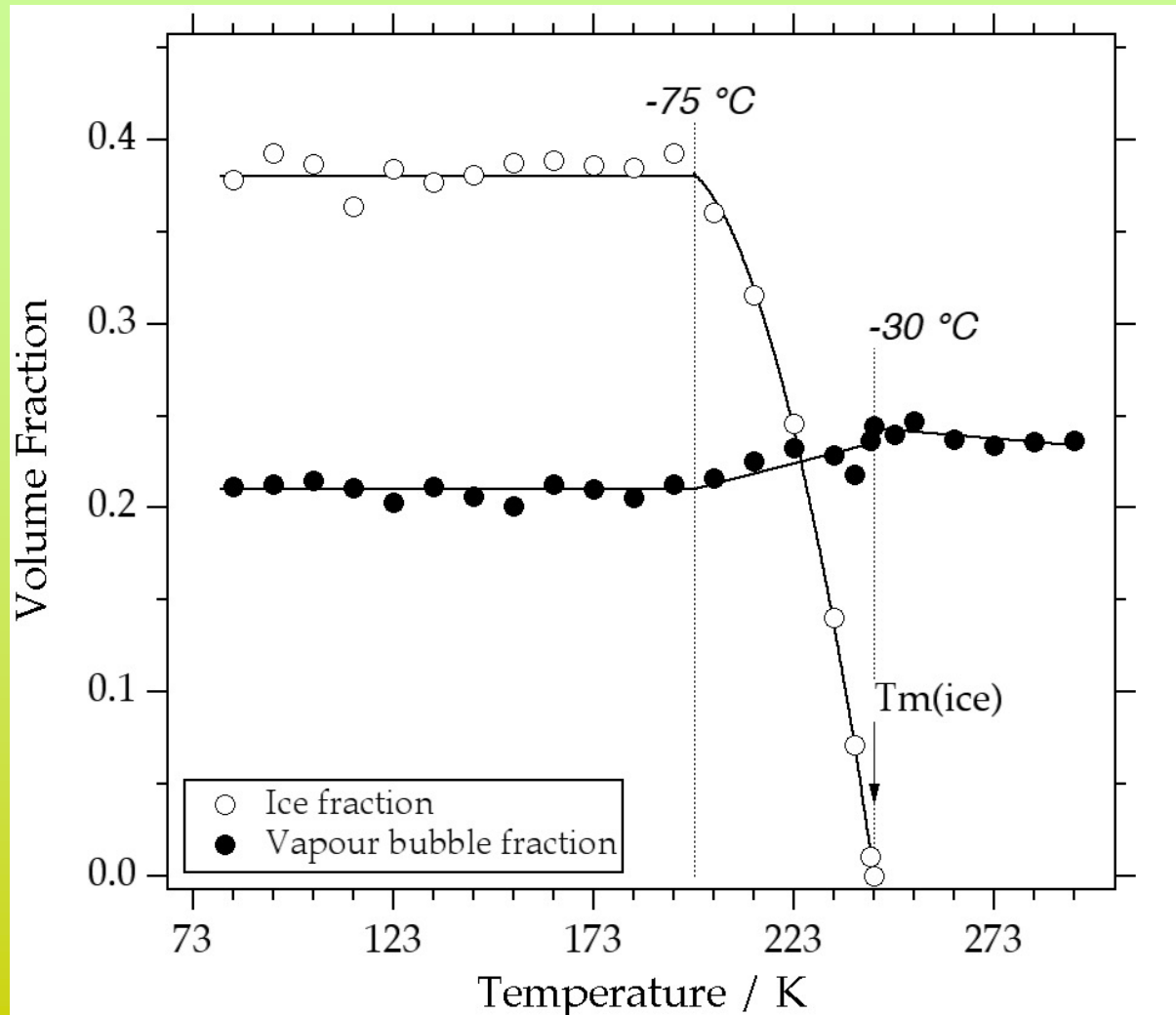


metastable brine in the range of -30 to -90 °C

metastable brine+ice below -30 °C



## Metastable phase assemblage: Ice + Brine( $\text{MgCl}_2$ ) + vapour

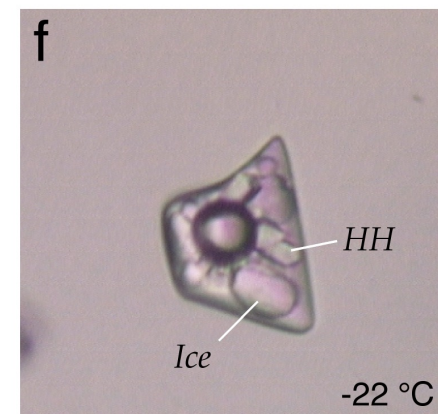
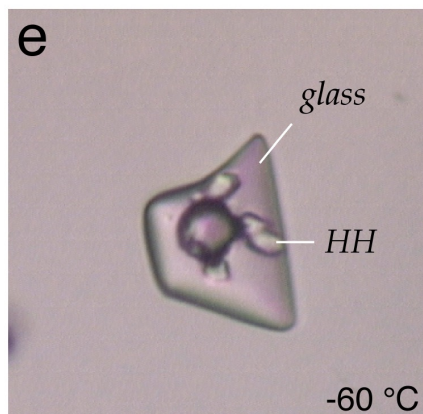
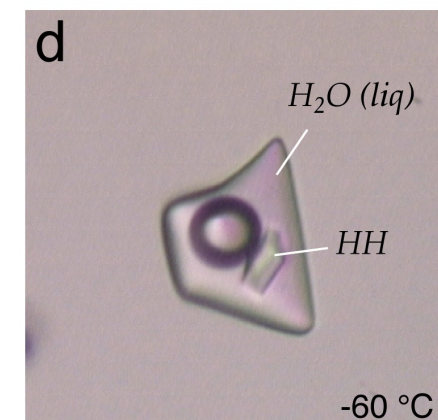
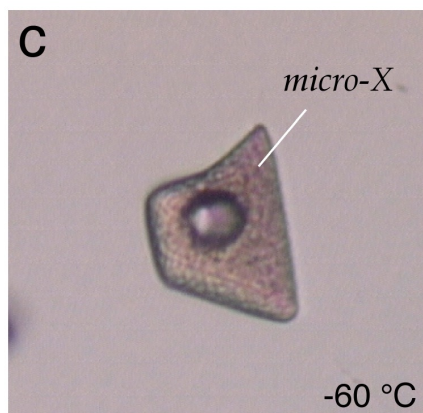
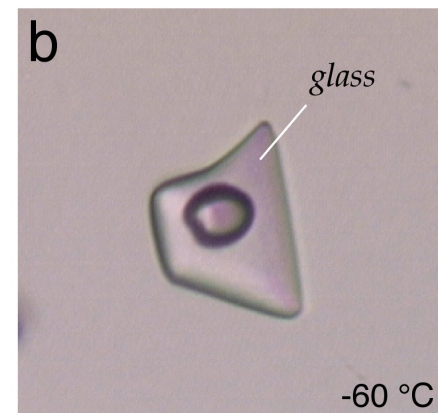
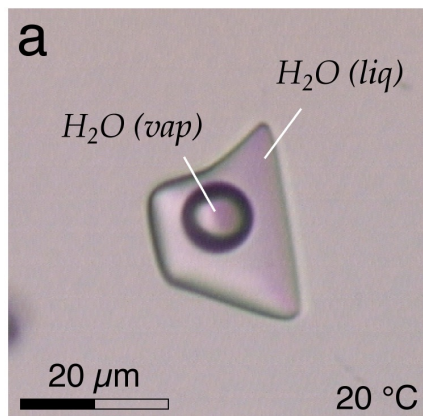


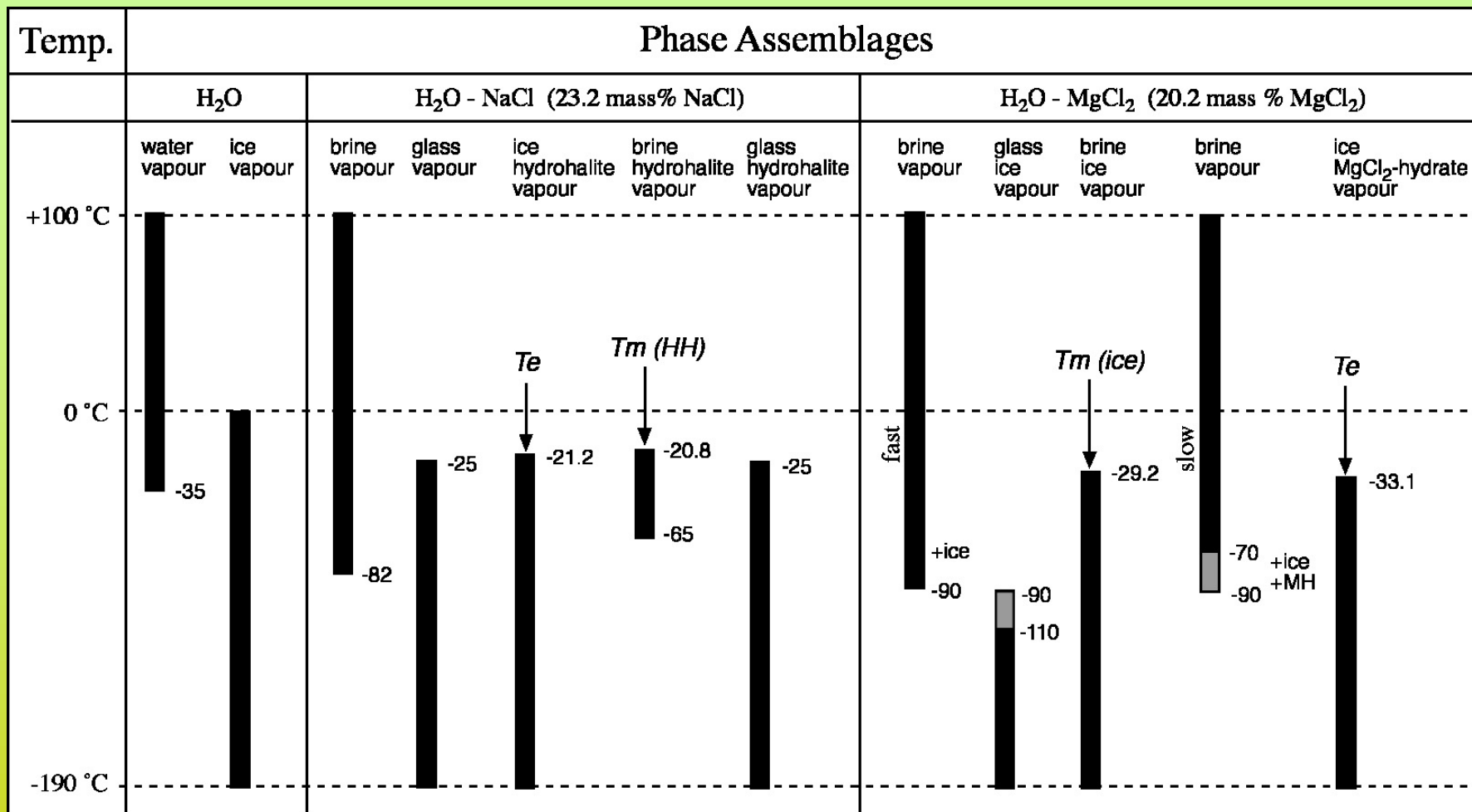


(meta-) stable phase assemblages in  
fluid inclusions (or micropores)

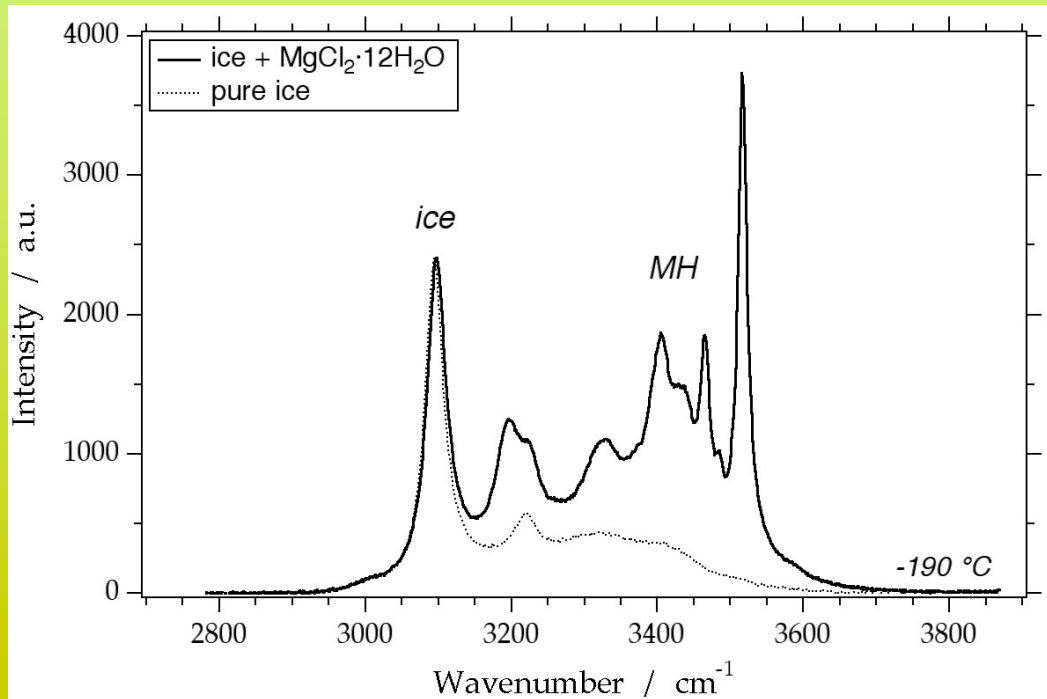
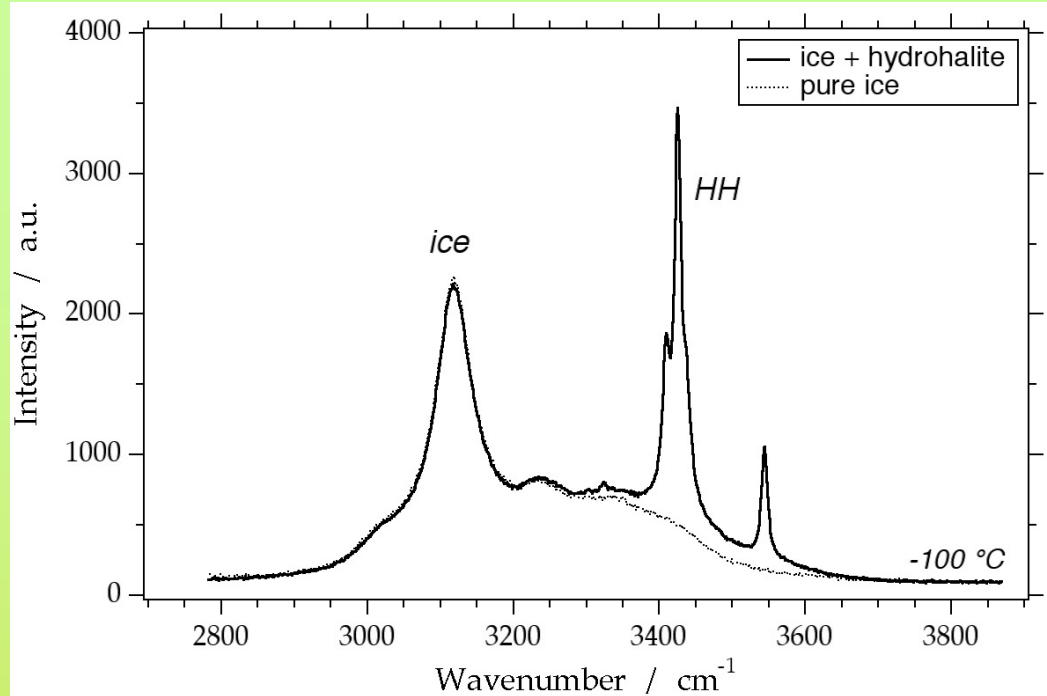
$\text{H}_2\text{O} - \text{NaCl}$

- vapour
- brine
- glass
- ice
- hydrohalite



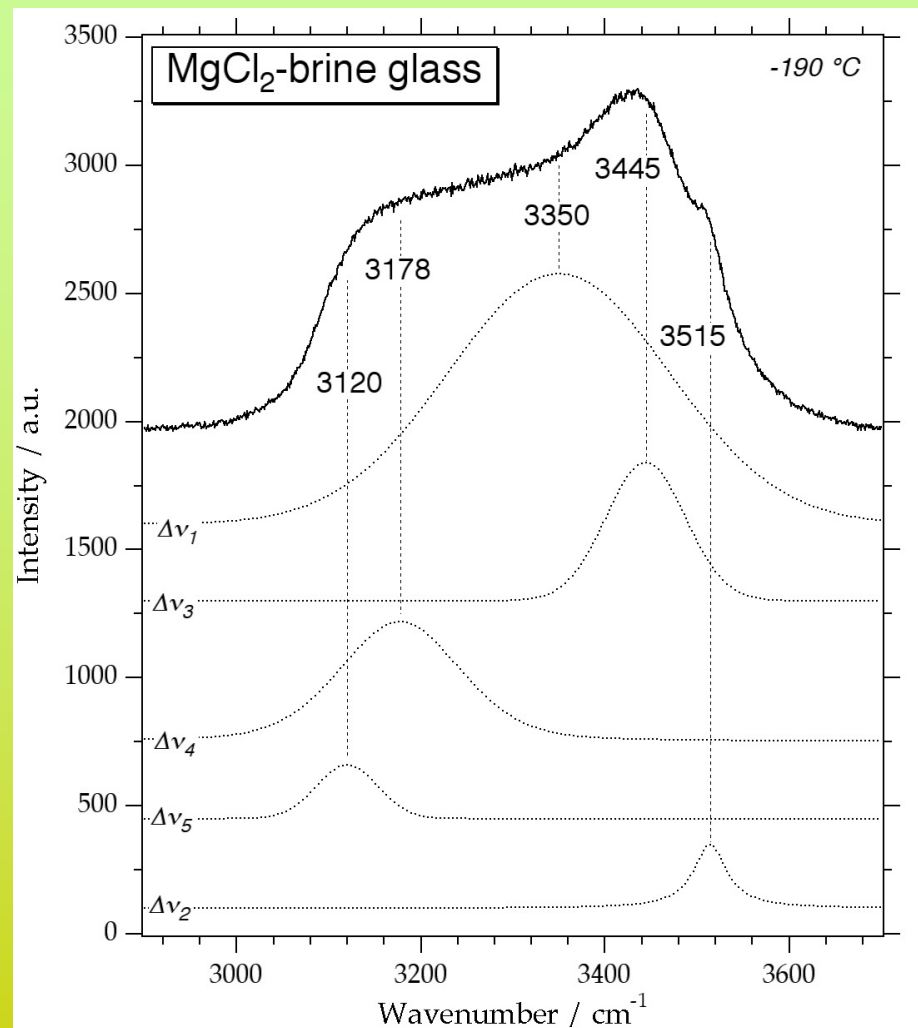
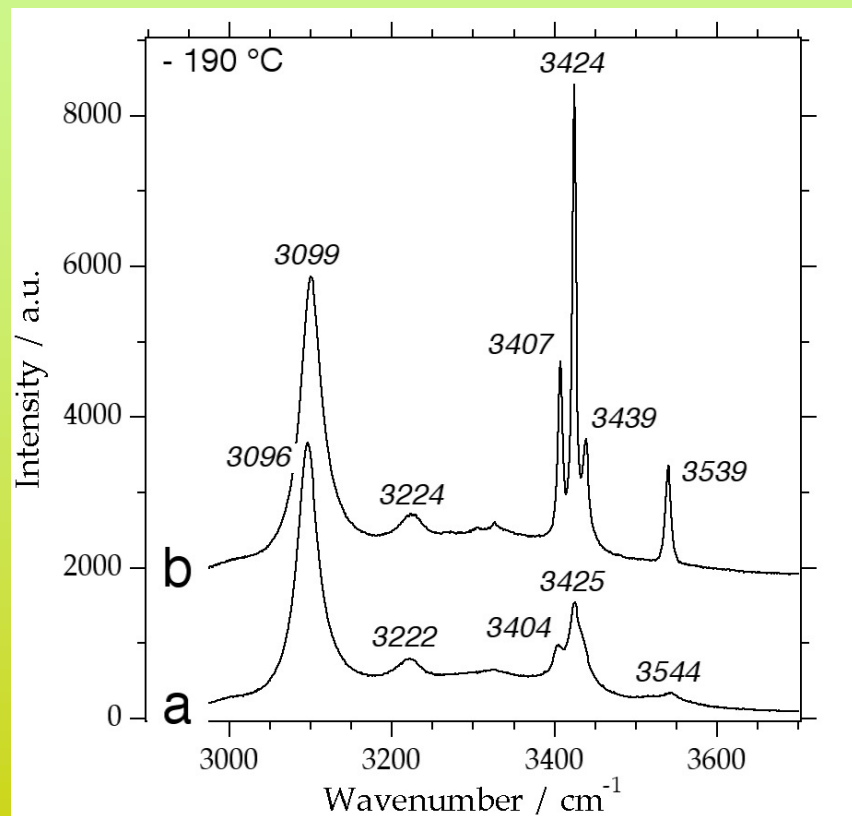


# Identification Salt-hydrates



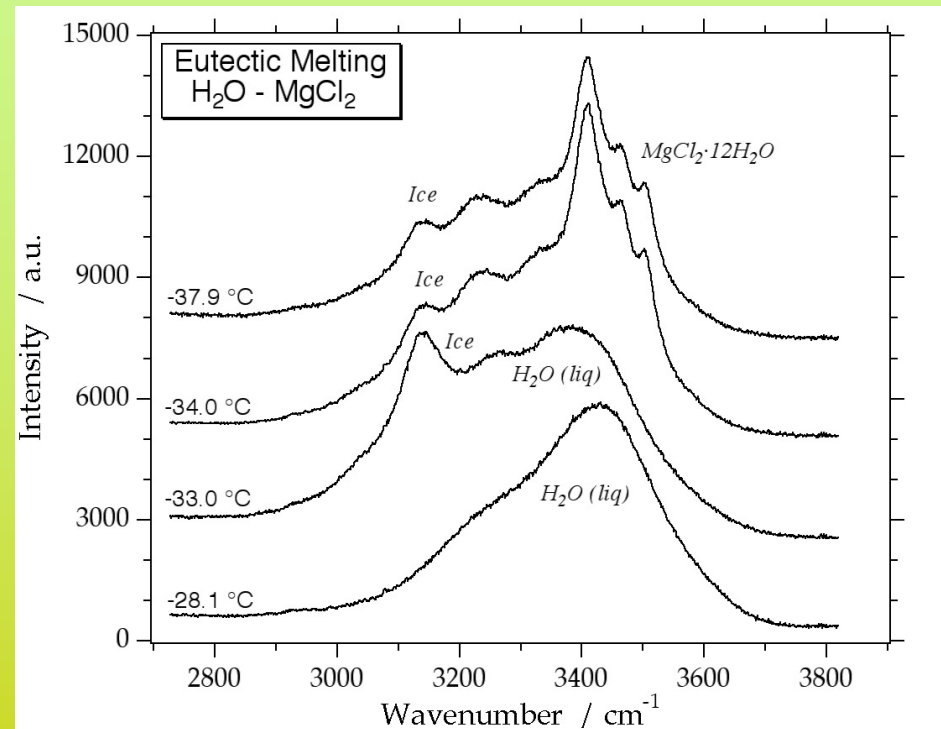
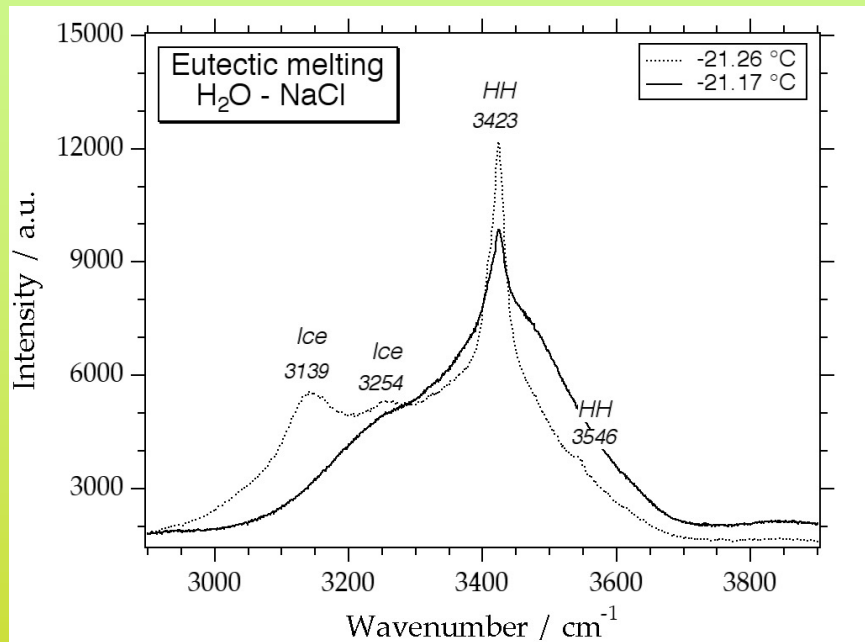
# Glass

## NaCl-brine glass

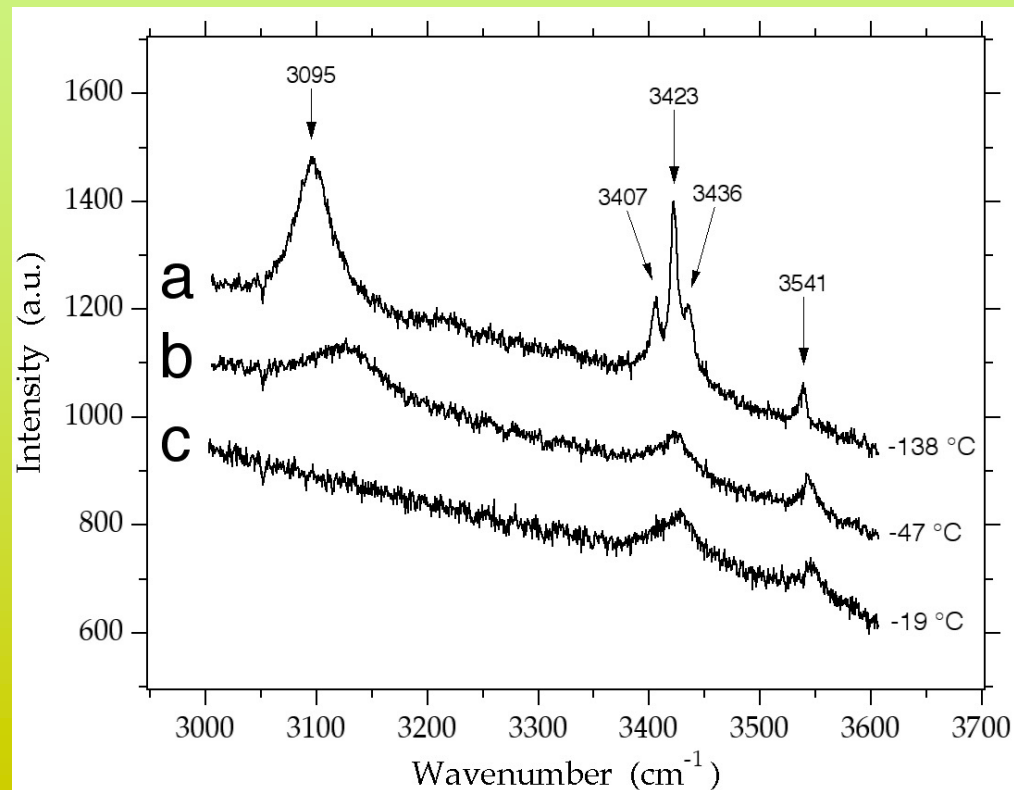
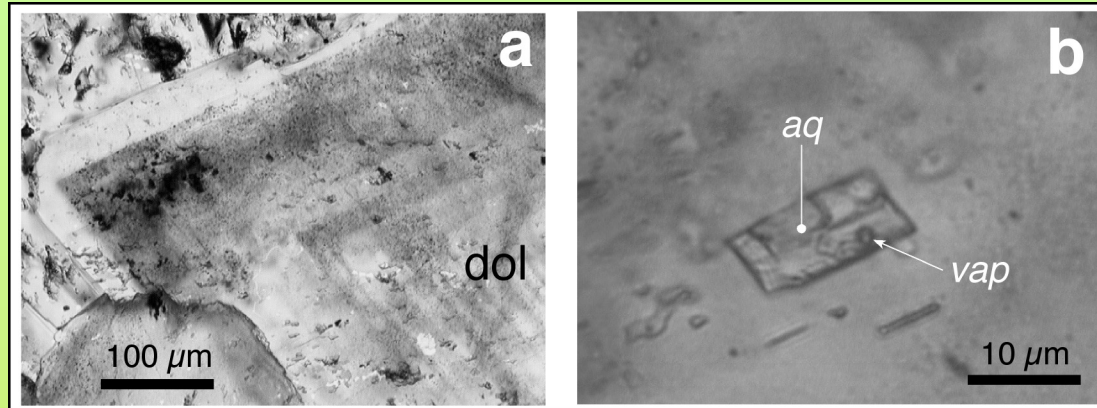


# Phase changes in Fluid Inclusions

## Eutectic Temperatures



# Natural example



# Conclusions

## Properties of aqueous liquid solutions at low temperature

- metastable phases in micropores

## Low temperature behaviour of fluid inclusions

- phase changes, eutectic points
- salt hydrates