

## Relation between structural control and fluid characteristics, considering rocks migrating through the brittle/ductile transition during the development of a Metamorphic Core Complex (MCC), Naxos Island, Greece

L. Siebenaller

In collaboration with:

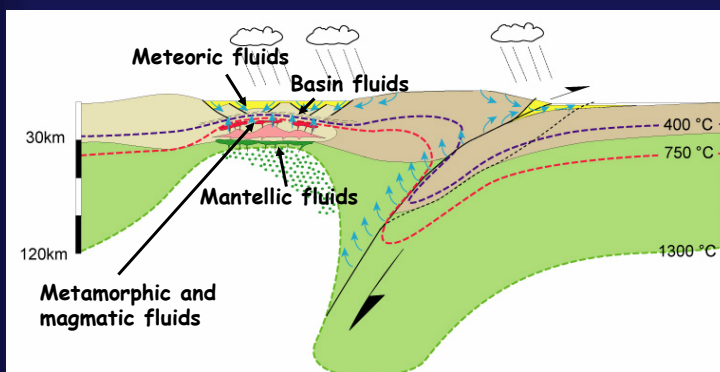
- O. Vanderhaeghe, M.C. Boiron, C. Hibsich, A.S. André-Mayer (UMR CNRS 7566 University Henri-Poincaré NANCY 1)

-D. Banks (University of Leeds)  
-M. Jessell (LMTG, Toulouse)



## Different types of fluids circulating during the evolution of a MCC

### General model

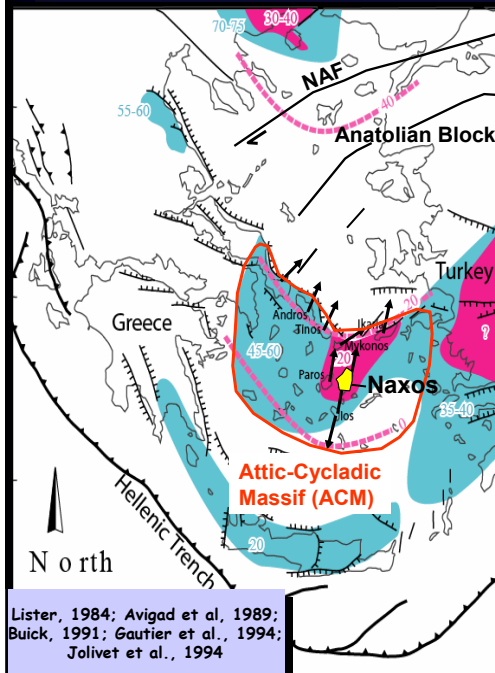


### Questionwork:

- Role of the fluids circulations, during the thermal evolution of the orogenic crust? fluids within the detachment (Vigneresse et al., 2004; Famin et al., 2004; Famin, 2004) → crustal derived
- Rheological layering and fluid circulation within the MCC: role of the detachment (migration of the ductile/brittle transition)? Fluid inclusions (Vapnik et al., 2004; Famin et al., 2004) → characterization of fluids circulating within a detachment zone

➡ Necessity to characterize the type, P-T trapping conditions and source of fluids

## Geological setting of the Aegean region



### Summary of the geological history:

> **Early Tertiary:** Alpine orogenic belt of the Hellenides (HP-LT metamorphism)

> **Since early Miocene:** **crustal scale extension**, MCC (LP-HT metamorphism),

> **Present-day kinematics:** extrusion of the Anatolian block along the NAF



HP metamorphic complexes



HT metamorphic complexes

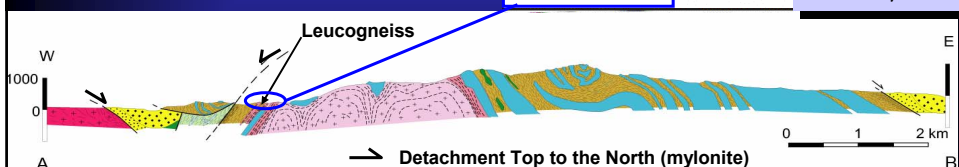
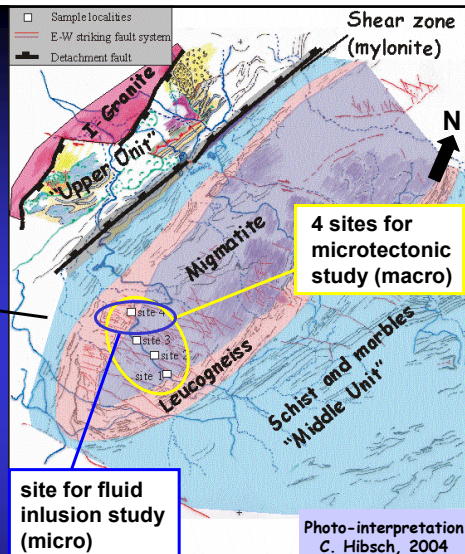
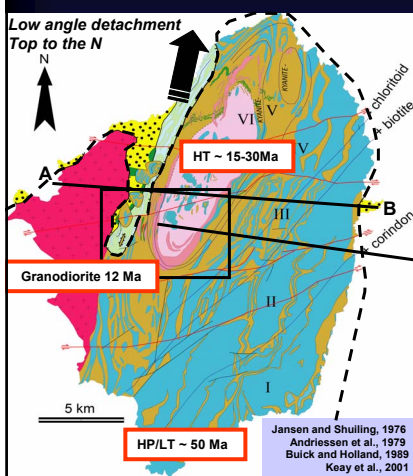


Calco-alcalin magmatism (age in Ma)

→ Movement direction of hanging-wall blocks along major extensional shear zones during Oligocene-Miocene extension

NAF: North Anatolian fault

## Naxos Island geological setting



## Methodology

→ **Microtectonics : relative chronologies and structural control**

→ **Fluid inclusion plane (FIP) study:**

- Relative chronologies and structural control
- Relations micro/macro (FIPs-tension gashes)
- Deformation characteristics (brittle/ductile)

→ **Fluid inclusions**

Microthermometry

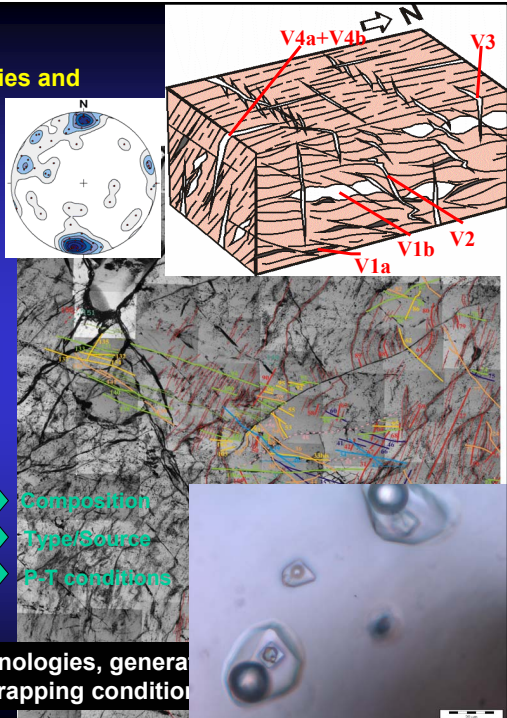
Raman Spectroscopy

Composition

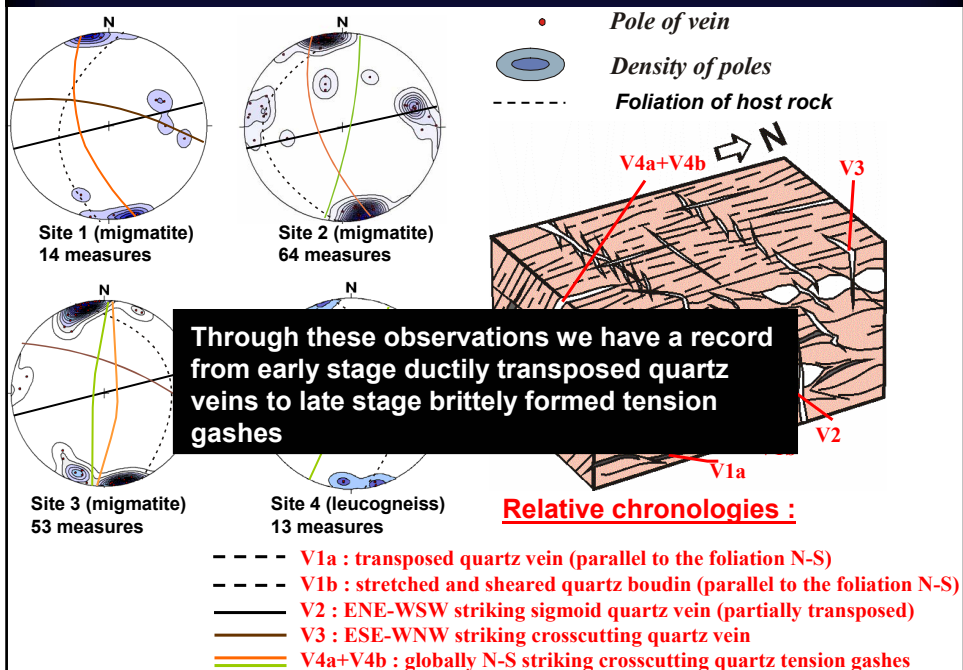
Type/Source

P-T conditions

Is there a relation between chronologies, general  
respective trapping condition



## Microtectonics (macroscopic scale): Chronologies and kinematics



## Fluid inclusion coupled to a FIP study:

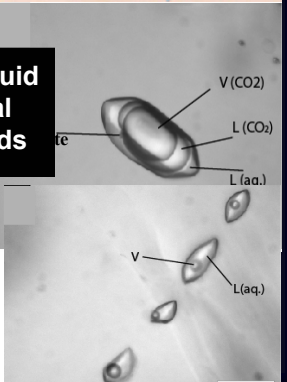
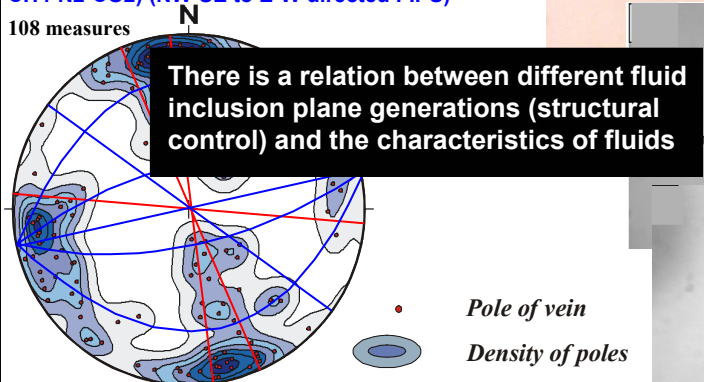
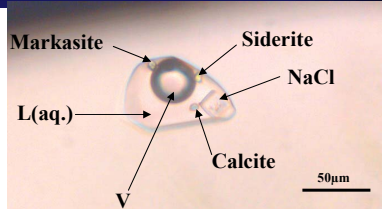
• V2 : ENE-WSW striking sigmoid quartz vein

3 major types of fluids are differentiated:

1) Early stage Halite-calcite-siderite-markasite bearing high salinity fluids (traces of CO<sub>2</sub>) not identified in fluid inclusion planes

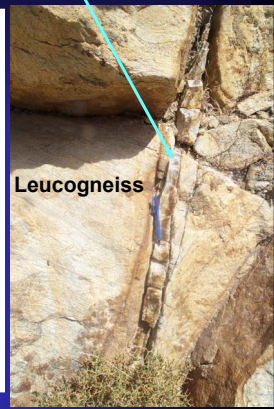
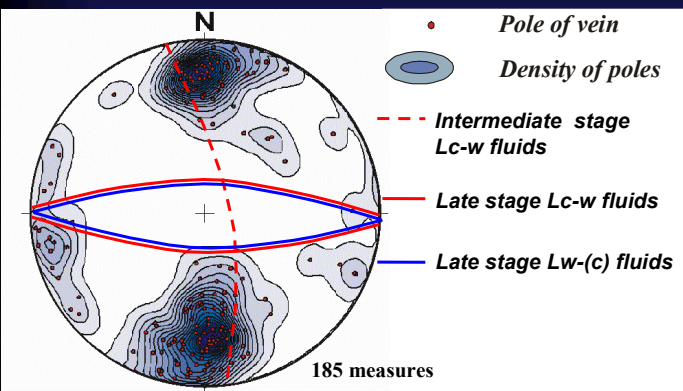
2) Intermediate (N-S) to late (E-W) stage triphased Lc-w inclusions with markasite (traces of H<sub>2</sub>S-CH<sub>4</sub>-N<sub>2</sub>) (NNW-SSE & E-W directed FIPs)

3) Late stage biphased Lw-(c) inclusions (traces of CH<sub>4</sub>-N<sub>2</sub>-CO<sub>2</sub>) (NW-SE to E-W directed FIPs)

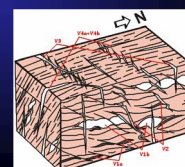


## Fluid inclusion coupled to a FIP study:

V3 : ESE-WNW striking crosscutting quartz vein

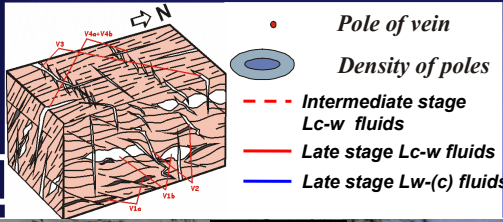


No early stage high salinity fluids!!



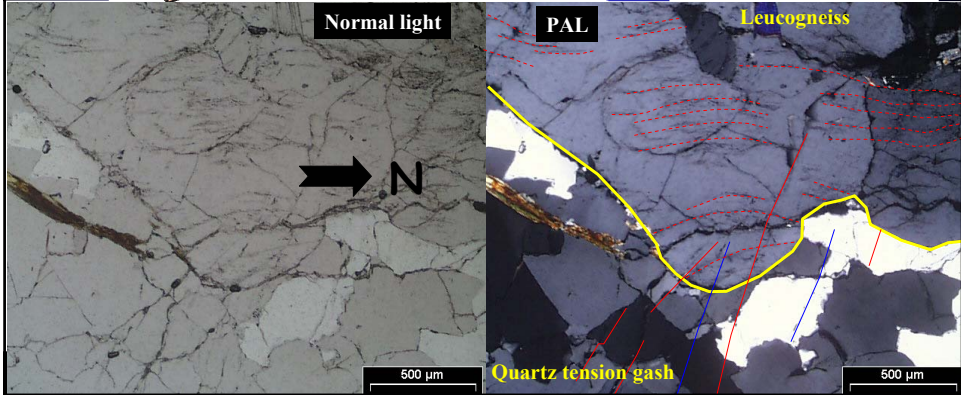
# Fluid inclusion coupled to a FIP study:

## Sample description

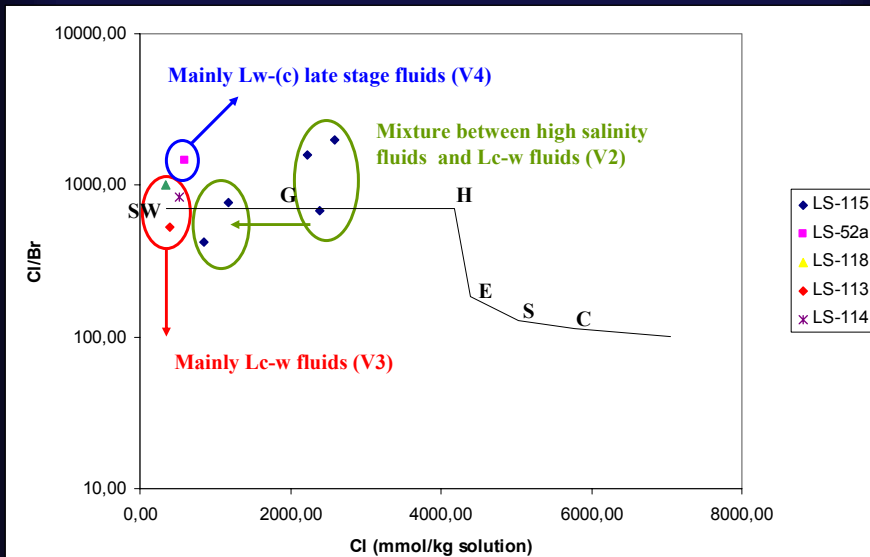


## Results

• NNE-SSW (V4b) striking tension gash



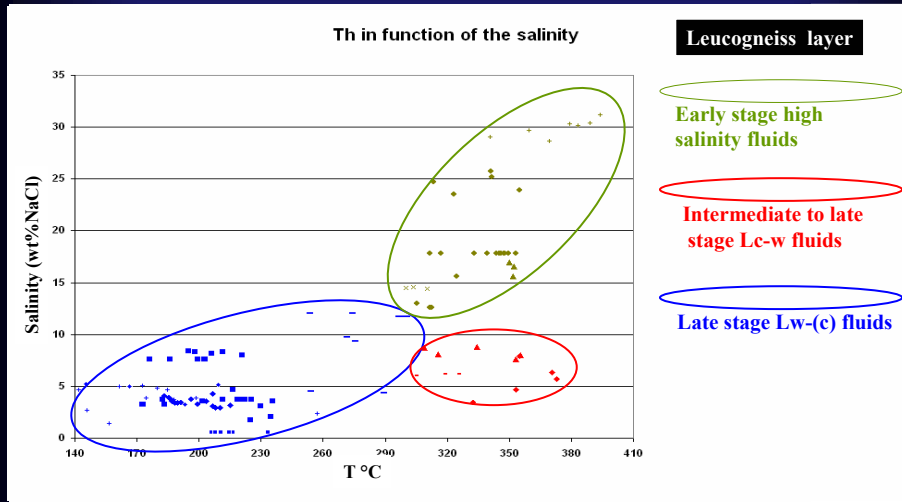
## Crush-Leach Data:



SW = SeaWater ; G = Gypsum ; H = Halite ; E = Epsomite ; S = Sylvite ; C = Carnallite

## Fluid inclusion study

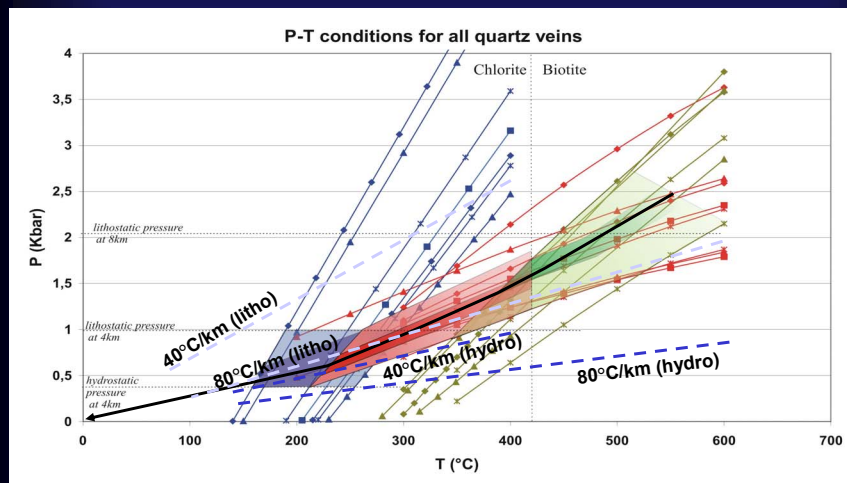
Homogenization temperature versus salinity plot ( samples from the Leucogneiss layer)



→ Salinity is decreasing with decreasing Th in agreement with the chronology between different fluid generations

## Fluid inclusion study

P-T conditions for samples from the leucogneiss layer



→ Early stage high salinity fluids : T: 350 to > 500°C ; P: 1.0 - 2.0 kbar

→ Intermediate to late stage Lc-w fluids : T: 210 - 400°C ; P: 0.4 - 1.5 kbar

→ Late stage Lw-(c) fluids : T: 150 - 280°C ; P: 0.4 - 1.0 kbar

→ High geothermal gradient of about 80°C/km