Laboratory of Fluid Inclusions

Department of Chemistry, Life Sciences and Environmental Sustainability

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INSTRUMENTS

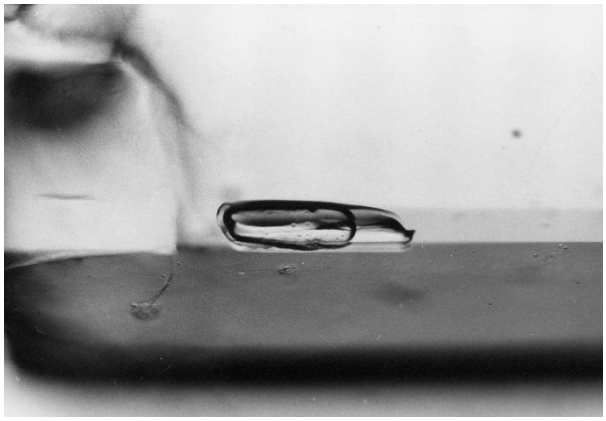
- heating/freezing stage LINKAM THMSG 600 (temperature range -180°/600°C) with software Linksys 32
- heating/freezing stage LINKAM THM 600 (temperature range from -180°/600°C) with camera, video and video recording system
- N° 2 heating stages LINKAM TS 1500 and LINKAM TH 1500 (temperature range 20-1500°C)
- crushing stage
- heating stage LEITZ 1350 (temperature range 20-1350°C)
- heating/freezing stage CHAIXMECA (temperature range -180°/600°C)

WHAT STUDYING

Fluids and/or liquids trapped in the minerals during their growth (primary inclusions) or in a later time as a result of opening and healing of fractures (pseudosecondary and secondary inclusions).

1) FLUIDS

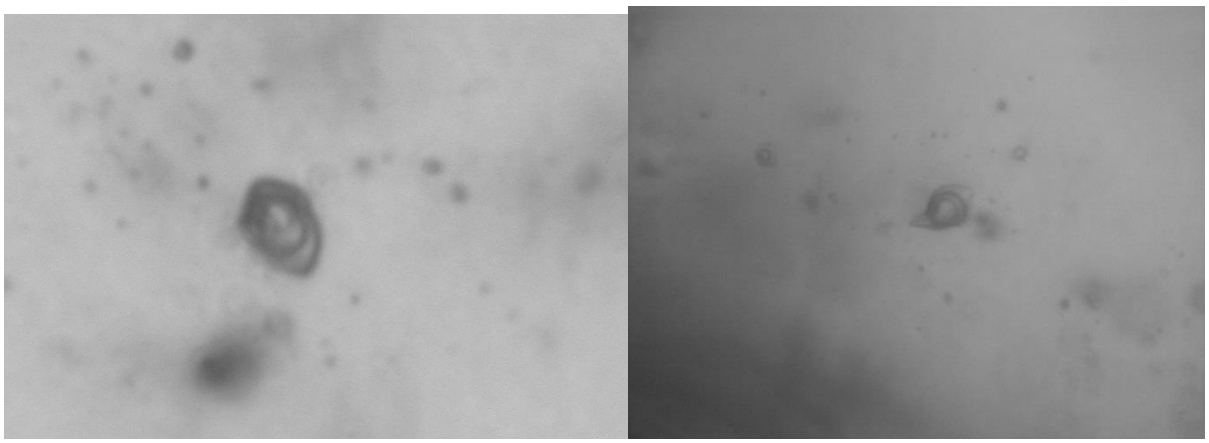
- **Simple systems: H_2O, CO_2, CH_4, N_2**, etc.



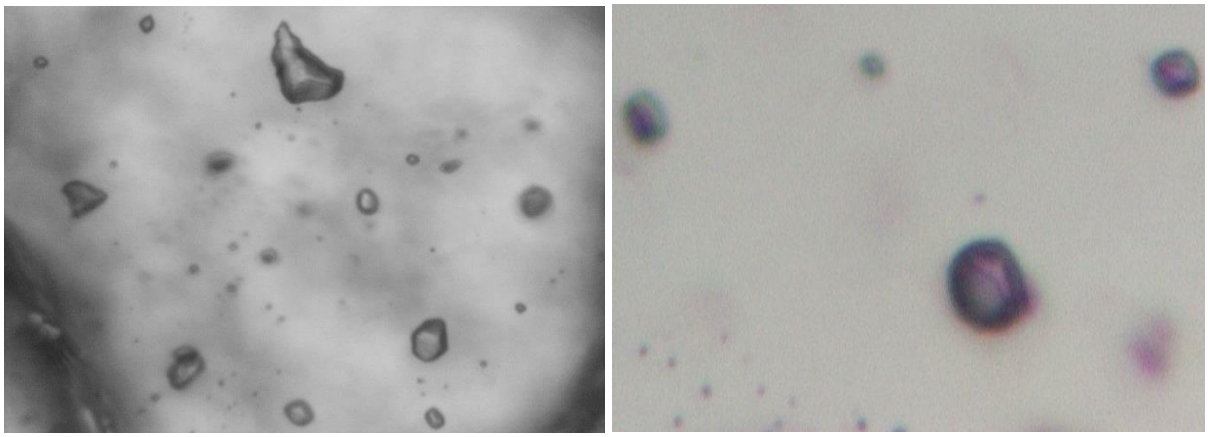
Liquid and vapour H_2O in apatite of lamproitic rocks (Jumilla, Spain)

Liquid and vapour CO_2 in clinopyroxene of peridotitic nodules (Antarctica)

- **Two-component systems: H_2O-NaCl, H_2O-CO_2, CO_2-CH_4**, etc.

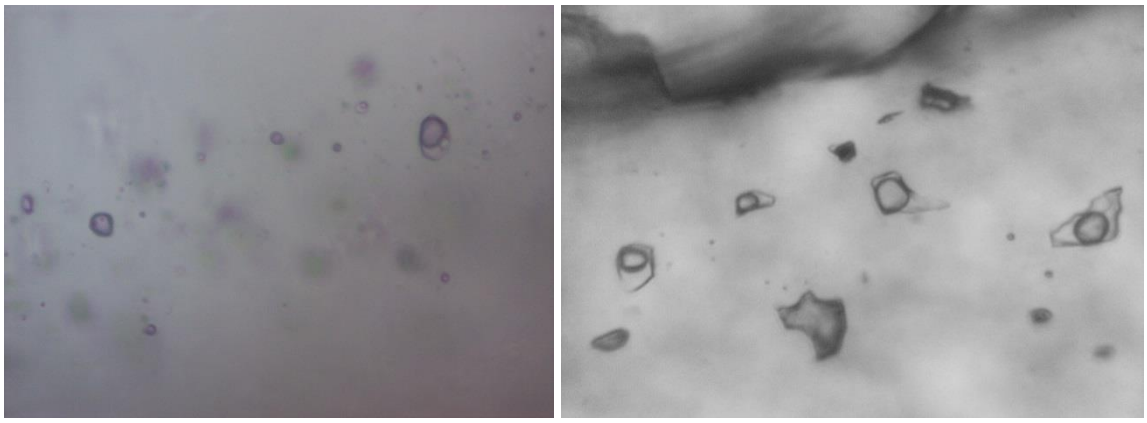


Aqueous inclusions containing liquid and vapour CO_2 in quartz (Honduras)



$CO_2 + CH_4$ in quartz (Honduras)

- **More component systems: H_2O-NaCl-CO_2, H_2O-NaCl-KCl, H_2O-NaCl-$CaCl_2$**, etc.

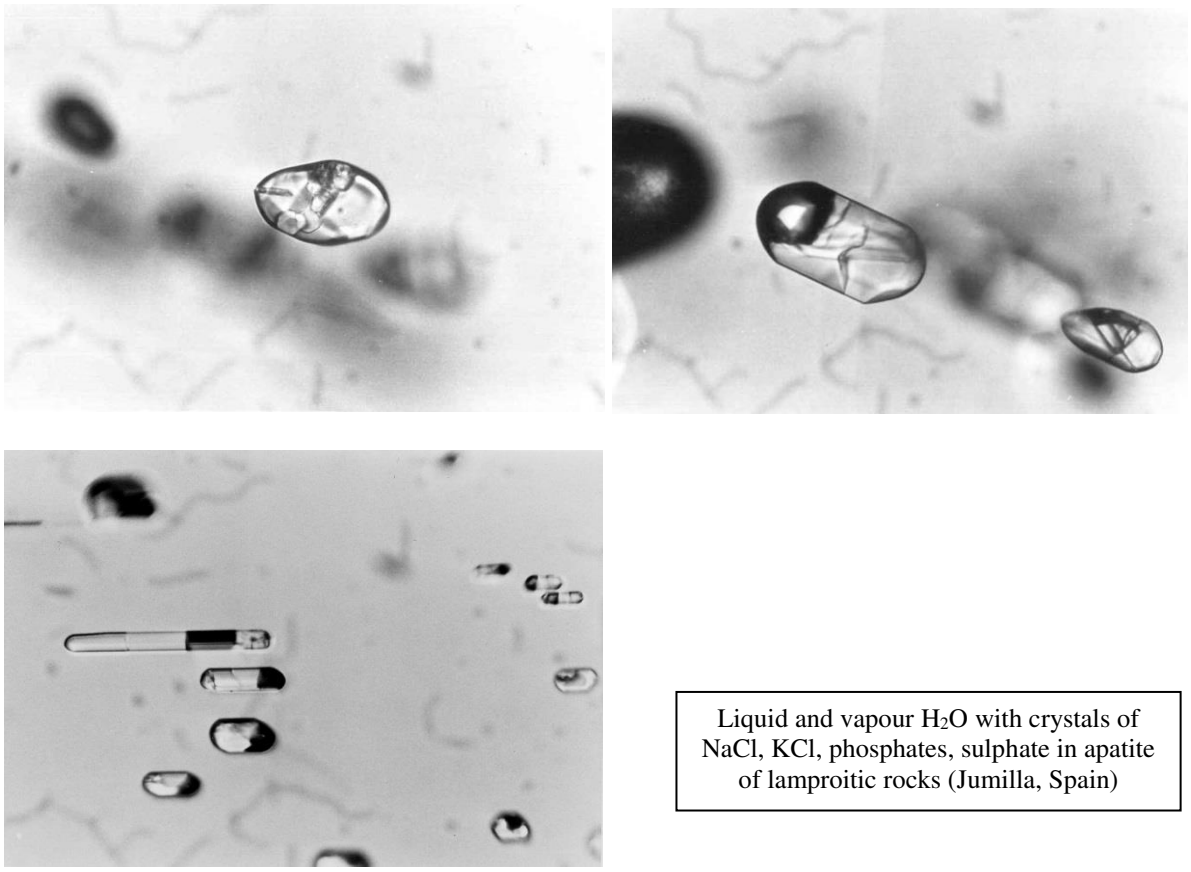


$H_2O + NaCl + CO_2$ in quartz (Honduras)

2) LIQUIDS

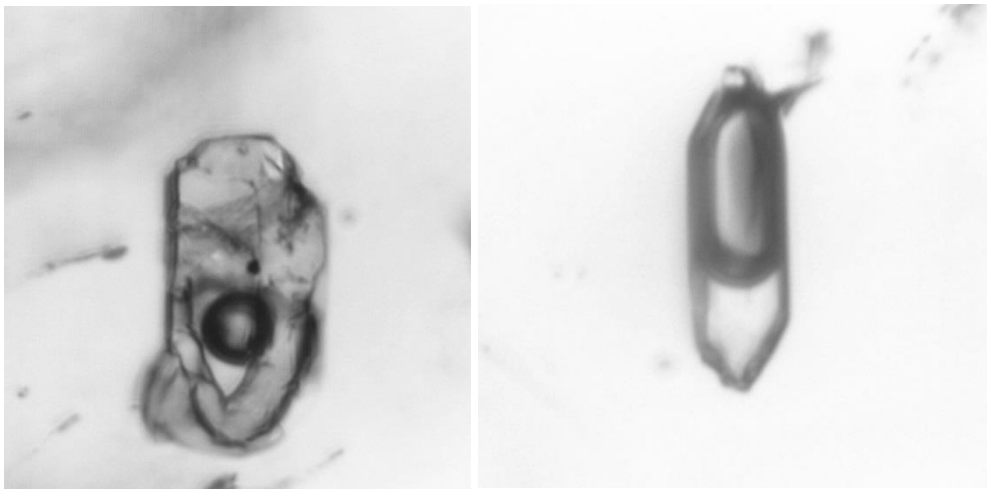
The liquids trapped in the minerals may have variable composition, such as:

- **Salt liquids:** brine, i.e. supersaturated aqueous solutions of salts of various nature



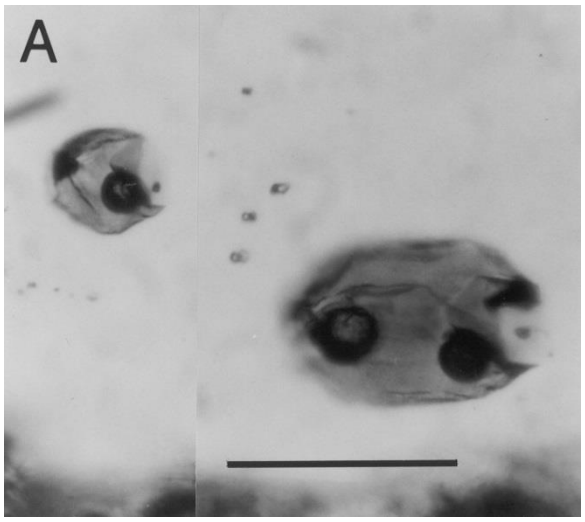
Liquid and vapour H_2O with crystals of NaCl, KCl, phosphates, sulphate in apatite of lamproitic rocks (Jumilla, Spain)

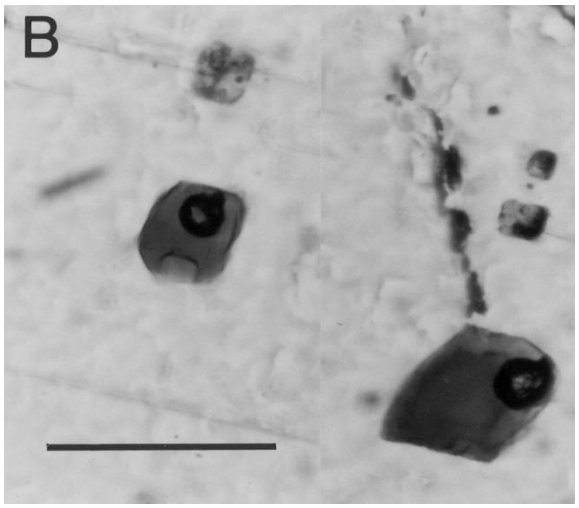
- **Carbonatitic liquids:** supersaturated aqueous solutions in carbonates to form carbonatitic liquid, often associated with silicate liquid (immiscibility)



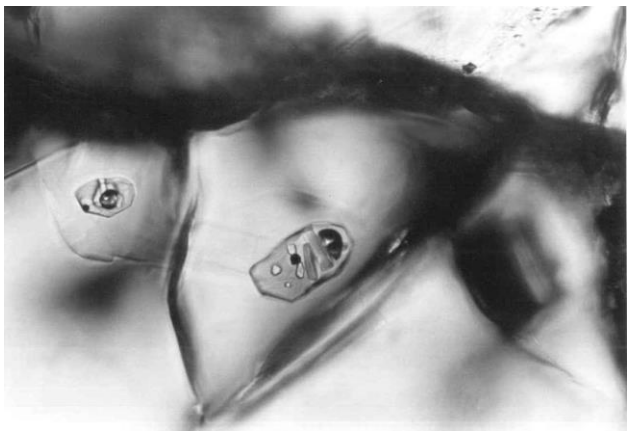
Vapour and liquid H_2O with carbonates in apatite of carbonatites (Jacupiranga, Brazil)

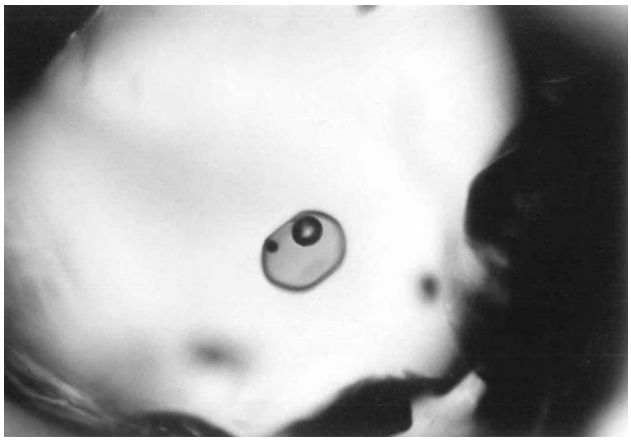
- **Silicate liquids:** they are the most abundant melt inclusions



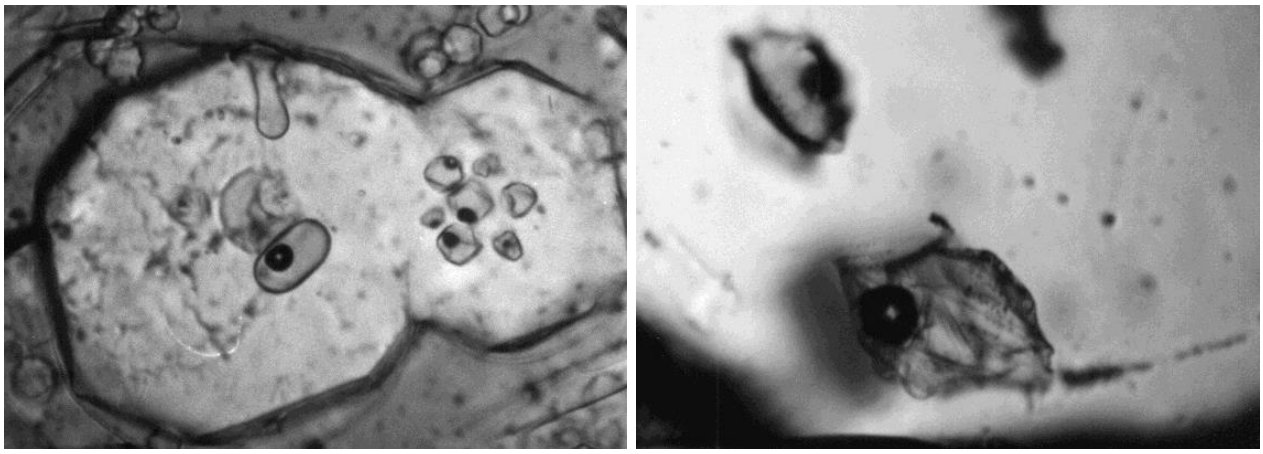


Silicate liquid with a bubble of CO_2, crystals of oxides and silicates in clinopyroxene (on the left), with a bubble of CO_2 and a blob of sulphide liquid in plagioclase (on the right) of gabbroic nodules (Stromboli, Aeolian Islands, Italy)





Silicate liquid with a bubble of CO_2, a blob of sulphide liquid and silicate crystals in clinopyroxene (on the left), with a bubble of CO_2 and a blob of sulphide liquid in olivine (on the right) of peridotitic nodules (Monti Vulsini, Italy)



Silicate liquid with a bubble of CO_2 in leucite (on the left), devitrified silicate liquid with a bubble of CO_2 in olivine (on the right) of olivin-leucitite (Gaussberg, Antarctica)

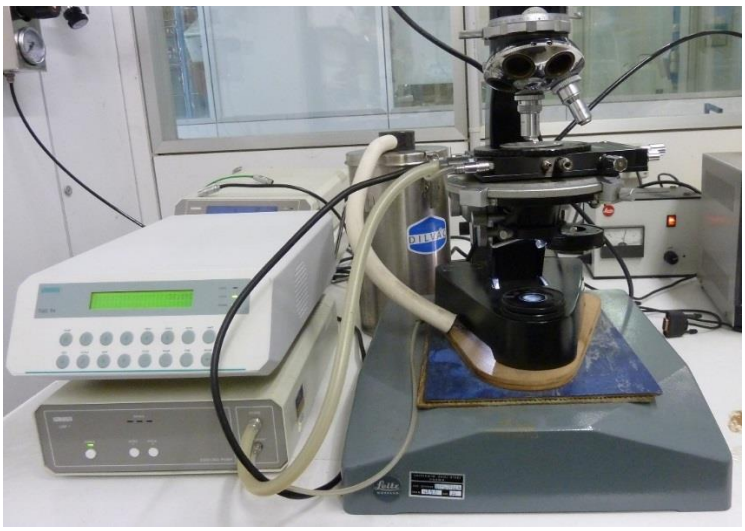
THERMOMETRIC ANALYSES AND OTHER MICROSCOPE TECHNIQUES

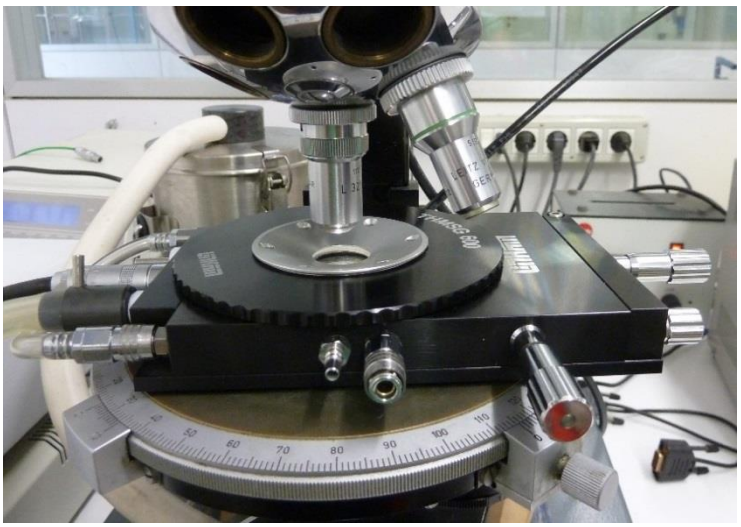
The devices used for the study of fluid inclusions allow to make microthermometric experiments on small slices (wafers) of the mineral containing the inclusions under investigation. The thickness of the wafers depends on the size and abundance of inclusions and the mineral transparency. A high-quality polish on both sides of the wafer is extremely important. Then the mineral wafers must be freezed and/or heated and the temperature of each phase variation in the inclusions should be recorded.

The instruments used for the thermometric investigation consist in devices, called “stages”, which are placed on the rotating stage of a microscope for petrography

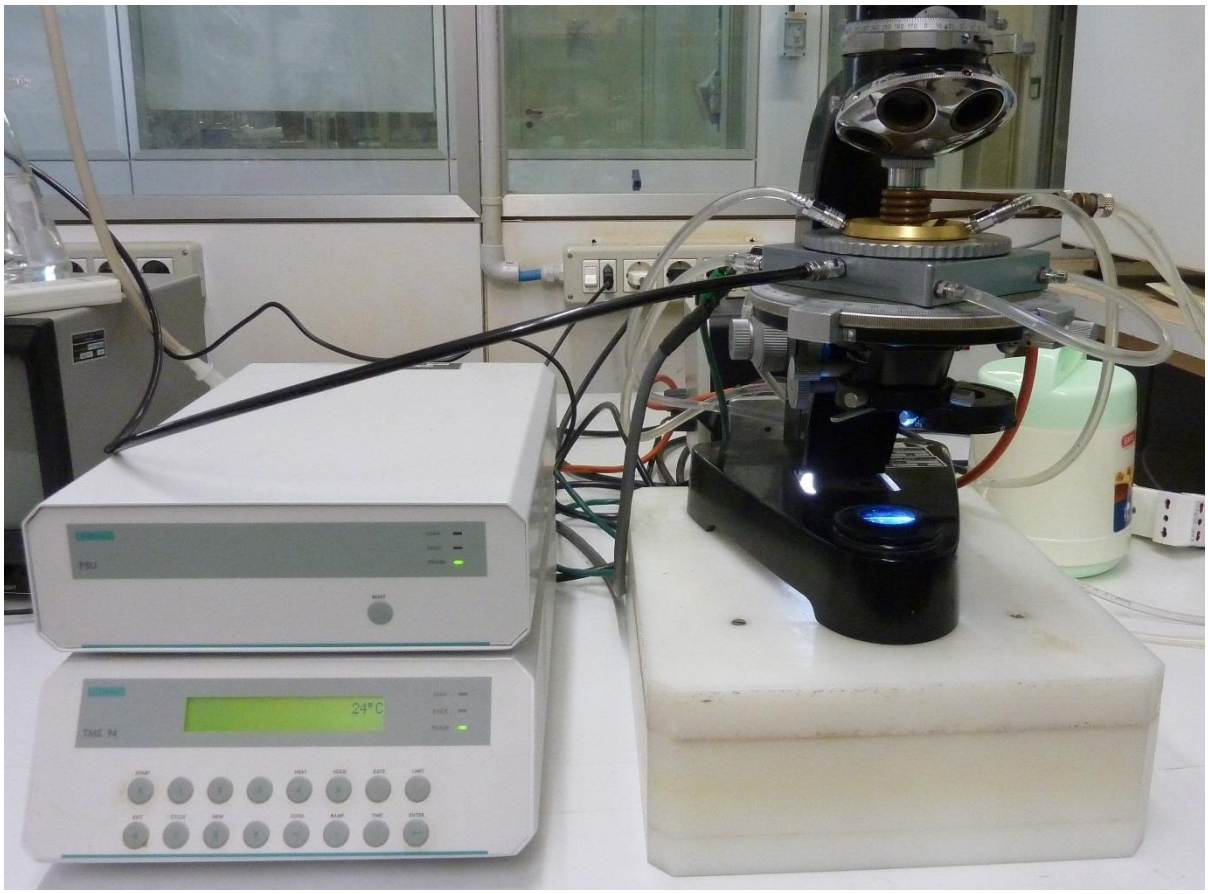
- **Freezing/heating stages.** They are used for experiments on fluid inclusions and are constituted by the following devices:
  1) a stage containing a heater, in which the sample is placed, surrounded by a resistance and equipped with thermocouple
  2) a container of nitrogen (dewar) that circulates inside the stage by means of a pump to cool the sample up to -180°C
  3) a programming unit to set heating cycles with different speeds.

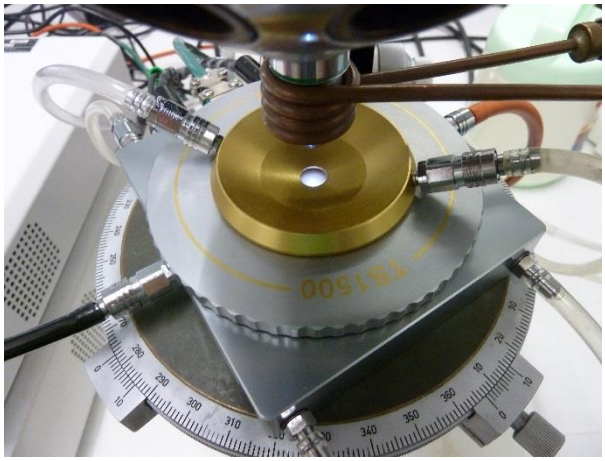
  They can freeze up to -180°C and heat up to 600°C.





- **Heating stages.** They are used for inclusions containing liquids, above all silicate melt inclusions. They are constituted by the following devices:
  1) a stage containing a heater, in which the sample is placed, surrounded by a resistance and equipped with thermocouple; in the stage it is possible to circulate an inert gas (He) to avoid sample oxidation and water to prevent overheating and damage of the microscope optics,
  2) a power unit to reach temperatures up to 1500°C
  3) a programming unit to set heating cycles with different speeds.





- **Crushing stage.** It a small device placed on the rotating stage of a microscope for petrography. It allows to perform simple chemical and physical tests on the contents of the inclusions by opening them in a suitable medium under the microscope. Crushing studies are very effective means of confirming the presence of compressed gas, of testing for carbonate daughter minerals or carbonate ions in solutions, of measuring the refractive index of daughter minerals.

INFORMATIONS PROVIDED BY MICROTHERMOMETRIC DATA

From the microthermometric data it is possible to know:

- **Composition of the fluid**
- **Density of the fluid**
- **Trapping temperature and pressure of the fluid/liquid in the mineral**

The fluid composition and density are needed to obtain the trapping conditions (temperature and pressure) of the fluids by softwares that use the MRK equation of states.

The data obtained from fluid inclusion study are used in many investigation fields.