Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland
Advanced Methods and Diagrams for Fluid Inclusion Studies

ADVANCED METHODS AND NEW DIAGRAMS FOR FLUID
INCLUSION STUDIES.

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1. **Nature and range of data to be measured in
fluid inclusions:**
   - Composition of fluids, solids and gases
   - Density of homogenized fluids

   Problems:

   a) Size and mass of inclusions in common
   rock-forming minerals is very small
   (10^{-12} to 10^{-9} g).

   b) Complexity of included material
   (multi-component systems) is often very
   high.

   c) Availability of PVTX data is limited,
   mostly restricted to few (1 to 3)
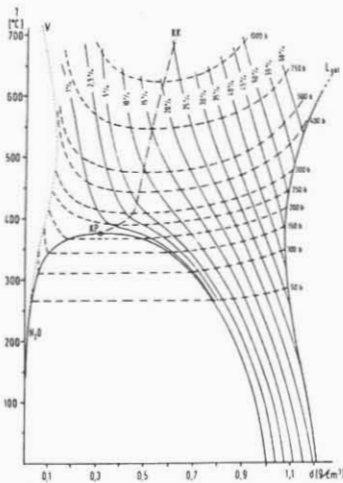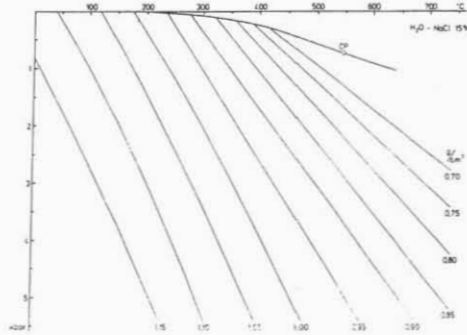   components and low to intermediate P,T
   range.

Fig. 1: H_2O-NaCl, T-d projection of the
boiling surface of the binary system
(contoured by isoplethes and isobars). For
conversion of microthermic homogenization
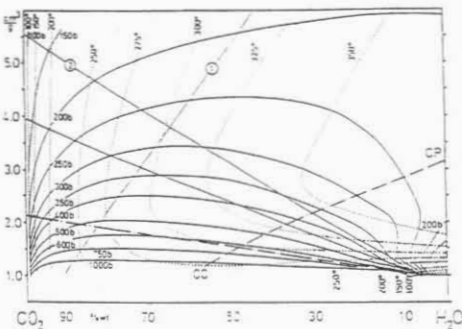temperatures to densities of hydrosaline
microsystems.

Fig. 2: CO_2-H_2O, V-X projection of the
miscibility gap (contoured by isotherms and
isobars). For determination of composition
and density of inclusions from temperatures
measured at partial (CO_2-subsystem) and total
homogenization.

2. **Model systems:**
   - Saline fluids: system H_2O-NaCl (fig. 1).
   Data available partly to 400-600°C,
   4-1 kbar.

   - CO_2-bearing fluids: System H_2O-CO_2
   (fig. 2). Data available partly up to
   750°/2 kbar, 500°/4 kbar.

   - Fluids with higher complexity:
   Construction of isoplethal sections with
   reduced variance through multi-
   dimensional PVTX space (ideally:
   univariant polychoric PT-diagrams) from
   existing data. Extra- and interpolation
   as well as application of
   physicochemical principles (fig. 3).

Fig. 3: Isoplethal PT section (solution with
15% wt NaCl) contoured by isochores
(univariant curves). For thermo barometric
interpretation of fluid inclusion data.

3. **Systems under construction:**
   CH_4-H_2O; CH_4-CO_2; CH_4-CO_2-H_2O
   N_2-H_2O; N_2-CO_2; N_2-CH_4; N_2-CH_4-CO_2
   H_2O with KCl, $CaCl_2$, carbonates, sulfates
   etc.
   Hydrosaline systems with gas components:
   H_2O-NaCl-CO_2; H_2O-NaCl-CH_4

   Basis: Existing data in boundary systems
   and scarce informations on complex
   compositions.

4. **Advanced analytical methods:;**
   Data on chemical composition obtainable
   from
   a) Bulk methods after crushing or thermal
   decompostion
   b) Electron, Raman or other microprobes
   Disadvantage: Limited informations only

   New method: LAMMA (laser activated
   microprobe mass analysis).
   Principle:
   - Opening of single individual fluid
   inclusions by laser shots and
   evaporation of contents
   - ionization of liberated cloud of atoms,
   molecules and fragments by secondary
   excimer laser
   - analysis of resulting particles in a
   mass spectrometer (time of flight)

   Possibilities:
   - **Analysis** of single inclusions, also of
   small size, for all **elements** (even light
   elements), many **molecules** and some
   isotopes (fig. 4, plate 1).
   - High sensitivity and good accuracy
   - Applicable also for components which are
   not suited for Raman analyses.
   - No interference from reaction with host
   minerals or fractionated adsorption.

Fig. 4a,b: LAMMA spectrum of the host quartz
resp. a hydrosaline fluid inclusion about
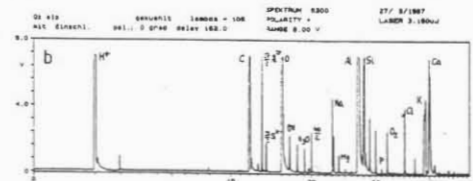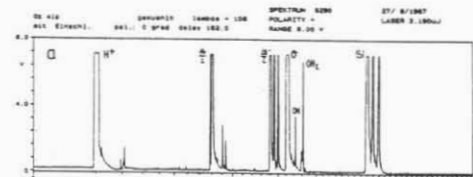20 μm below the surface.

Fig. 5: High resolution LAMMA spectrum of ice
(-150°C), isotopes M2 and M3 are clearly
visible.