« Geothermal Energy » FP6 EC call (12/2004)

Probing high temperature geothermal reservoirs from electrical methods : HiTi EC project and the IDDP

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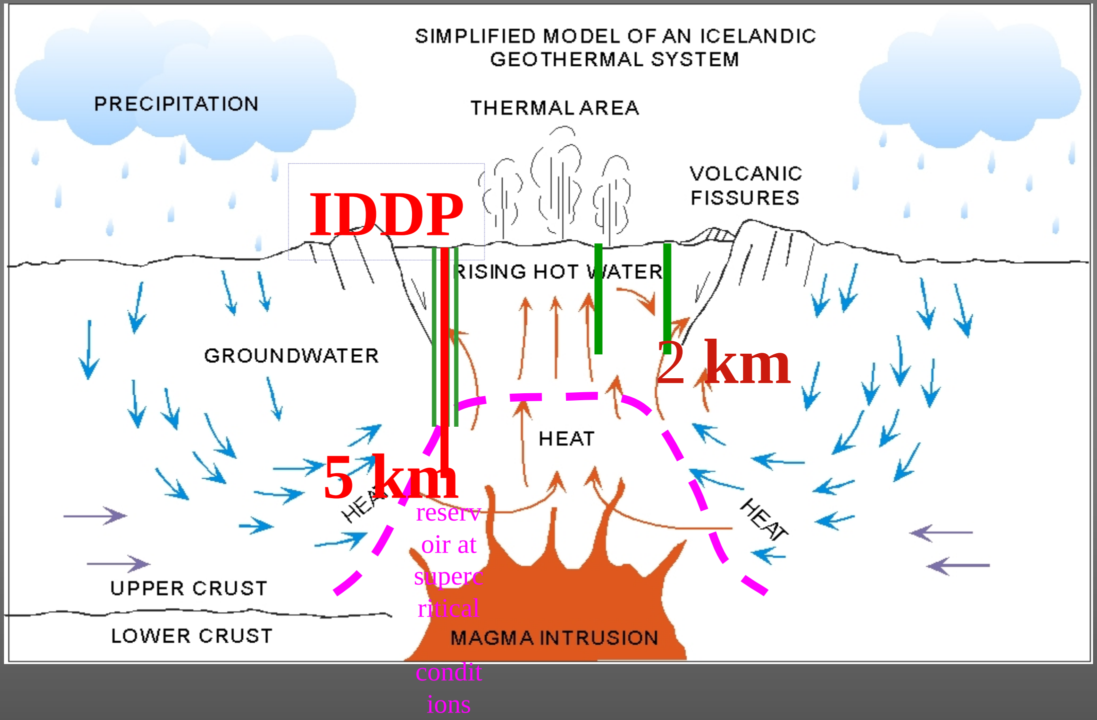
HiTi : *"High Temperature Instruments" (2007 - 2010)*

Structure and general approach of *HiTI*

- Integrated industry and science cooperation to progress in the understanding of very high enthalpy geothermal systems
- Innovative but "realistic" approach … (≤ 2010 !)
- Strong link to Iceland and the IDDP



- Two main thrusts :
  - Reservoir appraisal (exploration phase)
  - Production monitoring (exploitation phase)

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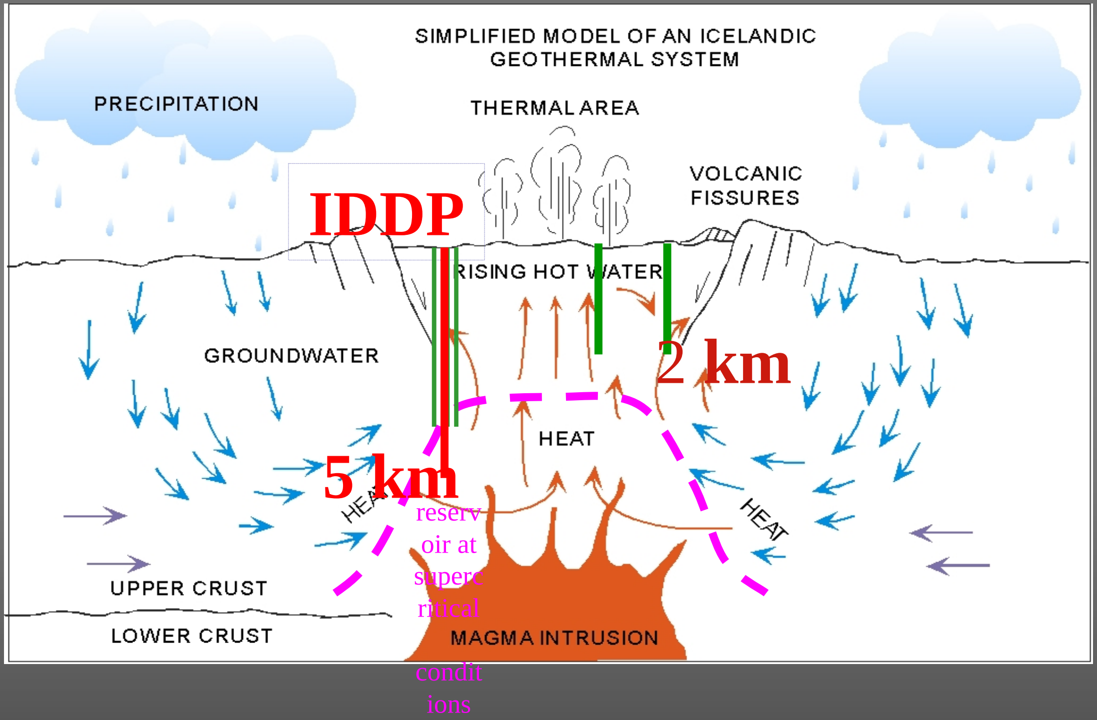

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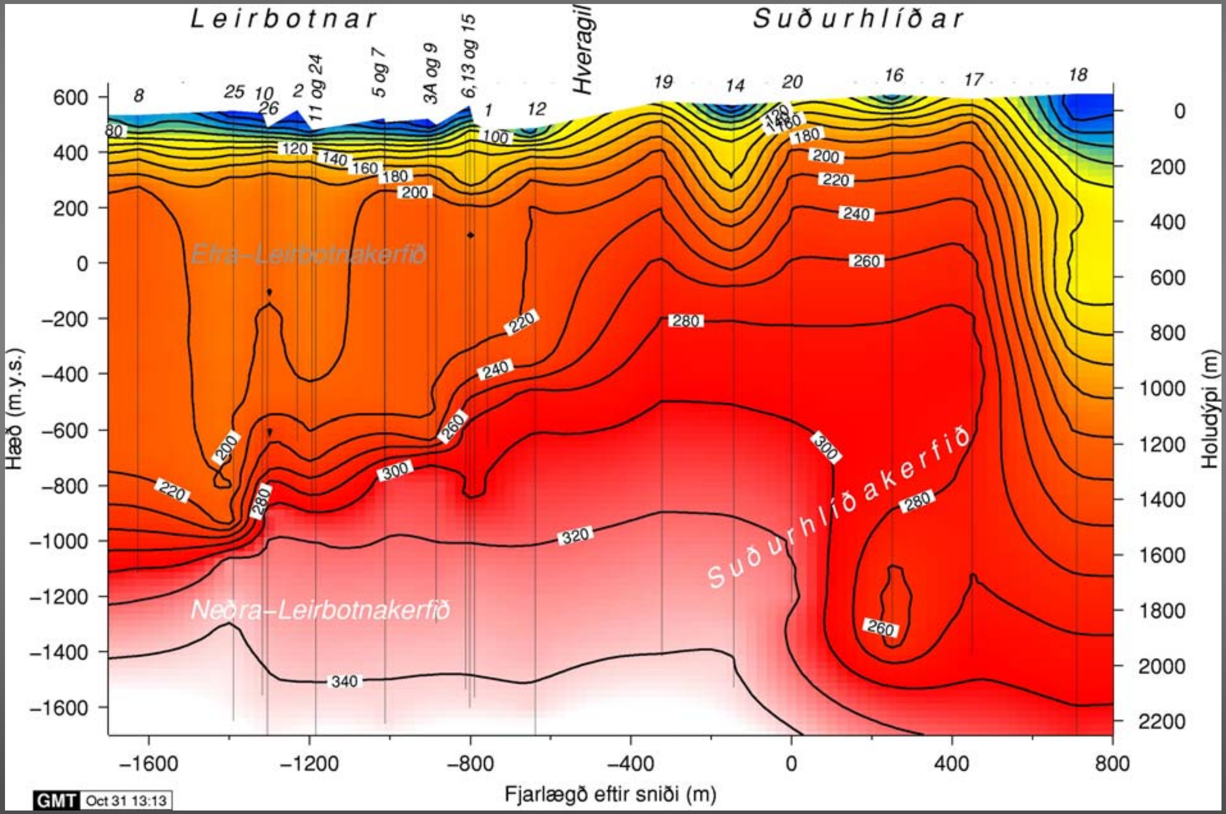
Reservoir probing from electrical properties as part of *HiTI*

- **Electrical resistivity** provides large-scale investigation
- What does it really mean (clay, porosity, pore fluid) ?
- Here : case of Krafla in Iceland in prevision for IDDP



Solving the electrical problem in a geothermal environment

$$C_0 = \frac{C_w}{F} + C_s$$

from Waxman & Smits (1968), Pape et al. (1984), Flovenz et al. (1985), Pezard (1990), Pezard et al. (1991), Ildefonse and Pezard (2001), and a few others.

- $C_w = f\ (s, T)$ with ''s'' (pore fluid salinity) largely unknown
- $C_s = g$ (alteration, T) with alteration from GR and core analyses
- $F = h\ (\varnothing, \tau)$ both from core for matrix and altered phases

=> **ONE** equation and **FIVE** unknowns (*to the first order*)

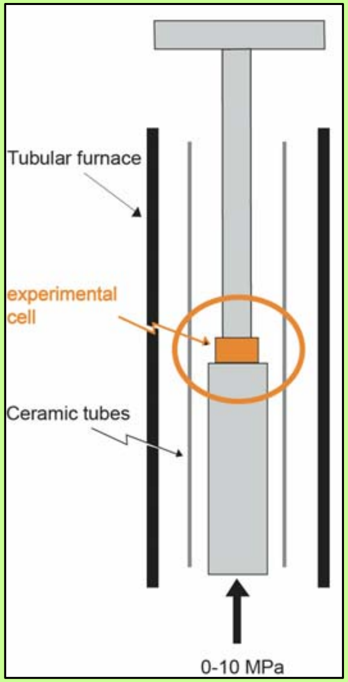
=> **integrated analysis** of core and *in situ* measurements **required.**

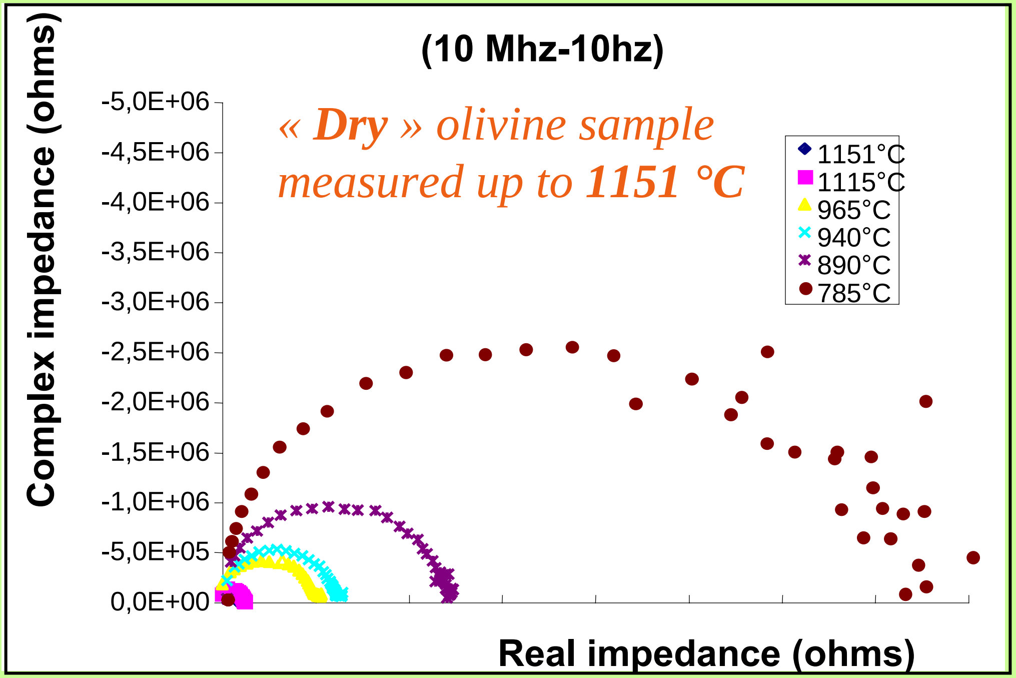
Solving the electrical problem in the laboratory (Paterson press)

$$C_O = \frac{C_W}{F} + C_S$$

- **electrical** and thermal properties
- rheology at supercritical conditions
- mass balance from fluid chemistry

Paterson gas cell





Experiments on « wet » samples up to 500-600°C and 200-300 bars

Solving the electrical problem downhole: new tools development ($T \leq 300°C$)

$$C_o = \frac{C_w}{F} + C_s$$

with $C_o = (1/R_o)$ from LLd (DLL)

- **integrated analysis** of core with *in situ* measurements :

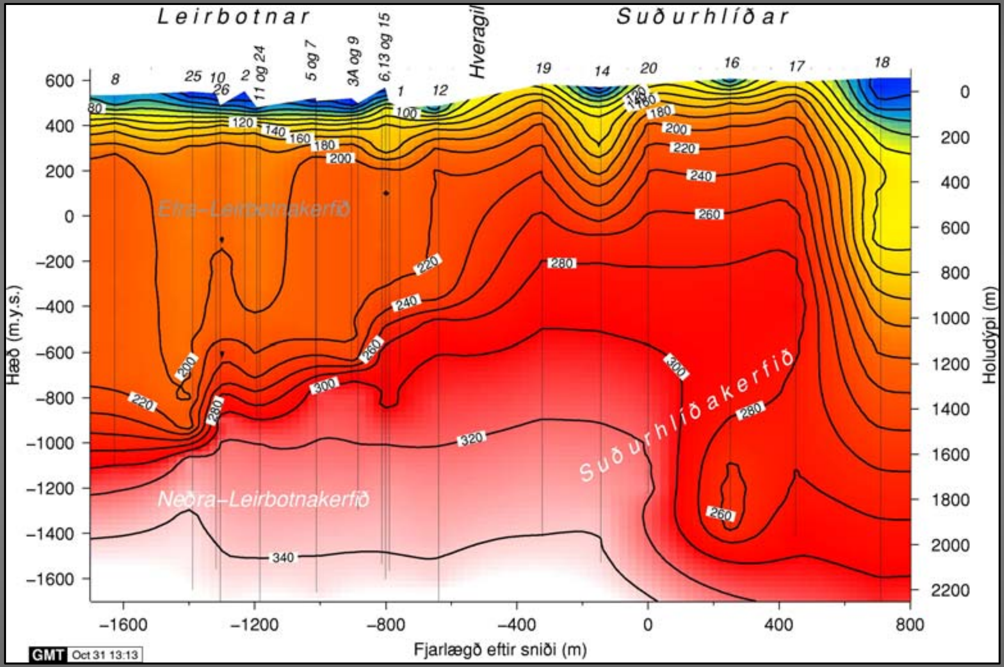
  - C_o and T measured in situ with new DLL (CALIDUS)
  - alteration clays and C_s from GR (ALT) and core
  - fracturing from BHTV images (ALT)
  - stress field from BHTV travel time (ALT)
  - Ø in the matrix from core and BHTV amplitude
  - m or T for the matrix (pore topology) from core only

=> appraisal of **pore fluid salinity** (C_w) in the rock

Reservoir probing from **electrical properties** as part of ***HiTI***

- **Electrical resistivity** problem solved in the ocean crust for hydrothermal circulation and with IODP data.

(T ≈ 200°C)



IDDP : T ≈ 300°C to 450°C

- Potential benefit : an improved integrated **reservoir appraisal**.