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THE GEOTHERMAL OPEN LABORATORY

A free space to measure thermal and hydraulic properties of geological materials log laboratoire Ouvert de géothermie

To measure thermal and hydraulic properties of geological materials

- Portable electronic divided bar
- Infrared scanner
- Needle probe
- Gas permeameter-porosimeter
- Portable permeameter

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CENTRE D'ÉTUDES NORDIQUES
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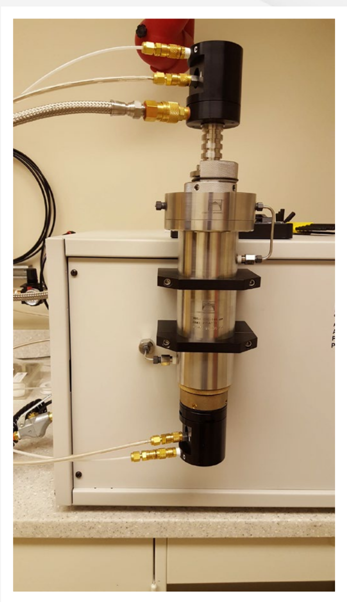
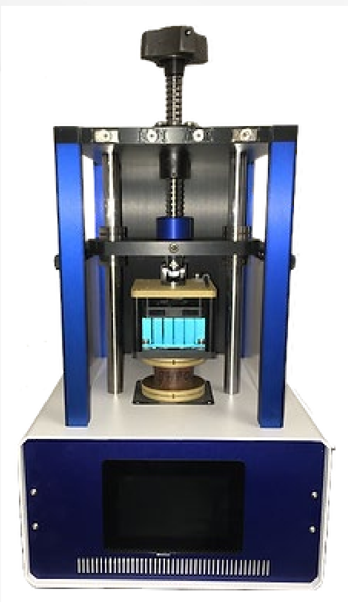
The LOG (Laboratoire ouvert de géothermie)

Open access in exchange of contributions to a shared database

- Users can do its own analysis for free
- Results are compiled in a common database
- Sample location and geological description have to be supplied
- All data become public three years after analysis





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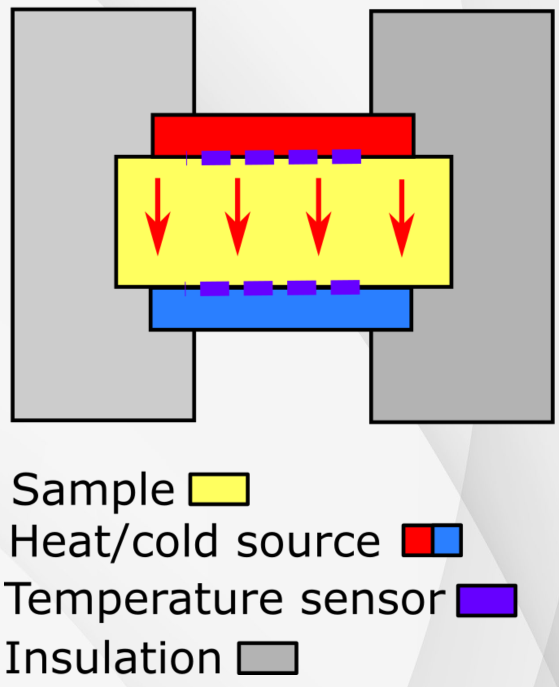
Portable electronic divided bar

Hot Dry Rocks PEDB Mk II

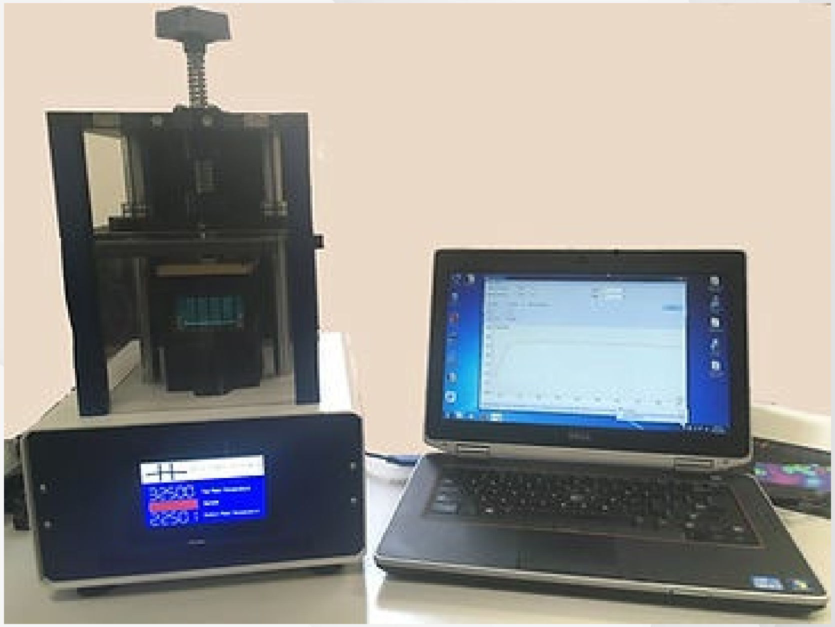
- Steady-state thermal conductivity (λ – W/mK)
- Heat transferred across the whole sample
- Hot and cold plate
- Bulk measurement
- Ambient temperature
- Volumetric heat capacity possible (C – J/m^{3}K)



Portable electronic divided bar

Samples of arbitrary shape

- Up to 65 mm maximum width
- 0.5 to 12 W m^{-1} K^{-1} (± 2 %)
- ± 0.01 ºC temperature control
- Heat capacity to ±3%



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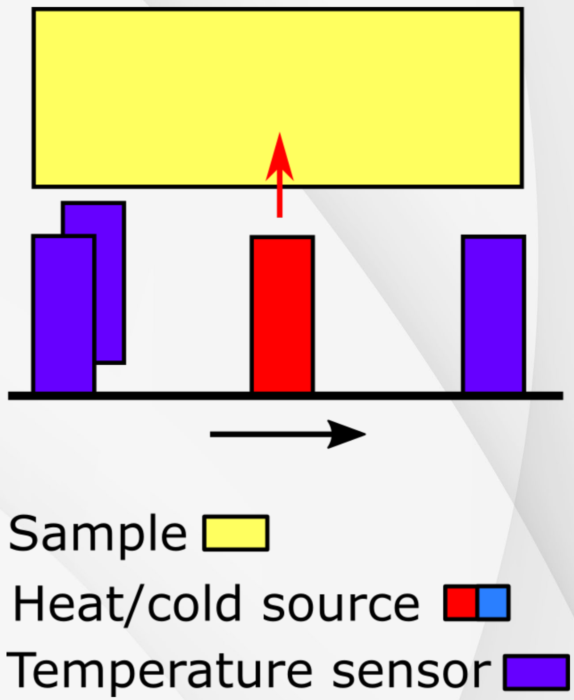
Infrared scanner

LGM Lippmann TCS

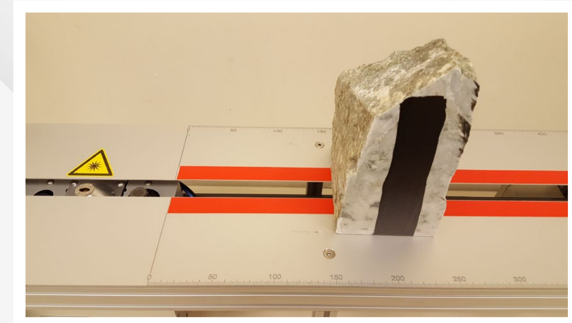
- Transient thermal conductivity (*λ* – W/mK)
- Punctual measurements along scan lines
- Heat pulse sent by a laser
- Infrared temperature sensors
- No contact with sample
- Thermal diffusivity from temperature offset ($\alpha = \lambda / C$ – m^2/s)



Infrared scanner

Flat and cylindrical sample faces

- 40 to 500 mm in length
- Spatial deviation of the sample surface < 5 mm
- Need black paint
- 5 mm s^{-1} scanning speed
- 0.2 to 25 W m^{-1} K^{-1} (± 3 %)
- 0.6×10^{-6} to 3.0×10^{-6} m^2 s^{-1} (± 5 %)



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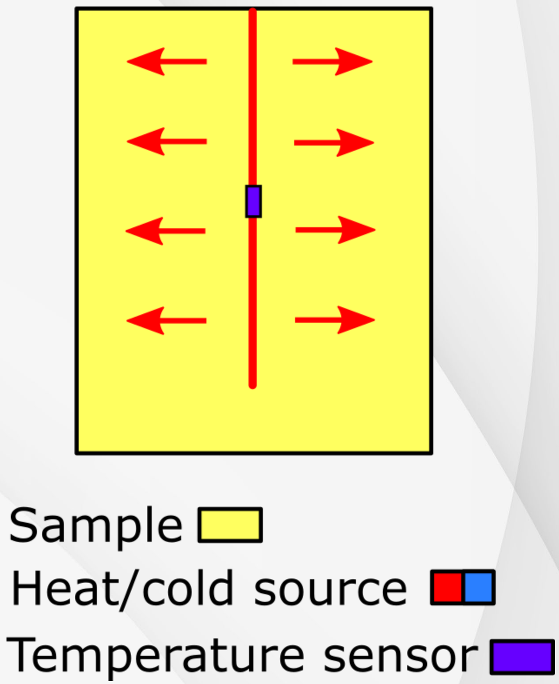
Needle probe

Decagon KD2Pro

- Transient thermal conductivity (λ – W/mK)
- Heat pulse sent by a needle
- Needle pushed / hole drilled
- Best for unconsolidated sediments
- Thermal diffusivity with a dual needle ($\alpha = \lambda/C$ – m^2/s)



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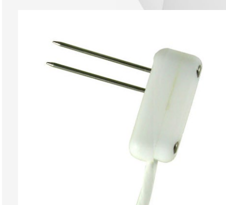
Soft/hard samples

Needle	KS-1	TR-1	SH-1 (dual)	RK-1
Material	Liquid and paste	Soft solid (soil)	Soft solid (soil)	Hard solid (rock)
Diameter (mm)	1.3	2.4	1.3	3.9
Length (cm)	6	10	3	6
Thermal conductivity range ($W\ m^{-1}\ K^{-1}$)	0.02-2.00	0.1-4.0	0.02-2.00	0.1-6.0
Thermal conductivity accuracy (%)	5	10	10	10
Thermal diffusivity range ($m^2\ s^{-1}$)			1.0×10^{-7}- 1.0×10^{-6}	
Thermal diffusivity accuracy (%)			10	



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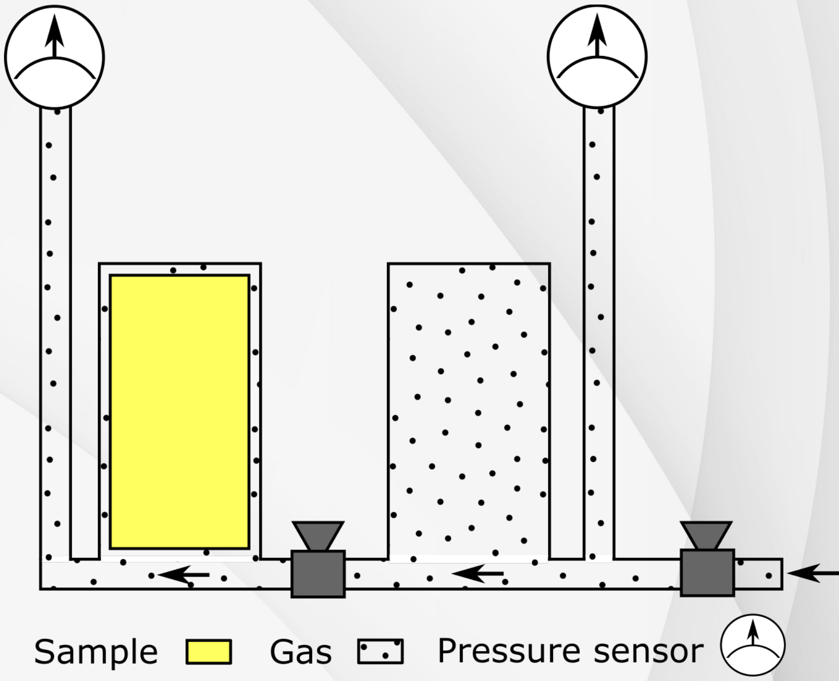
Gas permeameter-porosimeter

Core Test Systems AP-608

- Porosity according to Boyle's law (*n*)
- Pressure exerted by a mass gas is inversely proportional to its volume
- Digital caliper for sample volume
- Permeability based on transient pressure decay (*k* – m^2 or D)
- Darcy's law analysis
- Klinkenberg correction for gas slippage
- 34.5 - 689.5 bar confining pressure



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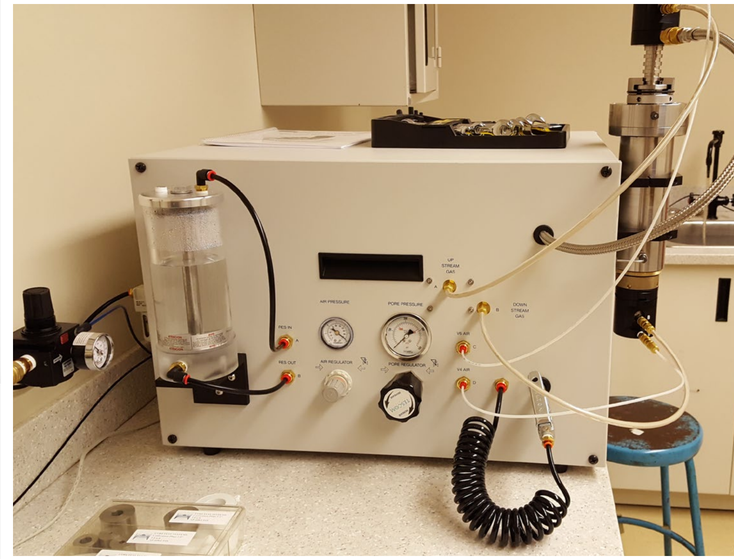
Gas permeameter-porosimeter

Cylindrical core plugs

- 25.4 mm or 38.1 mm diameter
- 25.4 to 101.6 mm length
- Flat and parallel
- Room temperature
- Air and helium
- Porosity at 13.8 bar
- 0.1 - 40 %
- Permeability with 6.9 - 17.2 bar pulse
- 0.001 mD to 10 D



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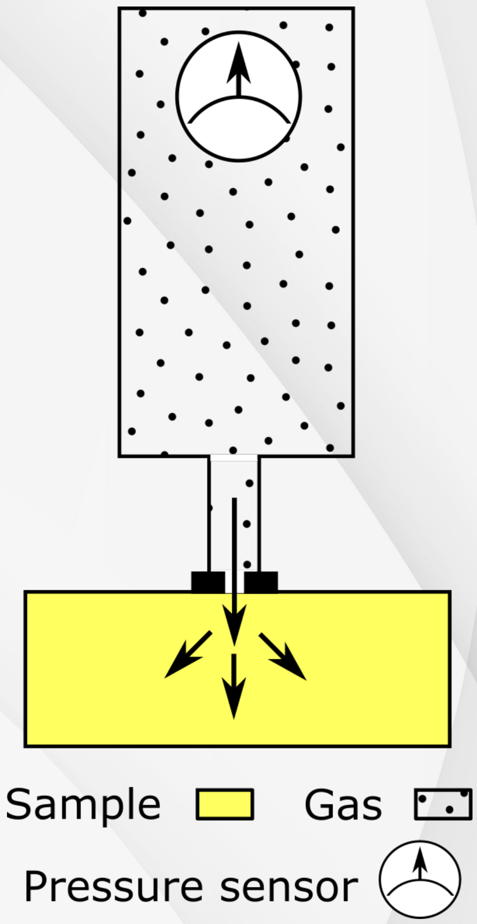
Portable permeameter

Core Laboratories PPP-250

- Permeability based on transient pressure decay (*k* – m^2 or D)
- Darcy's law analysis
- Probe tip on rock surface
- Gas reservoir for field measurements



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Portable permeameter

Core samples or flat outcrop surfaces

- At the core shack or in the field
- 1.7 bar injected in rock mass
- Compressed air
- 0.001 mD to 5 D

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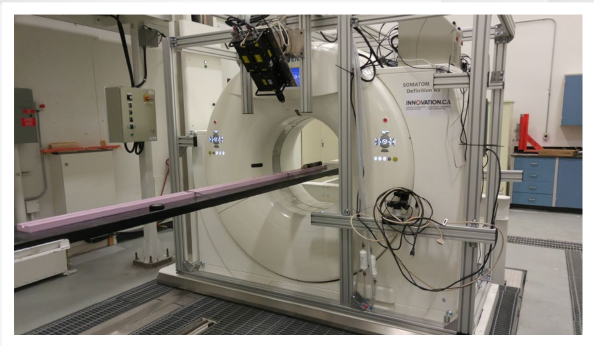
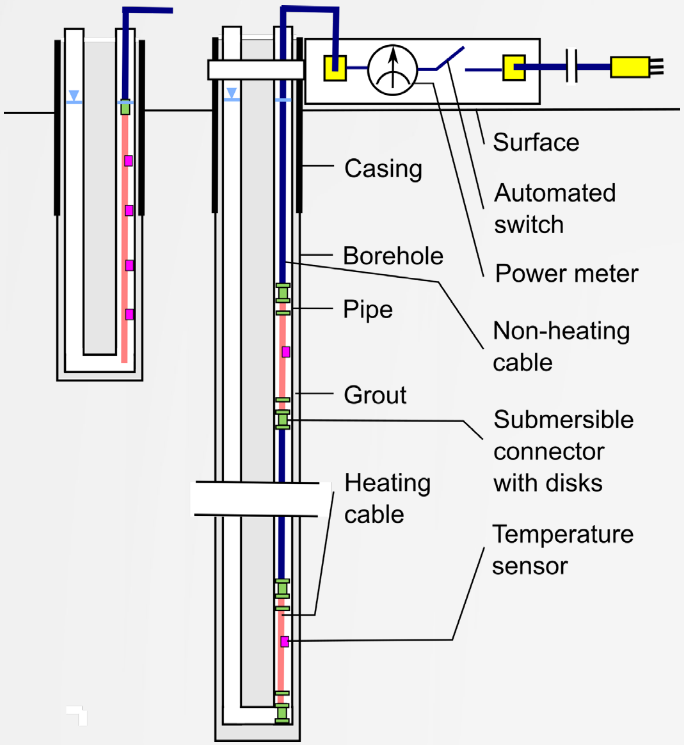
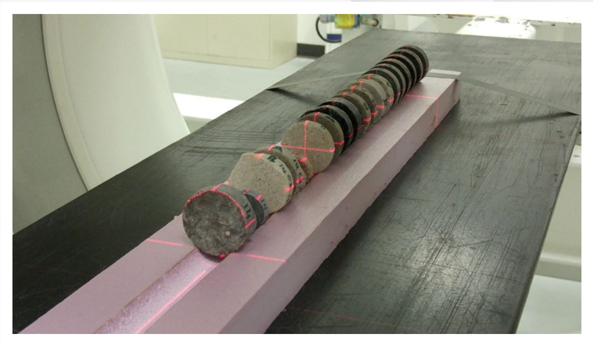
Additional infrastructure and instruments

Not operated with open access

- Medical CT-Scan
- Thermal response test unit with heating cables
- Pilot ground heat exchanger site







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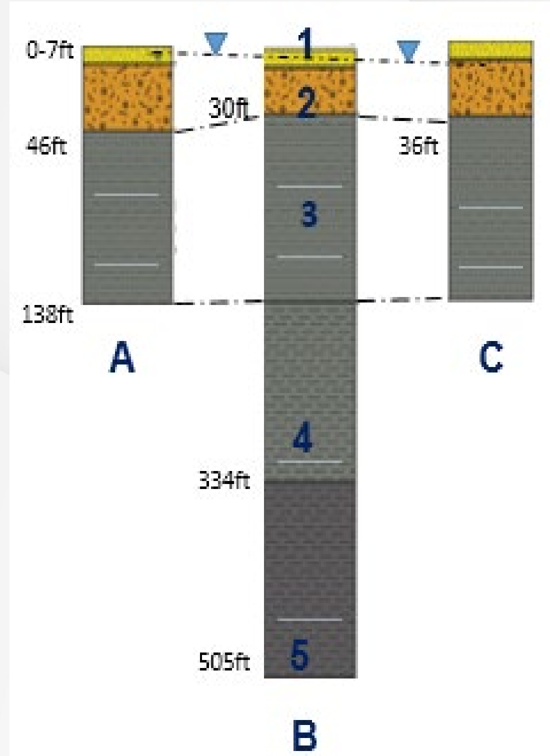
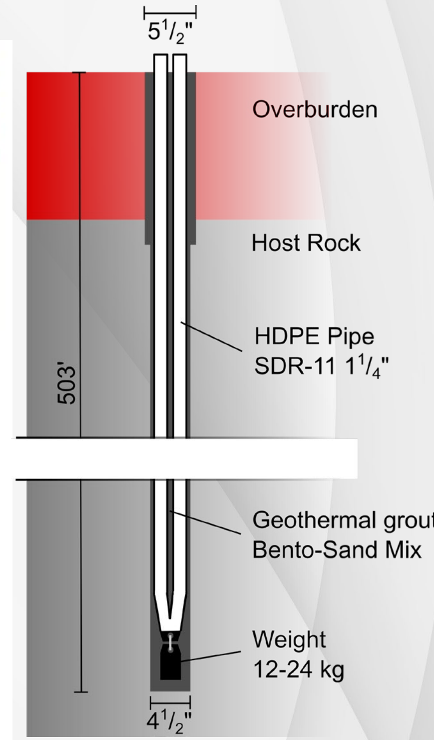
INRS ground heat exchanger site



Legend

1- Backfil, ground and till deposit with pebbles
2- Clay and weathered rock
3- Gray shale rock
4- Greenish-gray shale rock
5- Dark-gray shale rock
A and C: Monitoring borehole
B: Experimental geothermal borehole (1U-pipe)
▼: Water level (6ft)
—: Fracture zone *(82- 98ft;118-125ft; 310ft; 450ft)*



- 1 GHE - 154 m deep
- 2 observation wells - 42 m deep

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CONCLUSIONS

The LOG is the infrastructure needed to characterize subsurface thermo-hydraulic properties and better constrain numerical model development

HOPE TO HOST YOUR ANALYSIS AT INRS!