Relative chronology of deep circulations within the fractured basement of the Upper Rhine Graben

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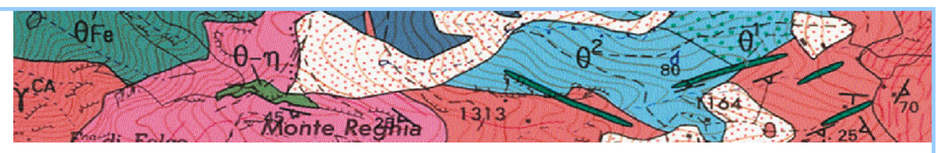
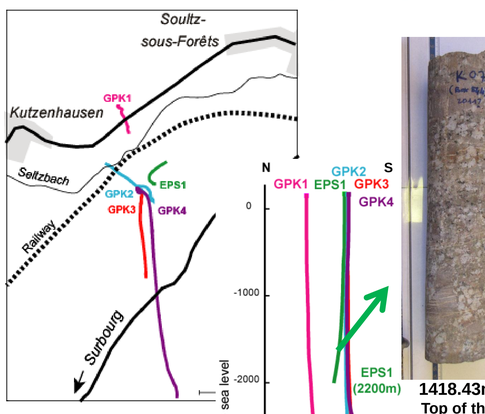


Relative chronology of deep circulations within the fractured basement of the Upper Rhine Graben

In the Upper Rhine Graben, geothermal projects are strongly under development, especially for the exploitation of fluid within the top of the basement. In order to better understand the hydraulic behaviour of the fractured crystalline basement for the development of geothermal reservoir, we propose to study the nature of palæo-circulations.



Location and trajectory of the Soultz EGS project wells (France)

Six samples have been also collected among the granite cores of the EPS1 well on the EGS site of Soultz-sous-Forêts.

1418.43m
Top of the granite. Numerous horizontal fractures

1434.31m
High dipping fracture N160°E

Examples of fractures on EPS1 well cores

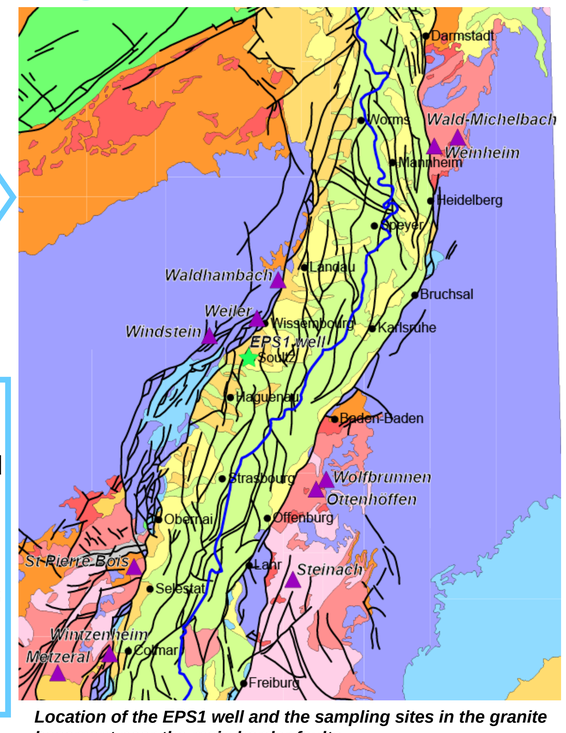
2161.66m
High dipping fracture N150°E

The sampling aims at collecting structural measurements of fractures and faults linked to nature of their mineralogical filling

Fracture in granite with quartz filling and alteration halo (Ottenhöffen quarry, Germany)

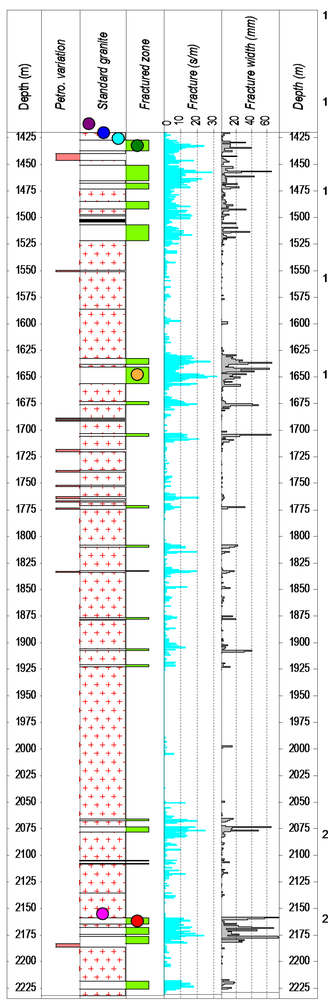
Several outcrops have been visited in the granite basement along the main border faults at the both side of the graben. Generally, the sites are quarries, abandoned or with activities.

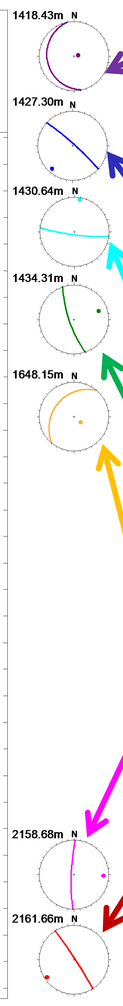
On these outcrops, we have measured planes of fracture and fault, described the associated filling and the facture network relationship. Samples have been collected to detail mineralogy and micro-textures.

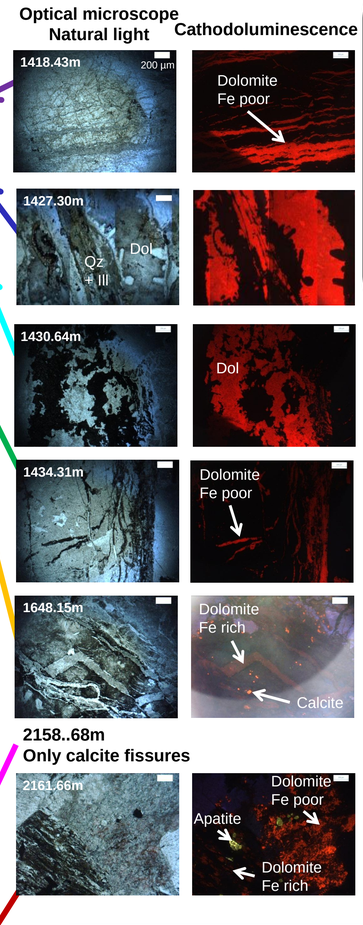


Location of the EPS1 well and the sampling sites in the granite basement near the main border faults.

EPS1 well







Orientation of fractures and location of the associated samples in the EPS1 well (log from Genter & Traineau, 1996).

EPS1 well
NE-SW, NW-SE fractures:
1) shear/cataclasis with sericite mass/granite clasts cemented by illite and microquartz
2) dominant dolomite
3) minor ankerite
E-W fractures:
1) dominant dolomite
2) minor ankerite
N-S fractures: Calcite

Windstein
NW-SE fractures :
1) quartz vein,
2) cataclasis
N-S fractures :
ill + µQtz

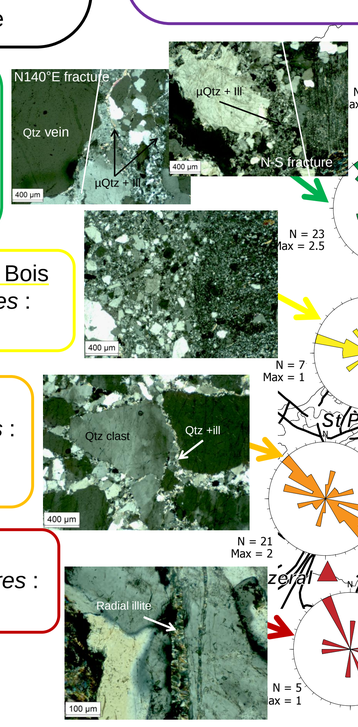
Saint Pierre Bois
E-W fractures :
cataclasis

Wintzenheim
NE-SW fractures :
1) Qtz infilling,
2) cataclasis

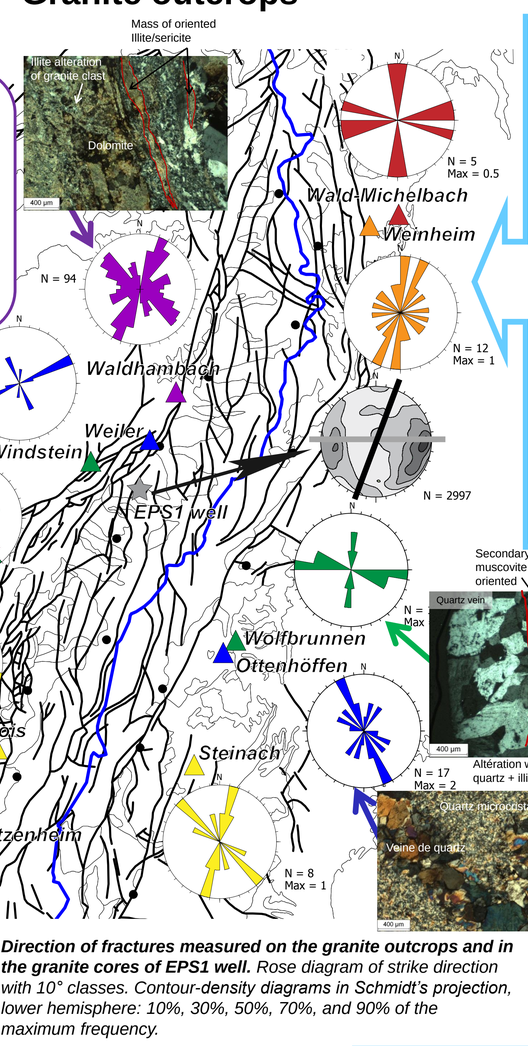
Metzeral
N170°E fractures :
radial illite

Micro-textures observed under microscope

Waldhambach
NW-SE fractures:
1) shear/cataclasis with sericite mass/granite clasts, 2) quartz filling,
3) Fe-bearing carbonates,
4) dolomite/ankerite, 5) barite



Granite outcrops



The global orientation of the fracture measured on the field in the granite basement on the shoulders shows different sets :
- NW-SE associated to N20°E and E-W in the southern part and at Windstein and Waldhambach
- E-W at Saint-Pierre-Bois and Wolfbrunnen
- N-S associated with E-W direction set in the Odenwald

Wolfbrunnen
E-W fractures :
1) cataclasis,
2) quartz filling
N-S fractures :
cataclasis

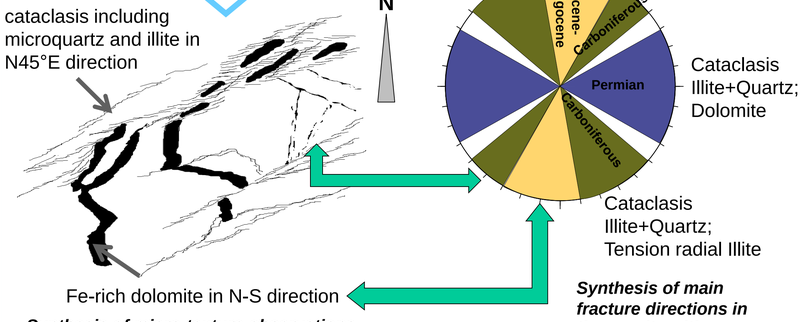
Ottenhöffen
NW-SE, E-W fractures :
1) cataclasis,
2) microquartz filling
N-S fractures :
1) cataclasis,
2) quartz/silica coating

Direction of fractures measured on the granite outcrops and in the granite cores of EPS1 well. *Rose diagram of strike direction with 10° classes. Contour-density diagrams in Schmidt's projection, lower hemisphere: 10%, 30%, 50%, 70%, and 90% of the maximum frequency.*

On the cores of the Soultz well EPS1, numerous fractures have been observed (almost 3000 on 800m of borehole cores). Because of the long geological history of the granite, most of fractures are reactivated at different tectonic phases.

The analyses of the palæocirculation in the granite basement show several stages of fracturing following by several pulses of fluid circulation.

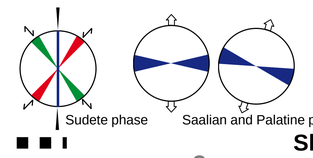
The determination of fracture infillings shows that some types of filling may be linked to the main identified fracture set directions



Synthesis of micro-texture observations

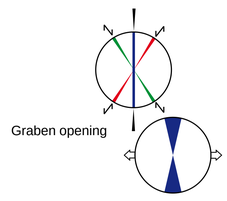
Synthesis of main fracture directions in the granite with associated filling

Paleozoic		Mesozoic			Cenozoic			
Hercynian orogenesis		Clastic and marine deposits			Graben formation			
Carboniferous	Permian	Trias	Jurassic	Cretaceous	Pal	Eo	Ol	Mio



Sudete phase — Saalian and Palatine phases

← Main tectonic phases →



Graben opening

Shearing Muscovite
Cataclasis Qtz + illite
Siderite/ankerite

Cataclasis Qtz + illite
Euhedral Quartz
Dolomite/ankerite
Barite
Calcite

Diagenetic sequence of fracture infillings in relation with the main tectonic phases

Conclusions

The reactivation of old Hercynian structures in relation with the Tertiary tectonic history of the graben formation develops the fluid/basement interaction in deep temperature conditions. In the contrary, the N-S large structures favor recent circulation system and rather constitute a recharge drain.

Perspectives

This work constitutes the first step to understanding the palæo-circulations within the granite basement of the Rhine Graben. These textural and mineralogical data need to be completed by microthermometric, isotopic and geochronological investigations. Those give information of the fluid circulation within the fracture network to help exploration and development of future geothermal operation.

Auteurs

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