Defining, exploring, imaging and assessing reservoirs for potential heat exchange

Summary of Workshop 1,

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ENGINE Mid-Term Conference
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Session 4: Investigation of Unconventional Geothermal Resources and in particular Enhanced Geothermal Systems

Goal: discuss all parameters that should be known before drilling for exploitation of potential geothermal reservoirs.

Focus: debates about the definition of targets, characterization of reservoirs and optimisation of investigation methodology for EGS.

Thematic sessions:

- Signatures of temperature field for defining and exploring potential geothermal reservoirs
- Signatures of fluid transport in Earth's crust
- State of the Art in the exploration of potential geothermal reservoirs
- Processes in geothermal reservoirs

Requirements: a significant improvement of the imaging and modelling of fault and fracture systems, of the knowledge of the paleostress field as well as of the heat flow and temperature distribution at depth.

Research needs:

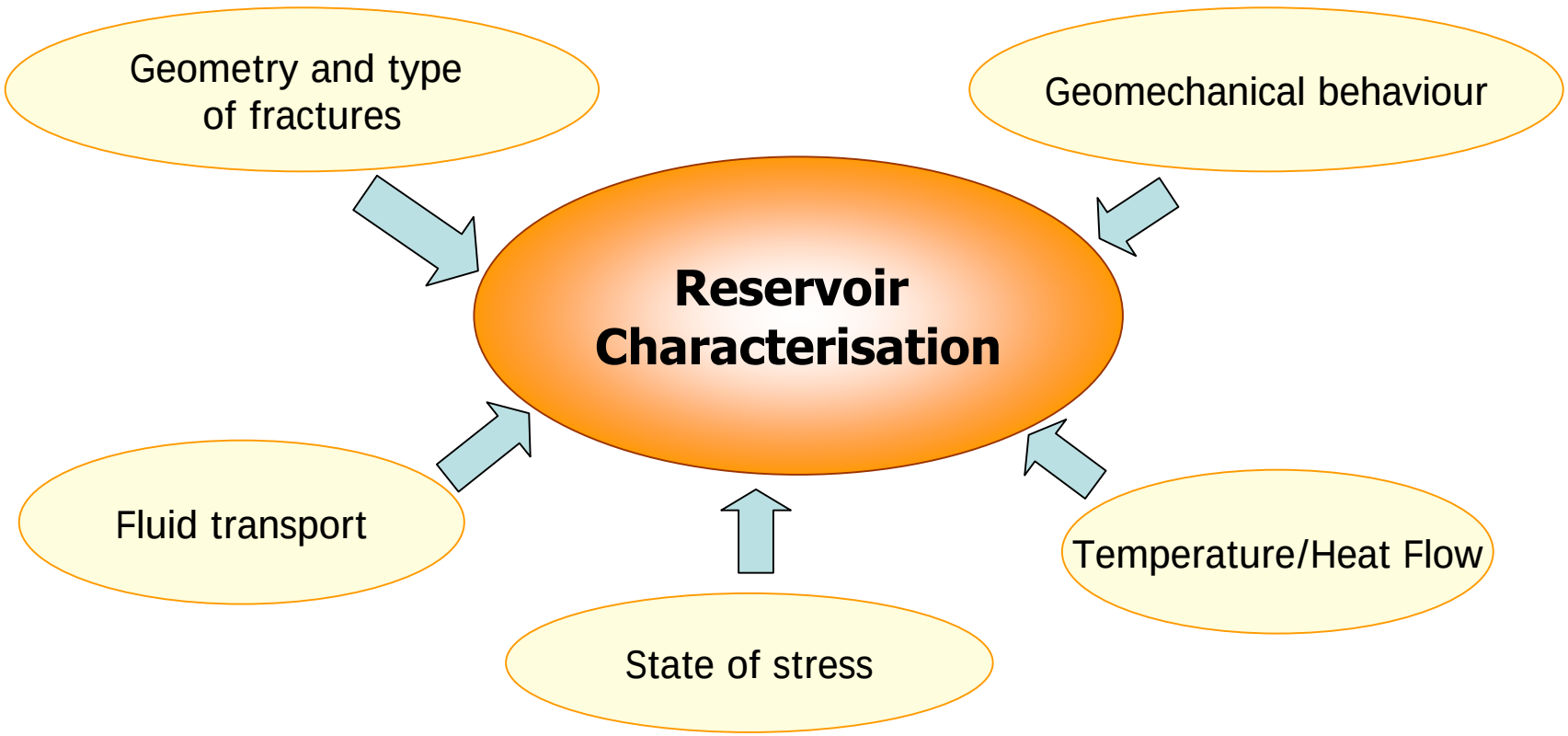
- structural inventory of the subsurface
- heat, temperature, stress and pathways as well as chemical and mineralogical composition of rocks hosting the geothermal system

Main research targets:

- Structural Geology: imaging potential geothermal reservoirs
- Heat: finding heat at depth
- Stress: understanding and stimulating fluid circulation
- Pathways: defining integrated conceptual models

Structural Geology: imaging potential geothermal reservoirs

In order to understand the geothermal potential of a reservoir some relevant properties should be defined



Structural Geology: imaging potential geothermal reservoirs

Geophysical methods -> architecture, geometry, and quality of target intervals

Requirements: Methodological improvements

Combination of methods

Petrophysical validation (Logging and laboratory)

Hydrocarbon explorationfor fluid pathways : to be improved for EGS

Large scale approaches supplemented by high-resolution experiments

Adapted processing techniques

Heat: finding heat at depth

Maps of the heat flow distribution at surface and at the crust-mantle boundary provide far-field conditions for any definition of possible targets for EGS.

Heat-flow pattern -> lithospheric and crustal temperatures

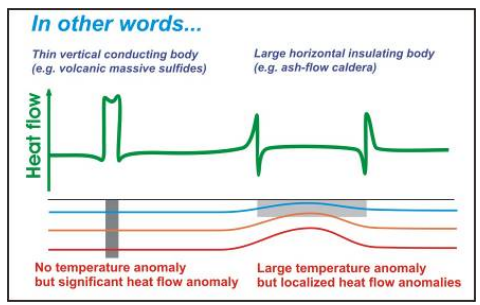
To avoid inaccuracy of heat flow extension at depth. However, especialy in active tectonic settings, relative shallow (< 10 km) static and dynamic phenomena must be carefully:

- magma intrusions into high crustal levels (e.g., Larderello, Soultz)
- thermal conductivity variations, both vertical and horizontal (sedimentary basins)
- large- and small-scale fluid flow (e.g. the Rhine Valley)
- radiogenic sources in the upper crust (e.g. areas of high-heat-production granites)

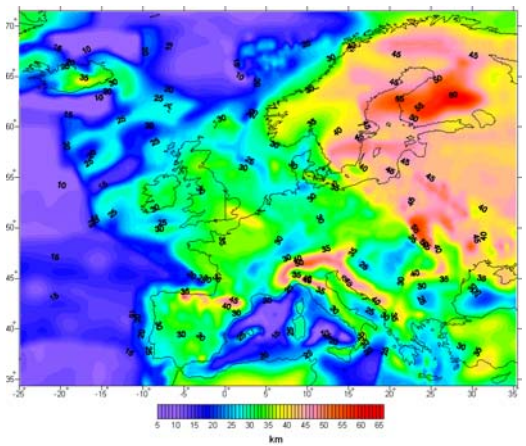
EGS database of temperature and heat distribution requires:

- thermal conductivity
- radiogenic heat production

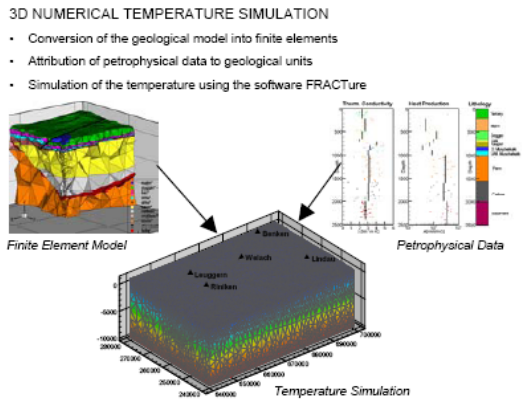
Interpretation in terms of heat-transfer processes, with some care



Heat: finding heat at depth



On a global scale, temperature and strength distribution can be calculated and crustal models defined.



On a local scale, examples of integration of geological, geophysical, petrophysical data are available, in order to reconstruct temperature distribution at depth using modeling tools

The definition of possible targets for EGS could be improved by the use of a 3D modelling platform, in which all solutions from geological, geochemical and geophysical modelling, direct and inverse, could be combined and analysed.

Stress: understanding and stimulating fluid circulation

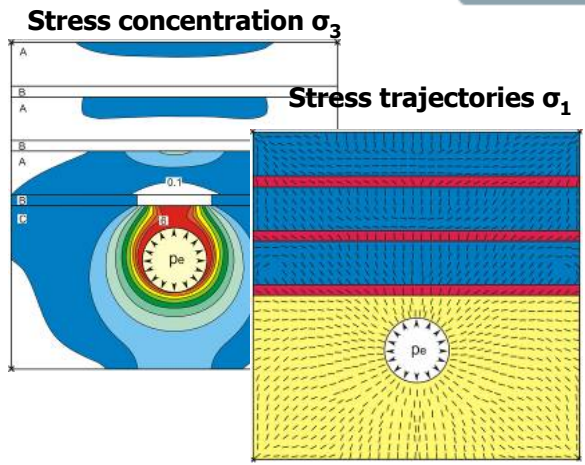
There is abundant evidences of the influence of the stress field on hydro fracturing.

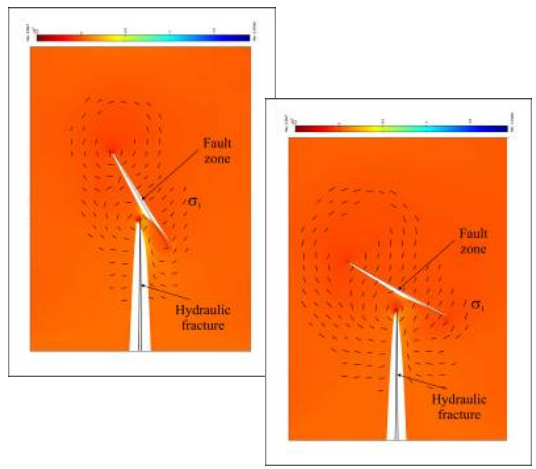
Spatial stress distribution (map and depth) on a local as well as on a regional scale Mechanisms of rupture and propagation of faults -> sustainable permeability.

The geometry of the fault and fracture systems control the circulation and accumulation of fluids in the crust.

Stress field (orientation and intensity) -> channelling of fluids

Tectonic context and geological environment -> favourable and unfavourable conditions





Stress: understanding and stimulating fluid circulation

Hydro-fracturing is not the only option to enhance the permeability of reservoir rocks.

Selective dissolution should also be taken into account (as a technique to increase *effective* porosity and permeability) as it could be more effective than fracturing, provided that it is applied to suitable lithological frameworks (e.g., sandstones made up of quartz and silicate minerals but also containing relevant amounts of fast-dissolving carbonate minerals) and under carefully selected conditions.

Pathways: defining integrated conceptual models

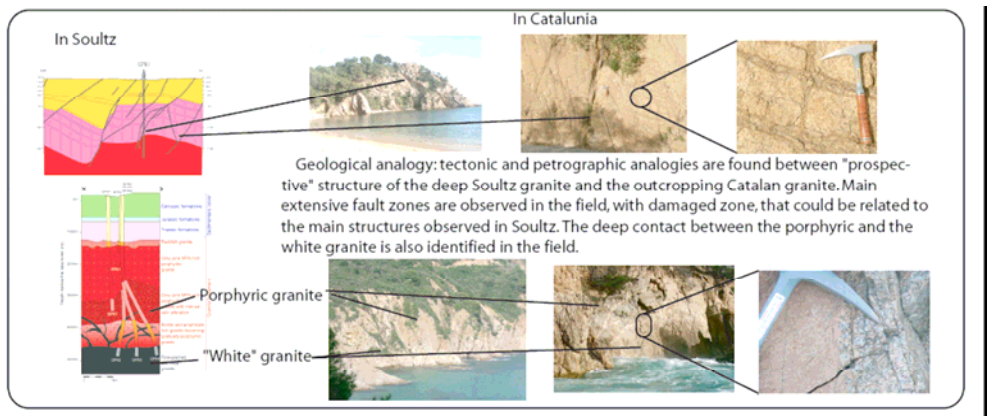
What starting conditions are necessary to develop/stimulate an EGS?

What are the conditions classifying a thermally suited area for the development of an EGS?

Conceptual models

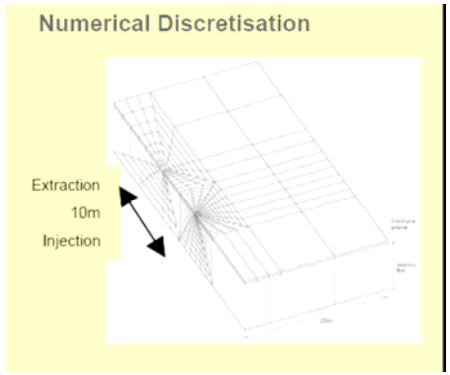
Integration of the most significant datasets and their interpretation on reference key areas, e.g., Larderello, Bouillante, Soultz, Groß Schönebeck.

Natural analogues to test, e.g., circulation of fluids in relation with seismicity and heterogeneity of the lithologies, thermal imprint of fluid circulation.



Pathways: defining integrated conceptual models

The links with other investigation programmes such as nuclear waste storage, capture and storage of CO2 and oil and gas field development will be developed to take advantage of existing installations and experiences.



Workflows encompassing fault interpretation from 3D seismics and geostatistic tools, 3D retro-deformation and fracture interpretation from well data should be further developed to give a base for possible pathway interpretation through time. Palaeostress maps may also help in distinguishing between open or closed pathways. Technological platforms could be promoted to develop new methods and tools, test hypotheses in situ or the accuracy of conceptual models.

GFZ POTSDAM

Exploring High Temperature fluid reservoir: new challenges for geothermal energy

Workshop 2,

2-4 April 2007, Volterra, Italy

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