Photonics (Electromagnetics)

for Deep Geothermal Energy Harvesting

Werner Foppe – Fusion Drilling Projekt 2012

Energy resource
SuperDeep-HotRock

- SuperDeep-Hot Rock (400°C – 600°C) is the only available cost-effective and clean energy source for all countries

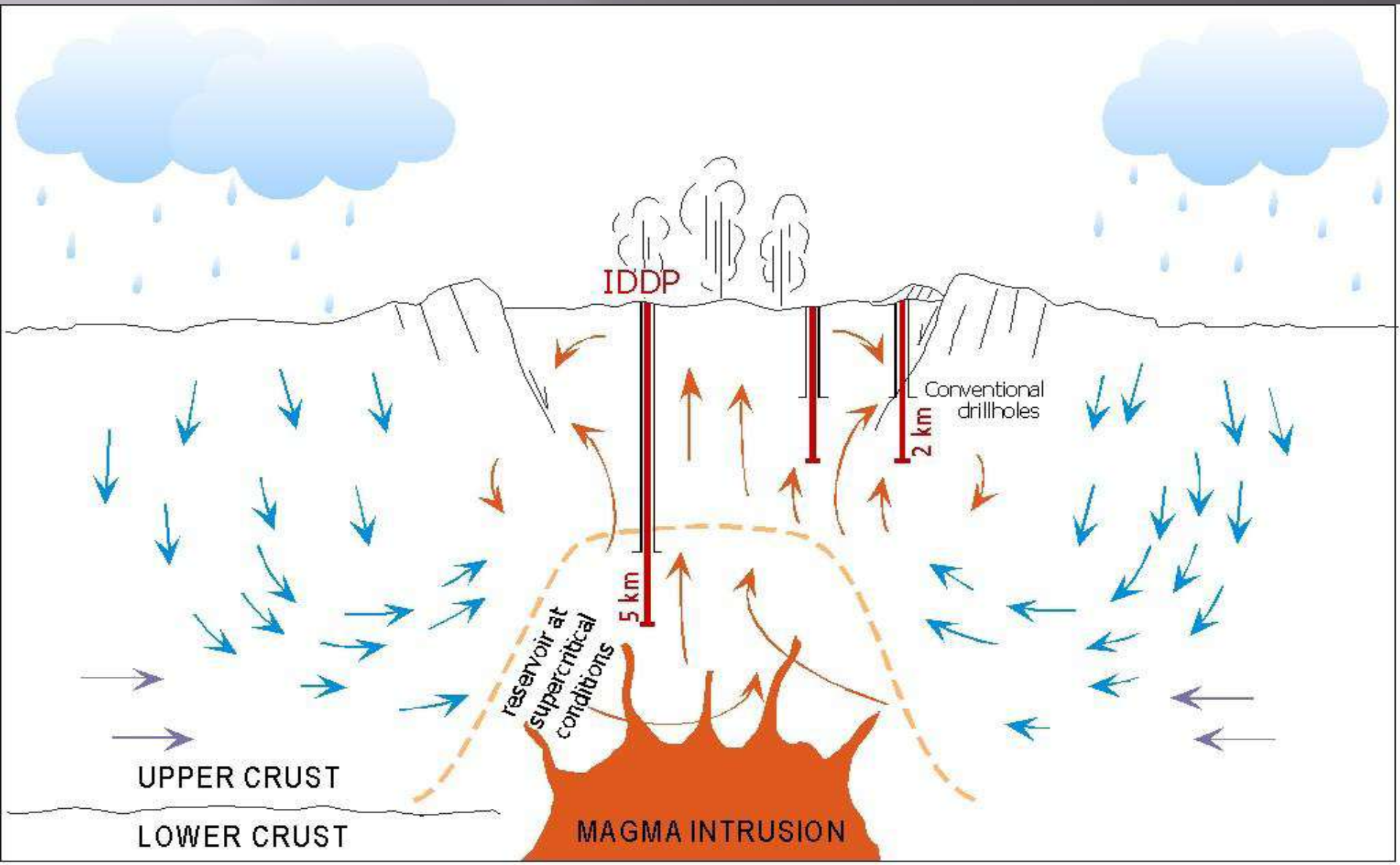
Energy resource
SCW(super-critical-water) inHotRock

- SCW(super-critical-water) is the ideal transport- and storage-medium for energy-mining out of SuperDeep-Hot Rock to transform the stored heat to high-pressure process-steam, electricity or to make use of dissolver for crude oil

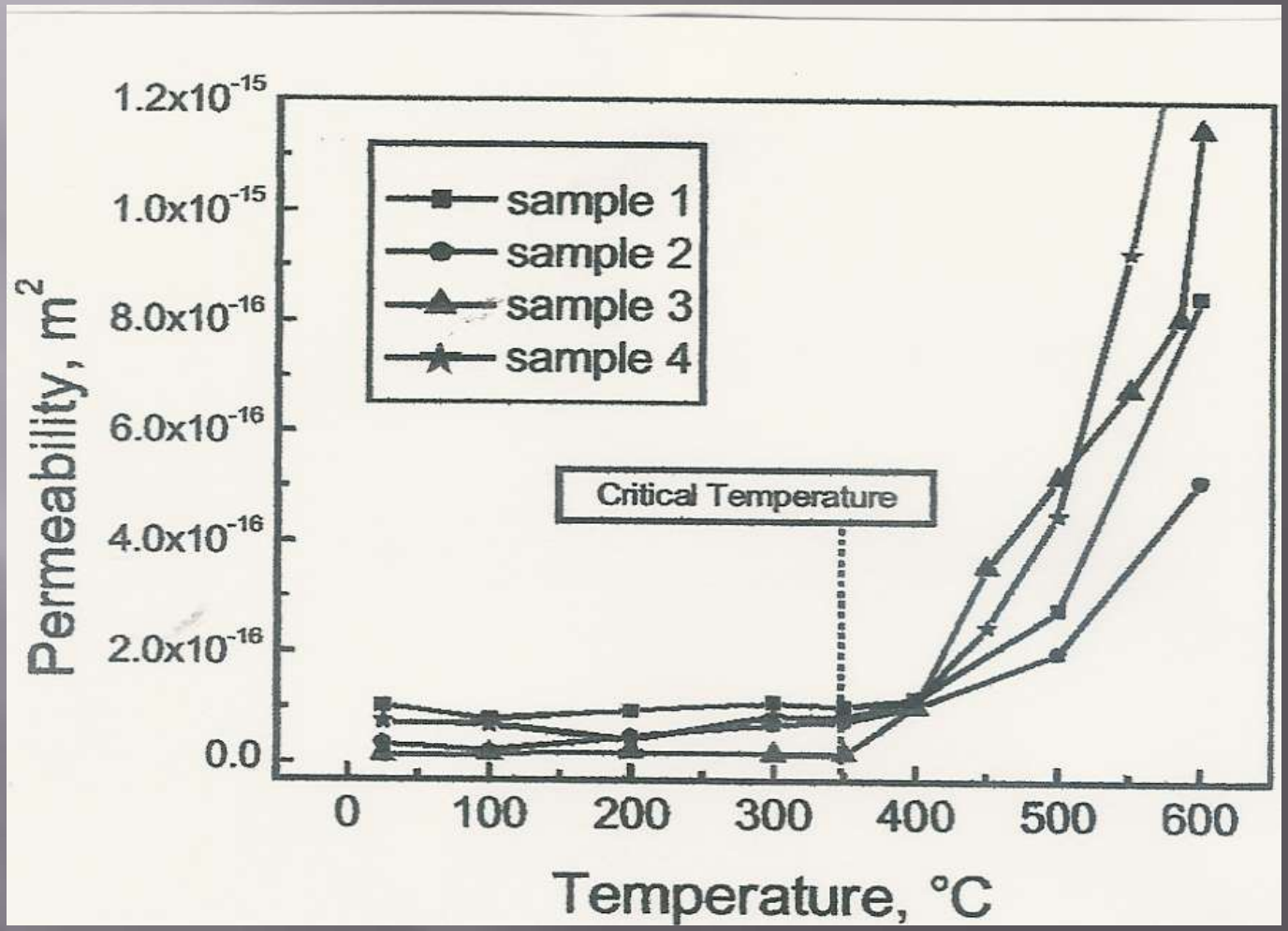
Energy resource
SuperDeep-GeoPower

- SC(supercritical) – GeoPower out of SuperDeep-Hot Rock is potentially available on Earth at GW-scale, every-where round a clock without competition

By drilling deeper we should reach supercritical conditions (IDDP –Island Deep Drilling Project)



Permeability of SCW
SCW=(super-critical-water)



Viscosity of SCW (super-critical-water)

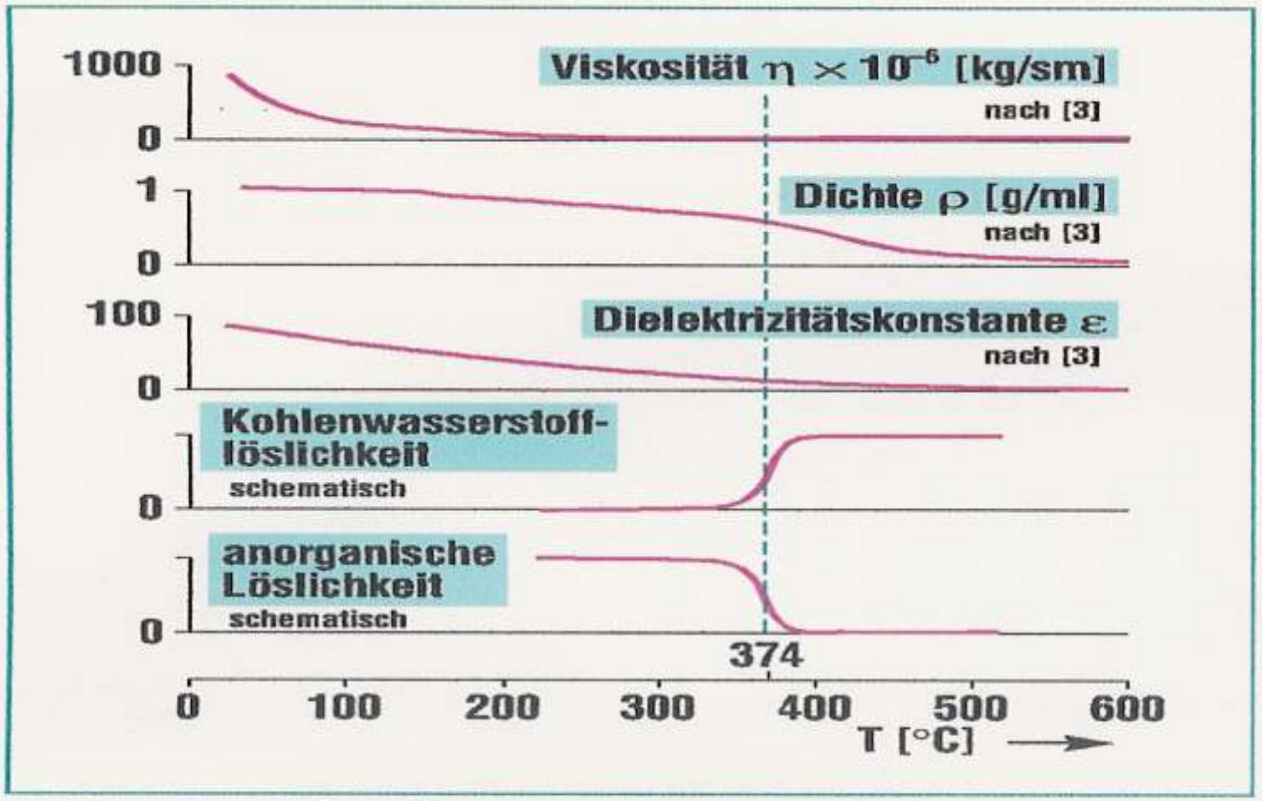


Abb. 2: Die Änderung wichtiger Eigenschaften von Wasser beim Übergang in das überkritische Gebiet bei einem konstanten Druck von 400 bar.

Why conventional drilling ist unable to mine SCW in SuperDeep Hot Rock ?

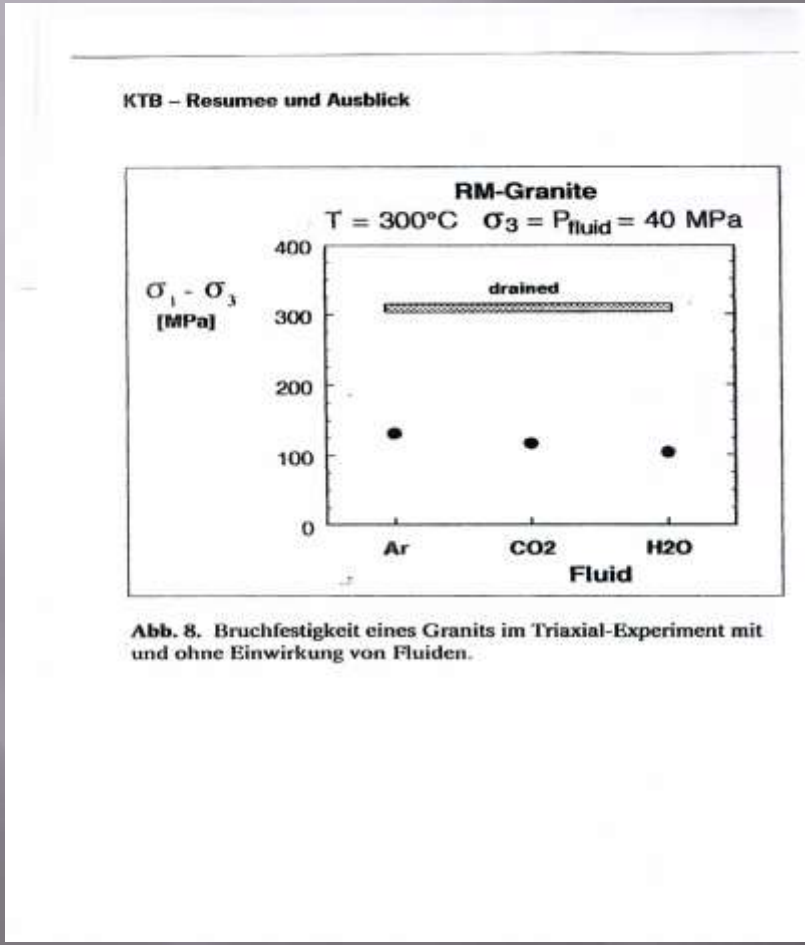


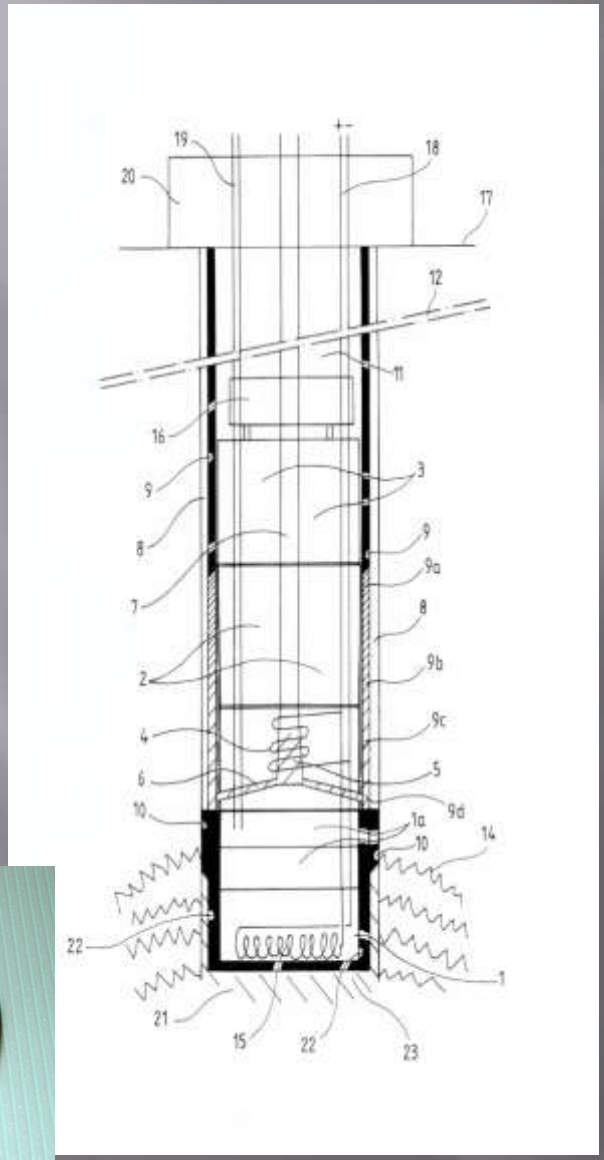
Abb. 8. Bruchfestigkeit eines Granits im Triaxial-Experiment mit und ohne Einwirkung von Fluiden.

- The compressive strength of hot rock drops dramaticly in vicinity of water
- Conventional drilling works open-hole
- Under SuperDeep condition the rock change from brittle to ductile
- The unsealed well collaps under the overburden rock

I.
SUPER-DEEP
FUSION DRILLING

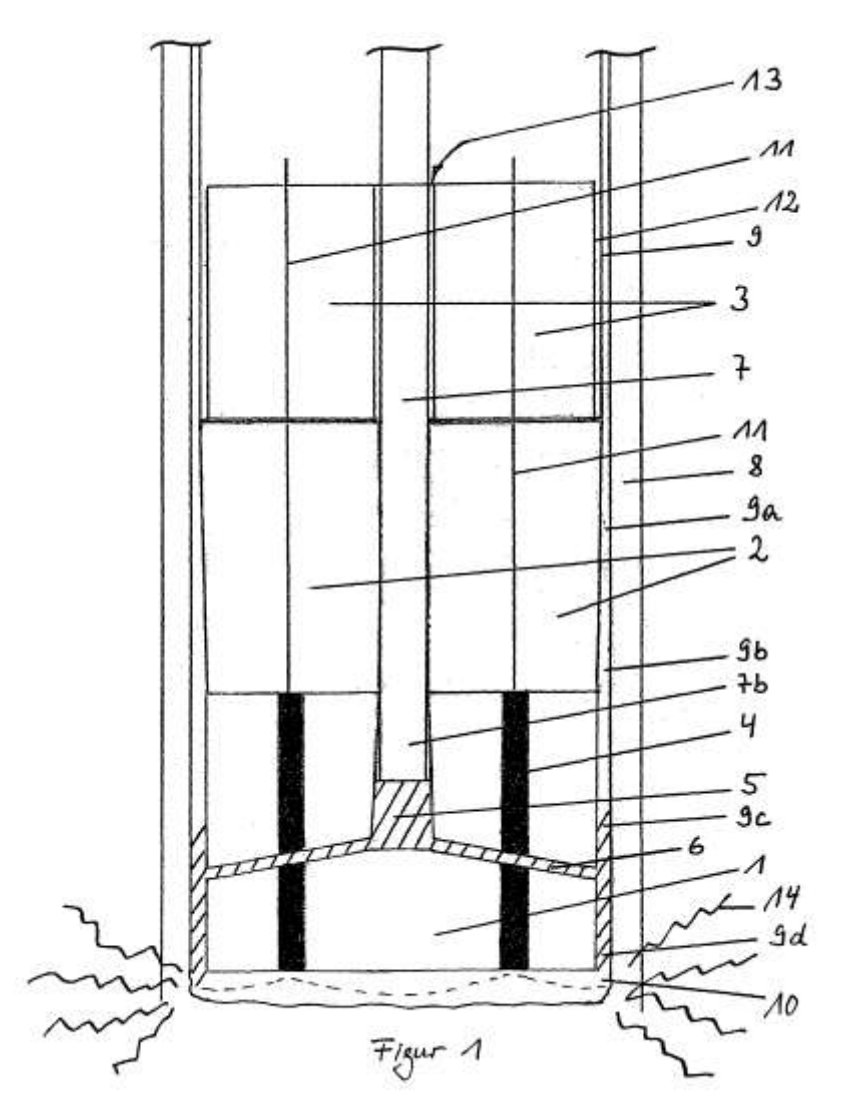
‚GAMECHANGER' in SuperDeep-Drilling-Technology

SuperDeep-FusionDrilling-Robot



1. Carbon Pressure-Bit
2. Conical Compactor
3. Cooling element
4. Induction coil
5. Steel-melt
6. Steel feed-pipe
7. Continuous Steel bar
8. Rock-melt casing
9. Cast -steel casing, 9a – 9b solidified steelmelt, 9c – 9d steel-melt casing
10. Solidified rock-melt barrier between rock-melt and steel-melt casing
11. Shaft flooded with heavy liquid
12. Carbon-Pressure-Drillhead
13. SuperDeep-Well in progress
14. Indction loops or coils
14. Hydraulic-Molch with integrated high-pressure pump
15. Tube-coil power-supply
16. Cooling-water supply-line
17. Installation- and Deinstallation-Automat
18. Pressurised rock-melt cracks are runnig ahead of the rock-melting zone
19. Fusion-Drillhead enlarged by diameter of the cast-steel casing
20. Rock-melt pressure-pillow

Laser- & Electrode Fusion-Drilling



Figur 1

Unique selling points
SUPER-DEEP FUSION-DRILLING

- Schmelzbohrschächte von 20 km Tiefe bis 2 m Durchmesser
- Kontinuierliches Bohrverfahren bis zum Bohr ziel
- Kontinuierliche Stahlguss-Bohrschacht-Verschalung
- Bohrschächte mit großem, konstanten Durchmesser
- Abraumschmelze-Verdrängung ins Seitengestein
- Verdichtung des Bohrschacht-Umfelds
- Keine Abraumschmelze-Förderung
- Kein Bohrkopfwechsel, keine Round-trips
- Kein Bohren mit offenem Bohrloch
- Kein Bohrschachtwand-Einbruch
- Kein Fluide-Einbruch

II.

HIGHTECH-MATERIAL

ISO - CARBON

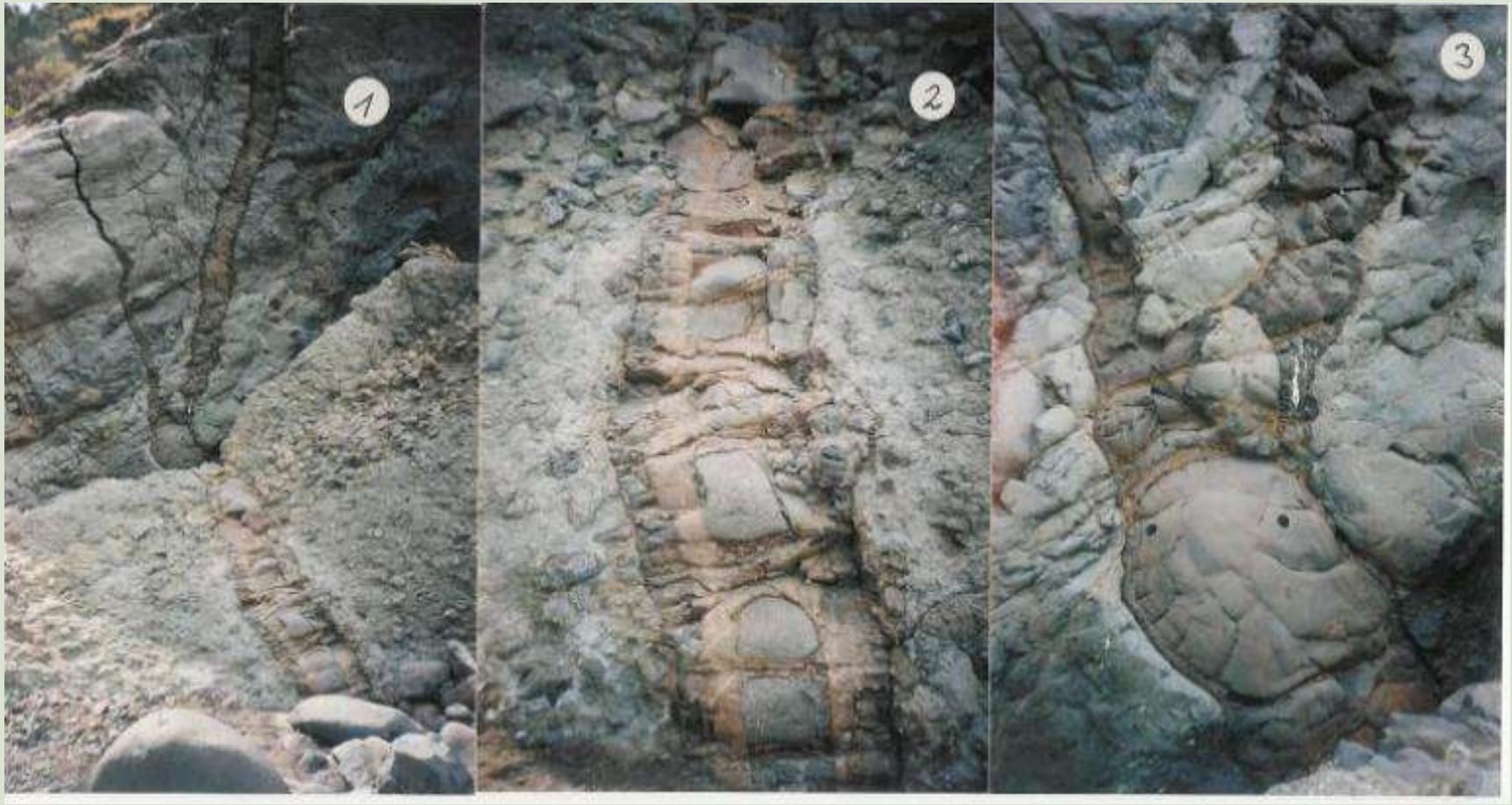
Carbon/Steel-melt Materialtest 2000°C & 2000bar

Elektron-microscopic cut across Steel-annulus & Carbon-cylinder

III.

ROCK-MELT DISPLACEMENT IN COMPACT ROCKFORMATION IN NATURE & TECHNIQUE

Volcano-Crack-Formation
La Palma



Volcano generated crack

Displament of Rock-melt in a Basaltbloc by ‚Litho-Jet' Fusion-Drilling

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Demonstration of Thermit-melt
Displacement in dolomite & chalk stone quarry

- **Thermit-reaction is a cost-effective demonstration to simulate rock- & iron-melt displacment at high-pressure, generated 3000°C reaction-heat.**

Steam blow off after Thermit-Reaction in the steep face of Dolomit-Quarry

Dolomit- Quarry with a big excavator to exposure the injected Thermit-melt

Bohrlochdruckverschluss aus Thermitschmelze und Schotter

Gesteinschmelze-Verpressung (weiß) horizontal um das gesamte Bohrloch

Bohrlochverschalung aus Thermit- und Gesteinsschmelze

Freilegung des Bohrlochs in Kreide nach erfolgter Thermit-Reaktion

Freigelegtes Bohrloch mit verpresster Thermitschmelze

Unter Schmelzedruck erzeugter und verfüllter Rissbereich

Im ‚Thermo-Frac' verpresste Thermitschmelze(schwarz) zu beiden Seiten des Bohrlochs

Vertikal und horizontal mit Schmelze gefüllte Rissflächen

Durch Bagger und per Hand freigelegte verpresste Schmelze im Kreidesteinbruch

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2012

SC(SUPERCRITICAL) - GEOPOWER

SOLUTION of Global Energy & Climate Problem

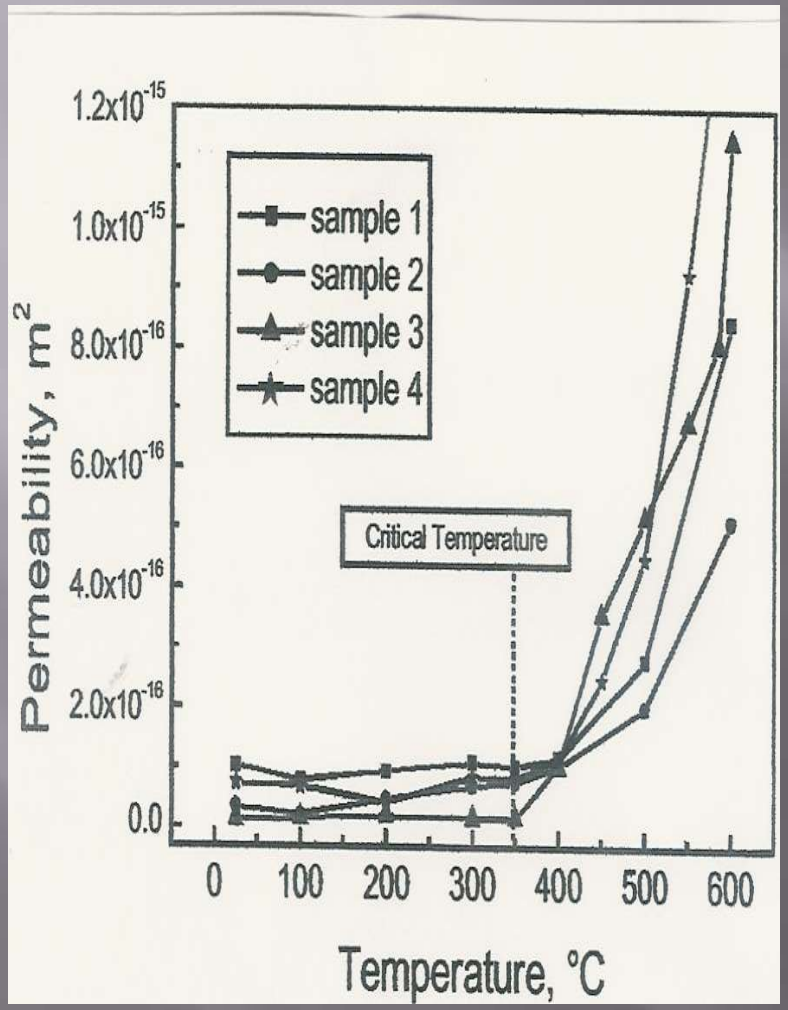
SC(supercritical)-GeoPower

- SC(supercritical)Water(SCW) is the medium to mine the stored energy in hot-rock without fracing-problems
- SCW is able to create large SSB(Supercritical-Subsurface-Boiler) in ductile hot-rock, where fracing does not work

SuperDeep-Fusion-Drilling
Application-Technologies

- **SC-GeoSteam at GW-Scale everywhere on Earth**
- **Globale cost-effective Processteam- & Powerproduction**
- **Oilfield SC-GeoSteam Injection (90%recovery of original Oil in place(OOIP)**
- **SC-Geosteam Oil-refining (simple pressure reduction of SC-Oil-fluide)**
- **SC-GeoSteam Fluide-mining (ore-minerals dissolve at high pressure 1500bar and more)**
- **Self-burial of spend-fuel - Absolut save disposal-solution**
- **Recycling of CO2 to CH4 in 10-20 km SuperDeepWell**
- (CCS = CarbonCapture&Storage, SSB = Supercritical-Subsurface-Boiler)

Special Properties of SCW in Rocks



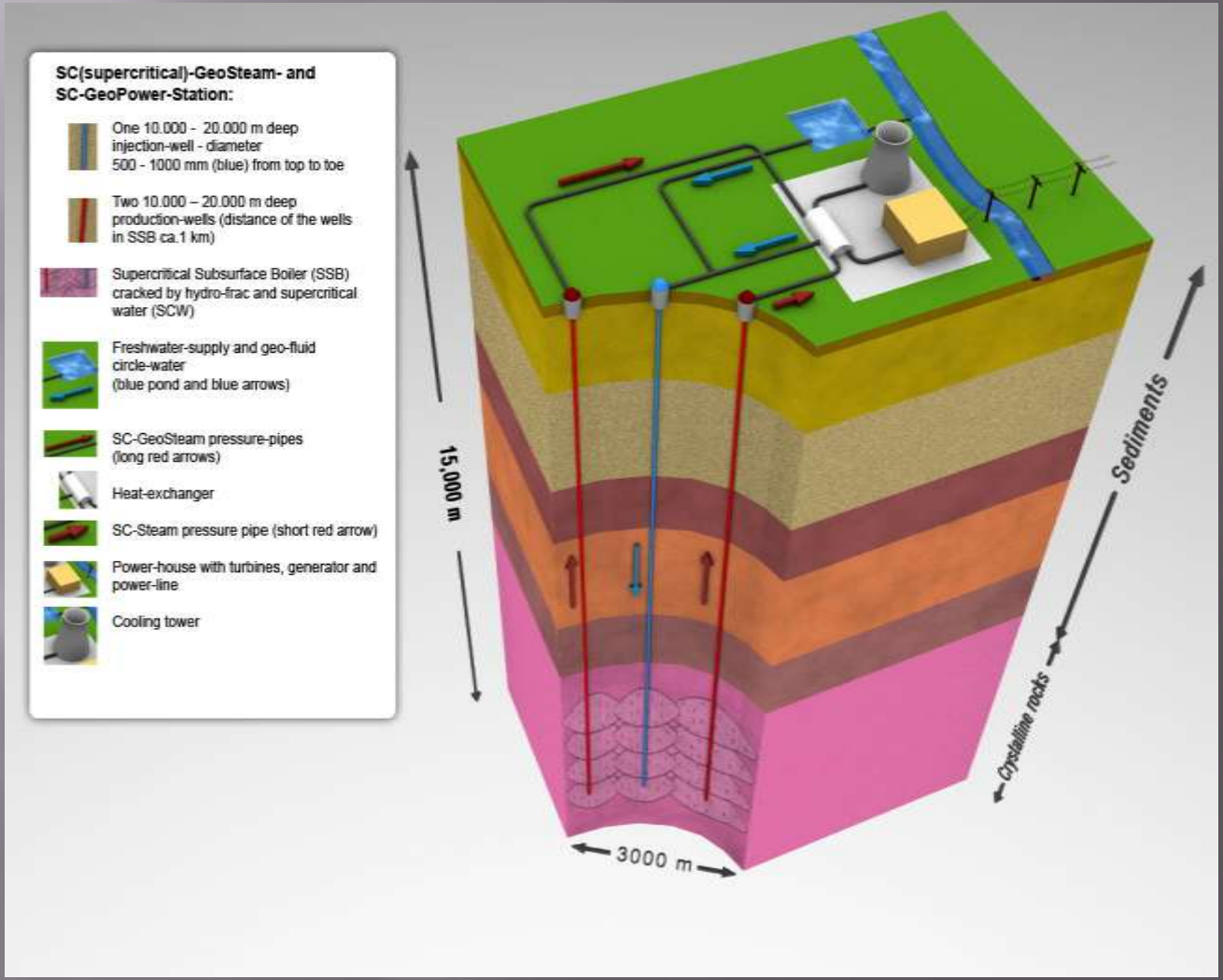
The Viscosity of Super-Critical Water(SCW) behind the critical point is going to zero. The permeability of the rocks escalates by rising temperature and pressure behind the critical point

SCW invaded all cracks and fissures and makes HydroFrac dispensable and deminish the impedance of the SSB (SupercriticalSubsurfaceBoiler)

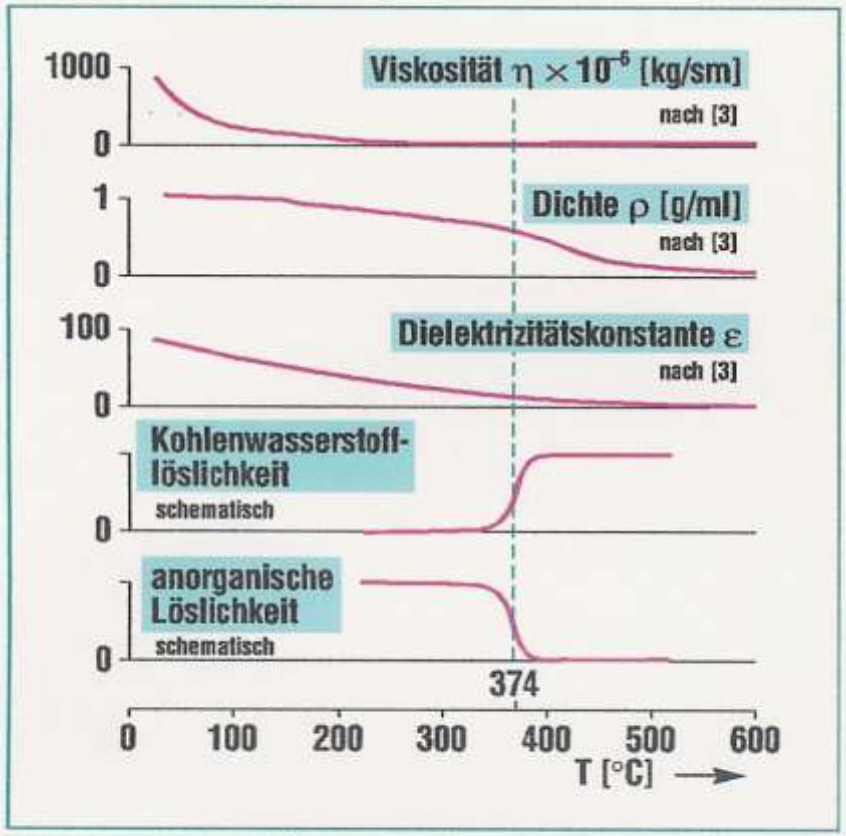
The solubility of minerals in the rock is rising steep behind the pressure range of 1500 bar and makes Fluide-Mining economic in combination with Energy-Mining

The solubility of SCW makes it an ideal agens to Oil-Mining in all Oilfields by SC-GeoSteam-Injection and makes the 2/3 of OOIP available, remaining in ,exausted Oil-fields

SC-GeoSteam & SC-GeoPower Plant



Special Properties of SCW in Rock and Oil



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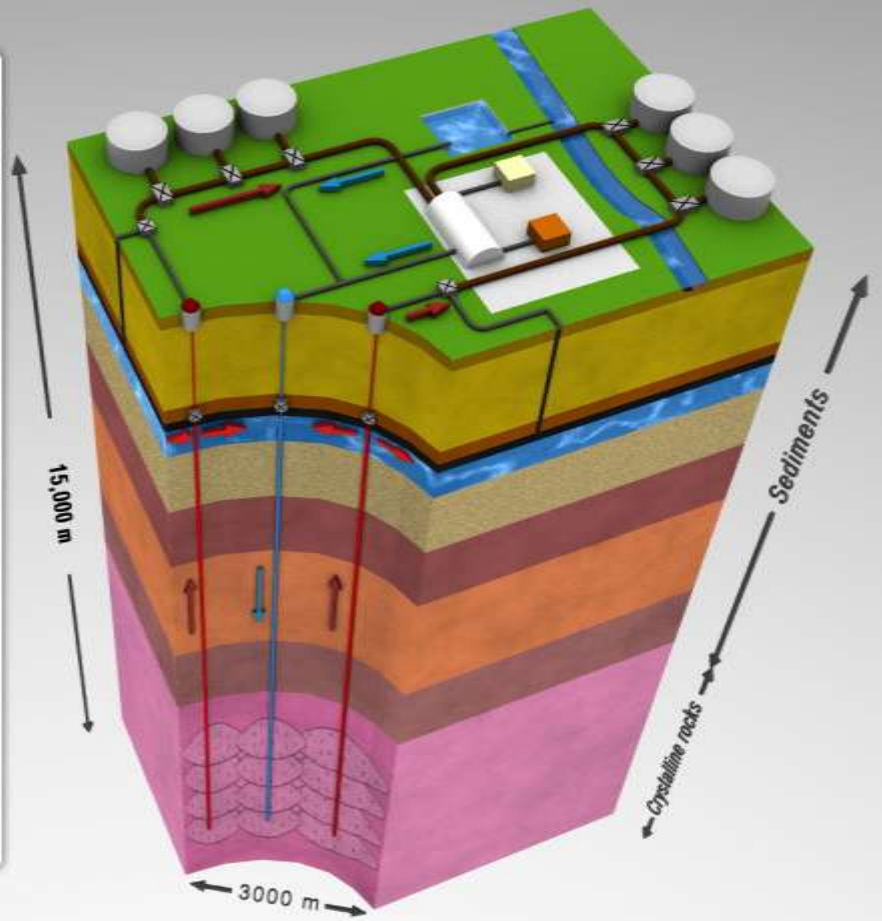
SC-GeoSteam-Injektion & Oil-extraction & refinery

kneier consult

SC(supercritical)-GeoSteamInjection and direct oilrefinery by simple press-release:

- One 10.000 - 20.000 m deep injection-well - diameter 500 - 1000 mm (blue) from top to toe
- Two 10.000 – 20.000 m deep production-wells (distance of the wells in SSB ca.1 km)
- Supercritical Subsurface Boiler (SSB) cracked by hydro-frac and supercritical water (SCW)
- Oilfield production-wells(black)
- Oilfield(black) and underlying water(blue)
- Direct SC-GeoSteamInjection from both production-wells in the oilfield
- Valve to release SC-GeoSteam to heat up oil in the SC-Oilfluide-Pipeline
- SC-Oilfluide-Pipeline(brown) for direct oil-refinery by press-release
- Valve to release different hydrocarbon-charges like diesel or naphta in vessels
- Facility for treatment of leftover-fluid of the SC-Oilfluide-Pipeline
- Silos to store risuduals like sulfur or phosphor and so on
- Freshwater-supply and treated geo-fluid-circle (blue pont and blue arrows)



Investment: 3000MWel SC-GeoPower-Anlagen

3x20 km Stahlguss-verschalteTiefbohrschächte/Durchmesser: außen 120 cm, innen 100 cm

- **Kosten der 6000MW SC-GeoSteam- & 3000MW SC-Geopower- Anlage**
  - **Stromkosten:** (€50/MW/h) Gestein- & Stahlschmelze= €7,5Mio. + sonstige €2,5 Mio. **= €10 Mio.**
  - **Stahlkosten:** (€600/to) (2,84 to/m x 60.000 m) €600 x 2,84 x 60.000=€102 Mio. ca. **= €100 Mio.**
  - **Bohrkosten:** a €30 Mio. 3 x 20.000 m (inklusive Bohranlagekostenanteil) **= €90 Mio.**
  - SC-GeoSteam-Anlage mit Sekundär-Wärmetauscher im Produktionsschacht **= €50 Mio.**
  - 3000MW SC-GeoPower-Kraftwerk(Turbinen, Generatoren, Transformatoren) **= €450 Mio.**
  - Industriegelände, Gebäude , Wasserversorgung, **=€200 Mio.**
  - Sonstiges **=€100 Mio.**
  - **Gesamtkosten: =€ 1 Mrd.**
  - **Investitions-Kosten SC-GeoPower = (300 €/KW)**: Solar-Derivate = (3000 €/KW) **= 10fach**
  - **Lebenslaufzeit SC-GeoPower = 80 – 100 Jahre /** Solarderivate=20 Jahre=4 x 3000MW **= 12000 MW**
  - **Verfügbarkeit** SC-GeoPower/ SolarDerivate 8000h/2000h = 4fach = 4 x 3000MW **= 12000 MW**
  - **Wirkungsgrad** SC-GeoPower/ SolarDerivate 60% / 20% = 3fach = 3 x 3000MW **= 9000 MW**
  - 2 x 3000MW Gaskraftwerke Ersatzkapazität (Laufzeit 40 Jahre) **= 6000MW**
  - 3000MW SC-GeoPower/39.000MW = 13fache Kraftwerkkapazität & 117fachen Kosten **=€117 Mrd**
  - **Das Resultat: 300**0MW SC-GeoPower-Anlagen erfordern im Leistungs- & Kostenvergleich mit Solar-Derivate mindestens die **10fache SolarDerivate-Kapazität** bei einem **100fachen Investitions-Volumen**

Literature:

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- **LABORATORY SIMULATION OF GRANITE-FLUID INTERACTIONS UP TO**
- **SUPERCRITICAL CONDITIONS**
- Greg Bignall1*, Nakamichi Yamasaki2 and Toshiyuki Hashida3
- 1Research Laboratory of Hydrothermal Chemistry, Kochi University, 2-5-1 Akebono-cho, Kochi shi, Kochi-ken, 780-8520, Japan
- 3Research Institute for Fracture Technology, Tohoku University, Aoba-ku, Sendai-shi, 980-8579, Japan
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- Toshiyuki Hashida1, Kazuo Hayashi2, Hiroaki Niitsuma3, Koji Matsuki3,
- Noriyoshi Tsuchiya3 and Katsuto Nakatsuka3
- 1 Fracture Research Institute, Tohoku University, 01 Aza-Aoba, Aramaki, Aoba-ku, Sendai, 980-8579 Japan
- 2 Institute for Fluid Science, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai, 980-8577 Japan
- 3 Department of Geoscience and Technology, Tohoku University, 01 Aza-Aoba, Aramaki, Aoba-ku, Sendai, 980-8579 Japan
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