Energy efficient use of geothermal energy
– sustainable use –

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Conference and fare on renewable energy

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Geothermal Energy

- *„**The optimum environment for a geothermal reservoir includes***
- ***(1)**potent **source of heat, such as a magma chamber; such heat sources are***

  most likely to occur in regions of late Cenozoic volcanism;
- *(2) **reservoirs of***

  adequate volume, permeability, and porosity; and
- *(3) **capping of rock of low permeability that inhibits convective loss of both fluids and heat. A deep***

  well-insulated reservoir may have at least 10 times the energy content of an otherwise similar, shallow, uninsulated reservoir.“ [Whi1968]

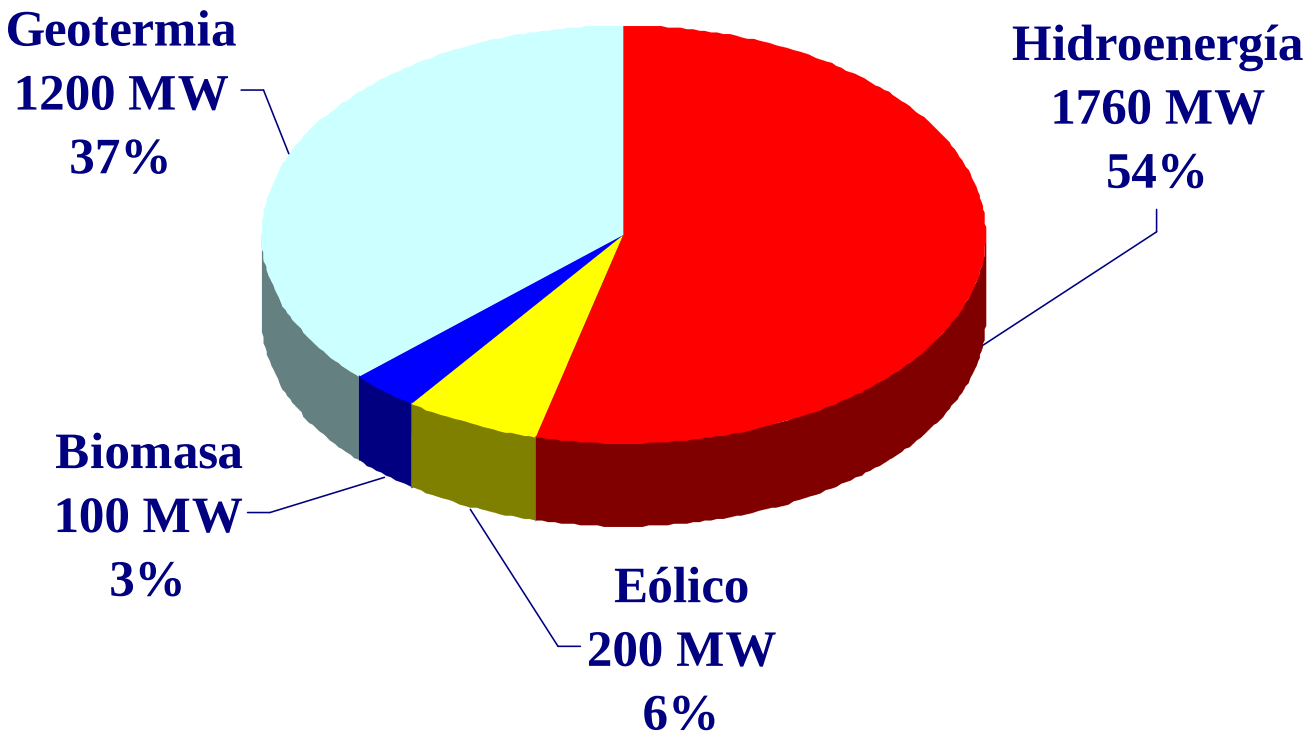
Natural high geothermal gradient

we are looking for a high geothermal gradient to reach high temperatures in shallow depth as in

- Vulcanic areas
- Subduction zones
- Hot spots
- Arcs

Favorable regions for geothermal energy production

Energy potential of Nicaragua



NICARAGUA: POTENCIAL GEOTERMICO

- **Existen 10 áreas con grandes perspectivas geo-térmicas en la zona del Pacífico.**
- **Un potencial estimado en mas de 1000 MW.**

AREA	
CASITA-SAN CRISTOBAL	224
TELICA –EL ÑAJO	127
SAN JACINTO-TIZATE	161
HOYO-MONTE GALAN	148
MOMOTOMBO	142
MANAGUA-CHILTEPE	107
TIPITAPA	18
MASAYA-NANDAIME	174
OMETEPE	100
TOTAL	1,200

What means efficient to me

The title

Energy efficient use of geothermal energy

implies:

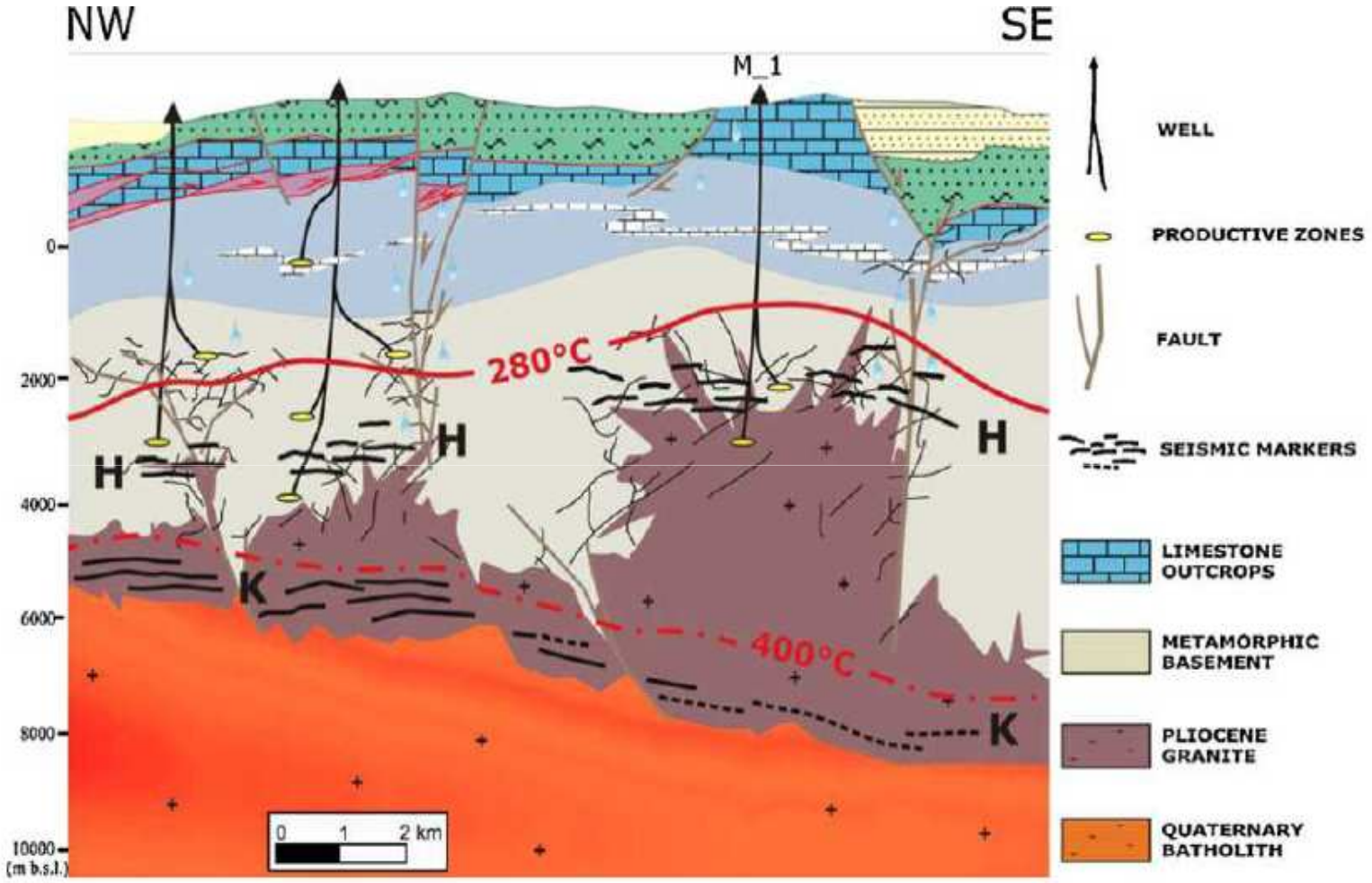
The use of the source must last as long as possible

And the environment must keep as much as possible in its natural condition

For geothermal energy :

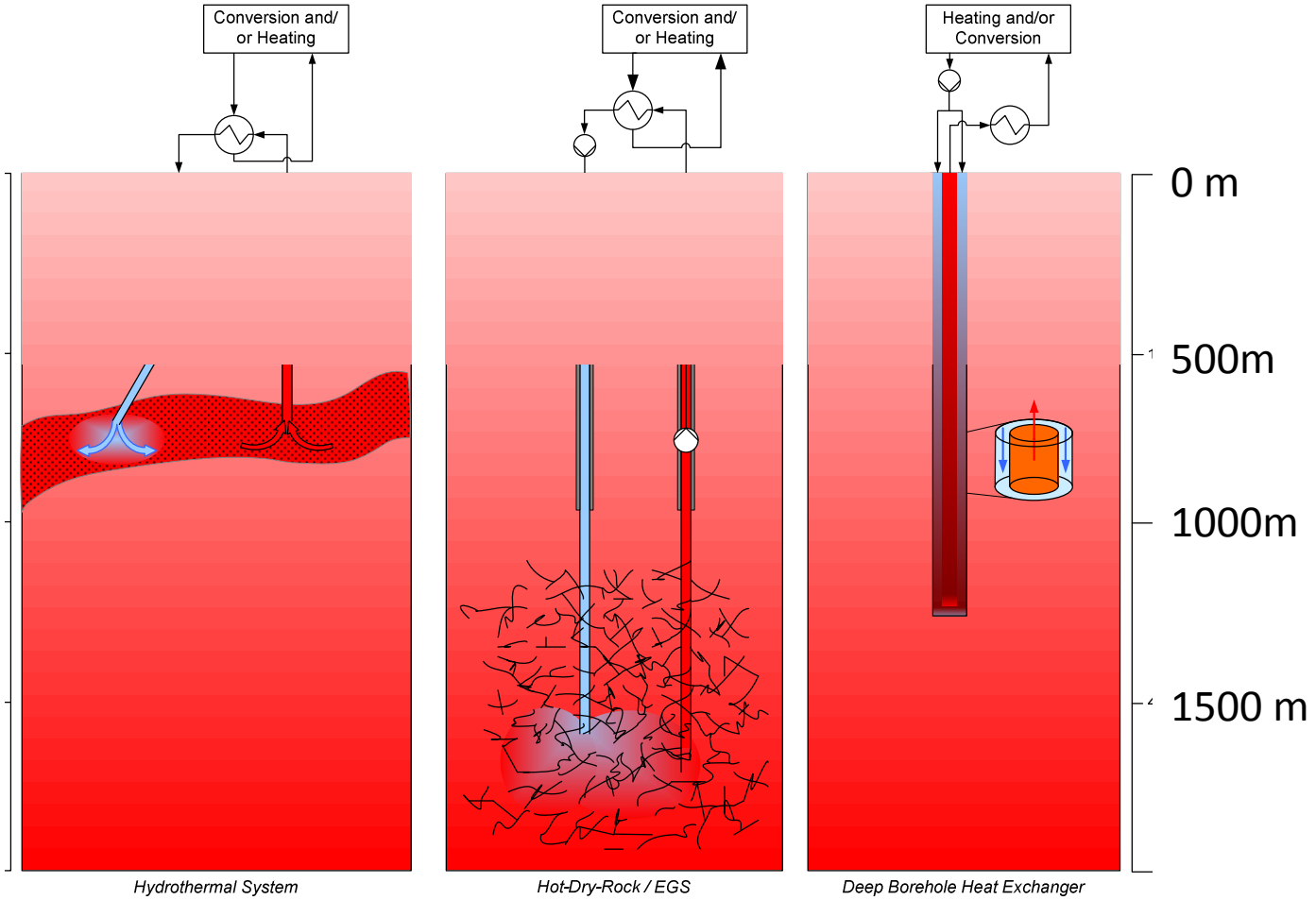
The time to recover the heat should be the same as the time of the use of the heat for energy production

Travale Region - Italy

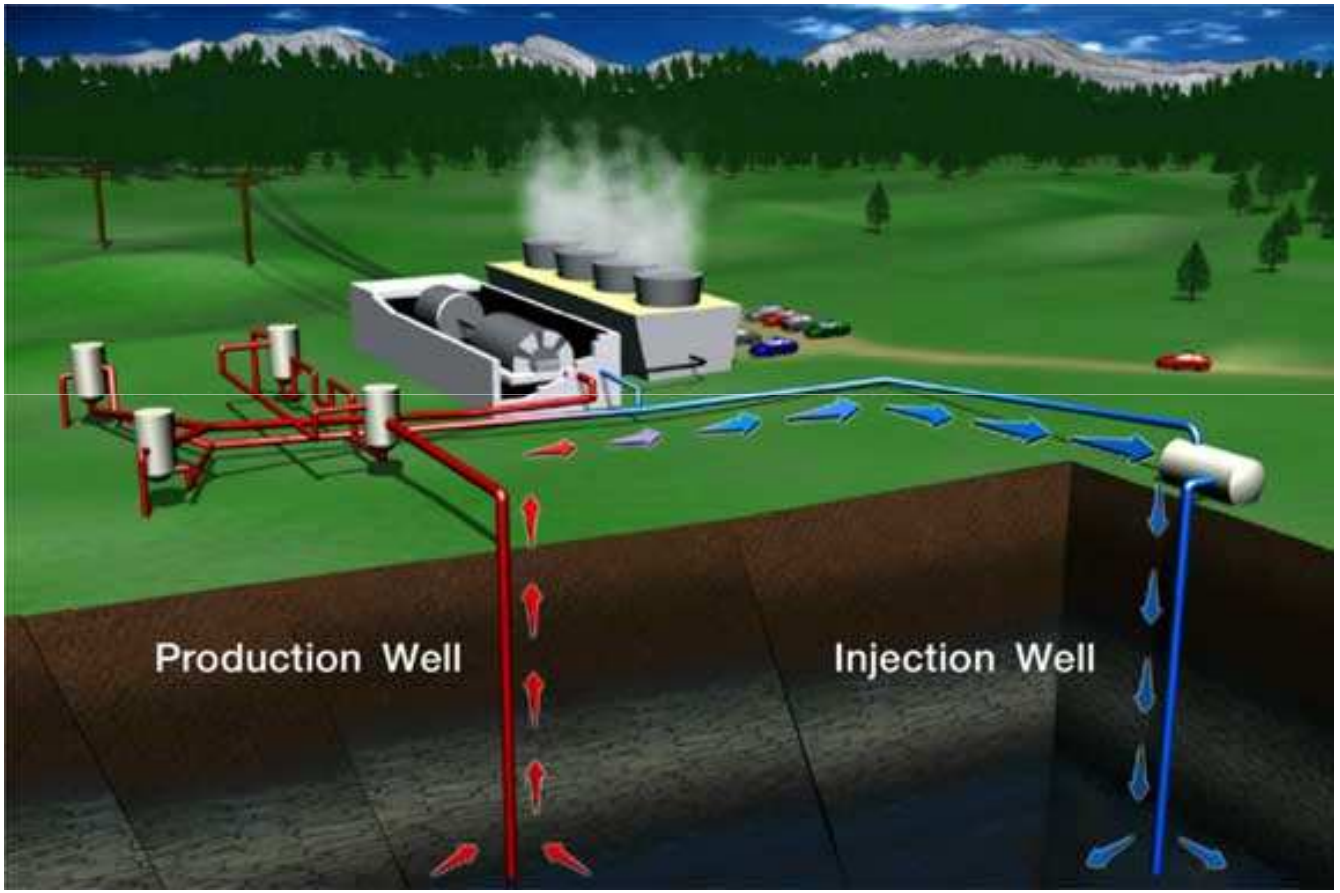


Explored since 1905 first natural steam and with deep drillings today

Conventional geothermal abstraction with high geothermal gradient



Conventional geothermal cycle



Risks of use of geothermal energy

- During drilling
- Induced seismic events
- Land – subsidence and landslides
- Water ability and reserves
- Hydrochemical changes
  - During abstraction
  - During and after reinjection

Long term not foreseen changes in rock and tectonic tension

RISK OF SUSTAINABILITY

Drilling risks

- To bore formations under high hydraulic pressure, quicksands, etc
- Not reach the target formation
- Not foreseen obstacles

Seismic risks

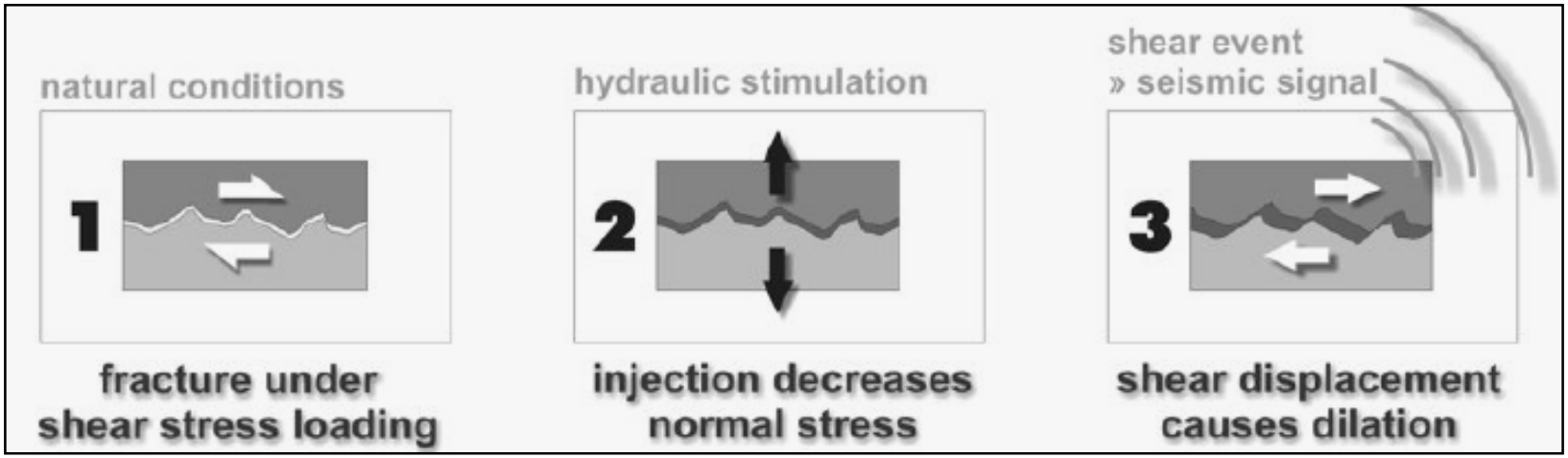
Origin

Higher fluid pressure

→ less effective tension

→ less static friction

→ displacement



Induced Seismic Risks

Origins

Temperature drop

→ fractures contract because of the cold fluid
→ the friction decreases, sliding is possible

Dramatic volume chance due to abstraction or injection of fluid

→ possible dramatic chances in the local stress field

Earthquakes may be induced

Induced Seismic Risks

Depending on

Local and regional geological conditions:

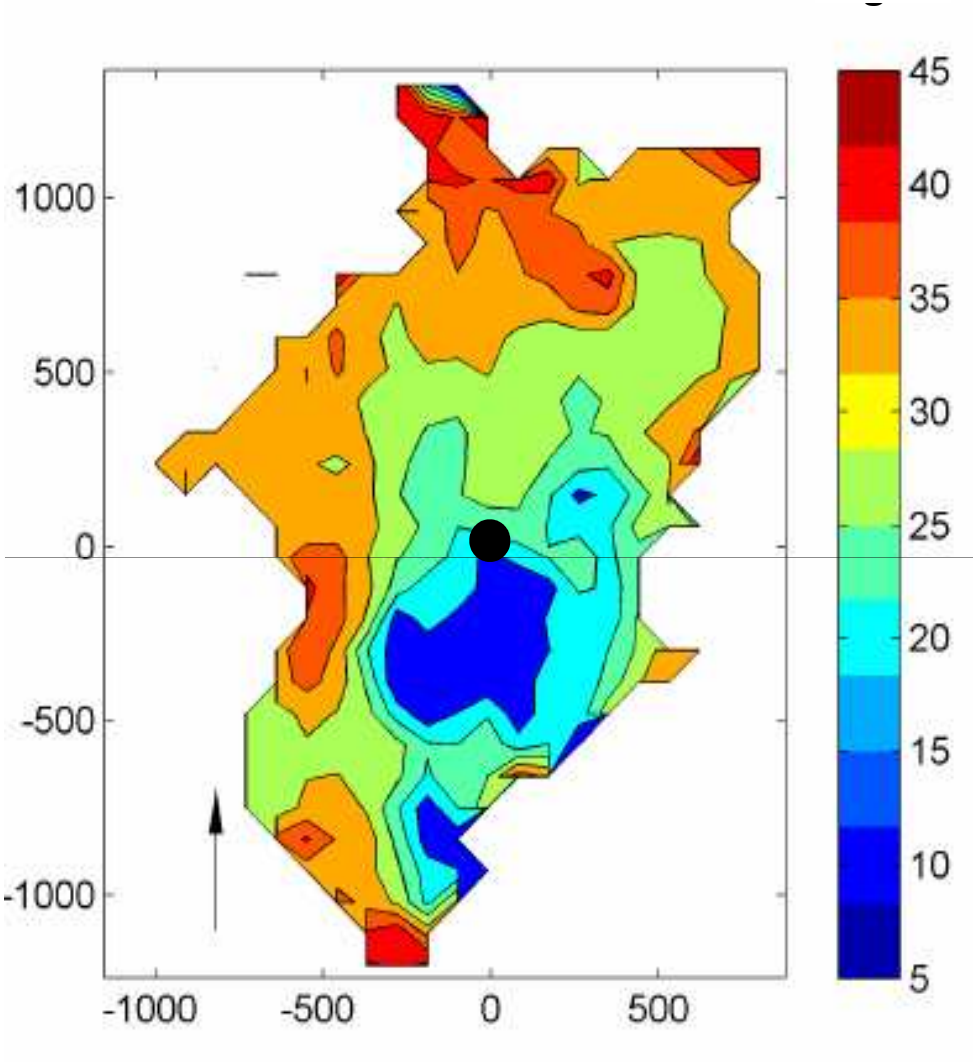
- orientation and magnitude of the deviationist stress field
- distribution and length of faults and fractures
- mechanical behavior of the rock
- hydraulic factors

Induced Seismic Risks

Distribution of hydraulic pressure

Example
Cooper Basin

Baisch, 2009



days

Causing seismic events days after beginning of the operation

Induced Seismic Risks

Induced seismic events during circulation

- Problems appearing using hydrothermal geothermal reservoirs

- induced seismic even in a balanced system possible
  → production = injection

- hydraulic pressure are stationary on the surface

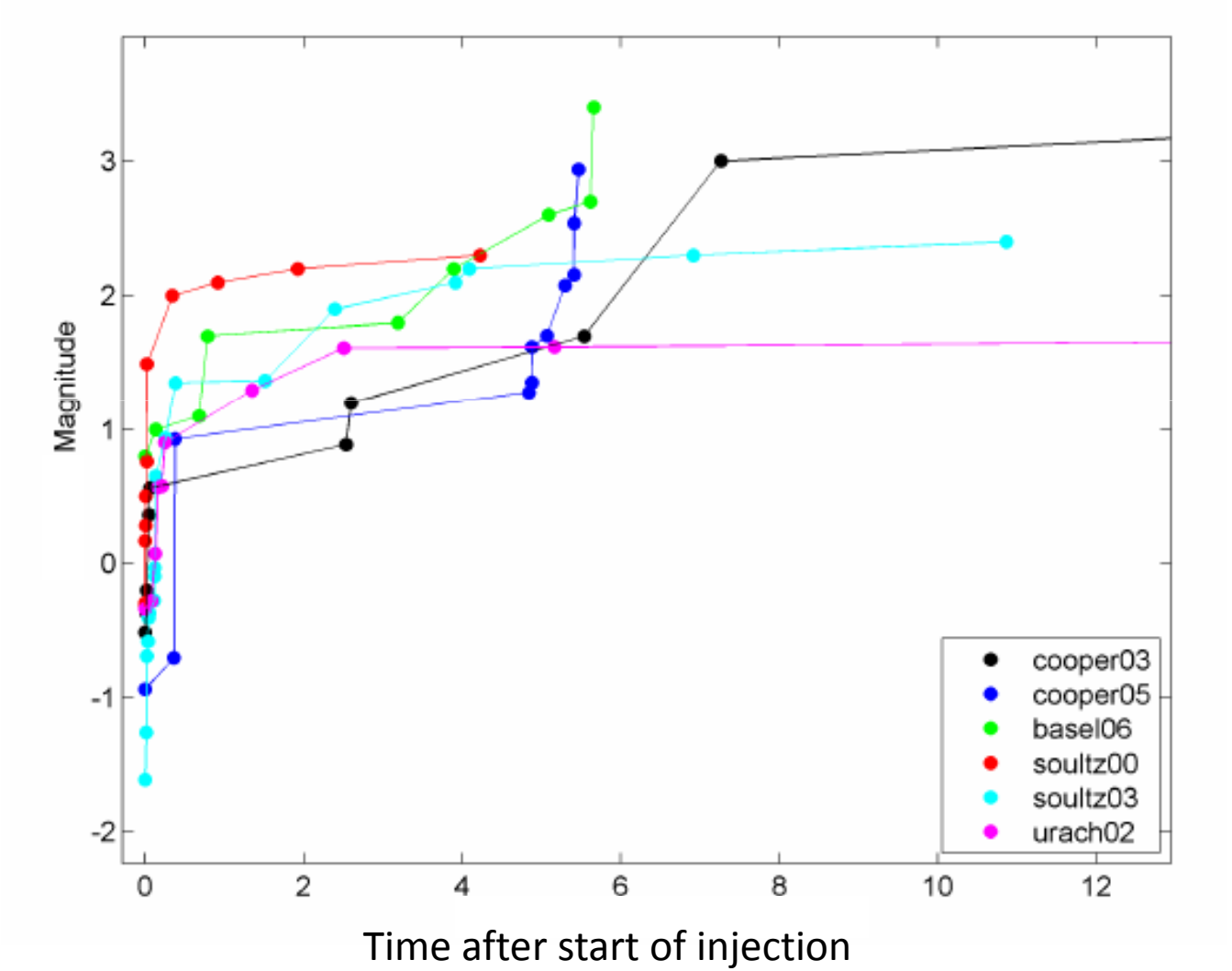
- but in the reservoir pressure increases locally due to injection

- risk increases if the hydraulic connection between production and injection well decreases

→ During production seismic events remain

Induced Seismic Risks

Increasing of earthquake magnitude



Baisch, 2009

Induced Seismic Risks

- If only a part of the used water is re-injected
- Shimon Wdowinski could prove that in seismic active regions the loss of mass trigger earth quakes
- The effect is not immediately but is reflected years later

Unconventional geothermal system – the Closed Loop Geothermal System (CLGS)

- No use of hot aquifer
- Long durable
- Good for the environment
- Less risk for nature
- Controlled cooling process

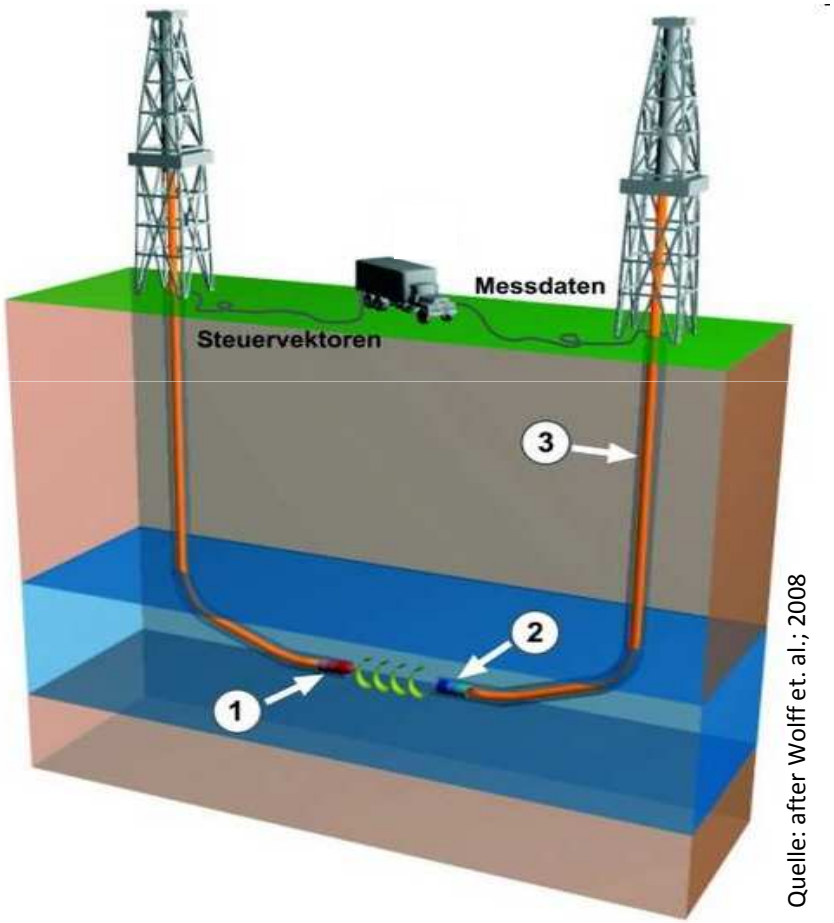
- **Less energy production but sustainable**

Closed loop geothermal energy generation

1 drilling bit with direction

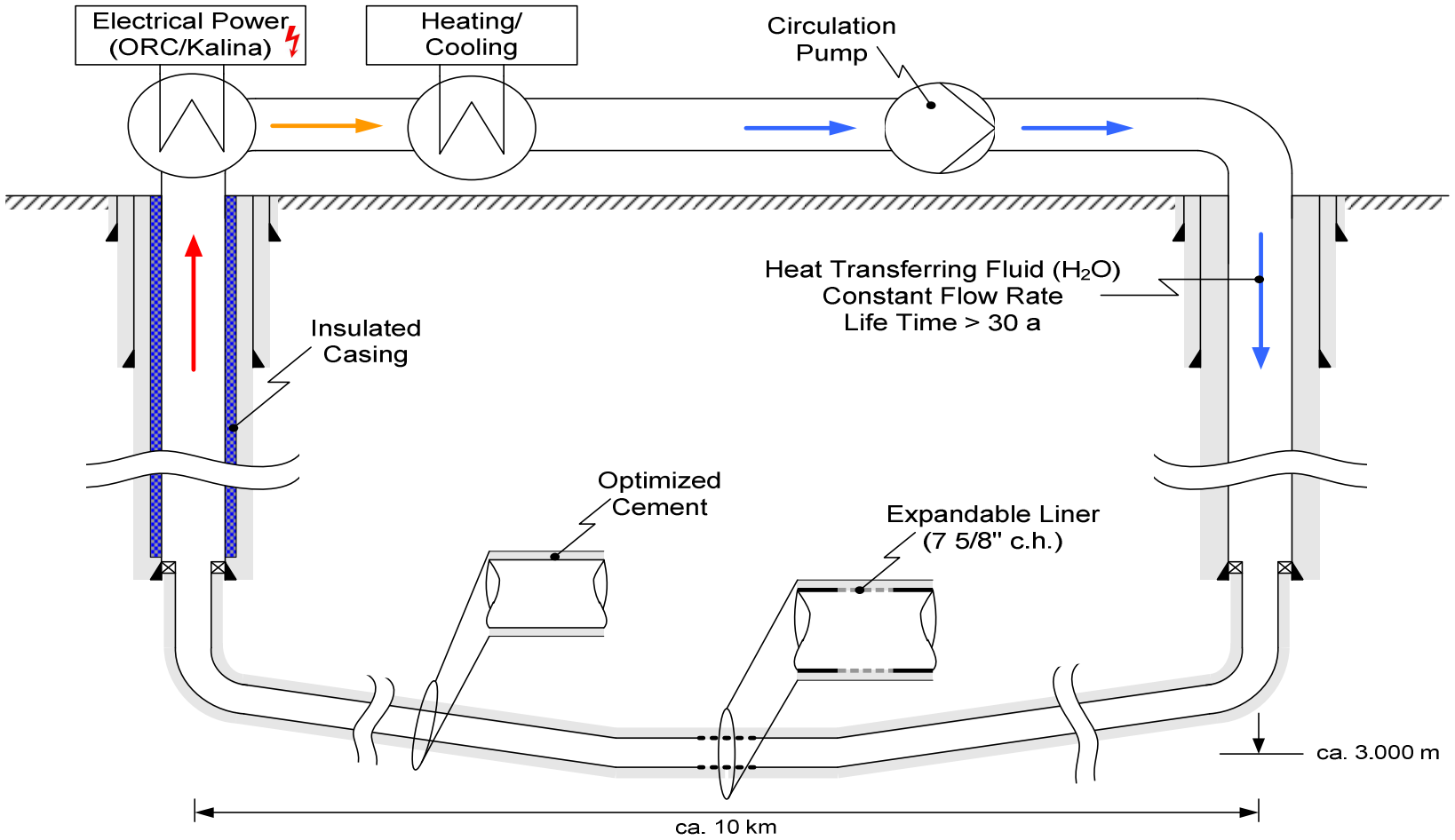
2 measuring devices

3 drilling pipes and casing

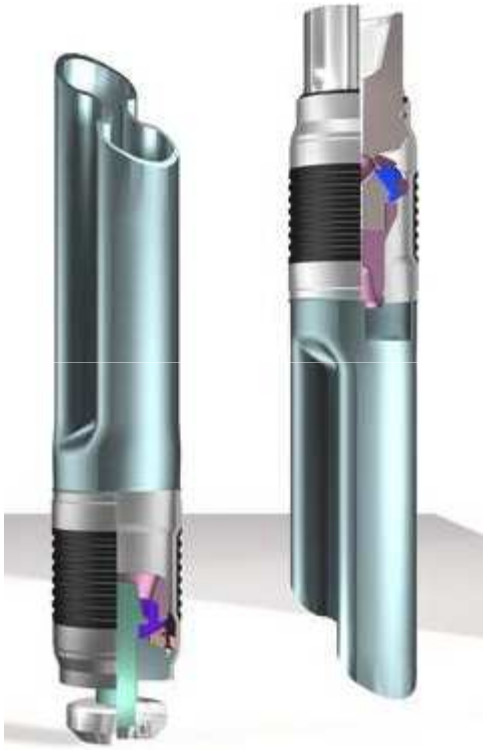


Quelle: after Wolff et. al.; 2008

The closed loop geothermal energy generation (CLGSystem)



Expansion of liner in the well CLGS

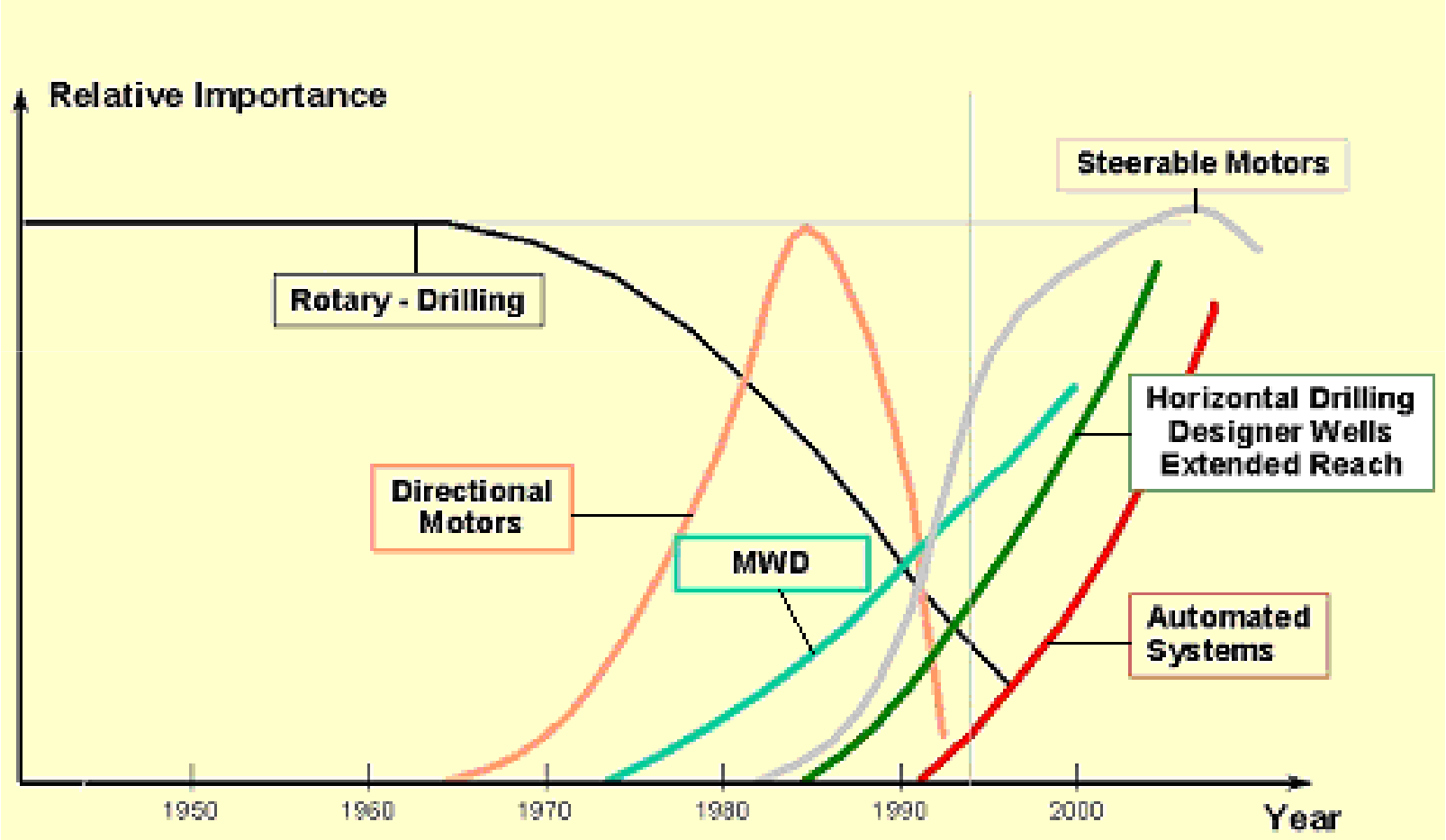


For surface extension the transport pipe is expanded and better shaped

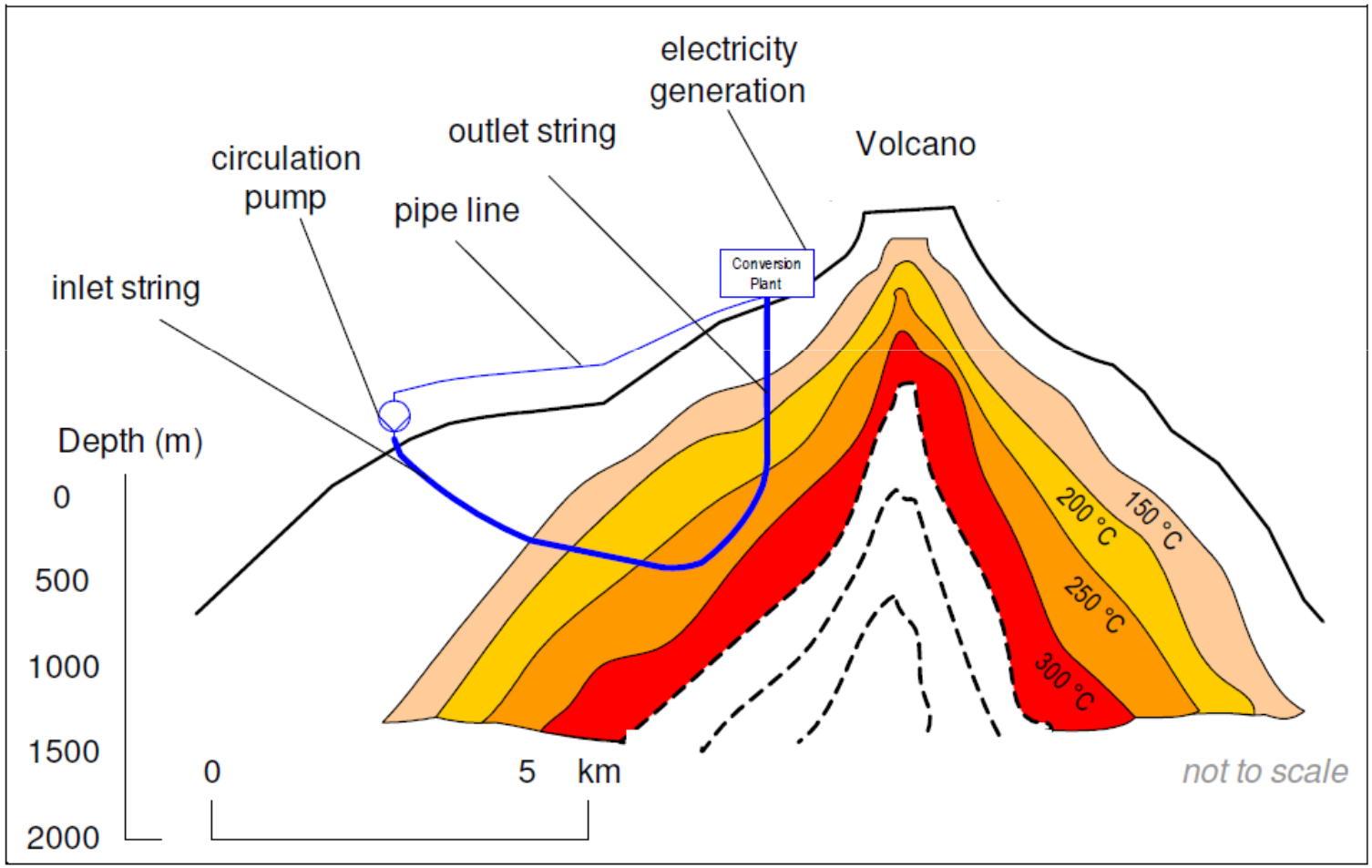
Comparison of systems

Open Systems	Comparison	CLGS
Yes	Geological Risc	No
yes	Technical Risics (drilling)	Yes
Geochemical changes during time	Target formation	Dedifined
Formation brines	Thermal carrier	Any which fits
Not constant	Heath flow	Constant
yes in wells and power plant	Sediments, crusts	No
Yes - acids blasting high pressure	Stimulating fractures	No
???	Duration	> 30 years
Yes	Corrosion	Yes/no depending on loop and fluid
Yes due to draw down and injection	Locality definition	No

How to drill – progress during the years



Geothermal energy from a CLGS



What is important for Nicaragua?

- A good exploration before deciding where to install a geothermal energy production (less seismic risks)
- Injection may cause many chemical and physical problems in the long term (precipitation of salts and carbonates, corrosion)
- In critical areas and in dry rocks a CLGS is an alternative to conventional systems
- To select the right system for each area and estimate the one with longest thermal energy production

Efficiency means sustainable use

- The system should be at least more than 30 years in operation
- Only heat should be taken from the underground
- The lowest risk is in dry areas where the natural water cycle is not effected (no change in fracture charcateristics)
- The energy efficiency in the Closed Loop Geothermal Systems is less in the first appearance but much more sustainable on the long term than the open system (no corrosion and less maintainance


Muchas Gracias

Sceme of a geothermal energy production