Drilling, Stimulation, and Reservoir Assessment state of the art & challenges ahead

SCHULTE Thomas, GeoForschungsZentrum Potsdam
HUENGES Ernst, GeoForschungsZentrum Potsdam
THORHALLSSON Sverrir, ISOR

and:

Abanes R., Asmundson R., Calore, C., Fokker, P., Hopkirk, R.J., Montanari, D., Monterrosa, M., Muller, J., Nami, P., Portier, S., Rummel, F., Sanjuan, B, Schindler, M., Seiersten, M., Stamatakis, E., Tischner, S., Vuataz, F., Zimmermann, G.

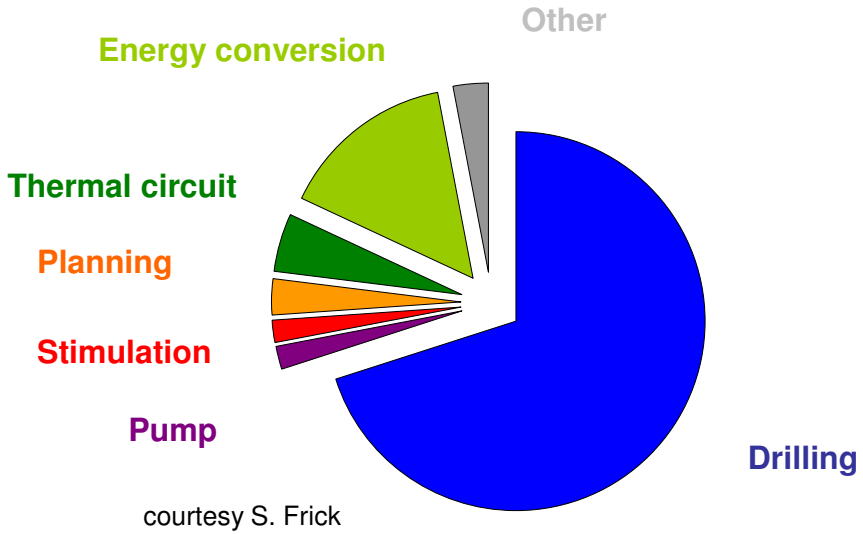
ENGINE FINAL CONFERENCE - VILNIUS
12-15 February 2008

GOALS OF R&D ACTIVITIES

RELIABLE TECHNOLOGY

ECONOMIC VIABILITY

- **Drilling**
- **Stimulation**
- **Reservoir assessment**



courtesy S. Frick

DRILLING

STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

SUPERCRITICAL SYSTEMS

GFZ POTSDAM

ÍSOR

engine

〉 DRILLING

STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

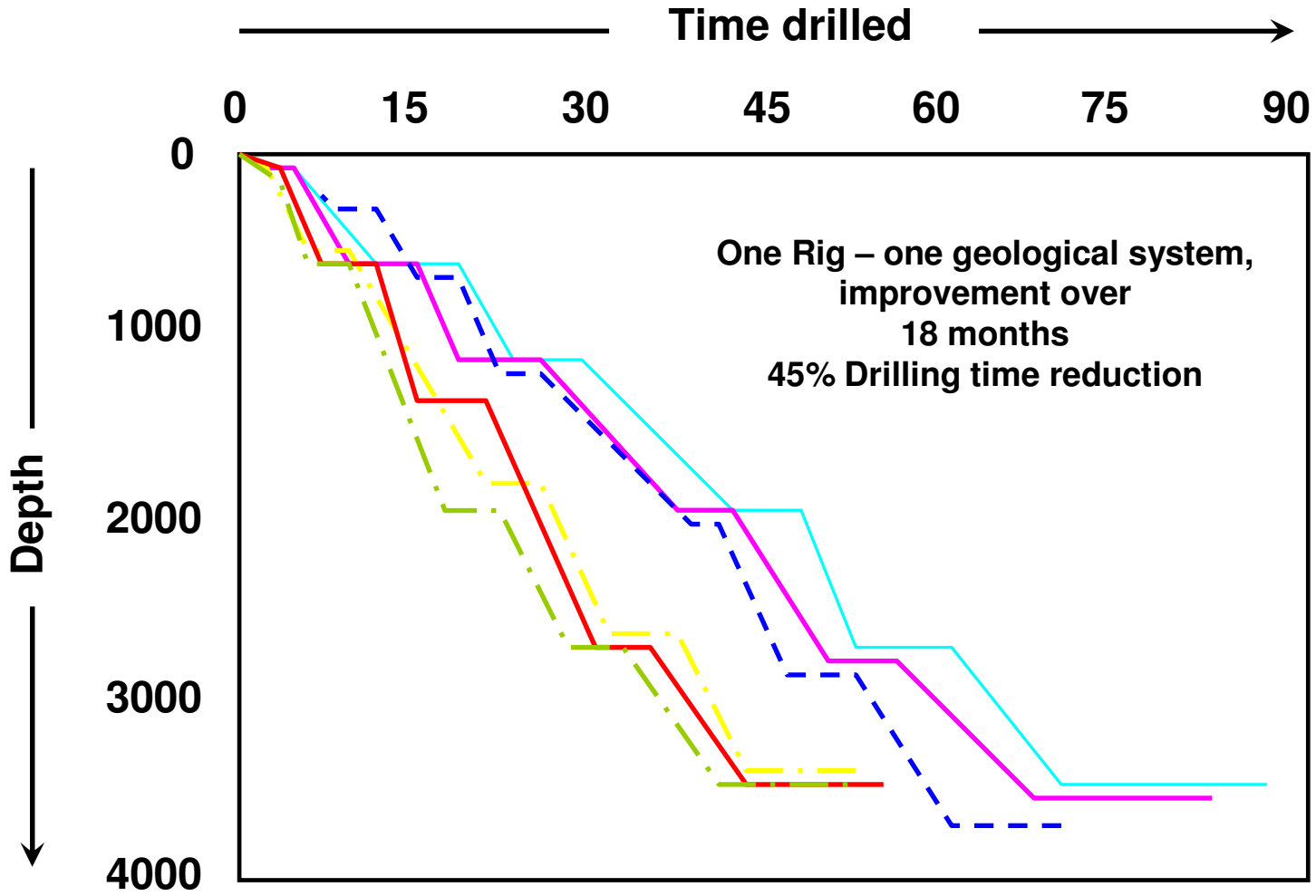
SUPERCRITICAL SYSTEMS

DRILLING PROCEDURES

General		Flat spots in drilling curves
		Drilling contracts with inceased risk sharing

System	State of the art	gaps & needs
Gross Schönebeck	Singular experiences	Standardization
Soultz	Singular experiences	Standardization
Iceland	Standardization	mitigate formation damage
Larderello & Philippines	Standardization	mitigate formation damage

DRILLED DEPTH VS TIME CURVES



DRILLING TOOLS

System	State of the art	gaps & needs
Gross Schönebeck	Standard HC tools	Advanced core drilling
Soultz	Standard HC tools	-
Iceland	Standard HC tools	Intelligent tools for T > 150 °C
Larderello & Philippines	Standard HC tools	Intelligent tools for T > 150 °C

DRILLING MUD & CIRCULATION TECHNOLOGY

System	State of the art	needs & gaps
Gross Schönebeck	Bentonite & additives	Aerated muds at large diameters and angles
Soultz	Natural salt & bentonite	-
Iceland	Bentonite, water & air only	Underbalanced drilling & aerated muds
Larderello & Philippines	Bentonite & additives	-

DRILLING COMPLETION

General		Optimize ratio drilled diameter / flow diameter

System	State of the art	needs & gaps
Gross Schönebeck	Complete cementation	Standardization
Soultz	Free floating casing	Standardization
Iceland	Standardization & BH completion, full cementation	-
Larderello & Philippines	Standardization & BH completion, full cementation	-

DRILLING - CASING MATERIAL

〉 **Reduce lost diameter in the well (small clearance)**

〉 DRILLING

STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

SUPERCRITICAL SYSTEMS

DRILLING

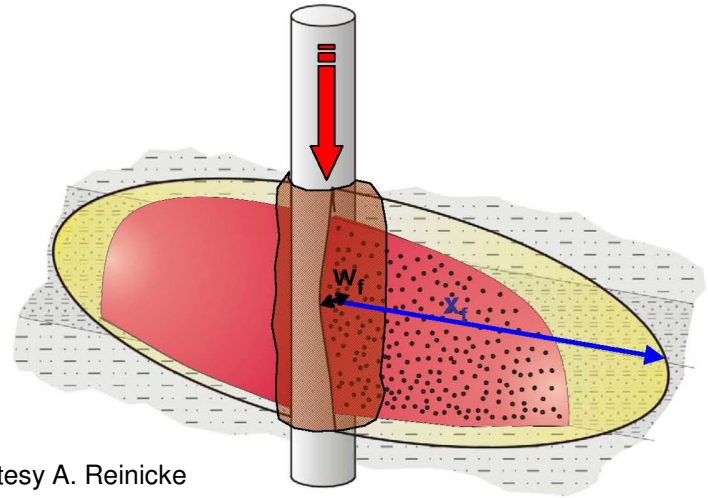
〉 STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

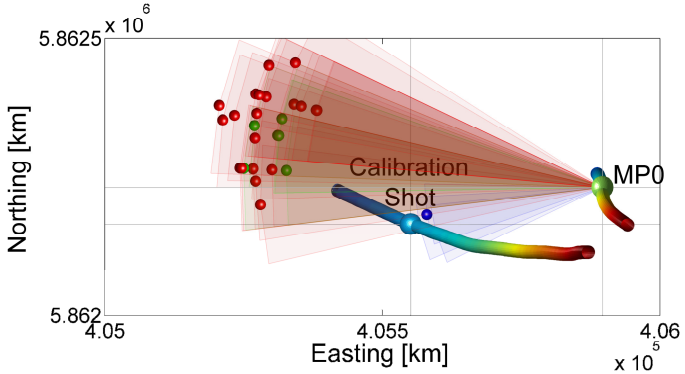
SUPERCRITICAL SYSTEMS

System	State of the art	needs & gaps
Gross Schönebeck	Hydraul. stimulation & acid	Optimize hydraulic stimulation in media with natural permeability
Soultz	Hydraul. stimulation & acid	Investigate thermal stimulation
Iceland	Hydraulic stimulation, thermal frac & acid stimulation	Investigate / improve thermal stimulation
Larderello & Philippines	Hydraulic stimulation, thermal frac & acid stimulation	-

HYDRAULIC STIMULATION



courtesy A. Reinicke



courtesy Kwiatek et al. (2008)

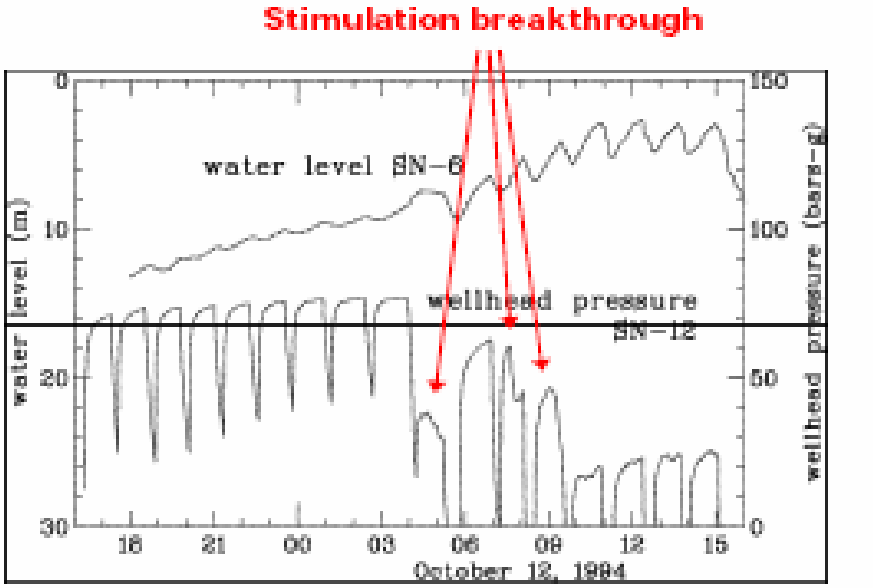
- **Optimize well design and stimulation geometry**
- **Improve stimulation procedures in rocks with natural permeability**
- **Increase monitoring - build a knowledge base**
- **Share experiences and improvements**

CHEMICAL STIMULATION

Courtesy: P. Rose

- Uncertain rock mineralogy
- Multiple types of coexisting formation damage
- Address fast reaction kinetics at elevated temperatures
- Investigate dissolution of secondary minerals

STIMULATION THERMAL



Courtesy: G. Axelsson & S. Thorhallsson

- **Investigate potential of thermal fracturing**
- **Applicable to systems with more moderate temperatures?**

DRILLING

〉 STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

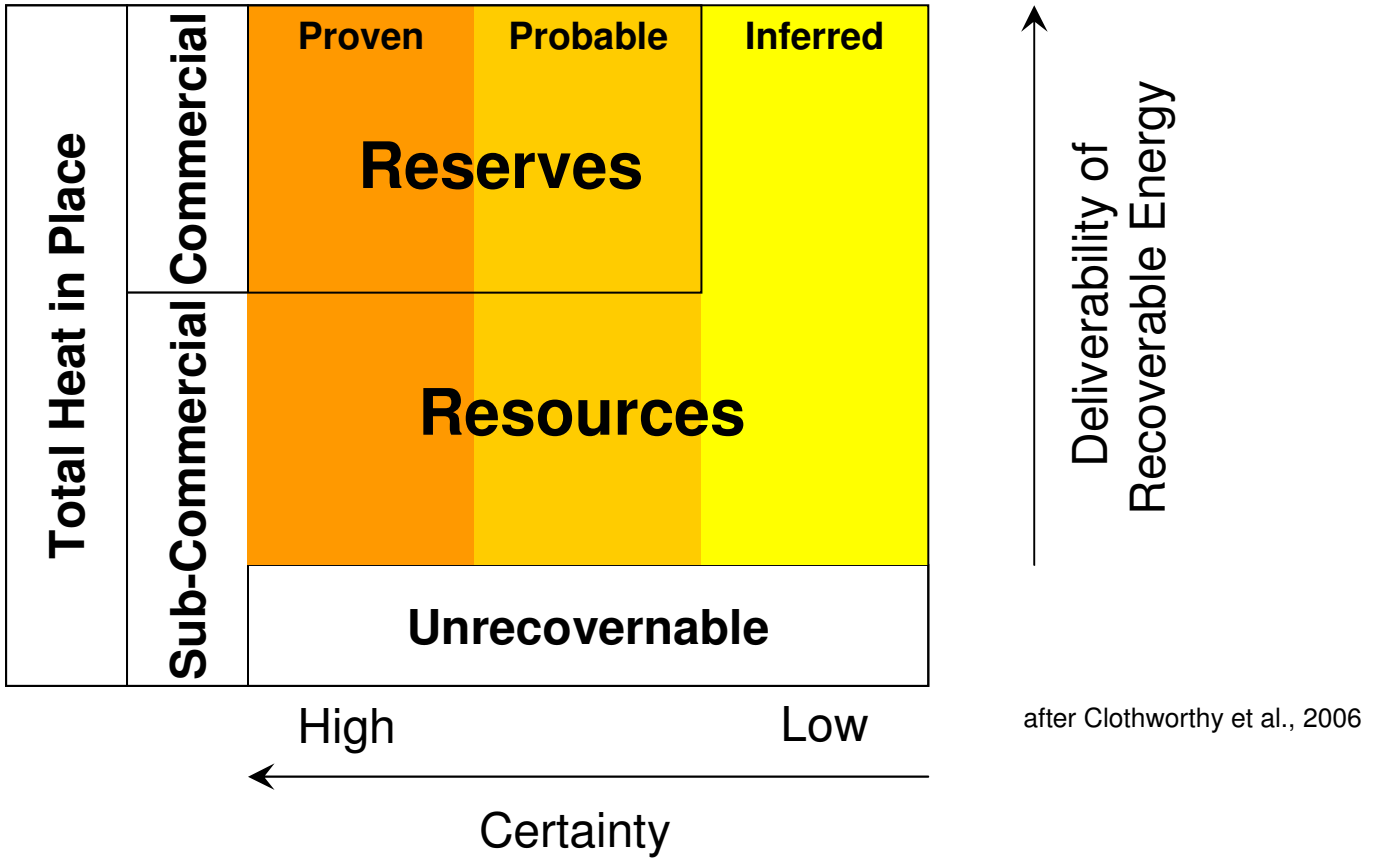
SUPERCRITICAL SYSTEMS

DRILLING

STIMULATION

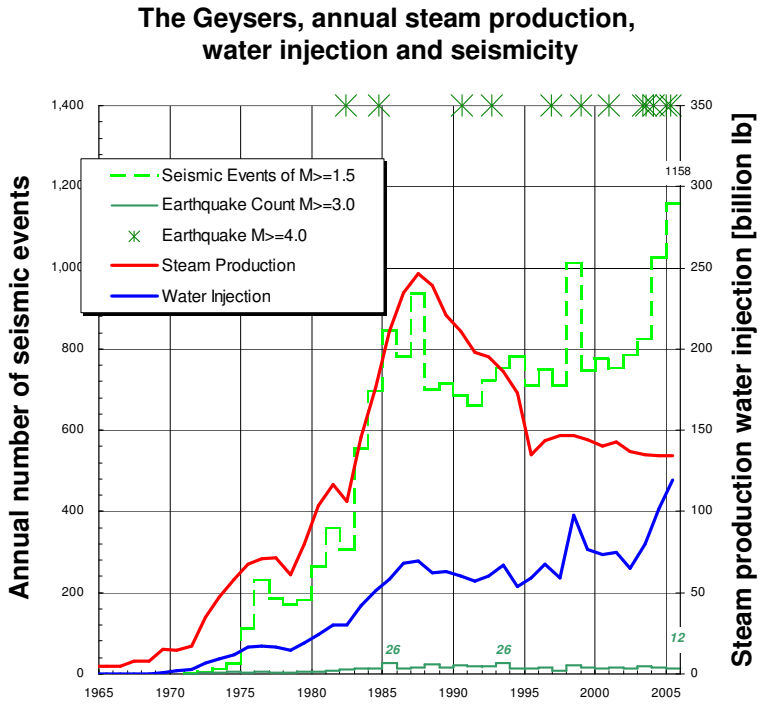
› RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

SUPERCRITICAL SYSTEMS



after Clothworthy et al., 2006

› **Work towards a standardized reserves valuation scheme**



from Majer et al., 2007

- **Strategies to sustainably maximize production and mitigate induced seismicity**
- **Better understanding of how geothermal reservoirs change over time**
- **Address issues of multiple users ulitizing the same resource**

General	Not allways common in commercial operations	Long term stable components

System	State of the art	needs & gaps
Gross Schönebeck	Seismic, geochemical, thermal, pressure	Multi - parameter monitoring
Soultz	Seismic, geochemical, thermal, pressure	Multi - parameter monitoring
Iceland	Seismic, geochemical, thermal, pressure	Limited Number of parameters at HT
Larderello & Philippines	Seismic, geochemical, thermal, pressure	Limited Number of parameters at HT

DRILLING

STIMULATION

〉 RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

SUPERCRITICAL SYSTEMS

DRILLING

STIMULATION

RESERVOIR ASSESSMENT, MANAGEMENT & MONITORING

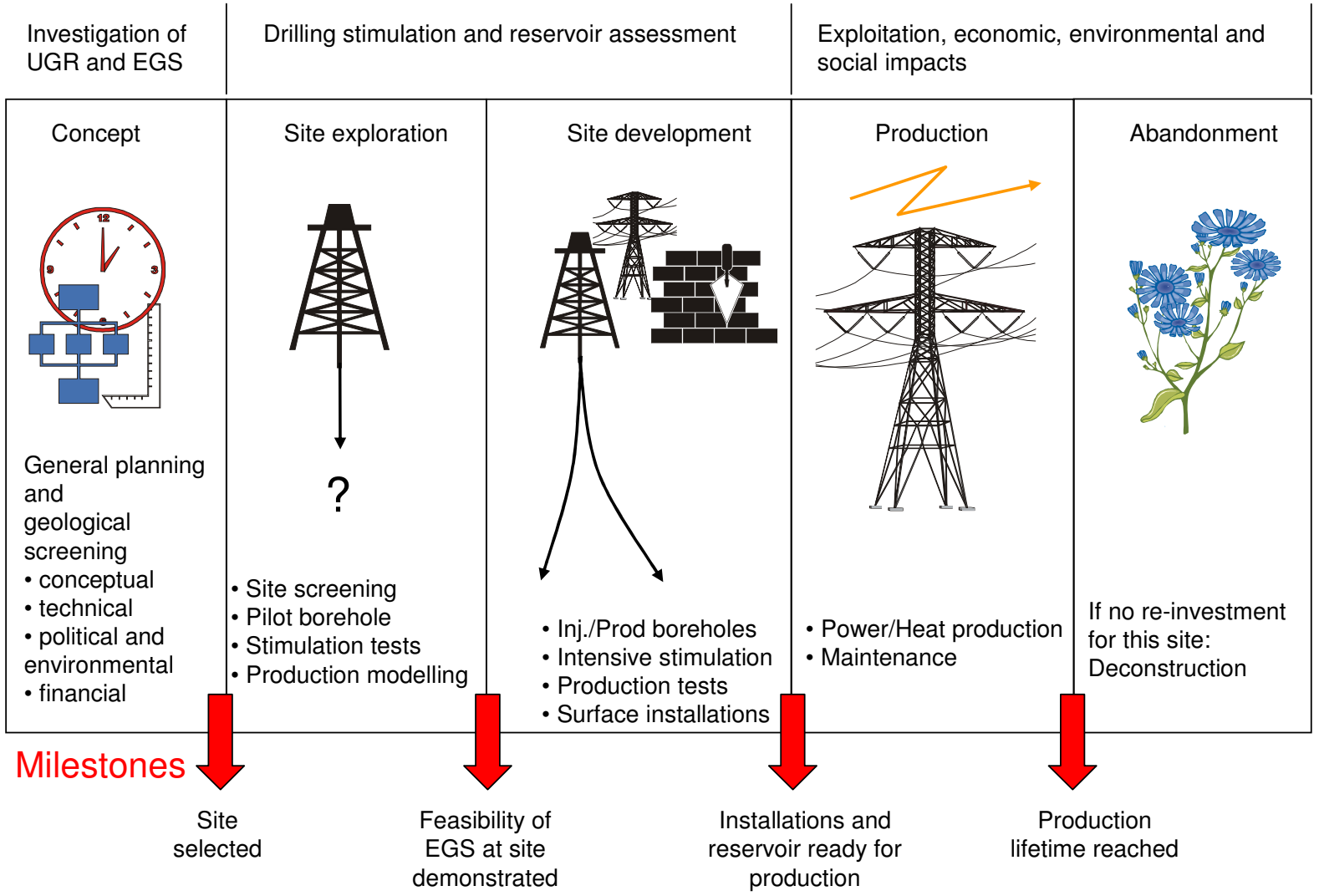
〉 SUPERCRITICAL SYSTEMS

System	State of the art	needs & gaps
Volcanics	Singular experiences	Cement
		Drilling muds
		Tracer
		Logging tools
		Monitoring tools

SUMMARY

- ✓ **TECHNOLOGY TO REDUCE DRILLING COSTS**
- ✓ **TECHNOLOGY CONTRIBUTING TO INCREASE PRODUCTION OF A WELL**
- ✓ **TECHNOLGY WHICH MAKES GEOTHERMAL PROJECTS TECHNICALLY FEASIBLE , SAFE AND SUSTAINABLE.**
- ✓ **TECHNOLOGY NECESSARY FOR SUPERCRITICAL SYSTEMS**

Thank you very much
for your attention!



courtesy T. Kohl