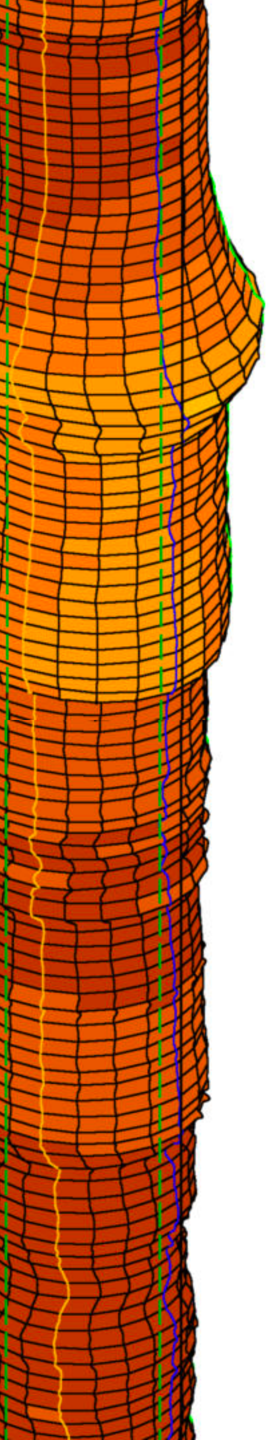

INTEGRATED STRESS FIELD ESTIMATION AND IMPLICATIONS FOR ENHANCED GEOTHERMAL SYSTEM DEVELOPMENT IN ACOCULCO, MEXICO

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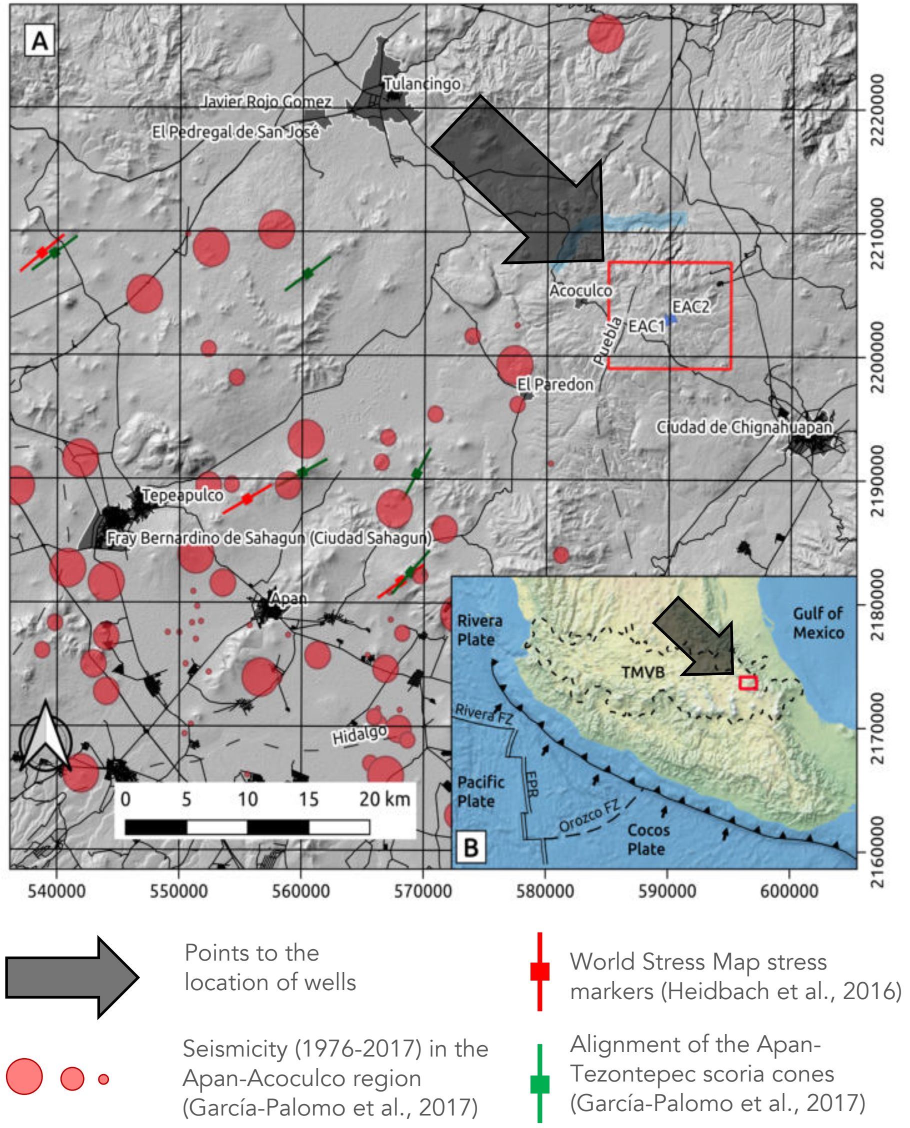
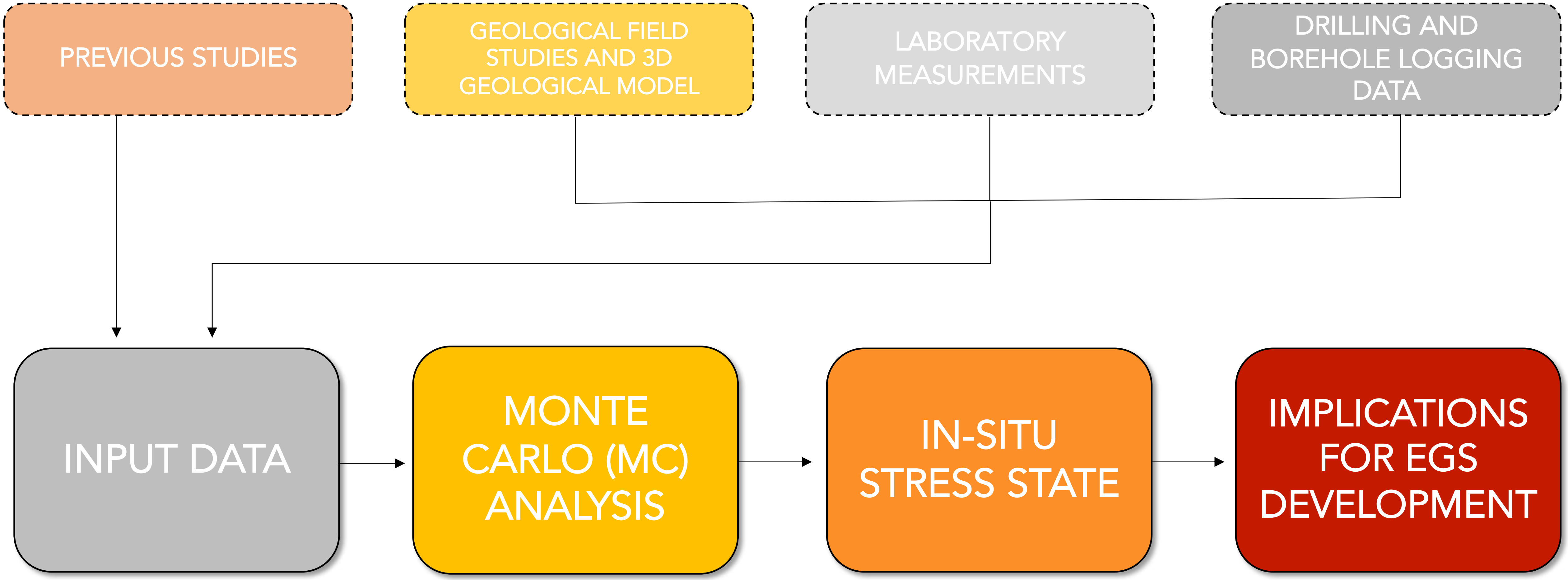
Introduction

- Acoculco caldera complex is located within the Trans-Mexican Volcanic Belt (TMVB) in the Puebla and Hidalgo states in eastern Mexico.
- Two wells drilled in 1995 (EAC-1) and 2008 (EAC-2) with temp. of approx. 300 °C, low permeability, and no geothermal fluids.
- The only possible way to extract geothermal energy is through permeability enhancement using EGS technology.
- For designing stimulation operation, contemporary in-situ stress tensor has to be well constrained. This heavily relies on the availability of stress information.

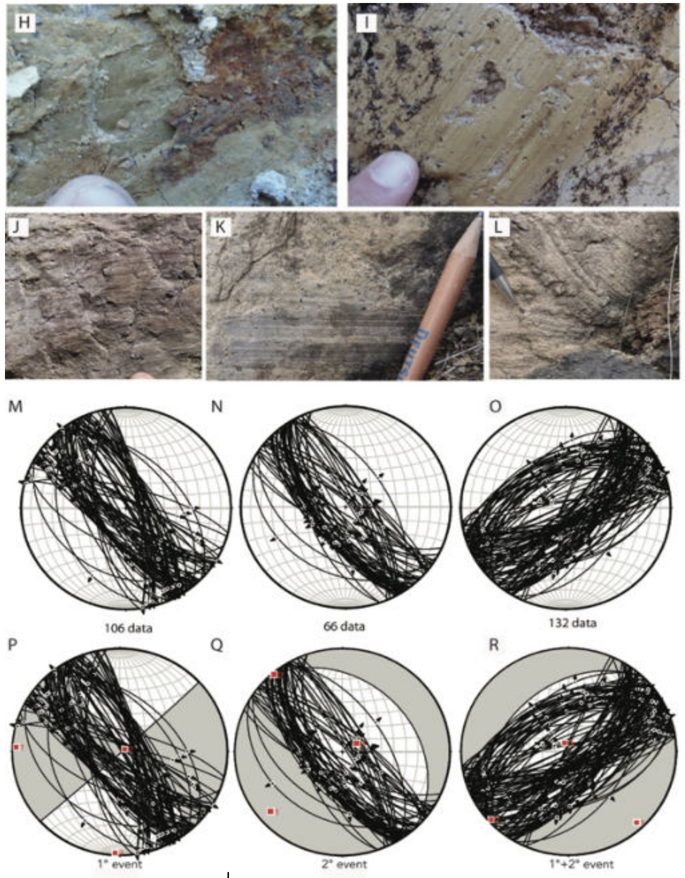
Kruszewski et al. (2021)



Workflow


PREVIOUS STUDIES
GEOLOGICAL FIELD STUDIES AND 3D GEOLOGICAL MODEL
LABORATORY MEASUREMENTS
DRILLING AND BOREHOLE LOGGING DATA
INPUT DATA
MONTE CARLO (MC) ANALYSIS
IN-SITU STRESS STATE
IMPLICATIONS FOR EGS DEVELOPMENT

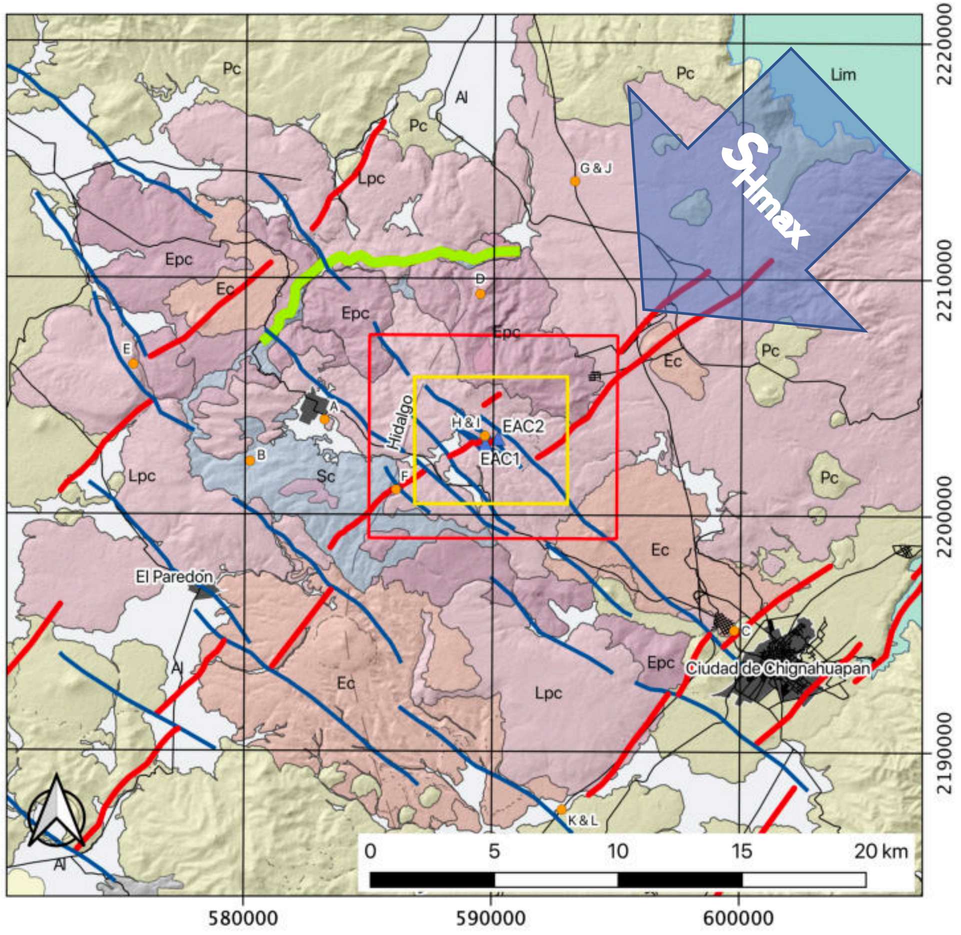
Geological field studies



Strike-slip to oblique

Oblique to normal

Kruszewski et al. (2021)



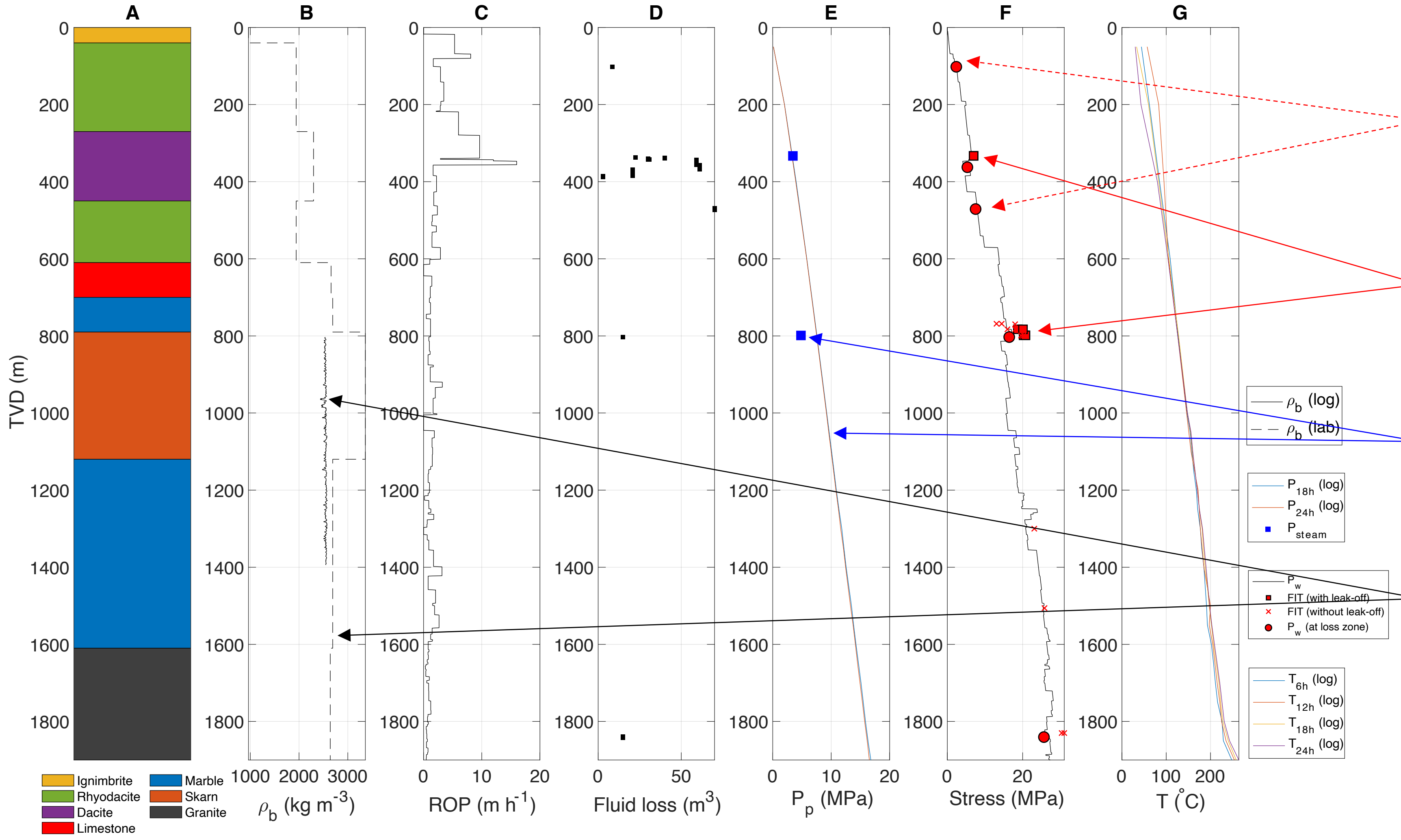
Oblique to normal NE-striking faults

Caldera rim

Oblique to strike-slip NW-striking faults

Azimuth of S_{Hmax}

Drilling, borehole logging, and laboratory data



Magnitude of S_{hmin} computed from applied P_w at fluid loss zones assuming impermeable formations and no pre-existing fractures.

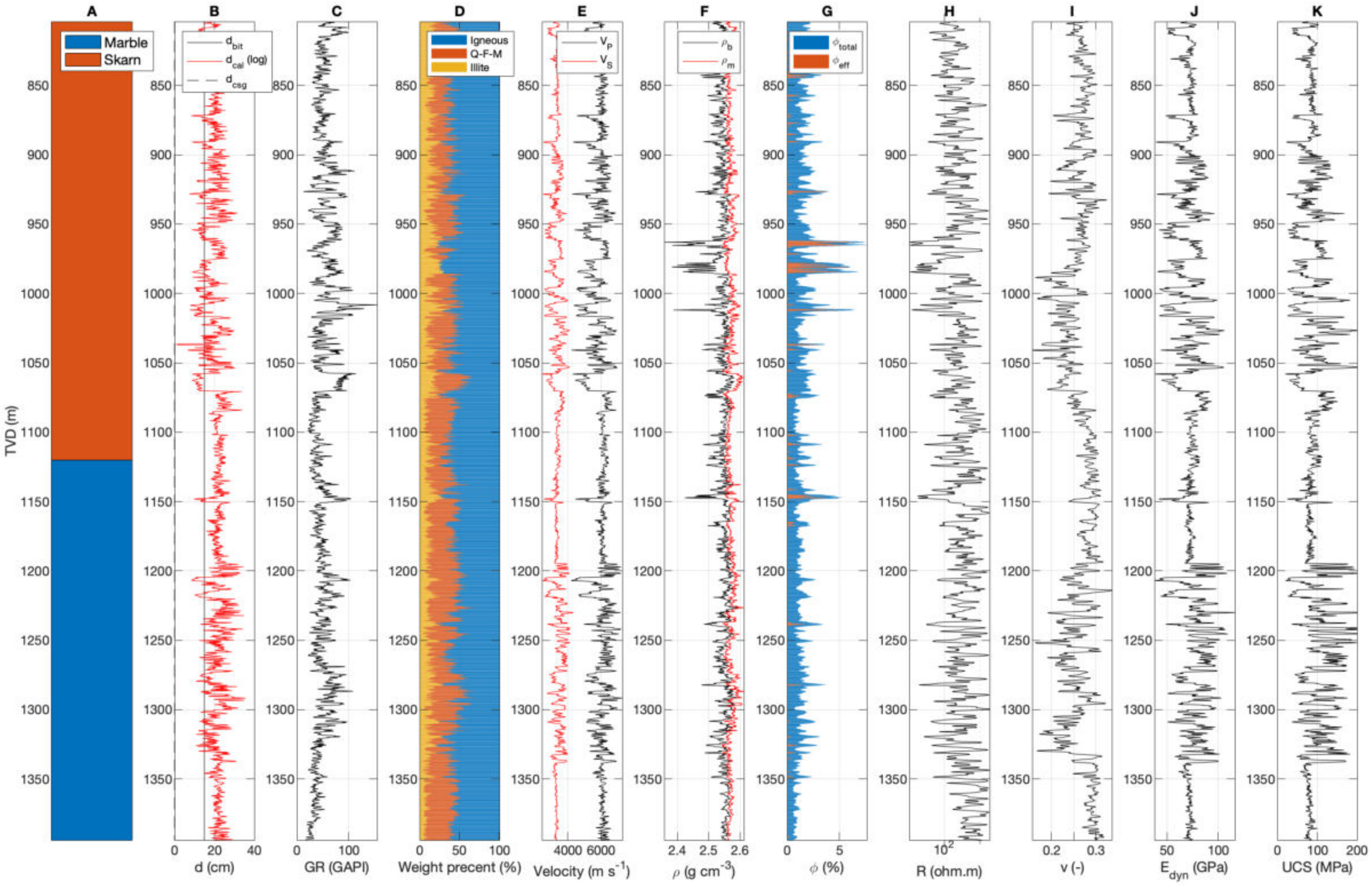
Magnitude of S_{hmin} computed from FIT carried out during drilling operations.

Magnitude of P_p based on pressure profiles in "equilibrium" conditions and steam influxes observed during drilling.

Magnitude of S_v from geophysical logging and laboratory studies on outcrop and reservoir core samples.

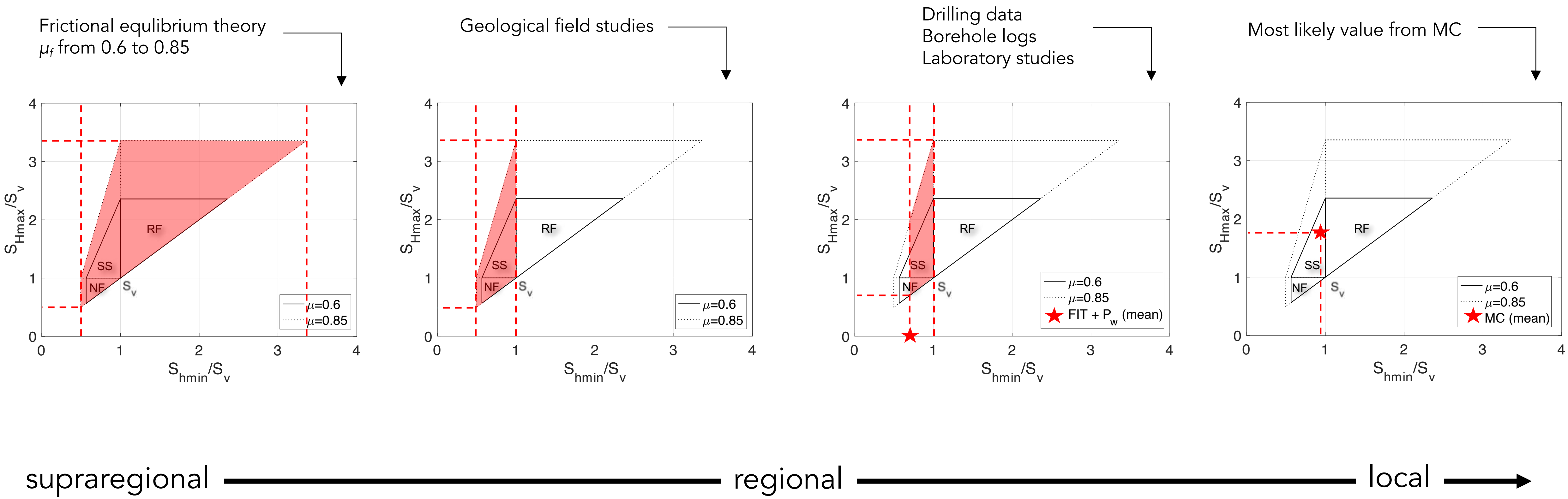
UCS and T_0 values from laboratory studies on outcrop and reservoir core samples.

Drilling, borehole logging, and laboratory data



Kruszewski et al. (2020)

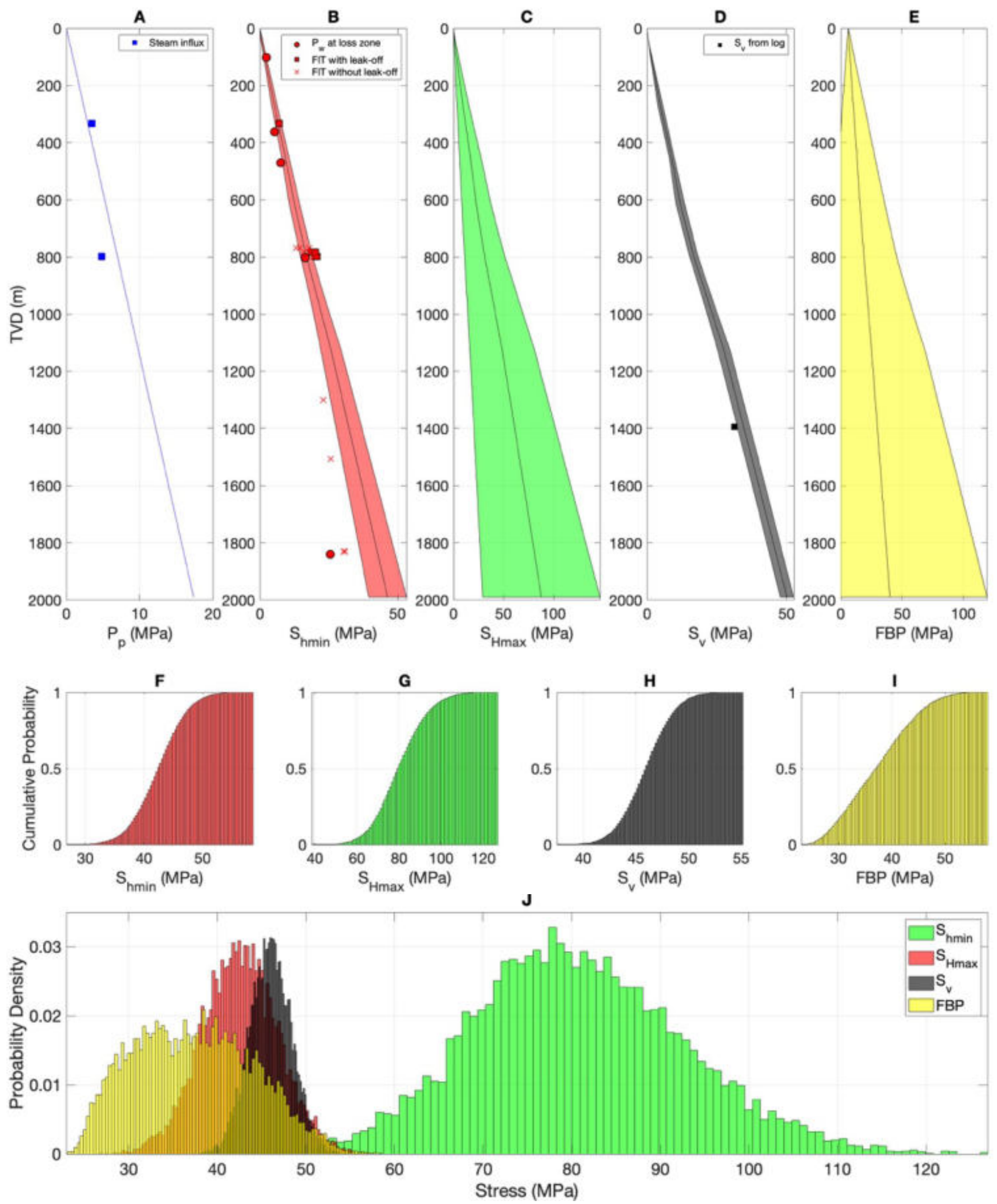
Stress polygon and Monte Carlo (MC) analysis



MC simulation results

- Stress regime is between normal ($S_v \geq S_{Hmax} \geq S_{hmin}$) and strike-slip ($S_{Hmax} \geq S_v \geq S_{hmin}$) faulting with NE-SW S_{Hmax} direction.
- P_p gradient equals to 8.73 MPa·km^{-1}, S_{hmin} to 22.8 ±3.3 MPa·km^{-1}, S_v to 24.3 ±1.5 MPa·km^{-1}, and S_{Hmax} to 42.9 ±28.5 MPa·km^{-1}.
- Stimulation pressures can range from relatively small to extremely high overpressures exceeding 100 MPa at depth of 1830 m (in granitoids).
- The highest uncertainties are registered for S_{Hmax} magnitude and stimulation pressures.

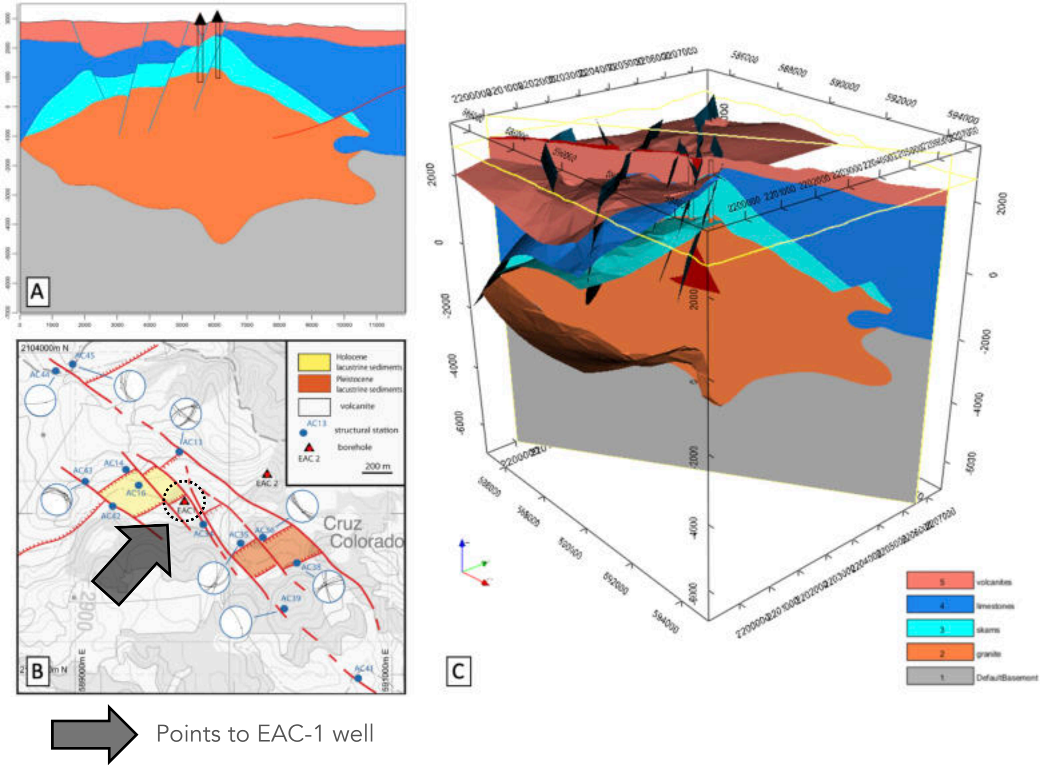
Kruszewski et al. (2021)



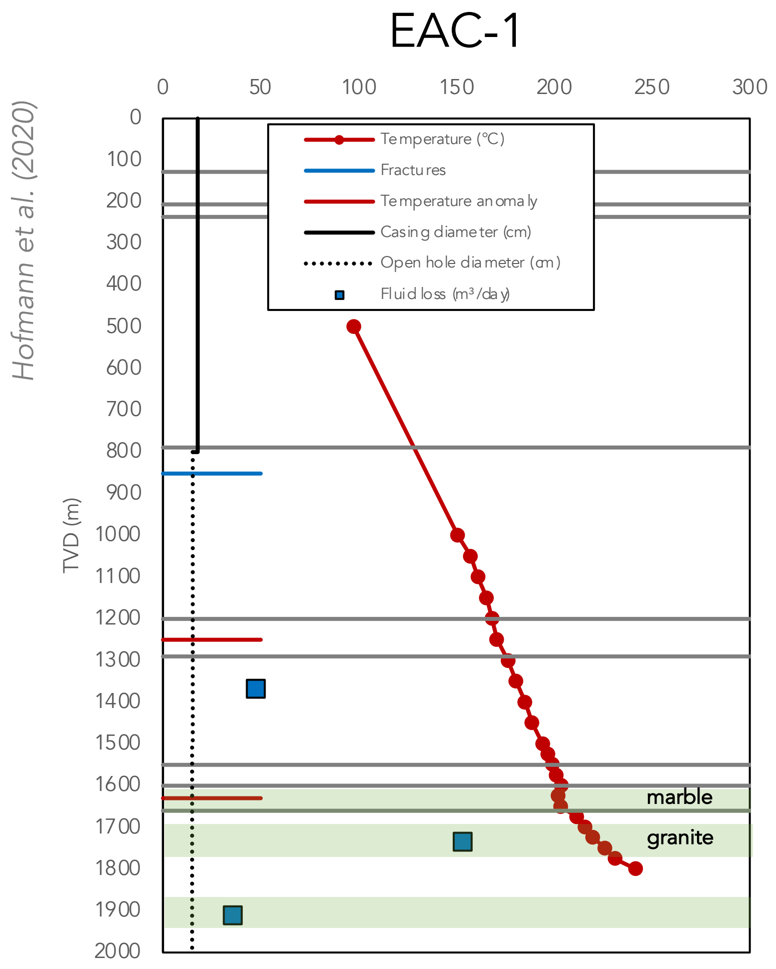
Implications for EGS development

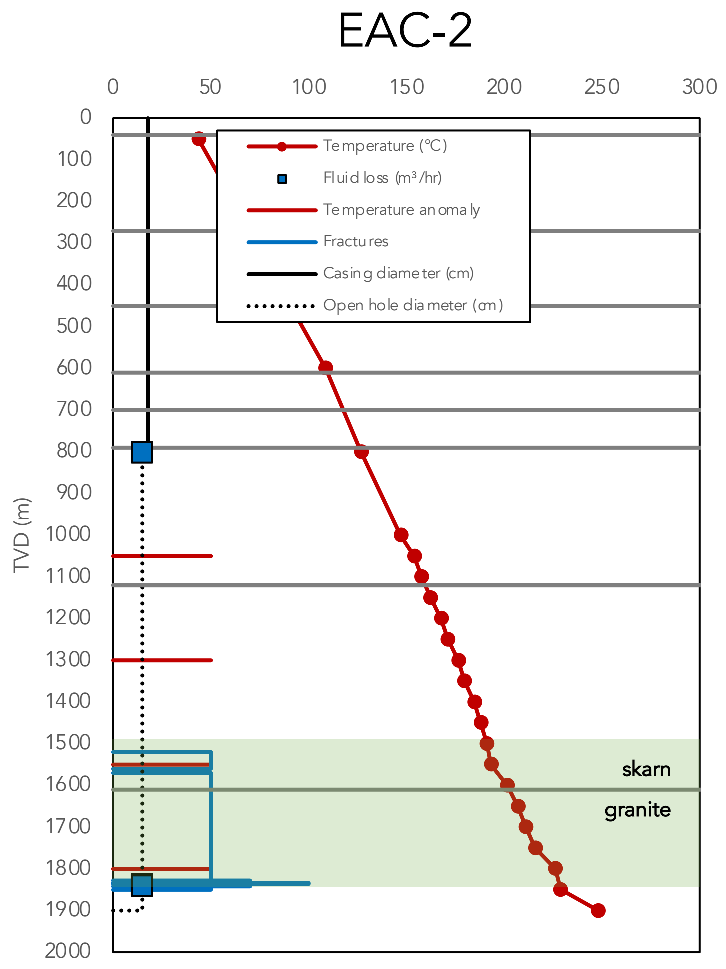
- The EAC-1 well, due to its proximity to the fault structures, is a preferred well to begin stimulation measures.
- Hydrofracking would develop new vertical to sub-vertical fractures parallel to NE- and perpendicular to NW-striking faults.
- It is highly unlikely that both wells can be directly hydraulically connected by stimulation measures.
- The inferred NE-striking faults, or fault intersections can be potential targets for stimulation operations.

Kruszewski et al. (2021)

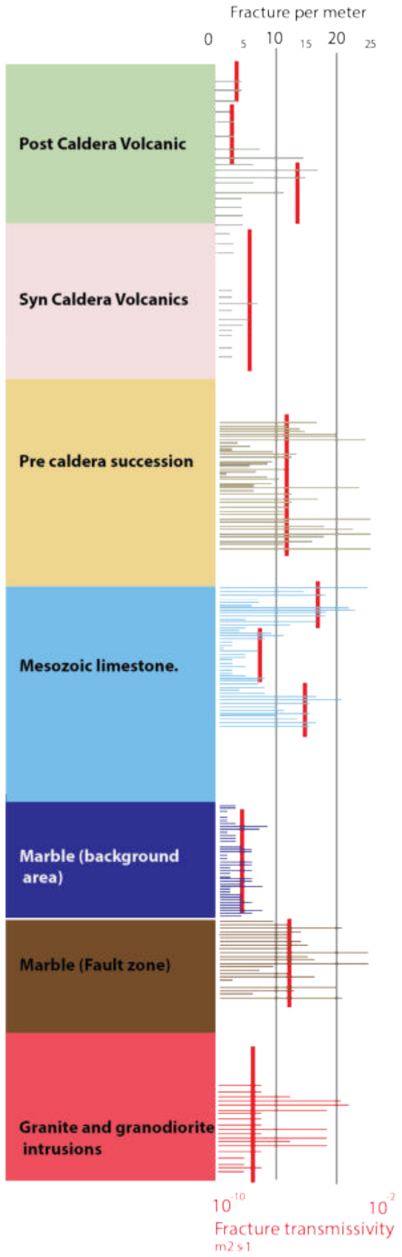


Implications for EGS development



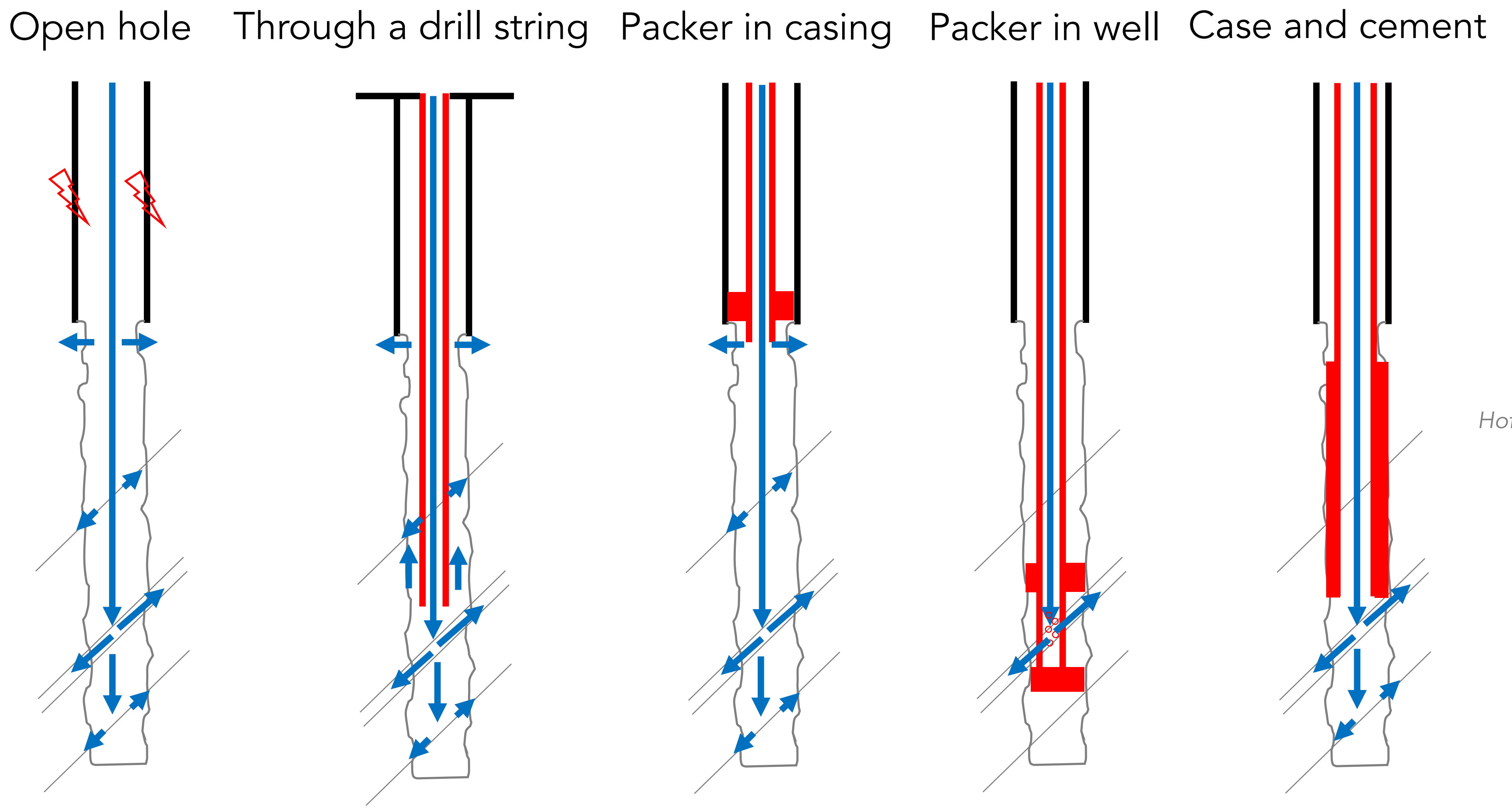


Kruszewski et al. (2021)



Kruszewski et al. (2020)

Implications for EGS development



Hofmann et al. (2020)

Kruszewski et al. (2020)

Conclusions

1. Acoculco field is characterized by transtensional regime with P_p of 8.73 MPa·km^{-1}, S_{hmin} of 22.8 ±3.3 MPa·km^{-1}, S_v of 24.3 ±1.5 MPa·km^{-1}, S_{Hmax} of 42.9 ±28.5 MPa·km^{-1}, and NE-SW orientation of S_{Hmax}.
2. Large uncertainty of S_{Hmax} warrants further measurements, i.e.: image, caliper logging, leak-off tests, to improve in-situ stress state understanding. Monte Carlo analysis may be a useful tool for indication of the most likely stress state, with its uncertainty, once only limited data is available.
3. Fluid-injection-induced and/or activated fractures and faults are likely to be (sub-)vertical and striking in the NE-SW direction. Potential faults between the EAC wells and vertical fracture growth likely prevent the direct hydraulic connection between both wells.
4. A long-term injection through the open hole section into the fluid-loss zones at low pressures (i.e., thermal stimulation treatments) in granite/marble is considered the most viable stimulation option.
5. It is advied to carry out wellbore integrity logging prior to stimulation measures. During stimulation, rapid ΔT, ΔP shall be excluded and the condition of the operation shall be selected to accommodate the cement sheath and casing materials used. Acid-insensitive (e.g., non-Portland) cement blends are recommended for chemical stimulation operations.

References

This presentation was based on

- Kruszewski et al., Integrated Stress Field Estimation and Implications for Enhanced Geothermal System Development in Acoculco, Mexico, Geothermics 89:101931, (2021), DOI: 10.1016/j.geothermics.2020.101931

For more reading on Acoculco please check GEMex project deliverables

- D7.1 Report on model of potential drill target and proposed drill path by Peters et al. (2020)
- D7.2 Report on optimised stimulation scenario for Acoculco by Hofmann et al. (2020)
- D7.3 Report on environmental risk assessment and mitigation strategies by Peters et al. (2020)
- D7.4 Report on results of concepts, surveys, and scenarios for public engagement by Contini et al. (2020)

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Thank you!

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